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# DEVELOPMENT OF COMPETENCE FOR SUSTAINABLE MANUFACTURING BY USING SERIOUS GAMES

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**Summary**

This paper will present preliminary results of the EU-funded FP7 integrated project TARGET. The main aim of the project is to develop a novel technology-enhanced learning platform that provides learners with a responsive environment that addresses the rapid, personalized competence development and the sharing of experiences associated with introducing sustainability into a manufacturing enterprise. The main objectives of the paper are to deduce specialized sustainability-related competences for managers and to convert them into a virtual game scenario. Besides the research approach of deriving the competences, critical incidents in the game will be presented. The findings and potential application will be demonstrated in a case based on Life Cycle Assessment (LCA).

*Key words:* *Sustainable Global Manufacturing, Serious Games, Competence Development, Life Cycle Assessment*

## 1. Introduction

Manufacturing is one of the primary wealth-generating activities for any modern nation [1, 2]. Manufacturing industries have a major potential for becoming a driving force for the creation of a sustainable society [1, 3, 4]. "Sustainable manufacturing" can be understood as a holistic business practice of the industrial sector, which expands all the processes and decisions of a company into broader social and natural environments in which the company operates and affects with its actions [5]. It is more comprehensive and systematic than green or eco-manufacturing as it deals with all three components of sustainability – environment, society and economy – by aiming for a triple bottom line. The adoption of more integrated and systematic methods to improve sustainability performance has laid the foundation of new business models or modes of provision which can potentially lead to significant environmental, societal and economic benefits [6].

From a historical perspective, different objectives for education that face environmental and sustainability challenges have been documented for the first time at the Intergovernmental Conference on Environmental Education organized by UNESCO in Tbilisi in 1977, also known as the "Tbilisi declaration" [7]. Furthermore, Education for Sustainable Development is perceived as a matter of global importance and has been one of the top priorities in national policy documents and on the global agenda since the UN's Earth Summit in Rio de Janeiro in

1992 [8]. It was brought to the forefront of the international attention at the UN World Summit on Sustainable Development in Johannesburg in 2002 [9]. It is argued that education is critical for promoting sustainable development issues which should be integrated into all disciplines, should employ formal and informal methods and effective means of communication [8, 9].

The work presented in the paper is a part of the on-going research within European FP7 Integrated Project "TARGET", which aims to revolutionize competence development by providing technological support to reduce the "time to competence". The main objective of the TARGET project is to develop a new genre of TEL environments that support rapid competence development within the learning domains of innovation, project management and sustainable manufacturing. The TARGET environment consists of a learning process supported by a componentized TARGET platform. The core component of the TARGET platform consists of a serious game combined with virtual world technology, which confronts individuals with complex situations in the form of game scenarios. The serious game facilitates situated learning that results in experiences leading to the development of competences, whilst the interaction within a virtual world enables individuals to externalise their tacit knowledge acquired whilst engaged with a game [10].

TARGET project consortium has identified sustainable manufacturing as an emerging field where new competences are required to facilitate the new manufacturing paradigms and technologies, where the consumer and environment play a key role. An educational game scenario is being developed. It will drive and scope the development of new narrative building blocks that are specific to the domain of sustainable manufacturing. The aim is to support manufacturing enterprises to develop new and effective strategies for managing their explicit and implicit knowledge toward becoming a true learning organization.

In the field of sustainable manufacturing many possible scenarios can be developed to train specific competences. Implementing standards is a good way to introduce sustainability into companies and at the same time to develop associated competences. In the sustainable global manufacturing scenario the player plays a role of a "sustainability manager" who is on the one hand knowledgeable about the domain but on the other hand needs some practical experiences in solving real-life problems. Life Cycle Assessment was chosen for its complexity and current widespread use in manufacturing companies: divided in its main stages, it allows the achievement of intermediate goals that lead to the main competence, the ability to implement and evaluate an LCA. The paper is organized as follows: section 2 addresses the objectives of the paper; section 3 deals with competences needed for effective performance in the field of sustainable manufacturing with a special focus on competences needed for conducting the LCA process; section 4 describes the game scenario; section 5 concludes by addressing future research steps and challenges.

## 2. COMPETENCES IN THE FIELD OF SUSTAINABLE MANUFACTURING

### 2.1. Literature overview

The traditional emphasis on factual knowledge no longer seems to meet the requirements of the industry and society as a whole [1, 11, 12, 13]. As employers demand employees who will be able to operate in complex environments, it appears that the results from the accomplishment of learning tasks which support a traditional knowledge-based curriculum are no longer sufficient for these dynamic social and working conditions [12, 14]. The concept of competence is closely associated with the ability to handle such complex and ill-defined problems and situations. As a result, the term has become attractive for both educators and employers because it can be identified with valued capabilities, qualifications and expertise. The competence-based education is recently being embraced by enterprises and

educators as a new standard for curriculum design, training and professional development [12, 13, 14, 15]. It appears that the general understanding is that competences are the crucial explanatory factor in situations where the employee is theoretically equipped to handle a work situation but in practice fails. Therefore, competence-based education can be seen as a way forward in addressing this kind of "a missing piece" required in successful work performance.

There is a broad range of research described in the literature dealing with competences in the field of sustainable manufacturing and sustainable development. In his paper, de Haan proposed a model of "Gestaltungskompetenz" that centres on defining key competences and related sub-competences in the field of sustainable development in the education sector [16]. These competences are expected to enable active, reflective and co-operative participation in sustainable development. Those who possess the "Gestaltungskompetenz" can help to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development. The research of Rauch and Steiner proposed a set of specific competences in the domain of sustainable development [17]. In her paper Geertshuis argues that critical competencies that lead to effective decision making are required in order to foster sustainability culture and implement sustainability strategies in an organization [18].

Furthermore, The Australian Manufacturing Skills Council imported the Guideline Competency Standards for Sustainability, designed to guide the acquiring of competences required in the field of sustainable manufacturing in formal vocational training and education settings as well as in the job [4]. The Institution of Civil Engineers (ICE) established a Task Group to drive the implementation of sustainability principles into education, training and professional development [19] (proposing a requirement for a range of skills in the domain of sustainable development). The Royal Academy of Engineering (RAE) identified a set of principles and competences for sustainable development in engineering [30]. Engineering Department at the University of Cambridge proposed essential competence ingredients for well-informed engineers to tackle the sustainability issues [19]. Forum for the Future established a Higher Education Partnership for Sustainability that involved universities and colleges across the UK. It identified a sustainability literate person and proposed required competences to tackle sustainability related issues [20]. Business Council of Australia identified innovation as one of the most important factors stimulating the economic growth and employment boost in Australia, with sustainability as a key element of corporate innovation strategies [4]. The report demonstrates that sustainability training programs should be focused on developing innovation related skills. These skills are of particular value when seeking to reduce environmental impacts in an industrial setting where many of these impacts do not have immediately obvious solutions. The Advanced Manufacturing Competency Model [22] is depicted in a pyramid graphic with nine tiers, and illustrates how occupational and industry competences build up on a foundation of personal effectiveness, academic competences and workplace competences. Each tier is comprised of blocks representing the skills, knowledge, and abilities essential for successful performance in the Advanced Manufacturing Industry, giving a special focus on sustainability-related competences.

In summary, the literature overview proposed the following set of generic competences that are essential for managers to respond to sustainability-related challenges in manufacturing:

1. Holistic / systems thinking
2. Dealing with complexity and incomplete information
3. Decision making for sustainability

4. Fostering sustainability culture and thinking
5. Forming and leading multidisciplinary teams
6. Encourage stakeholder involvement
7. Readiness to compromise
8. Innovation and coping with change
9. Managerial skills (develop, communicate, implement and evaluate the sustainability strategy)
10. Communication and negotiation skills

### 2.2. Empirical approach

The methodology for identifying competences essential for effective performance in the field of sustainable global manufacturing followed the classic full-scale 6 step version of a competence study [23]: *1. Define performance effectiveness criteria; 2. Criterion sample; 3. Data collection and analysis; 4. Structuring competences in the form of a competence model (Competence modelling); 5. Validation of the competence model; 6. Application of the competence model.*

As a starting point in defining competences in the field of sustainable global manufacturing, several existing competence sets, standards, frameworks and models in the domain of sustainable development and sustainable manufacturing have been identified and analysed. Next, different job descriptions of the job function "sustainability manager" have been analysed focusing especially on the identification of required knowledge, skills and competences from business perspective. Furthermore, different training and education programs in the field of sustainable manufacturing have been analysed focusing on the identification of target competences that they are aiming to develop. Next, case studies, scenarios and critical incidents on implementing sustainable development strategies from different manufacturing companies have been reviewed with the extrapolation of necessary competences. All these data collection methods have been applied in order to define a preliminary set of competences in the domain of sustainable global manufacturing that were further reviewed and analysed by the TARGET sustainability expert panel group. The expert panel group consists of different domain experts from business, educational, pedagogical and sociological background.

The TARGET project consortium has utilized the existing research on competences and has gone beyond the state-of-the-art by engaging with a wide range of different European manufacturing organizations in order to conduct in-depth interviews with subject matter experts in the field of sustainable global manufacturing. The study identified 14 manufacturing organizations and gathered data from 14 subject matter experts from Slovenia, Germany, Italy, Poland and Bulgaria. The in-depth interviews were based on job analysis [24], critical incident technique [25, 26, 27, 28] and supported by the OKEI competence modelling framework [29]. The aim of the interviews was firstly to identify different individual, knowledge, organizational and environment factors that contribute to successful sustainable manufacturing practices. Furthermore, the interviews identified the context of the work (work description, requirements, responsibilities, typical tasks and other work characteristics) and 3 – 5 critical situations (per each interview) that the person has faced in the past while dealing with issues related to sustainable manufacturing. The competences that were instrumental for the success in his/her work were extrapolated from the job content and the gathered critical incidents.

### 2.3. Identified generic competences in the field of sustainable global manufacturing

The research showed that knowledge workers at upper management level (i.e. sustainability managers) are involved in the development and implementation of strategic sustainability initiatives. They are required to consult widely with different stakeholders in order to develop a workplace sustainability strategy and procedures that are in agreement with the strategy. They are furthermore required to demonstrate personal responsibility and autonomy in performing complex technical operations and to take full responsibility for personal and group outcomes. The generic competences that have been identified in the field of sustainable global manufacturing at upper management levels are:

1. Personal commitment to sustainability
2. Systems / holistic thinking
3. Development of a sustainability strategy and related policies
4. Communication of a sustainability strategy in the organization and fostering of sustainability culture
5. Implementation of a sustainability strategy
6. Formation and leadership of multidisciplinary teams (multidisciplinary cooperation)
7. Review, evaluation and reporting of strategy implementation

A sustainability strategy that is focused on conducting and evaluating the Life Cycle Assessment (LCA) has been identified through our study as a crucial organizational competence required to assess and improve the environmental aspects and potential impacts associated with the product, process or service. The LCA process requires a systematic approach with analytic, life-cycle thinking and time management skills involved. Besides that, the sustainability managers need to be able to collaborate widely with different stakeholders in order to gather required data, to be able to properly interpret the LCA results and, last but not least, to communicate the results and technical concepts to non-technical audience.

## 3. GAME SCENARIO

### 3.1. Game Scenario in a Nutshell

The game is designed as a 3D virtual environment in which a company with its administrative and productive facilities is modelled. Different non-playable characters (NPC) in the game take the role of certain positions in the company, from the management level like CEO, CTO, CFO and others to the workshop level. The user is brought into the game as the sustainability manager of the company. Like in entertaining role playing games, the user can interact with the NPC by chatting, talking and by non-verbal expressions.

The game is designed in order to fill the gap between competence in management and skills in sustainability in manufacturing. Since this area is still emerging and finding its way steadily into enterprises, it is important to train people not only to gain the background knowledge of sustainability but to experience the difficulties in making multi-dimensional decisions and to be faced with typical challenges.

The game consists of different scenarios and steps. A scenario in this case is a certain set of tasks a player has to fulfil. Those tasks are arranged into the processing of a sustainability method or tool which is defined by standards. Steps are defined as distinguishable but recurring actions in the game which activate the same skill sources. The main steps of the game are “options”, “decision making” and “problem solving”. Every scenario is structured in the same way: the user has to evaluate different options in which supporting information required for the problem solving might be, he has to make a decision on the approach to be taken and to apply the standard in the problem-solving step.

Standards have been chosen as an initial point in the game scenario development because they provide guidelines, measures and best practices, and also the opportunity for benchmarks. The Life Cycle Assessment is the first scenario which is currently in the stage of development.

### 3.2. Life Cycle Assessment Game Scenario

Two main processes within the LCA have been identified in the stage of development of the sustainable global manufacturing scenario: LCA conducting and LCA using. The former is more concentrated on the collection of data and calculation and the latter on the use of the results achieved. The focus is on the first phase, where the main important competence is the ability to implement and evaluate a Life Cycle Assessment (LCA). Several main steps within this phase were outlined from the literature on LCA: definition and scoping, data collection, calculation and interpretation of results. The chosen competence to be taught is divided into critical incidents, which are events that make a significant contribution to achieving the desired competence. This will allow the player to proceed step by step, obtaining intermediate results. The outcome of this first research is shown in the table below:

**Table 1** Critical Incidents

| PHASES | CRITICAL INCIDENTS |
|---|---|
| 1. Definition and Scoping | • Choosing a product<br>• Setting objectives/goals<br>• Setting boundaries<br>• Measures for objectives (impact categories) |
| 2. Data collection | • Drawing flow diagrams of processes<br>• Defining input/output of flow diagrams<br>• Data collection plan including the level of precision<br>• Data evaluation |
| 3. Calculation | • Choosing right impact categories<br>• Doing the calculation (linking matrices with impact factors) |
| 4. Presentation and Interpretation | • Completeness check<br>• Identification of critical areas<br>• Reporting |

Once the critical incidents had been defined, the next step was identifying the difficulty in the processing of every critical incident to ensure that the player can gradually achieve the competence. It means that for every critical incident, possible challenges that the player should face to achieve the competence were defined. The challenges in the game were gathered from a detailed study of an LCA process and 14 interviews with experts in this field (sustainable managers from European countries). Taking into consideration the first and the second critical incident, the main challenges discovered were related to the choice of the parameters and the definition of an attainable scope. In the first case, i.e. decision on the parameters of LCA, a wrong choice of parameters can have a negative impact on the overall quality, time and cost of the LCA process. The player faces the challenge of getting information from the right source of information. In the second case, i.e. definition of the scope of LCA, the player needs to define the scope of the process in order to outline how to proceed and to make efficient use of time and resources. The system boundary determines

which unit/department processes are included in the LCA and it must reflect the goal of the project. The same was done for every critical incident mentioned above. Meeting these challenges in the most efficient way leads the player to obtaining the predetermined competence, but many mistakes can be made in the process. For this reason, after the definition of challenges, mistakes that a player can make when dealing with the phases of the process were defined for each critical incident. Choosing the right direction leads to a better performance in terms of efficiency of the process and allows the achievement of the necessary skills. In this way, different behavioural actions have been identified and also a measure of the level of time, cost and quality for every alternative. An example is given in Figure 1:

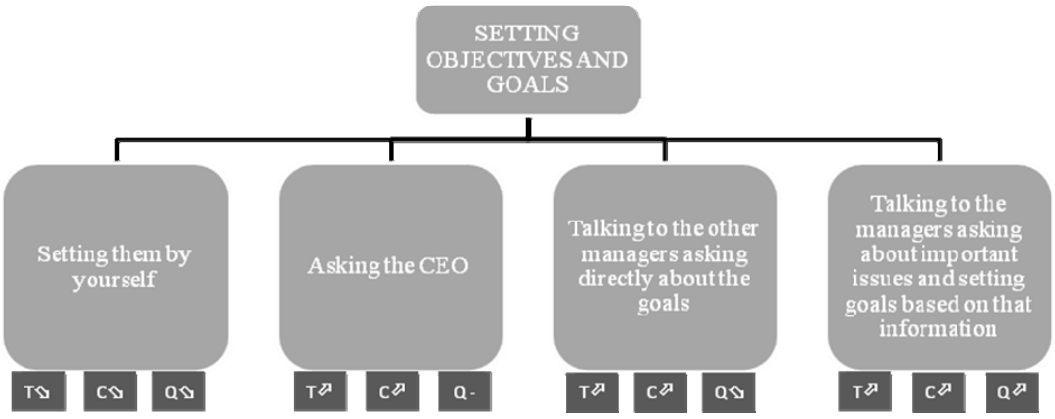


**Fig. 1** Example of behavioural actions

The critical incident taken into account is “Setting objectives and goals” from the first phase of the LCA process “Goal definition and scoping”. The main output of this phase is a report for the CEO containing the objectives and goals in terms of why the LCA is performed for a specific product and what the output should lead to. In the figure above, the critical incident is divided into four major steps that a player can make in the game, independently of the kind of LCA or targeted product. In an initial situation the player is seated in the conference room of the company with the CEO and other NPCs, who belong basically to the management board of this company. The CEO gives an introduction to the audience about the new sustainable manager. This situation is created like a formal round of introduction. After this short briefing, the player receives detailed instructions on what is expected from him in this scenario. At this stage of game development, the game is played with MBA students who have also attended lectures on sustainable manufacturing. Hence, they are familiar with the theoretical process of conducting an LCA, but have a lack of experience of performing it. After those instructions, the player is by himself. He needs to take action and talk to NPCs, write emails, hold meetings, etc. If the player acts non-progressively, the game will support the player in taking actions, e.g. by receiving an email from the CEO that the Sustainable Manager has to talk to the Production Manager about the LCA goals. The scenario is constructed in a way that the player (Sustainable Manager), who deals with setting objectives and goals for the LCA, can basically choose among four alternatives: the first is setting the objectives by himself without consulting other managers or workers; the second is directly asking the CEO about the goals without forming his/her own opinion; the third is talking to the other managers and asking them about their needs in terms of objectives and goals; and the fourth is talking to the NPCs asking about important issues/problems to be solved and then make the decision alone based on the answers. Different choices in the behaviour of the

player facing the challenge of setting goals and objectives for the LCA will in the end lead to different results of the LCA. The basic measures taken into account are: the time, cost and quality. Different alternatives for setting the objectives lead to the following properties of the measures:

- *Setting goals by player himself:* time and cost both decrease in the end because there is no waste of time while talking to the other managers, making appointments, gathering information, etc.; on the other hand, the quality of the LCA decreases due to the fact that making a decision without information coming directly from the inside can lead to wrong objectives. This alternative is the worst that the player can find.
- *Asking the CEO:* time and cost increase due to the time dedicated, while the quality is at a minimum level because the CEO does not have all the data necessary to carry out efficiently the LCA, but at least the CEO can provide some information.
- *Talking to the other managers and asking directly about the goals:* time increases due to the meetings the player has to hold, cost increases with the time spent in these meetings and the quality decreases because the player will not gather data or information but requests only final objectives.
- *Talking to the managers and asking about important issues and then setting goals based on that information:* the time, quality and cost all increase due to asking for information and data from all the managers. This takes time and brings costs but also results in a good quality of research. This choice is the best in the critical incident considered because it allows reaching a good balance between efficiency and quality.

In the scenario of the LCA, 7 crucial steps have been identified, with the step of setting goals and objectives briefly described above. The next step was to point out 3-6 solutions which the player can choose and match those with critical incidents. Based on those findings, the measures, which will be used in the future work on the player's performance evaluation, are assessed.

## 4. CONCLUSION AND OUTLOOK

The paper has presented the current status of the EU-funded FP7 integrated project TARGET. Competences for sustainability in manufacturing have been elaborated based on the literature overview and interviews with experts. Based on those findings, a game scenario with the focus on the LCA has been constructed. Within a 3D game environment, the player has to respond to certain challenges and experience skill improvement by facing critical incidents. The next step involves the validation of the findings and verification of the game scenario results. This is going to be done by the Applied Cognitive Task Analysis (ACTA). Experts in the field of LCA are interviewed and their knowledge on novice mistakes, challenges and critical incidents is going to be externalized in order to enhance the game scenario and learning objectives.

## REFERENCES

[1] Maxwell, D., Sheate, W., van der Volst, R. (2006), *Functional and systems aspects of the sustainable product and service development approach for industry*, Journal of Cleaner Production, Vol. 14, No. 17, pp. 1466-1479.

[2] O'Sullivan, D., Rolstadas, A., & Filos, E. *Global Education in Manufacturing Strategy*. Journal of Intelligent Manufacturing (2009), doi: 10.1007/s10845-009-0326-2

[3] IMS (2007). *Euro Swiss MTP Workshop*, Zurich. http://cordis.europa.eu/ims/past001_en.html. Accessed 15 November 2010

[4] NCS (2007). *Standards for Sustainability*. Resource manual. National Centre for Sustainability at Swinburne University of Technology. https://www.skillsonline.net.au/clearhse/Preview.do?no=216&type=O. Accessed 15 September 2010

[5] Leahu-Aluas, S. (2010). *Sustainable Manufacturing – An Overview for Manufacturing Engineers*. Resource document. Sustainable Manufacturing Consulting. http://sustainablemanufacturing.biz/media//DIR_17101/9543103a2878dfb8ffff83b8ffffd524.pdf. Accessed 15 September 2010.

[6] OECD (2009). *Sustainable Manufacturing and Eco-Innovation*. Synthesis report. http://www.oecd.org/dataoecd/15/58/43423689.pdf. Accessed 15 September 2010.

[7] ICEE (1977). Intergovernmental Conference on Environmental Education in Tbilisi. UNESCO. Report. http://unesdoc.unesco.org/images/0003/000327/032763eo.pdf. Accessed 5 January 2011.

[8] UN (1992). United Nations Agenda 21: Earth summit – The United Nations programme of action from Rio. http://www.un.org/esa/dsd/agenda21/res_agenda21_00.shtml. Accessed 15 September 2010

[9] UN (2002). United Nations Report of the World Summit on Sustainable Development. http://www.un.org/jsummit/html/documents/documents.html. Accessed 15 September 2010.

[10] Andersen, B., Fradinho, M., Lefrere, P., Niitamo, V. (2009). *The Coming Revolution in Competence Development: Using Serious Games to Improve Cross-Cultural Skills*. Online Communities and Social Computing, doi: 10.1007/978-3-642-02774-1_45 Key: citeulike:5866740

[11] Kirschner, P., Van Vilsteren, P. (1997*). The design of a study environment for acquiring academic and professional competence*. Studies in Higher Education. 22(2), 151-175;

[12] Westera, W. (2001). *Competences in education: a confusion of tongues*. Journal of curriculum studies. 33(1), 75-88;

[13] Dolinšek, S., Starcic, A., & Kopac, J. (2004). *Education for manufacturing – from discipline to the competency based approach*. In M.Taisch, E. Filos, P. Garello, K. Lewis, K. & M. Montorio, M. (Eds), International IMS Forum 2004, Global Challenges in Manufacturing (pp. 1354-1362).

[14] Sampson, D.G., & Fytros, D. (2008). *Competence Models in Technology-enhanced Competence-based Learning*. In H. H. Adelsberger, Kinshuk, J. M. Pawlowski & D. Sampson (Eds.), International Handbook on Information Technologies for Education and Training, 2nd Edition (pp. 1-25). New York: Springer;

[15] Rolstadas, A., & Dolinsek, S. (2006). *Global Education in Manufacturing: Basic Framework, Industrial Survey and Possible Implementation*. Managing Global Transitions, 4( 3), 261-278;

[16] de Haan, G (2010)., *The development of ESD-related competencies in supportive institutional frameworks*, Int. Review of Education, vol. 56, no. 2-3, pp. 315-328.

[17] Rauch, F.; R. Steiner, R. (2006) *School development through education for sustainable development in Austria*, Environmental Education Research, vol. 12, no. 1, pp. 115-127.

[18] Geertshuis, S., *Improving decision making for sustainability: a case study from New Zealand*, Int. Review of Sustainability in Higher Education, vol. 10, no. 4, pp. 379-389, 2009.

[19] Fenner, R.A., Ainger, C.M., Cruickshank, H.J., & Guthrie, P.M. (2005). *Embedding sustainable development at Cambridge University Engineering Department*. International Journal of Sustainability in Higher Education. 6(3), 229-241

[20] Forum for the Future (2004). Higher Education Partnership for Sustainability. *Learning and Skills for Sustainable Development*. Report. http://www.forumforthefuture.org/files/learningandskills.pdf. Accessed 15 September 2010

[21] US Department of Labor (2010): *Framework of Competencies by the Advanced Manufacturing Industry,* Employment and Training Administration, available at: http://www.doleta.gov/pdf/AdvncdManufactFWK.pdf. Accessed, 5 October 2010.

[22] Spencer, L., & Spencer, S. (1993). *Competence at work: Models for superior performance*. New York: John Wiley & Sons.

[23] Pearn, M., & Kandola, R. (1990). *Job Analysis, A Practical Guide for Managers*. London: Institute for Personnel Management

[24] Flanagan, J.C. (1954). The Critical Incident Technique. Psychological Bulletin. 51(4), 327-358;

[25] McClleland, D.C. (1973). *Testing for Competence rather than for "Intelligence"*. American Psychologist. 28(1), 1-14;

[26] Cerinsek, G., Dolinsek, S., & Oliveira, M. (2007). *Using Critical Incident Technique with Serious Games as the Next Step in Organizational Competence Development.* Conference Learning with Games, Sophia Antipolis, France;

[27] Cerinsek, G. & Dolinsek, S. (2009). *Identifying employees' innovation competency in organisations*. International Journal of Innovation and Learning. 6(2), 164-177

[28] Petersen, S., & Heikura, T. (2010). *Modelling Project Management and Innovation Competences for Technology Enhanced Learning*. EChallenges 2010, Warsaw, Poland.

[29] Fisk, D., McQuaid, J. (2004): *Principles of Engineering for Sustainable Development*, Royal Academy of Engineering, London.

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