Learning by Designing, Imagination and Programming

Piet Kommers

Preface We as members of the FITPED project team asked ourselves: What directions of innovation look promising in terms of 'perceived needs' and 'meeting endemic values'. From a pure scientific point of view, operationalizing "Quality of Learning" is one of the hardest nuts to be cracked; Once listing all relevant dimensions of learning processes and outcomes, there is no end. Similar to listing qualities in fashion, gastronomy, music, every new trend in socio-economic era, brings its own new desires and ideologies. The list of quantifiers for qualities of learning: the speed of, easiness for the student and the teacher, endurance of what is learnt, the depth of it, its flexibility, its authenticity, its pedagogical soundness, self-efficacy and … indeed, the students' capacities to become a successful programmer. For those ICT teachers who admit that student autonomy is key in future societies, there might still be hurdles before arriving at confirmation on how to nurture entrepreneurship: "Are there dependencies between pure knowledge, craftmanship and programming skills?" And also: "To what extent is the programming skill a generic one?" Taking gamification as major source for acquiring a programmer's mindset, is a bold statement. Gamification pretends to be "catalytical" to the ongoing evolution of Higher Education and its fan out for socio–/economical evolutions nowadays; Kommers (2021).

Gamification seems to be a strong trigger for changing the school- and course culture in ICT education. Are the traditional teacher-student roles in conflict with the specific didactics as we ought to prefer in computer science? We think not; a large part of the algorithmic mindset relies on the apprentice's eagerness to learn from unexpected situations and persons who can demonstrate competencies that may lead to solutions for unexpected problems. However, this very 'transfer-paradigm' (from teacher to student), though very much needed, is not enough as

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students in a receptive attitude are slow and even averse from ‘changing themselves’. The classical teaching-learning paradigm is that students are supposed to adapt in order to comply with the assessment criteria. In order to create a life-long ICT-savvy learner it is more the ‘willingness to change oneself’, in order to grow along dimensions that were not foreseen by experts so far. Good examples are the growing battles against viruses, fake news, fake identities, big data etc. In this sense computer sciences are more than adapting your competences; it is developing a sharp eye for ‘what is needed by others’ rather than obeying your superordinate. A good programmer does not just follow what his/her customers want now. It is a matter of narrating to your potential customer in order to create his/her need of tomorrow. Here is where gamification and constructivist learning come in: It helps Higher Educational students to open additional mindsets. The real job for FITPED now is to find effective design rationales on how to weave gamification in existing computer science curricula. Rather than delivering hard-core recipes, we claim that ICT trainers need to go through a set of experiences how gaming opens additional genres for our mentor roles in entrepreneurial stages of FITPED.

1 Introduction

Creative didactics is the core target for future ICT curricula in this FITPED project. As will be elaborated further in this book, student-oriented learning is as multifacetted as programming itself. There are many avenues for innovating ICT curricula that have not been fully exploited yet: 1. Gamification, 2. Playing, 3. Collaborative Learning, 4. Storytelling and 5. Simulations are just the most obvious ones. However also Mobile Learning, Virtual Reality and the many more technodriven innovations to come are essentially promising candidates for the future of ICT curricula. In order to make programming more effective, efficient and sustainable we need a strong foundation for its embedding in the actual educational situations and further consolidation. Seen the recent scientific literature and good practice examples, this envelope is PBL (Problem-Based Learning): The method to place the apprentice at the very core of his/her learning process; (s)he (re)gains full ownership of the start of a life-long learning process. For the sake of innovative ICT skills it means that apprentices who typically have a less favorable earlier school experience, they need to be encouraged by being welcomed and empowered through a student-centered pedagogy. Problem-Based Learning should not be confused by Project-Based Learning. The essence of the PBL approach is to learn about a subject through the experience of solving open-ended problems found in trigger material; prototypical questions that orient the learner towards understanding what PBL questions ideally are. The PBL process does not focus on problem solving with a defined solution, but it allows for the development of other desirable skills and attributes. This includes knowledge acquisition, enhanced group collaboration and communication. As overall recommendation: Motivate ICT trainers to see the elegance and sustainability of PBL; (Smyrnova-Trybulska et al., 2017). It is a powerful

paradigm before adopting and integrating the new ICT-based tools as presented before. Main driver behind the integration of PBL in ICT is that it fits very well with the type of motivation of young apprentices "to make a difference" and "find a job" or "start a company". More in general, we see a recent policy towards preparing ICT students for "Smart Jobs"; (Issa et al., 2017). It preludes a more active learning approach and ready for the post-industrial era where men and machine face new complementary skills and autonomous life-long learning. This inherent trend not only holds for including ICT skills; it is a much more intricate shift from technical-, via communicative- to conceptual skills. According to "Balance-Careers" the Top-Five conceptual skills are: Analysis, Communication, Creative Thinking, Leadership and Problem-Solving. According to "Business-Directory," conceptual skills can be delineated as: The ability to think creatively about, analyse and understand complicated and abstract ideas. Using a well-developed conceptual skill set, top level business managers need to be able to look at their company as a holistic entity, to see the interrelationships between its divisions, and to understand how the firm fits into and affects its overall environment. Until very recently these 'conceptual skills' were supposed to belong to the repertoire of corporate leaders and top managers. Now we see that very rapidly these skills are seen as essential for labour force throughout the enterprise pyramid.

2 Cognitive Hexagon

Before going into details on how the didactics in 'learning to programming' needs to be developed further, it might be good to present the 'cognitive hexagon' by Valera Mariscal. Its six ingredients show a wider context of disciplines then we generally accept (Fig. 1).

1. At the top is philosophy. Its role is not only to reify the traditional desire towards Ph.D. certification. It is the deep trust that true knowledge on learning can only be harvested if we owe the discipline to think about all transitions between the involved concepts. For instance, if we value the process of 'understanding' rather than acquiring knowledge and skills, it is inevitable that we concern all super- and sub-ordinate concepts and processes around the phenomenon of 'understanding'.
2. Going clockwise we meet Mariscal's (2014) mentioning of 'linguistics'. Not only to stress the need for De Saussure's or Chomskian attention for structuralism of transformable generative syntaxis. The need for linguistics in learning goes deeper. It is the acknowledgement that language, consciousness, and knowledge go hand in hand; they need each other and finally it is hard to pin down the three in its contrast to the other two. Lev Vygotsky (1986) is maybe the most renown pioneer who questioned maybe the most essential question in his book "Thought and Language". For instance, Vygotsky's attention for 'private language' has been inextricably linked to the question in how far pre-

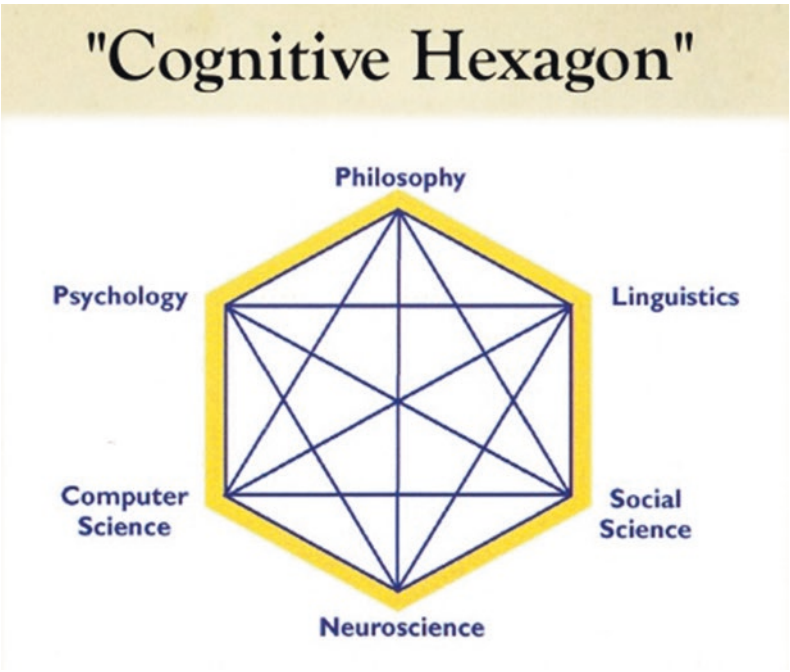

Fig. 1 the 'cognitive hexagon' by Valera Mariscal

communicative language is needed before youngsters can sense the root of one's existential roots? As we come closer to the need for reflection and metacognitive awareness, it will be clear that linguistics is a much deeper need than just sharing ideas amongst tutor and tutee.

3. Social science gained momentum in the sixties as human processes need an idiosyncratic stand, based upon the cognitive duality that we typically call "the phenomenological" stand towards understanding human development. Typical for social science is its in-depth need for multi-variate constellations rather than the two or three parameters that we meet in for instance physics. Social sciences are not only the aggregation of adding individual disciplines like psychology, pedagogy, sociology etc.; it is rather an epitome that alerts us for the needed uniqueness of cases as we look to persons and unique situations.
4. Neuroscience conquers more and more attention from educationalists. It alerts teachers and student coaches to be keen on the neural substrate of the human mind, memory, and processes like 'self-regulation' and 'consolidation' as it now manifests to be crucial for semantic integration during the slow-wave sleep. Until 10 years ago it was generally understood that sleep is vital for new learning. Since few years we now know what happens if (even without being awakened) one's slow wave sleep is interfered with a subtle sound. Its effect is monstruous and will lead to psychotic problems. We recently discovered that during the slow wave sleep, the spread of neurotransmitters goes from the hip-

pocampus to the cortex, where the electric patterns from the experiences of the day before becoming 'consolidated' into chemical structures so that it is ready for being reconciled with earlier prior experiences and ready for future new information.

5. Computer science, and the term 'information science' might even fit better in this context, has already been proven a wide set of learning theoretical orthogonalities that would never had emerged from psychology or pedagogy. For instance, Wiener's coining of 'cybernetics' has been the trigger to frame the teaching/learning process as a progressive targeting of 'hitting' the right learning 'goals'. Gordon Pask can be seen as one of the most influential cyber protagonists who formalized the learning/teaching dialogue a discursive process where students were supposed to 'teach back' to the tutor in order to provoke a new diagnostics and complementary instructional intervention.
6. Finally, but not least is 'psychology' as catalyst for innovating teaching/learning processes. Most characteristic is its attempts to find underlying mechanisms in the learning processes. Behaviourism, cognitivism, and later neural modelling; they all show attempts to formalize the wide plethora of types of learning and the even more wide scale of individual characteristics in one's fully unique reflections and deriving meaning from earlier experiences (Fig. 2).

In summary: even the widest circle of disciplines brings limited views on how to arrange a better learning. It seems that there is no hope to reduce learning models to the formal categories as we have nowadays. Similar to food, fashion, art and lifestyles, learning will show new varieties the coming decades.

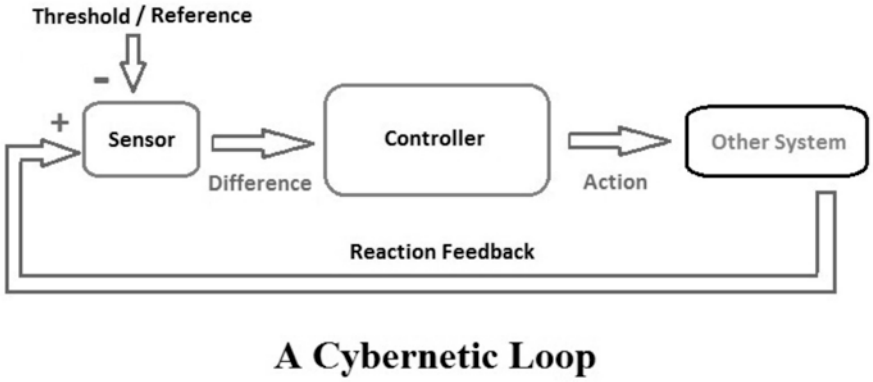

Fig. 2 Wiener's Cybernetic control loop

3 Five Dimensions for Innovative Didactics

At the outset of the wide spectrum of didactic rationales and methodologies we see the next five dimensions that have generally been recognized as the most prominent ones (Fig. 3).

1. The first one is the most undisputed one: The attempts to make students active learners. Active learning implies that the teaching/learning process is no loner limited to sending and receiving; The student is considered to regain ownership of his/her own learning processes and thus becomes a co-designer of the didactic situation.
2. It leads to the more articulate second dimension towards constructivist learning. In its most radical interpretation, it is the apprehension that during the learning process the actual formation of concepts and understanding is one of 'reverse engineering': Though all of the concepts to be learnt are ready for 'taking away' it is not enough to see, hear, feel and taste the ideas. Before understanding the full meaning and impact of a concept, the learner needs to 're'-build a concept from its primitives and through applying it in various contexts.
3. The third dimension is the trend towards 'cooperative' rather than 'soloistic' learning. At least it is hard to see that from the pragmatic side we claim that job performance is teamwork for 90% of the cases, while we still defend its stages of learning, training, and maturation as an individualistic process. By accepting the full collaborative paradigm, we need to accept that learning processes not only need to be orchestrated as collectivistic ones; also, its testing and accreditation need to be in the full collaborative context.

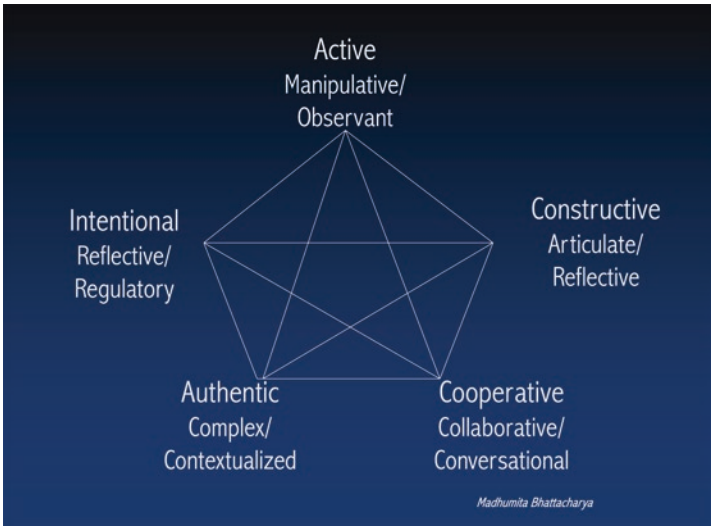

Fig. 3 The five most prominent innovative dimensions for future didactics

4. The authentic learning paradigm is the plead for students' unique personal traits like incidental prior knowledge, idiosyncratic passions, hobbies etc. This alternates to the overall view that learning in curricular contexts needs to focus on the commonalities rather than its differential elements.
5. Intentional learning is the recommendation to teachers to embed instruction in holistic real-world actualities; What keeps students busy before entering the lecture hall is no longer seen as 'noise' or as 'distraction'. It is the real cognitive basis where next formal education needs to be built upon.

In case of 'learning programming skills' it is of vital importance that both content and method of didactic innovation needs to be mapped back to at least one of these five essentials. Too often, educational novelties carry away teachers' full attention, without promoting the awareness that students are not that impressed by 'new' tools and methods like for instance 'learning by simulations', 'gamification' or '3D virtual worlds'. In case of teaching programming skills, it is important that the 'skill' element does not 'supplant' the awakening of meaningful intuition and understanding. Especially the ingredient of 'conceptual reconstructions' in combination with reflection and the promotion of imagination, are vital in order to improve the essence of the learning process.

4 Learning by Designing

The notion that 'programming skills and experiences' are vital for making learning more 'active' and 'generic', has been coined by Seymour Papert who created the LOGO system for educational purposes; Papert, 1980. At that time the ultimate term was 'constructivism'. Based upon students learning algorithmic thinking, the implication was that the inevitable way of learning primitives like Boolean expressions, control variables for iterations, etc. was to let some-one build and explore its behaviour in a wider context. In this way, Papert's idea on constructivist learning in his book 'Mind Storms' started a Copernican swivel in thinking on conceptual learning, where exploration, imagination and 'playing' were the key ingredients. The FitPed project builds upon the essential understanding that students in Higher Education need at least one curricular strand that allows them to explore consciousness and metacognition in order to become better learners.

4.1 Gaming by Playing for Learning

Before exploring the potential of Gaming and Storytelling it is useful to provide two main reasons for our searching in the next directions. The first is that, complementary to our day-to-day classroom efforts for converting students into better learners, the main question is to make educational systems better by rephrasing Kenneth

Dunn (Kaufman et al., 1997): "If students don't learn the way we teach the, let's teach them the way they learn". The second one is the notion that programming competencies face moving targets; Progressing from procedural to declarative to object-oriented to functional programming. The third direction is that employees face more and more demands for strategic thinking. Though the term "conceptual skills" may suggest that it belongs to high level managers, there is a growing understanding that for a large class of jobs conceptual thinking is needed in order to promote problem solving and creative approaches. This trend goes together with the growing need for knowledge- rather than industrial workers. Conceptual skills are the next step after we mastered factual and procedural knowledge. Both knowledge and skills are consolidations after good practice has found an optimum; As our surrounding world evolves, new ICT skills need to be identified: Its goal is to prevent a group of youngsters to become obsolete. We hope to illustrate that gamification, storytelling and many more are indispensable in this continuous process.

Definition Gamification is the application of game-design elements and game principles in non-game contexts (Werbach, 2014). The main reason for defining gamification as a process is that it provides a scale for gamification and not an absolute category. Gamification commonly employs game design elements to improve user engagement, organizational productivity, flow, learning, employee recruitment and evaluation, physical exercise, traffic violations, voter apathy, and more. Werbach and Hunter (2015) identified five game dynamics used in gamification:

- **Constraints** are about balancing limitations and freedom for a player as well as integrating forced trade-offs in the design of a gamified solution.
- **Emotions** aim to produce enduring player engagement and appear during an activity.
- **Narrative** is represented for a player through either an explicit or implicit storyline having its own consistent inner logic and following a certain context.
- **Progression** reports the player's growth and development when navigating through a game and the possibilities to do so.
- **Relationships** consider the social interactions of players in a game which can create feelings of camaraderie, status and altruism.

Jayalath and Esichaikul (2016) provide a model in which the dynamics, mechanics and Element are combined (see Fig. 1). This provides teachers and researchers with a framework to design engaging learning environments. Just using an element does not necessarily create an engaging gamification environment. For instance, providing points as in grading tests would not be considered an engaging gamification environment for most students as they a used to this. Creating teams to compete in an engaging set of problems to be solved and keeping a leaderboard scoring system might be challenging and create intensive team cooperation (Fig. 4).

A number of studies on gamification show that it has positive effects on individuals in terms of cognitive flexibility, changing role perspectives, etc. However, individual and contextual differences exist. Gamification can improve an individual's ability to comprehend digital content and understand a certain area of study such as

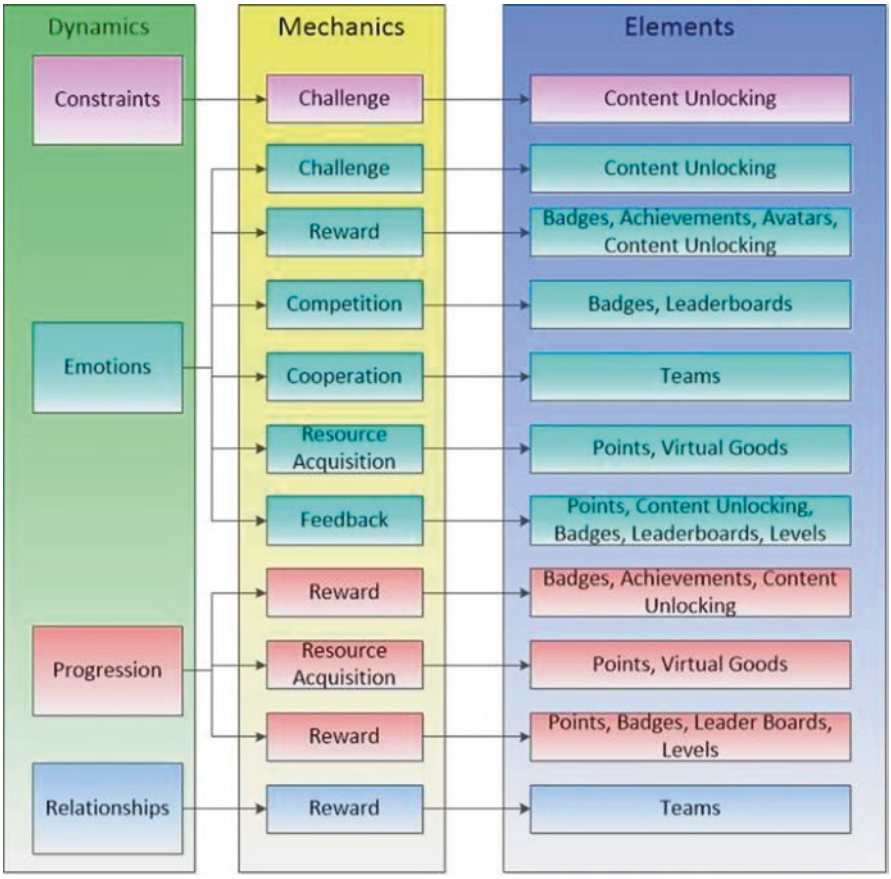

Fig. 4 Linkage Diagram of game dynamics, mechanics and elements. From: Jayalath and Esichaikul (2016)

music. Research into the use of gaming for learning shows that gamification penetrates all sectors of life where awareness, latent ambitions and mental growth are at stake. As such, gaming may not only increase the effectiveness of traditional learning goals like memorization and skill routinization; It may help learners to refresh their concept of what learning is about. In its deepest sense, learning can be seen as one's developing willingness to change him/herself; (Kommers et al., 2004).

The contrast between single- versus double-loop learning is that single-loop learning can be compared with a thermostat that learns to switch-off the heating when a certain temperature is reached, whereas double-loop learning occurs when a device (or a person) learns to monitor a wide set of parameters and becomes keen on which of them are the best first-order predictors for anticipation when heating or cooling is needed. Games as we typically know for increasing speed and precision have already proven its value for learning. Its overall metaphor is "beat your peer student or your own score in the past". Double-loop learning games place the learner

at the core of a realistic situation and ask to discover 'hidden' relationships in a certain domain. Where gaming aims at winning, playing aims at conquering new levels of understanding, self-awareness and self-efficacy. In terms of Constructionism, it is the learner who attempts to become his/her own coach (Figs. 5 and 6).

The relations Learning-Working and Playing-Working have been extensively explored in educational practice before. The intersection Playing-Working seems to be underexploited yet. Its goal is to make apprentices better new colleagues who dare to question and help to transform into new business models. As Steve Jobs claimed: "Traditionally we, as Apple, scout and hire the best people around the globe, pay them highest fees, and subsequently tell them what to do..."; It reflects the growing notion that in the post-industrial era, working is the efforts to exceed earlier expectations and survive in an ever more competitive market. The notion of 'double-loop' learning confirms the manifold efforts in the last four decades to equip the learner with ever more autonomy, self-regulation, and metacognition, in order to start the process of a life-long learning attitude as early as possible.

5 Playing Versus Gaming

Though playing and gaming have a completely different source, they have sentiments in common. Both emerge in situations when no real urgences or threats are at stake. So typically, between work and worshipping. The play is simply the lack of explicit external agendas; whereas the gaming allows external merits to penetrate. For instance, playing football may have no other goal than enjoying the ball to be traversed and experience one's body to be challenged in mastering the ball that

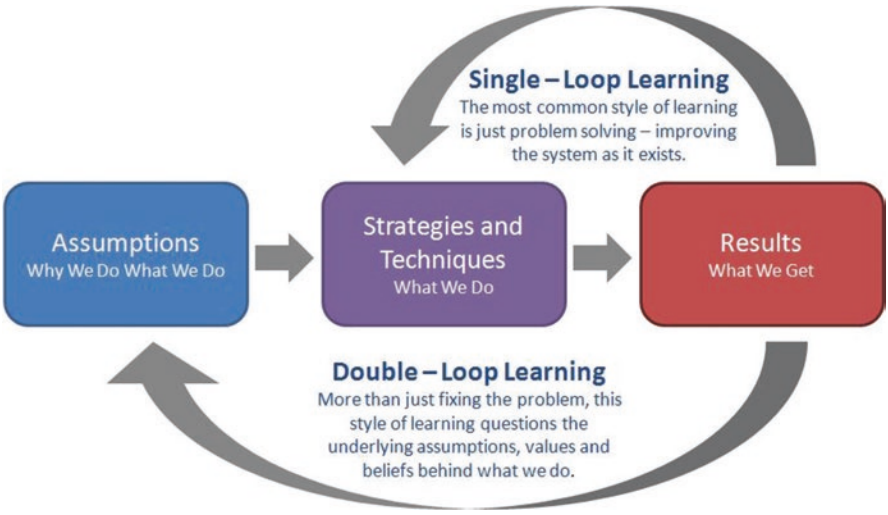

Fig. 5 Double-loop learning by Argyris (2005)

Fig. 6 Learning, playing, working as dynamics for double-loop learning (Bonanno & Kommers, 2008)

Fig. 7 Children's Games is an oil-on-panel by Flemish Renaissance artist Pieter Bruegel the Elder, painted in 1560. It is currently held and exhibited at the Museum in Vienna

shows unpredictable reactions initially. The 'game' of playing football starts from the playground where youngsters centre around two favourite players and pretend to 'win'. At the top level of the football game, the playing has evaporated: No risk taking, no search for additional challenges. One could say that at the top level of the gaming pyramid the goal is to 'bypass' the playing. The reward is much higher than the excitement of joining the match. Therefore, in the field of learning and education, the playing has a more direct role compared to competition and 'winning' (Fig. 7).

Pieter Breughel pictured a densely compiled set of plays that are typically invented by youngster at the very spot of 'feeling released' from pressure and being observed. Though the picture resonates an encyclopaedic collection of plays, it helps the spectator to admire the intrinsic motivation, the variety, and the improvisation of all types. Studies still lack a systematic characterization of how children learn from these plays and how they build new plays on earlier experiences. In the framework of the FitPed project, we can just say that playing in its purest form, offers an antagonism to the formal learning where grading and pass/fail decisions are at stake. Seen the attempts of didacticizing 'programming skills', there has been a high affinity for the exploratory- and experiential nature that helps novices to find out the power of 'new' control- and data structures. Constructivism as propagated by Seymour Papert has conquered its role among the many formalistic approaches where syntax- and correctness proofing have taken over the regime. From a

pedagogical point of view, Breughel's playground has the undertone of 'sense making': It is the actual moment of improvisation and excitement that keeps hum development going. Quite important for situations where the learner has only little affinity with 'writing code'. The Construit! Project[1] has formulated a more exact underpinning of why playing is a needed ingredient in the formation of creative procedural solutions for applications where the computer can soon exceed the human performance like in recursive and np-complete problems that fight the 'complexity wall'.

6 Why Play-Based Learning? Methodologies and Approach

Play-based learning as research topic has been presented as method for pre-school learning mainly. In this O1 an effort is made to position the playing-working combination as new prospect for VET. In the triangle learning-playing-working the phase of learning is traditionally seen as mitigation between work and play, in which play is unnecessarily seen as 'leisure time', 'divertissement' and 'digression'. The essence of playing is the immediacy between actual interest, affordance and try-out. There is no other agenda than "follow your interest" and "see how far you can go". So, though the improvisation and impulsiveness may look as "unfocussed" and "senseless", the optimal sense-making occurs in the playing attitude as it completely absorbs the person. In terms of the net learning (understanding a complex of variables through experiencing direct- and indirect side effects of an earlier intervention) one can say that playing is one of the very few activities with a minimal of cognitive overload; no prescriptive agenda, no extrinsic motivations and a one-to-one match between cognitive repertoire and intuitive horizon. Just like virtual and vicarious allow the learning to take freedom and fully focus on the proximate zone of achievement, so is a situation of playing the de-facto match between momentary intention, imagination and cognitive operation. It is now a matter of finding complementary arrangements for ICT teachers to convey such a process and find adequate scenarios for progressively integrating its learning outcomes in meaningful segments of the job performance. As a summary we may state that gamification is meant to regulate people's natural desires for socializing, learning, mastery, competition, achievement, status, self-expression, altruism, or closure. It provides incentives for players to master relevant tasks. Typical rewards include credit points, badges, play levels and tokenized recognition by the other players.

[1] The CONSTRUIT! project introduces new principles and tools that enable educators and learners to collaborate in creating 'construals'—live interactive resources that capture personal understandings of a phenomenon. Tools developed are more expressive and powerful than conventional programming tools, but yet accessible for everyone. http://construit.org/

7 Gamification of Learning: Principles and Mechanisms for Engagement

Gamification of learning is a much broader process than finding appropriate game templates and integrate them in curricular and instructional contexts. One of the recent efforts has been to classify better what element of gaming would contribute to the learning process. The prefix "serious" has been chosen to narrow the spectrum of diverse gaming genres. Critics came along that gaming for the gamer is always a serious matter. At the other side game ambassadors claim that an explicit serious connotation may squeeze out the attraction of game-experience soon.

1. One of the drivers of game-based learning is Engagement; Learners feel immersed and sometimes even obsessed while playing a virtual reality where a certain number of performance parameters are continuously measured and displayed.
2. The second driver is Flow; Its effects increase the learners' strength of experience, concentration, and endurance.

In particular for VET, gamification in learning has the extra effect of "Breaking the Yoke of Seriousness"; As "Work" is inextricably bound to serious business, the novice might easily get too much infatuated with "avoiding mistakes" so that "risk avoidance" easily emerges and hampers mindset for learning and understanding. Avatars in Gamified Instruction.

Characters or its representatives (Personas) allow the audience / student to identify with the teacher's exposition. The most compact guideline for the introduction of characters can be found in film-script guidelines. Crucial in establishing characters are the features of what we call 'a personality'. Let the listener immediately know who (s)he is via expose of (trans)actions and contrast with the other players on stage. Make clear that (s)he is going to play a decisive role in the coming adventure. Typically, the listener should be able to identify with the main character, but at some essential point there needs to be ambiguity: 'strange' behavior that cannot be explained or could not be recognized before. Overwhelm the listener very soon with typical bloopers ('big mistakes') by the main character. Keep your instruction compact so that the main line can easily be remembered. Insert looking back and forth as mental perspective; The listener is supposed to 'create' his/her own interpretation. In case of more abstract concepts in the knowledge domain, elaborations are needed; encourage the listener to interweave prior and final understanding and keep this discrepancy until the very end of the lesson.

8 Procedural and Spatial Imagination for Programming

Both gamification and narrative discourse for learning can be seen in the many simulation programs that have been integrated in various levels from early regular unto the highest levels in corporate and civil training in everyday life already. Since computers became multimedia (Multi Modal), its potential contribution to let people explore almost any context, inclusively 3D spatial environments with stereopsis for surgical training, kinematic and proprioceptive sensations for vehicle control and haptic experience for training manipulation feedback. The instructional context and the apprentice's prior knowledge and skills is decisive for what is actually learnt from a simulation model. The underlying photo of an expert surgeon who calibrates a haptic device before the students start working with it; (Kommers et al., 2004). A typical phenomenon is that after few hours of practicing, the novice will perform better than the expert. This is the moment that the students need to go to the more realistic context so that many more parameters like the total constitution of the patient, the smell, heart functioning etc. should be taken into account (Fig. 8).

As many competences imply social interaction and teamwork, also a large proportion of didactic simulations demand collaborative tasks. The Teams-Games-Tournament format (Ke and Grabowski, 2007) originally defined by Bob Slavin (1977), prescribes an overall sequence of cooperative- and competitive group work. Skills progress through simulations have been described by Luursema et al. (2008). Its conclusion is that stereopsis only makes a positive difference in case the novice has a limited capacity in spatial imagination (Figs. 9 and 10).

Monitoring pathways of skills: One critical factor in the success of learning with simulations is the overview of students' partial successes/failures in the targeted skill domain. The underlying diagrams allow trainers to quickly analyze novices' learning performances. It is an example on how e-tools allow the human factor to survive and even excel, compared to the f2f classroom situation (Figs. 11, 12, 13).

The study by revealed that though virtual reality is one of the prime candidates in vitalizing learning by its realism and direct appeal to the students' natural

Fig. 8 Dr. Bob Geelkerken calibrating the haptic feedback that corresponds with palpating a virtual patient's stomach

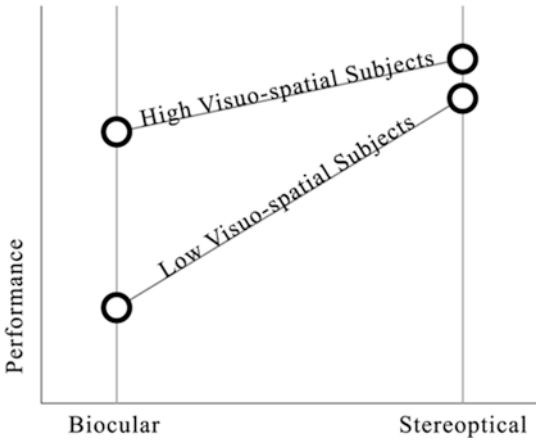

Fig. 9 Luursema's finding that the added value of the heavier 3D stereoptic goggles emerges more in case of a weaker visual imagination

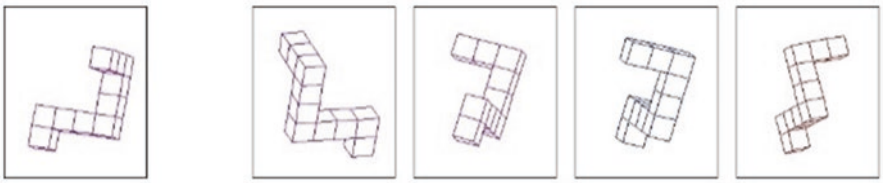

Fig. 10 Pretest: (visuo-spatial ability) Mental rotation test

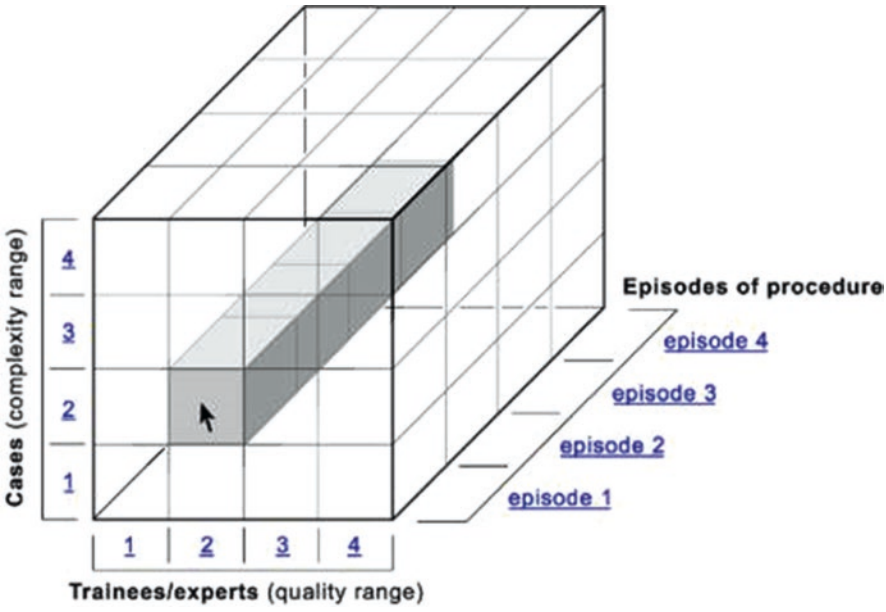

Fig. 11 Selecting a trainee/patient intervention history

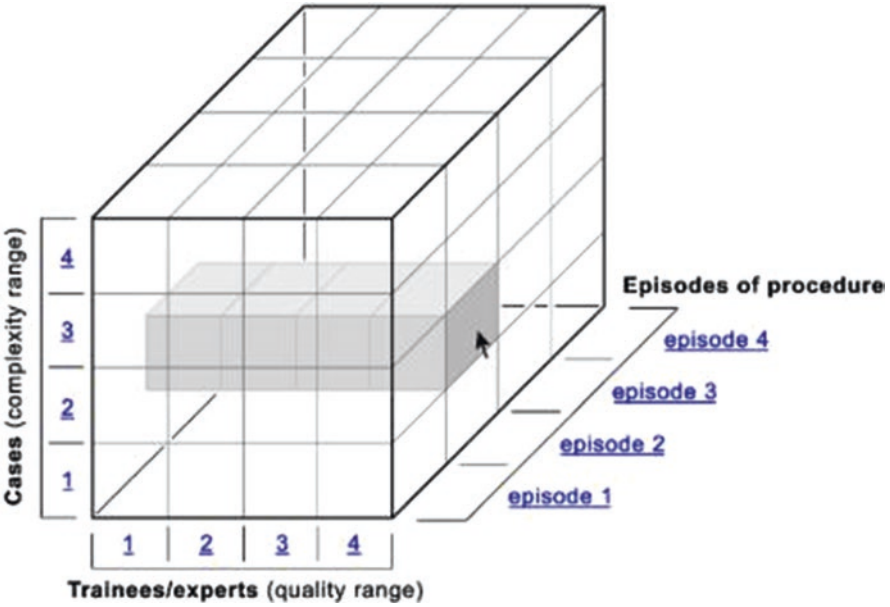

Fig. 12 Selecting a particular intervention episode across all trainees for one particular patient

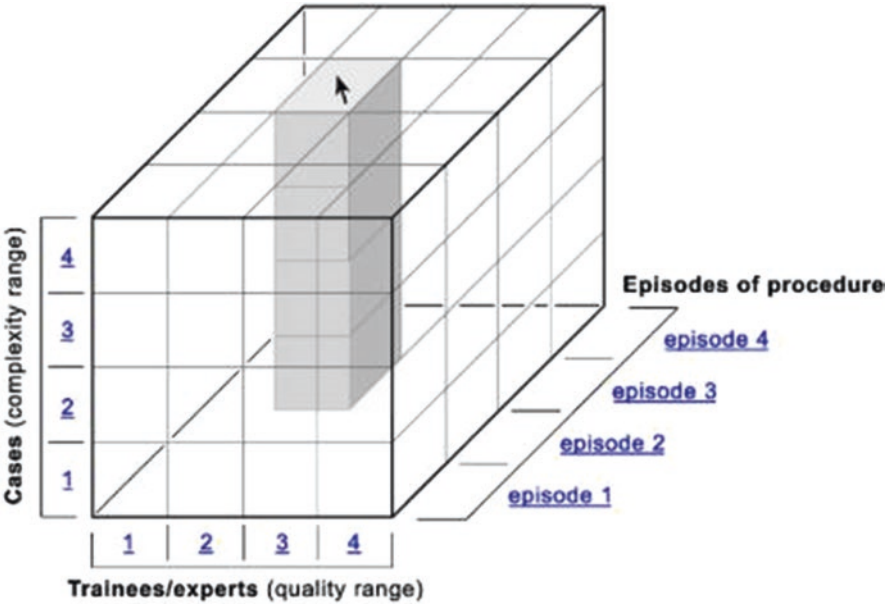

Fig. 13 Selecting a particular intervention episode across all patients for one particular trainee

affordance to act upon urgencies rather than to "know" what experts are saying; VR in itself is not enough to make the learning more effective. Obviously, the realism in VR cannot exceed the real situation itself. As the experiences with Link Trainers for airplane pilots has shown, we know that the simulation can be more effective, once it elicits the novice to go into critically complex situations; exactly those situations that we never hope to meet in reality. The added value is not just that the learner's reflexes are trained to survive in the panic of preciously decisive seconds. The value is also that learners can best understand the fundaments of complex mechanisms when they are forced to work on the edge of what is a success versus a failure. Training through real-patient interventions are not allowed to approach this area. That is why the VR-based medical intervention is an even better preparation to the first clinical steps compared to witnessing dozens of impeccable operations performed by the master. For clarifying the potential value of simulations in ICT, few examples maybe be helpful: One of the programs used in secondary education in The Netherlands is a simulation environment called SIMQUEST in which teachers can create their own simulations to use in their lessons. The program is free and available in Dutch and English. Although the example is from physics it can be used in any area that employs numeric equations (Fig. 14).

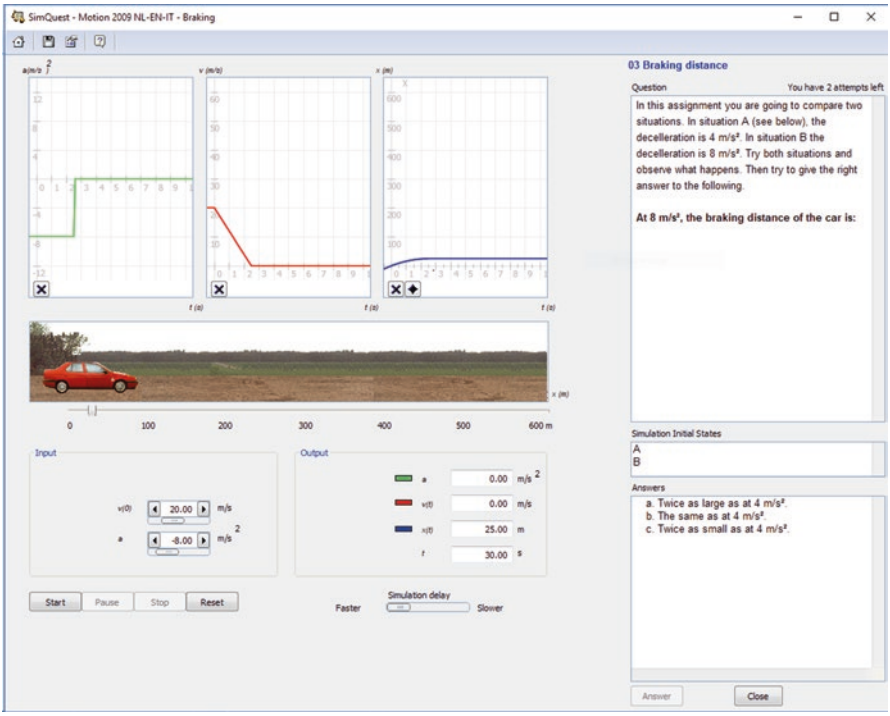

Fig. 14 The SIMQUEST environment for the students

Advantages of simulations:

- Safety; E.g. flight simulator, nuclear power plant or operating cranes
- In most cases cheaper than real-life
- More accessible than real-life; You can take it home
- Platform for discovery learning; Students can manipulate and observe (intrinsic feedback)
- Learning as (guided) discovery
- Student controls the learning environment
- Does research to foster knowledge just like a researcher
- Constructs knowledge in his/her personal way
- Skills should be more flexible and retained longer
- Fostering of research skills

9 Lego Serious Play

"… The LEGO® SERIOUS PLAY® Method is a facilitated meeting, communication and problem-solving process in which participants are led through a series of questions, probing deeper and deeper into the subject. Each participant builds his or her own 3D LEGO® model in response to the facilitator's questions using specially selected LEGO® elements. These 3D models serve as a basis for group discussion, knowledge sharing, problem solving and decision making…" Its method is the collaborative process in which each of the participants have a decisive role. The group process needs to be moderated by a trained LEGO® SERIOUS PLAY® facilitator. As conditions for applying Lego Serious Play its web-site mentions:

- The subject is complex and multifaceted and there is a need to grasp the bigger picture, find connections and explore options and potential solutions
- It is important to reach decisions which everyone commits to and honors after the meeting even though he or she does not agree 100%
- Asking each team member or participant the same question results in substantially different answers
- Everyone in the group has an interest or stake in what is on the agenda
- It is important that everyone participates in the discussions and contributes with his or her knowledge and opinions
- You want to increase team understanding and at the same time avoid frustration
- You want to use the time efficiently
- There are no obvious answers
- You would like to gain new learning, insights and new ways of thinking
- You want to deal with tough and complex issues in a constructive atmosphere

- It is vital that participants speak their true feelings without intimidating anyone or being intimidated
- You have a situation in which a few members tend to dominate the discussions and you want to break that routine without offending anyone
- You have a group which feels meetings tend to be a waste of time
- You want to create a level playing field for discussion
- Your meetings or learning events tend to focus more on the messengers than on the messages
- You want to avoid excuses or lack of initiative after the meeting
- There's a risk, participants feel they were not heard or involved in the decision
- You want to ensure that all participants share a common understanding and frame of reference

Its "Creative Commons License Deed" declaration can be found here. The web-site mentions that the LEGO Group after 2010 no longer offers certification programs in the LEGO® SERIOUS PLAY® method, nor does it have a direct association with the end-client. As preliminary conclusion we may say that Lego Serious Play is an elegant demonstrator method to let trainers and students experience the difference between gaming and playing. Gaming is to let its members compete in a limited set of skills and performance qualities, while playing is a broader exploration method for letting its members discover a certain design/creation domain and eliciting one's latent intuition in that field.

10 Contexts for Simulations

Simulations have been developed in industrial projects in order to prepare better for the unforeseen complexity during calamities. Its main effect was that engineers and decision makers became better prepared compared to those who just concentrated on formal models with a high degree of precision. As simulations became easier to emulate more complex realities, education has gathered more than only interest and got more and more convinced that a reduced reality had advantages for gaining understanding compared to the situation with full reality and scale. Simulation has even become a metaphor for education at large: If the real setting cannot absorb novices' presence and contributions, it is needed to build a reduced version of a particular enterprise. Not only to increase safety and flexibility for the time of learning, also for breaking-out when no urgent maintenance or trouble shooting was needed. For example, Hewlett-Packard's inkjet cartridge filling factory in Dublin had a mini factory where employees could exercise in fault-finding so that they reached a shorter downtime in case of failure. In other words: Simulations have a wide potential scale of functions. Its use for learning purposes can be focused on tackling renown problems like flight pilots who need to practice emergency

landings that they would never voluntarily undertake in reality. But also, simulations allow novices to explore and experiment configurations in order to develop a better What-If thinking for the cases that fresh reasoning is needed in a future break-down.

11 Minecraft for Schools: MinecraftEdu

A New York City school teacher has crafted a version of Minecraft for schools called MinecraftEdu. Given the sandbox game's simple premise—a pixelated world of blocks that users manipulate with tools—plus the ability to add customizable maps, educators can drop students into a world of ancient cultures, Chemistry, English, and more. MinecraftEdu creator Joel Levin, who teaches second-grade computer classes at Columbia Grammar and Preparatory School in New York City and runs a Minecraft club for high schoolers, has been incorporating Minecraft into his classes for the past 2 years.

12 Storytelling: Didactic Genre for Initial Programming Skills

Before any computational- and even procedural thinking emerges, learners need to develop episodic reflections, based upon facts, dependencies, and agents as we know from literary theories. Hypertext has brought us the beauty of decontextualization, however at the same time it demanded the price of losing chronology and situational coherence. This is the main reason the teachers' expositions again tend to build upon storytelling. Also for the stage of natural language preceding formal assertions like clauses and declarative logic, the storylines need to be developed in students' meta-cognitive awareness.

13 Integral Justification of Innovative Learning Paradigms

The reader may ask him/herself to what extent the various innovative approaches bring better formats for learning and teaching? The summative answer is complicated as learning is a multi-facetted process and has a wide spectrum of positive side effects to be included. So indeed, we still need more wide and intense studies on the precise effects of Gamification, Playification, Collaborative Learning, Narration and Simulations. What are recent understandings that may help you to trust the added values of active learning methods that make the learner as a codesigner / co-owner of his/her learning process.

14 Conclusions

Game-oriented learning can only be adopted and effectively integrated if an overall pedagogical framework has been articulated. Problem-Based Learning seems the best candidate as it places the learner at the very core of the life-long learning process. Scaffolding (and subsequent fading) is seen as a safe way to make learners less dependent from the teacher and institutional guidance. The same is true for the initial and further (in-service) training of ICT teachers. The choice of "narration" is a clever choice to let existing ICT trainers build upon their prior traditions and reflexes; (Kommers & Simmerling, 2015). At the same time, they need an appropriate didactic framework that allows all the new-coming ICT tools to be integrated by the learners themselves. For the moment it is gamification and simulations. In the near future it will be a wealth of MOOCs, Big Data applications, Learning Analytics, Artificial Intelligence, etc. The chosen didactic framework is Problem-Based Learning with an ever-stronger focus on the existential factors of the learner with his/her unique talents.

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