

# **INNOVATION, CREATIVITY AND ENTREPRENEURSHIP COMPETENCE IN HIGHER EDUCATION. LEARNING OBJECTIVES AND MEASUREMENT**

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## **Abstract**

In the permanent change context, innovation has become a vital value for the survival and development of organisations. The development of this increasingly important value will help students to improve their skills and to adapt to their future jobs in accordance with required characteristics. Competency describes what training participants should be able to do at the end of such training. Competency is acquired through the various learning objectives to be achieved. Innovation competency is closely related to Self-assessment and the learning methods, Ability to work in interactive communication situations, Ability to create and maintain connections work, Ability to cooperate in a multidisciplinary and multicultural environment and Ability to communicate and interact in an international environment, etc. In this chapter, we develop a method for measuring the innovation competencies in higher education by introducing different levels of mastery.

Keywords: Online assessment, case study methodology, active learning.

## **1 INTRODUCTION**

Innovation is becoming a requirement for competitive advantage in organisations. Therefore, it is an increasingly demanding and important aspect. Promoting the acquisition of innovation competence is one of the aspects to be solved. The current trend in higher education is improving the creativity and individual thought of students to bring them closer to the world and complex problems that they will find. The qualifications of the UPV have a structure based on subjects and matters. Matters include the list of subjects. The dimensions of UPV competence aim to synthesise the skills profile acquired by UPV students by also ensuring the framework of regulations and recommendations in bachelor and master degrees. Thirteen competences have been defined: Understanding and integration; Application of practical thinking; Analysis and problem solving; Innovation, creativity and entrepreneurship; Design and project; Teamwork and leadership; Ethics and professional responsibility; Effective communication; Critical thinking; Knowledge of contemporary issues; Lifelong learning; Planning and time management; Instrumental specific.

To acquire competences, certain learning objectives are established, which must be met. The way to transmit knowledge to fulfil these learning objectives is through learning objects. The relation between these elements is illustrated in the figure below

According to [1] we can define competence as the complex know-how resulting from the integration, mobilisation and adaptation of capacities and skills to situations that share common characteristics. Competence describes what training participants should be able to do at the end of such training. In this work, corresponds to undergraduate and master students. The objectives are the way to get to the acquisition of such competence. One competence is acquired through several learning objectives to be achieved.

Thus, we find two distinct aspects, how to encourage or promote the ideal environment for the development and achievement of these learning objectives and secondly how to evaluate the acquisition of those objectives. The first issue should be addressed through learning objects given to students. These learning objects are given in form of lectures, laboratory practices, case studies etc. Learning objects can be used to support the achievement of one or more learning objectives. (The definition of learning objects is beyond the scope of this paper). Moreover, it should be able to assess the level of achievement of the learning objectives to measure the degree of acquisition of competence. In this second part is where the objective of this work is framed.

Innovation, creativity and entrepreneurship deals with the mindsets and skills associated with creativity and innovation as well as the qualities and practices associated with successful entrepreneurship. For example entrepreneurship is the individual's ability to translate ideas into action. It encompasses creativity, innovativeness and risk taking, as well as ability to plan and direct action towards the achievement of goals [2]. It is necessary to consider how to apply these mindsets and skills in their organisation/business [3]. Few innovations in education have been rigorously compared with traditional practices to measure quantitatively what they contribute to educational outcomes. Although traditional assessments are limited in the types of data they can provide to evaluate educational systems and practices, there are other means to ensure that educational practices achieve the desired ends [4].

Innovation has been a topic of considerable interest in the education sector for some time. Indeed, successful innovation depends upon the human creativity, knowledge, skills and talents that are nurtured and developed, in large part, through education [5].

Assessment is vital to the process of innovation. We can identify four terms related to assessment [6, 7]: measurement, testing, evaluation, and assessment. Measurement refers to the process by which a value, usually numerical, is assigned to the attributes or dimensions of some concept or physical object. Testing refers to the process of administering a test to measure one or more concepts, usually under standardized situation. Evaluation refers to the process of arriving at judgments about abstract entities such as programs, curricula, organisations, and institutions. Assessment is defined as "the process of obtaining information that is used to make educational decisions about students, to give feedback to the student about his or her progress, strengths and weaknesses, to judge instructional effectiveness and curricular adequacy and to inform policy" [8]. Assessment in the context of individual learning is sometimes referred to as "formative assessment," in contrast to "summative assessment," which is intended to guide decision-making (see [9]).

In this sense, standardization is a prerequisite for fairness when scores must be comparable [4]. The rubric concept significantly facilitates the performance rating of the students in tasks that are vague and complex, and unwieldy subjectivity to the assessment. A rubric (or valuation matrix) can be defined as a scoring tool that lists the specific criteria for assessing a complex task (eg purpose, organisation, details, voice, ... ; also it articulates a gradient of quality for each of the criteria, from "weak" to "excellent" [10]. Usually designed so that the student can be assessed as "sufficiently objective" and consistent. It can remove the uncertainty associated to the evaluation, ensuring to the student a very accurate prediction of the evaluation that will make the teacher [11]. The criteria are defined which gives the position of the task and provides guidance for improvement.

## **2 LEARNING OBJECTIVES ASSOCIATED TO INNOVATION, CREATIVITY AND ENTREPRENEURSHIP COMPETENCE**

The list of learning objectives was generated by the Institute of Education Sciences [12] (ICE, 2013) of the UPV. These learning objectives have been identified for bachelor degree and master degree and grouped under a general aim.

**Table 1** Learning objectives in bachelor degree

<b>Bachelor Degree</b>	
<b>Aim</b>	<b>Learning Objectives</b>
<b>Generating and transmitting new ideas or producing innovative alternatives to the known situations or problems set out.</b>	Contributing their own quality suggestions for the given situations and problems.
	Questioning the reality in which innovation is put forward
	Expressing newly generated ideas to someone else

<b>Coming up with original, quality ideas that can be formally presented and defending them in known and unknown situations</b>	Offering suggestions to the ideas, situations, cases or problems that arise
	Using creativity techniques to propose and defend quality ideas that are original or not conventional
	Integrating knowledge of several disciplines, or from various sources or domains, to produce novel ideas for known or unknown situations
	Formally present the ideas generated
<b>Introducing new procedures and actions in the work process itself to better respond to any limitations and problems encountered</b>	Recognizing limitations and weak points in processes and working methods.
	Reflect on the new ways of doing things
	Seeking new procedures and methods to do things
	Experimenting with new procedures
	Identifying the innovation results
<b>Seeking and proposing new methods and solutions in real or hypothetical situations with problems</b>	Analyzing the given situation and identifying improvement aspects
	Becoming familiar with idea-generating instruments and techniques
	Offering suggestions or ideas, situations, cases or problems that arise.
	Considering who and how innovation affects
	Finding new methods and processes to do things
	Propose innovative ideas and solutions on the content and process to carry them out
	Analyzing the risks and benefits of innovation.

**Table 2** Learning objectives in master

Master	
Aim	Learning Objectives
<b>Contributing with original, practical and applicable, flexible and complex ideas and solutions that affect him/herself and the processes he/she is involved in, and closely related people and processes</b>	Adopting open attitudes to produce new lines of thought
	Introducing unique or leading solutions which improve some aspects or spheres of action
	Adopting creative approaches in relation to the content of the situation itself and the way to do so
	Using specific methods to improve creativity
<b>Designing and applying innovative process in the organization, which lead to better results for real situations and/or projects</b>	Identifying improvement requirements in complex situations and contexts
	Reflecting on causes and purposes of innovations
	Finding new methods to do things differently
	Using suitable methods and solutions for innovation
	Analyzing risks and benefits
	Get results or innovation.

<b>Design and conduct appropriate experiments, interpret data and draw conclusions.</b>	Constructing scientific knowledge about engineering problems (projects) in order to efficiently solve problems in a given context
	Taking a critical and autonomous point of view on knowledge about his/her own discipline
	Making searches in the technical literature using databases and other information sources.
	Identifying, locating and obtaining the required data
	Designing and conducting analytical model-based and experimental research
	Critically evaluating the data and reaching conclusions
	Investigating the application of new and emerging technologies in their field of engineering
<b>To undertake projects on their own initiative, committing certain resources in order to exploit an opportunity and taking the risk that this entails.</b>	Facing reality by weighing up risks and opportunities, and by assuming consequences
	Taking initiatives by counting on others by allowing them to participate in his/her vision of the future and his/her projects
	Embarking on ambitious (complex and challenging) projects that imply a social decision.

Once the final list was obtained, the learning objectives were classified according to [13] to obtain a structured list according to the characteristics of innovation.

[13] states that leaders must be able to think creatively while taking initiative and calculated risks. Effective leaders have a vision beyond the immediate work of the group. This involves exploring and integrating diverse perspectives and recognizing unexpected opportunities. The perspectives that should be considered in the innovation competence are creativity, entrepreneurship, integrating perspectives, forecast and change management.

**Creativity** includes, generating ideas, critical thinking, synthesis and reorganization; and creative problem solving.

**Entrepreneurship** corresponds to problem identification, seeking improvement, gathering information, independent thinking and technological savvy.

**Integrating perspectives** includes openness to ideas, research orientation, collaborating, engaging in non-work interests.

**Forecasting** comprises perceiving systems, visioning and managing the future.

**Managing change** consists of sensitivity to situations, intelligent risk taking and reinforcing change.

Once the learning objectives associated to innovation competence have been identified and classified, we are able to develop an assessment method for measuring the achievement of these objectives and therefore the acquisition of the competence.

### 3 ASSESSMENT METHOD PROPOSAL

The objective of this proposal is the measurement of the innovation competencies in higher education by introducing different levels of mastery. As noted in the introduction section, following a standard process improves the fairness when evaluating.

In this sense, rubrics can be considered a good assessment tool. A related concept to both structure and functionality is the maturity model. The maturity model provides a rubric for determining process maturity levels as well as a roadmap for achieving the optimal level of high-quality operations. Maturity is defined as a measure to evaluate the capabilities of an organization in regards to a certain discipline. As a rubric, the Maturity Model identifies critical factors with progressions across the levels of maturity.

In order to develop the rubric as an assessment tool and its similarity to established maturity models, we follow the methodology defined by [14].

Phase 1: Scope: The most significant decision in this phase involves focusing the model. This refers to which domain the maturity model would be targeted and applied. In this proposal the focus of the model is the competence of innovation, creativity and entrepreneurship.

Phase 2: Design: The design of the model incorporates the needs of the intended audience and how these needs will be met. In this particular case, it is necessary because of the impact the properly innovation assessment has on the students, the model design gives an appropriate definition of the learning objectives at different levels of education, in this sense the model can be applied to bachelor degree and master degree, it involves the participation of the students. The proposed assessment model will follow the common design principle to represent maturity as a number of cumulative stages where higher stages build on the requirements of lower stages.

According to [15] it is important that the final stages are distinct and well-defined, and a logical progression through stages. Stage or levels definitions should be developed to expand stage names and provide a summary of the major requirements and measures of the stage, especially those aspects that are new to the stage and not included as elements of lower stages. Table 3 describes the different levels to this proposal.

**Table 3** Maturity Levels

Maturity level definition in innovation competency	
Level 1:	Learning objectives associated with the management areas of change, creativity and entrepreneurship are considered of difficult or limited achievement. Integration of perspectives and forecasting shows little evidence.
Level 2:	Learning objectives associated with the management areas of change, creativity and entrepreneurship are generally limited, but predictable. Integration of perspectives, while forecasting is incomplete and contains few details.
Level 3	Learning objectives are generally adequate and complete.
Level 4:	Learning objectives associated with innovation, creativity and entrepreneurship are consistent, widely proven and complete.

Phase 3: Populate In this phase it is necessary to identify in detail what needs to be measured in the maturity assessment and how this can be measured. The goal is to collect all relevant criteria that are necessary for the assessment of the specific domain.

The proposed assessment model includes the best practices to be carried out on innovation competency that must be implemented to achieve the maximum level of maturity in the learning objectives, grouped by perspectives or key areas for bachelor degree and master degree.

Phase 4: Deploy: This phase includes a preliminary validation. This is the first step in determining the issue of model generalization and can lead to general acceptance of the model. In this case an evaluation was developed in a pilot group in the School of Computer Science, fifth year of computer science bachelor degree.

Phase 5: Implementation: The goal of this phase is related to the resources necessary to maintain the model's growth and use.

## 4 CONCLUSION AND FUTURE WORK

The learning objectives identified for the bachelor and master degrees are similar, but the deep in master degrees must be based on a broader, more long-term vision.

They are divided into different perspectives associated to creativity, entrepreneurship, integrating perspectives, forecast and change management.

The proposal facilitates the evaluation and identification of the relations between their learning objectives or different perspectives. When analyzed separately as areas or perspectives, it provides

flexibility and functionality when the results are analyzed and when applying proposals for improvement.

Regarding de evaluation, one aspect that it is important to analyze is the weight associated to each perspective and to each learning objective. For different subject it could be weighted in different ways.

Now it is necessary to work to correctly define the learning objects that improve and provide opportunities to students to help them meet and improve at higher maturity levels.

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## REFERENCES

- [1] Incode, 2012 Innovation competencies development as integral part of higher education.  
<http://www.incode-eu.eu/en/>
- [2] KEN 2013 Wolverhampton, UK, 1314 May2013 Entrepreneurial Education & Innovation Developing Entrepreneurial Mindset for Knowledge Economy <http://www.knowledge-economy.net/uploads/documents/2013/workshops/wolverhampton/Wolverhampton%20Workshop%20-%20Analytical%20Compendium.pdf>
- [3] Markwell et al, 2003 Improving teaching and learning in universities. Business/Higher education round table, issue 18, 2003
- [4] Braun H., Kanjee A., Bettinger E., and Michael Kremer, 2006 Improving Education Through Assessment, Innovation, and Evaluation. ISBN: 0-87724-058-2 by the American Academy of Arts and Sciences
- [5] Looney, 2009 Looney, J. W. (2009), "Assessment and Innovation in Education", OECD Education Working Papers, No. 24, OECD Publishing. <http://dx.doi.org/10.1787/222814543073>
- [6] Keeves, 1997; Keeves, J. P., ed. 1997. Educational Research, Methodology and Measurement: An International Handbook, 2nd ed. New York: Pergamon.
- [7] UNESCO, 2000 UNESCO 2000b. Status and Trends 2000: Assessing learning achievement. Paris:
- [8] NCME, 1990 American Federation of Teachers (AFT), National Council on Measurement in Education (NCME), and National Education Association (NEA). 1990. Standards for Teacher Competence in Educational Assessment of Students.Washington, DC: American Federation of Teachers.
- [9] Black, P. and D. Wiliam (1998), "Assessment and Classroom Learning", Assessment in Education: Principles, Policy and Practice, Vol. 5, No. 1, pp. 7-74
- [10] Goodrich H. (1997). Understanding Rubrics. Educational Leadership, 54(4), 14-17
- [11] Lopez J.L. (2002). Uso de rúbricas generalizadas para evaluar conocimientos en la técnica didáctica Aprendizaje Basado en Problemas. Documento en internet [www.mty.itesm.mx/rectoria/dda/rieee/html/2002.htm](http://www.mty.itesm.mx/rectoria/dda/rieee/html/2002.htm)
- [12] ICE 2014; Dimensiones Competenciales UPV Report Interno. ICE-Universitat Politècnica de València.
- [13] Bapat et al., 2014 Technical Report. [http://www.chsbs.cmich.edu/leader\\_model/assess.htm](http://www.chsbs.cmich.edu/leader_model/assess.htm)
- [14] Cuenca L., Boza A., Alemany MME, Trienekens J.. (2013) Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company. Computers in Industry 64 (2013) 898–911

- [15] Bruin, T. De., M. Rosemann, R. Freeze, U. Kulkarni, Understanding the main phases of developing a maturity assessment model, in: Proceedings of the 16th Australasian Conference on Information Systems, Sydney, Australia, 2005, pp. 1–10.