SIE 2015
6th International Symposium on Industrial Engineering
24th-25th September 2015
FACULTY OF MECHANICAL ENGINEERING
STEINBEIS ADVANCED RISK TECHNOLOGIES
INNOVATION CENTER FME

EDUCATION 3.0 AND SOCIAL NETWORK-BASED EDUCATION FOR EFFECTIVE LEARNING AND INTEGRATION WITH INDUSTRY[1]

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Abstract. *Emergent education paradigms of Education 3.0 and Social Network-based Education (SNE) are presented, as these are seen by many authors as drivers for the required change in education. Education 3.0 and Social Network-based Education (SNE) are inspired by several emergent disciplines, such as: chaos and complexity management in organizations, learning organizations, semiotics framework for system and organization integration and complex network theory. Further, the concept of Learning Factory (LF) is presented as well, as the instrument for innovative and effective true alignment of education with industry, especially for education and training for a large variety of advanced manufacturing concepts and emergent business models that re expected to characterize the 21st century manufacturing and related businesses.*

Key words: *Education 3.0, Social Network-Based Education, Learning Factory, complexity, industry*

1.INTRODUCTION

One of the main priorities of Europe 2020 agenda is smart growth, which (the smart growth) is presented by many authors as the growth based on knowledge and innovation on levels that require a shift in quality of education. In other words, the strategy of the Europe's economy growth is defined in a way that the (virtually) main instrument for its realization is seen in a shift in education paradigm, considering that the actual education paradigms could not provide required levels of knowledge and innovation.

Thus, the question is, why the actual education models cannot provide the required shift in knowledge and innovation, i.e. are effective knowledge and innovation creation processes parts of the traditional education processes (obviously not, as if it would be the case the problem would not exist) and does implementation of these processes would imply a new education paradigm ? And the answer is yes, the implementation of the processes that are perceived as more effective in creation of innovative knowledge and innovation itselfimplies a new educational paradigm.

Thus new educational paradigm is named Education 3.0 paradigm, in contrast to the traditional approaches which are classified in two large groups named Education 1.0 and Education 2.0 paradigms (of which the Education 1.0 represents older models than Education 2.0). (Curiously, some of the nowadays education models very recently developed and implemented, and presently under implementation at many universities under the label "advanced", could be already classified as "traditional" too, when comparing with the Education 3.0 paradigm features).

The subject ofthis paper is emergent education paradigms Education 3.0 and the Social Network-based Education (SNE) model (that belongs to the Education 3.0 paradigm).

Further, the concept of Learning Factory (LF) is presented as well, as the instrument for innovative and effective true alignment of education with industry, especially for education and training for a large variety of advanced manufacturing concepts and emergent business models.

There is also discussedconceptual framework for education 3.0 implementation.

2.EDUCATION 3.0

Education 3.0 is characterized in [1] *"by rich, cross-institutional, cross-cultural educational opportunities within which the learners themselves play a key role as creators of knowledge artefacts that are shared, and where social networking and social benefits outside the immediate scope of activity play a strong role"*.

According to [1], three aspects of Education 3.0 are of particular importance:

(1) The freedom of students in making their own choices;

(2) The concept of students as producers of reusable learning content;
(3) Institutional arrangements permit the accreditation of learning achieved, not just of courses taught.
In Table 1, a level of transformative capabilities and practices for education 3.0 in the 21st century are described, in accordance with some authors.

Table 1. Education 3.0 features (extracted from [1], Table 1: Educational generations in higher education)

Features	**Education 3.0**
Primary role of professor	Orchestrator of collaborative knowledge creation
Content arrangements	Free/open educational resources created and reused by students across multiple institutions, disciplines, nations, supplemented by original materials created for them
Learning activities	Open, flexible learning activities that focus on creating room for student creativity; social networking outside traditional boundaries of discipline, institution, nation
Institutional arrangements	Loose institutional affiliations and relations; entry of new institutions that provide higher education services; regional and institutional boundaries breakdown
Student behavior	Active, strong sense of ownership of own education, co-creation of resources and opportunities, active choice
Technology	E-learning driven from the perspective of personal distributed learning environments; consisting of a portfolio of applications

3. SOCIAL NETWORK-BASED EDUCATION

Social Network-based Education (SNE) basic features are described shortly in [2], as follows:
"*SNE is inspired by several emergent disciplines, such as: chaos and complexity management in organizations (e.g. [3]), learning organizations (e.g. [4]), semiotics framework for system and organization integration [5] and complex network theory (e.g. [6]).*
In SNE, students and teachers are seen as participants that form a network, in which the network structure, communication, learning process and behaviourexhibit features of a social network.
Social network is a kind of complex network. Complex networks are distinct from regular networks by several features: heterogeneity, self-organization, modularity, "emergent architectures with unexpected properties and regularities", "communities, motifs, hierarchies and modular ordering" [7] and similar.
The SNE implementation according to [2]provides "*a collaborative environment where participants have freedom to choose and work on the assignments they find more relevant and stimulating for their own objectives. They can interact with each other and edit documents at the same time, fostering their development in terms of collaboration, agility and self-organization*".

4. LEARNING FACTORY (LF)

The concept of Learning Factory (LF) is not new, it has appear about 25 years ago- However, the interest in this concept has increased significantly over the last years. LF could be considered as one of the most modern advanced instruments for enhancing education and training especially when addressing the dimension of "real-world problem solving", which is intrinsically related to industry, implying integration of the education system with the industry. LF represents a "*paradigm shift to industry-partnered, interdisciplinary, real- world problem solving in engineering education*" [8]. The goal is to "*integrate design, manufacturing and business realities into engineering education*" and this can be accomplished by providing a "*state-of-the-art, hands-on active learning laboratory, a practice-based curriculum, and real (industry-driven) projects*" [9].

A general model of a LF environment is represented in Figure 1 [10]. The orange arrows represent enterprises' orders (tasks, assignments), the green ones the execution of these orders and the blue ones some solutions provided by students and researchers. Implementation of LF logical general architecture could be realized in a number of concrete physical settings different learning objectives. However, addressing Education 3.0 and SNE, a specific LF model could be of interest. One of these specific LF models is a model developed at the University of Minho, in cooperation with a start-up company, presented on Figure 2. It is an Internet-based environment capable to integrate with industry in real-time providing capability to the industry to put their real-life tasks as work-assignments for students as well as for many other objectives.
In other words, the LF model developed – presented on Figure 2 – represents the instrument for innovative and effective true alignment of education with industry, especially for education and training for a large variety of advanced manufacturing concepts and emergent business models, such as:

- Internet-based work (design, management, operation);
- Product/Service Systems (PSS);
- cloud and ubiquitous manufacturing systems and enterprises;

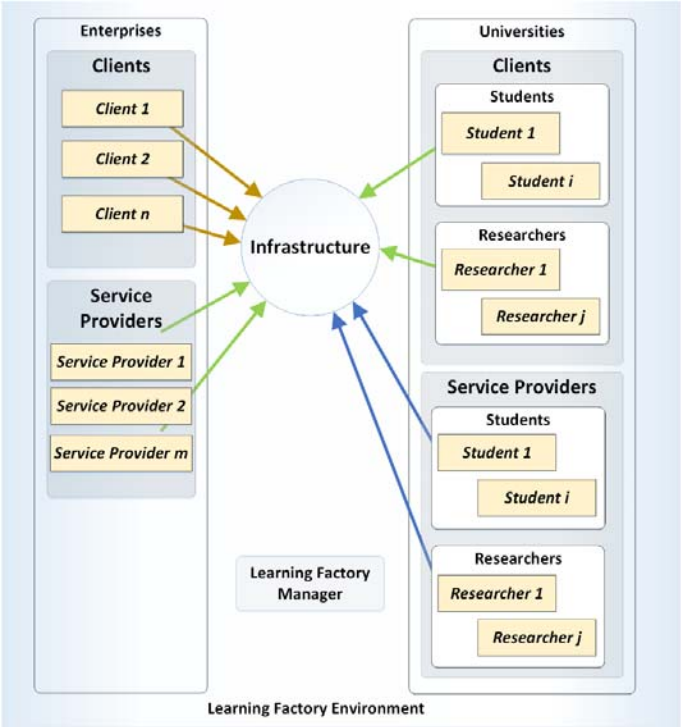

Figure 1. Informal view of Learning Factory environment logical general architecture [10]

- virtuality;
- agility;
- networked organization/ networking (supply-chain);
- social network-based and community-based manufacturing/production;
- crowdsourcing;
- open system architecture-based organization;
- learning organization;
- entrepreneurship;
- advanced ICT;
- complexity management in organization;
- integration and interoperability in organizations;
- Cyber-physical system (CPS);
- negotiation;
- human-centred view of organization vs technology-centred;
- game theory and use of serious games for organization management, decision making and design;
- competition-based environments (markets) and organizations (concurrent engineering);
- collaboration-based environments (communities) and organizations (collaborative engineering);
- large-scale open-ended projects;
- open-source projects;
- Web 3.0 & 4.0 –based organizations;
- Industry 4.0; and similar,

as virtually organizational and business models that will characterize the 21st century manufacturing and related businesses.

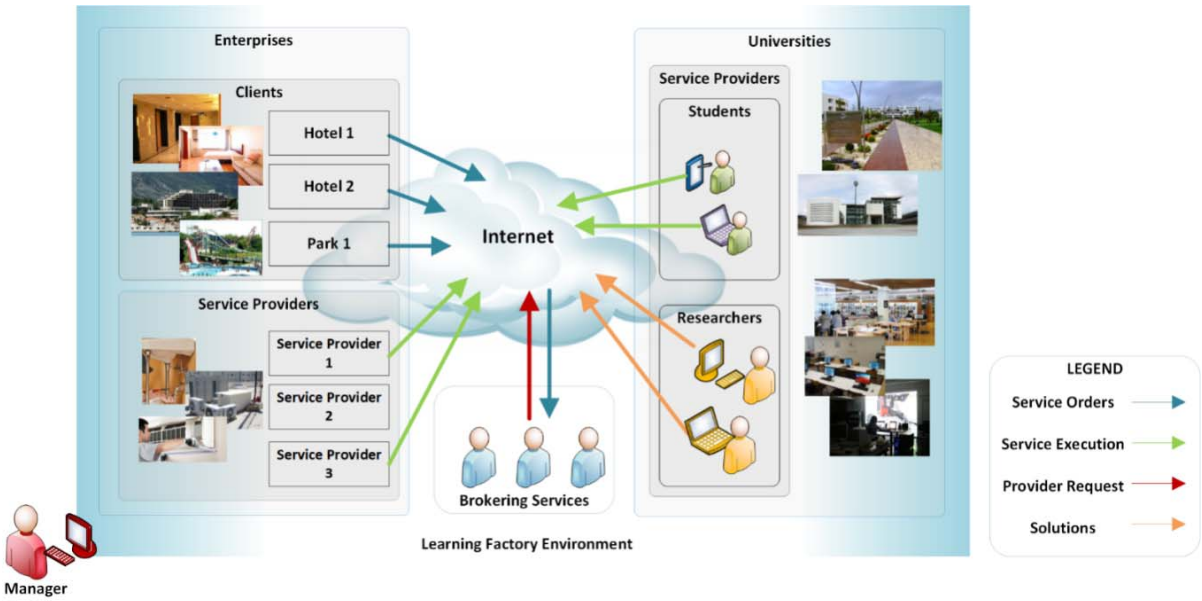

Figure 2. Learning Factory logical architecture with Internet-based platform [10]

5. CONCEPTUAL FRAMEWORK FOR EDUCATION 3.0 AND SNE IMPLEMENTATION

A conceptual framework for education 3.0 and SNE implementation should address several domains (dimensions), including interaction architecture, management, teaching and learning methodologies, curricula development, space and time[2].

Table 2, presents one of the frameworks developed for Education 3.0 and SNE implementation, addressing several Education 3.0 and SNE dimensions, with a comparison with the actualeducation models, such as Education 1.0 & 2.0 today widely used in European education systems.

Table 2. Framework for Education 3.0 Implementation (modified according to [2])

Dimensions	**Implementation**	
	Education 1.0 & 2.0	**Education 3.0**
System Thinking	Linear	Complexity
Learning	Individual Group	Generative Collaborative Proactive Unlearning
Teaching Method	Direct instruction PLE Seatwork	Blended Game based Co-teaching Hands-on activities
Interaction architecture	Client/server	P2P Cloud Hybrid
Management	Coordination	Semi-coordination Collaborative Self-organization
Curricula construction	Pre-defined	Open Semi-open
Space	Colocated Distributed (global)	Colocated Distributed (global)
Time	Syncronous	Syncronous Asyncronous
Population	Individual Group	Group Massive
Access	Closed	Open Conditioned
Knowledge base	IP Copyright	Open source
Supporting ICT technology	Proprietary	Open source Proprietary
Supporting ICT license	Open source Comercial	Free Open source
Business model	Subscription	Free Freemium Service-based

The conceptual framework presented providescriteria for differentiation between traditional Education 1.0 & 2.0models with Education 3.0 models and alternative implementations forms and technologies that could be employed in proposed Education 3.0 model.

6. SNE AND LF EXPERIMENT AT THE UNIVERSITY OF MINHO AS AN EDUCATION 3.0 EXAMPLE

SNE and internet-based LF platform are introduced at University of Minho as the Education 3.0 prototype implementation, and as further advances of the PLE (Project Led Education) experience that (PLE) has run successfully already for several years.

SNE and the Internet-based LF platform are implemented for the areas of CAD/CAPP and CAM already since the 2nd semester of scholar year 2012/2013 and from the beginning of scholar year 2014/2015 their use was extended additionally for two additional subjects, namely for the subjects/areas of 'Advanced Quality Management' and 'Reliability and Maintenance', all subjects within the Integrated Master course on Industrial Engineering and Management. As an illustration, it could be referred that for the 4 subjects involved in the prototype implementation was launched about 900 tasks, i.e. work assignments for students, among which they could choose freely which tasks to work on, in which number of tasks, when and where, and in which manner to acquire necessary knowledge.

In other words, students are allowed to study independently new conceptual material before it is exposed in classroom by professor [2]. Even professor's (traditional) lectures could be seen as a service that are launched only upon students requests when they need it for faster tasks execution or problem solving .In that way the students can learn intended contents faster and in a more agile manner. The methodology promotes development of a number of veryimportant technical and soft skills, such as work agility, problem-solving and self-organization.

In Table 3, the implementation of the SNE and the Internet-based LF platform is specified according to the implementation framework presented in above.

Table 3. Specification of the experiment at the University of Minho using the Education 3.0 implementation framework (modified according to [2])

Dimensions	**Implementation at the University of Minho**	
	Education 1.0 & 2.0	**Education 3.0**
System Thinking	-	Complexity
Learning	Individual Group	Generative Collaborative

		Proactive Unlearning
Teaching Method	-	Blended Game Based Hands-On Activities
Interaction Architecture	-	Cloud
Management	-	Self-Organization
Curricula Construction	-	Semi-Open
Space	-	Distributed (Global)
Time	-	Asyncronous
Population	-	Group Massive
Access	-	Conditioned
Knowledge Base	-	Open Source
Supporting ICT Technology	-	Open Source
Supporting ICT License	-	Free Open Source
Business Model	-	Service-Based

7. CONCLUSIONS

The prototype implementation of the Education 3.0 paradigm in the form of SNE and with use of the internet-based LF platform as its model, at University of Minho, is already running for three school years and its quality, advantages and benefits, comparing with traditional education methodology is systematically tested through the questionnaires given to students at the end of each teaching semester. The results of survey through questionnariescould be ratedas very positive and encouraging. Accordingly, they are giving a solid base for continuation and spreading of the proposed methodology.

However, the full implementation of the paradigm is still constrained by a number of constraints, such as, for example, teachers' awareness of the education paradigms, the required levels of agility to achieve, etc. One of the main constrains, which apparently will be most difficult to overcome, are the traditional "institutional arrangements" referring to the universities' traditional "business models".

The future workshouldaddresssurelyfurther methodology implementation, spreading, testing and improvement.

ACKNOWLEDGMENTS

The author wishes to acknowledge the support of the Fundaçãopara a Ciência e Tecnologia (FCT), Portugal, through the grants "ProjetoEstratégico – UI 252 – 2011–2012" reference PEst-OE/EME/UI0252/2011.

REFERENCES

[1] Keats, D., & Schmidt, J. P. (2007). The genesis and emergence of Education 3.0 in higher education and its potential for Africa.First Monday, 12(3).

[2] Putnik G.D., Alves C., Carvalho C., Sousa S., Varela L., Shah V, & Castro H. (2015). Social network-based education and learning factory as emergent forms of education and training: an application for quality management, in *Proceedings of 9th International Quality Conference*, June 2015, Centre for Quality, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, pp 641-646.

[3] van Eijnatten, F.M., Putnik, G.D., &Sluga, A. (2007).Chaordic systems thinking for novelty in contemporary manufacturing.*CIRP Annals-Manufacturing Technology*, *56*(1), 447-450.

[4] van Eijnatten, F.M., &Putnik, G.D. (2004). Chaos, complexity, learning, and the learning organization: towards a chaordic enterprise. *The Learning Organization*, *11*(6), 418-429.

[5] Putnik, G. D., &Putnik, Z. (2010). A semiotic framework for manufacturing systems integration–Part I: Generative integration model. *International Journal of Computer Integrated Manufacturing*, *23*(8-9), 691-709.

[6] Estrada, E. (2011). *The structure of complex networks: theory and applications*. Oxford University Press.

[7] Lengel, J.G. (2013). *Education 3.0: Seven steps to better schools*. Teachers College Press.

[8] Lamancusa, J. S. and Simpson, T. W., (2004). The Learning Factory - 10 Years of Impact at Penn State, International Conference on Engineering Education, Gainesville, FL, iNEER, October 16-21, pp. 1-8.

[9] Lamancusa, J. S., Zayas, J. L., Soyster, A. L., Morell, L., and Jorgensen, J., (2008). The Learning Factory: Industry-Partnered Active Learning. Journal of Engineering Education; pp. 5-11.Pedrycy, W., &Gomide, F. (1998).An introduction to fuzzy sets, Analysis and Design, MIT Press Cambridge Massachusetts.

[10] Putnik G. D., Castro H., Ferreira L.,Barbosa R., Vieira G.,Alves C., Shah V., Putnik Z., Cruz-Cunha M. M., Varela L. (2012). Advanced Manufacturing Systems and Enterprises: Towards Ubiquitous and Cloud Manufacturing, University of Minho, Portugal.

[11] Putnik G. D., Carvalho C., Alves C. (2015). Education 3.0 and Social Network-Based Education: An Implementation Framework and Experiment at the University of Minho for Education and Training in Quality Management, in *Proceedings of 9th International Quality Conference*, June 2015, Centre for Quality, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, pp 675-679.

[1] This paper is based on the previously published works by the author:[2], [10], [11].