Universitat de Girona

TECHNOLOGY-ENHACED SUPPORT FOR LIFELONG COMPETENCE DEVELOPMENT IN HIGHER EDUCATION

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Ph.D. Thesis

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Technology-Enhanced Support for Lifelong Competence Development in Higher Education

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List of Publications Resulting from This Thesis

Journal Papers

Florian-Gaviria, B., Glahn, C., & Fabregat, R. (2013). A Software Suite for Efficient Use of the European Qualifications Framework in Online and Blended Courses. *IEEE Transactions on Learning Technologies (TLT)*, 1–14. (In second round-review since December 2012). **ISI Impact Factor 0.823 (2011)**.

Florian-Gaviria, B., Solarte, O., & Reyes, J. M. (2010). Propuesta para Incorporar Evaluación y Pruebas de Usabilidad Dentro de un Proceso de Desarrollo de Software. *Revista EIA*, (13), 123–141. Retrieved from http://revista.eia.edu.co/articulos13/art.9 (123-141).pdf

Florian-Gaviria, B., Bustos, J. J., & Uribe-Narváez, F. (2009). Aplicación Web para Evaluación Formativa Universitaria Basada en Competencias. *Revista Educación en Ingeniería, Dic. 2009*(8), 1–12. Retrieved from http://www.educacioneningenieria.org/index.php/edi/article/view/82/72

Book Chapters

Florian-Gaviria, B., Glahn, C., Drachsler, H., Specht, M., & Fabregat, R. (2011). Activity-Based Learner-Models for Learner Monitoring and Recommendations in Moodle. In C. Kloos, D. Gillet, R. Crespo García, F. Wild, & M. Wolpers (Eds.), *Towards Ubiquitous Learning* (Vol. 6964 LNCS, pp. 111–124). Springer Berlin / Heidelberg. doi:10.1007/978-3-642-23985-4_10. Retrieved from http://www.springerlink.com/content/d743t57707600827.

Florian-Gaviria, B., & Fabregat, R.. (2011). Usability Study of TEL Recommender System and E-Assessment Tools United. In C. Stephanidis (Ed.), *HCI International 2011 – Posters' Extended Abstracts* (Vol. 173, pp. 138–142). Springer Berlin Heidelberg. doi:10.1007/978-3-642-22098-2_28. Retrieved from http://www.springerlink.com/index/P4357612682V4062.pdf.

Conference Papers

Florian-Gaviria, B., Baldiris, S. M., Fabregat, R., & De la Hoz-Manotas, A. (2010). A Set of Software Tools to Build an Author Assessment Package on Moodle: Implementing the AEEA Proposal. *10th IEEE International Conference on Advanced Learning Technologies* (pp. 67–69). Sousse: IEEE Computer Society. doi:10.1109/ICALT.2010.26. Retrieved from http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5571142.

Feliu, L., **Florian-Gaviria, B.,** Fraguell, M. R., Montoro, L., Planas, A., Saurina, J., Suñol, J. J., et al. (2010). Implantación de una Red de Innovación Docente para el Análisis y Mejora de la Evaluación de los Estudiantes en la Universidad de Girona. *Proceedings VI CIDUI Congreso Internacional Docencia Universitaria e Innovación (Nuevos espacios de calidad en la educación superior. Un análisis comparada y de tendencias).* Barcelona. Retrieved from http://web2.udg.edu/ice/doc/xids/doc549.pdf

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Florian-Gaviria, B., Baldiris, S. M., & Fabregat, R. (2009). Adaptive Evaluation Based on Competencies. In O. Santos, J. Boticario, J. Couchet, R. Fabregat, S. Baldiris, & G. Moreno (Eds.), *Proceedings of the Workshop on Modeling and Evaluation of Accesible Intelligent Learning Systems. (AIED 2009)* (Vol. 495, pp. 54–63). Brighton: CUER Workshop Proceedings. Retrieved from http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-495/paper8.pdf

Florian-Gaviria, B., Baldiris, S. M., & Fabregat, R. (2009). Adaptive Integral Assessment Package for the A2UN@ Project. 20th EAEEIE Annual Conference (pp. 1–6). Valencia: IEEE Computer Society. doi:10.1109/EAEEIE.2009.5335460 http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5335460&tag=1

Invited Talks

Florian-Gaviria, B. (2011). Learning analytics in competence development based on learners' activity and learning outcomes. *Creació d'objectes d'aprenentatge adaptatius, Projecte FEDER – Clúster TIC MEDIA de Girona*, Girona, 17 October 2011

Florian-Gaviria, B., (2009). Arquitectura para la Evaluación Adaptativa Basada en Competencias. *Congreso Internacional de Ambientes Virtuales de Aprendizaje Adaptativos y Accesibles, CAVA 2009*, Universidad de Córdoba, Montería - Colombia.

List of Publications Resulting from Collaboration with Other UdG Ph.D. Thesis

Journal Papers

Mejía, C., **Florian-Gaviria, B.**, Bull, S., Vatrapu, R., Díaz, A., & Fabregat, R. (2013). A Novel Approach for Visualization and Inspection of Reading Difficulties on University Students. *IEEE Transactions on Visualization and Computer Graphics*, 1–14. (Awaiting submission 2013). **ISI Impact Factor 2.215 (2011)**

Conference Papers

Mejía, C., Díaz, A., **Florian-Gaviria, B.,** & Fabregat, R. (2012). Uso de las TICs en la construcción de analíticas de aprendizaje para fomentar la auto-regulación en estudiantes universitarios con dislexia. *Congreso Internacional EDUTEC 2012*. Las Palmas de Gran Canaria.

Mejía, C., Bull, S., Vatrapu, R., **Florian-Gaviria, B.,** & Fabregat, R. (2012). PADA: a Dashboard of Learning Analytics for University Students with Dyslexia. *Last ScandLE Seminar*. Copenhagen. Retrieved from http://www.itu.dk/people/rkva/ScandleSeminar_CPH/doctoralConsortium/Paper-ScandLE Seminar%28Mejia%29_v5.docx

LIST OF ACRONYMS

Institutional Acronyms

ATC	Department of Architecture and Computer Technology, UdG
BCDS	Broadband Communication and Distributed System Group, UdG
CELSTEC	Centre for Learning Sciences and Technologies, OUNL
COLCIENCIAS	Colombian Management Department of Science, Technology and Innovation
ETH Zurich	The Swiss Federal Institute of Technology Zurich
ICE	Josep Pallach Institute of Education Sciences, UdG
IIIA	Institute of Informatics and Applications, UdG
LASPAU	Academic and Professional Program for the Americas
OUNL	Open University of the Netherlands
UdG	University of Girona, Girona, Catalonia, Spain
UNIVALLE	University of Valle, Cali, Colombia

Technological Acronyms

AEEA	Adaptive Engine Evaluation Architecture
CBA	Competence Based Assessment
CBL	Competence Based Learning
DAO	Data Access Object
ECTS	European Credit Transfer and Accumulation System
EDM	Educational Data Mining
EHEA	European Higher Education Area
EQF	European Qualifications Framework
HR-XML	Human Resources eXtensible Markup Language
ICOPER	Interoperable Content for Performance in a Competency-driven Society
ICOPER-LOD	ICOPER Learning Outcome Definitions

ICT	Information and Communication Technology
IEEE-RCD	IEEE Standard for Learning Technology—Data Model for Reusable Competency Definitions
IMS GLC	IMS Global Learning Consortium
IMS-CP	IMS Content Package
IMS-LD	IMS Learning Design
IMS-QTI	IMS Question & Test Interoperability
IMS-RDCEO	IMS Reusable Definition of Competency or Educational Outcome
IT	Information Technology
LA	Learning Analytics
LAK	Learning Analytics and Knowledge
LD	Learning Design
LLL	Lifelong Learning
LMS	Learning Management System
LO	Learning Outcome
LOCO	Learning Object Context Ontologies
MACE	Metadata for Architectural Contents in Europe
OBE	Outcome-Based Education
OICS	Open ICOPER Content Space
PALO	Personal Achieved Learning Outcomes
PBL	Project-Based Learning
PLE	Personal Learning Environment
POL	Project-Organized Learning
RecSys	Recommender Systems
RQ	Research Question
SRL	Self-regulated Learning
TEL RecSys	Recommender Systems for Technology-Enhanced Learning
TEL	Technology-Enhanced Learning
TENCompetence	Building the European Network for Lifelong Competence Development
UML	Unified Modelling Language
VET	Vocational Education and Training
VLE	Virtual Learning Environment

LIST OF KEY TERMS

360-Degree Feedback: (1)-Organizational field-. Performance-appraisal data collected from 'all around' an employee his or her peers, subordinates, supervisors, and sometimes, from internal and external customers. Its main objective usually is to assess training and development needs and to provide competence-related information for succession planning not promotion or pay increase. [1] (2)-Education field-. It is feedback that comes from all around the student. The name refers to the 360 degrees in a circle, being the student in the centre of the circle. Feedback is provided by subordinates, peers, and teachers. It also includes a self-assessment and, in some cases, feedback from external sources. (Florian-Gaviria, Baldiris, & Fabregat, 2009a)

Activity-Based Learner-Models: An activity-based learner-model creates a semantic structure of dynamically generated learner properties that reflect observed actions of a learner. Activity-based learner models are a prerequisite for activity-centred assessment and process support for competence development.(Florian-Gaviria, Glahn, Drachsler, Specht, & Fabregat, 2011)

Aggregator: (1) Typically used to aggregate context information of real world entities such as users or places. By acting as a gateway between applications and elementary widgets, aggregators hide even more complexity about the context-sensing mechanisms. (Dey, 2000). (2) The definition of how the data from one or more sensors has to be transformed is called an aggregator. That is, aggregators refer to semantically enriched information that is based on sensor data. An aggregator defines a rule set how the underlying sensor information has to be aggregated. These rules are named according to their meaning, for instance activity or interest.(Glahn, Specht, & Koper, 2007)

Awareness: The understanding of a learning task and the phenomena that is relevant for the task. (Marton and Booth 1997)

Blended Learning: Blended learning is a coherent design approach that openly assesses and integrates the strengths of face-to-face and computer-mediated learning to address worthwhile educational goals. (Garrison & Vaughan, 2008)

Competence: The ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development). Competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (involving technical skills) as well as interpersonal attributes (e.g. social or organisational skills) and ethical values. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

[1] http://www.businessdictionary.com/definition/360-degree-eedback.html#ixzz29Ownu6to

Competence-Based learning (CBL): It refers to the formal and informal learning and training activities that individuals and/or groups perform to improve their competences in a particular field, given some personal, societal or employment related motives. (C. Griffin, 1999), (Aspin & Chapman, 2000), (Field, 2001)

Contextual Awareness: It refers to the ability of a system to adapt its behaviour to the current situation. That is, the situation of the system itself, of its environment, and of its users. Contextual awareness is useful to adapt both what the users should be made aware of (i.e. to provide an information filtering mechanism), and how they should be made aware of it (e.g. prefer an auditory to a visual notification), depending on their situation. (Liechti & Sumi, 2002)

Controllers: Refer to dynamic and adaptive processes. Each controller implements an adaptation strategy that arranges the interplay of aggregators and indicators. (Glahn, 2009)

Dropout: Withdrawal from an education or training programme before its completion. This term designates both the process (early school leaving) and the persons (early school leavers) who fail to complete a course; besides early school leavers, dropouts may also include learners who have completed education or training but failed the examinations. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Educational Data Mining (EDM): It develops methods and applies techniques from statistics, machine learning, and data mining to analyse data collected during teaching and learning. EDM tests learning theories and informs educational practice. (Bienkowski, Feng, & Means, 2012)

EQF Competence: In this thesis the concept *EQF competence* refers to a competence (knowledge, skill or wider competence) with an associated expected EQF level of qualification that is either a prerequisite or a learning outcome of a course.

European Credit Transfer System (ECTS): A systematic way of describing a higher education programme by attaching credits to its components (modules, courses, placements, dissertation work, etc.), to: – make study programmes easy to read and compare for all students, local and foreign; – encourage mobility of students and recognition of formal, non-formal and informal learning; – help universities to organise and revise their study programmes. ECTS is based on the student workload required to achieve the objectives of a programme, specified in terms of learning outcomes to be acquired. The student workload of a full- time study programme in Europe amounts in most cases to around 1500-1800 hours per year and in those cases one credit stands for around 25 to 30 working hours. Individuals who can demonstrate similar learning outcomes acquired in other learning settings may obtain recognition and credits (waivers) from the degree awarding bodies. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

European Qualifications Framework (EQF): A reference tool for the description and comparison of qualification levels in qualifications systems developed at national, international or sectoral level. The EQF's main components are a set of 8 reference levels described in terms of learning outcomes (a combination of knowledge, skills and/or wider competences) and mechanisms and principles for voluntary cooperation. The eight levels cover the entire span of qualifications from those recognising basic knowledge, skills and competences to those awarded at the highest level of academic and professional and vocational education and training. EQF is a translation device for qualification systems. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Formal Learning or Formal Education: Learning that occurs in an organised and structured environment (e.g. in an education or training institution or on the job) and is explicitly designated as learning (in terms of objectives, time or resources). Formal learning is intentional from the learner's point of view. It typically leads to validation and certification. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Indicator: Indicators describe the presentation mode of aggregated information. An indicator defines what information is highlighted or diffused in what way. (Glahn, 2009)

Informal Learning: Learning resulting from daily activities related to work, family or leisure. It is not organised or structured in terms of objectives, time or learning support. Informal learning is in most cases unintentional from the learner's perspective. Informal learning outcomes do not usually lead to certification but may be validated and certified in the framework of recognition of prior learning schemes; informal learning is also referred to as experiential or incidental/ random learning. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Information and Communication Technology (ICT): Technology which provides for the electronic input, storage, retrieval, processing, transmission and dissemination of information. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Knowledge: The outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study.(European Centre for the Development of Vocational Training (CEDEFOP), 2008) In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual. (European Communities, 2008a)

Learning Activity Management System (LAMS): It is a tool for designing, managing and delivering online collaborative learning activities. It provides teachers with a visual authoring environment for creating sequences of learning activities. These activities can include a range of individual tasks, small group work and whole class activities based on both content and collaboration.[2]

Learning Analytics (LA): They loosely joins a variety of data-gathering tools and analytic techniques to study student engagement, performance, and progress in practice (explicit student actions and tacit actions), with the goal of using what is learned to tailor educational opportunities to each student, assess academic progress, predict future performance, spot potential issues, and revise curricula, teaching, and assessment in real time. (Johnson, Smith, Willis, Levine, & Haywood, 2011)

[2] http://www.lamsinternational.com/

Learning Design (LD): (1) A 'learning design' is defined as the description of the teaching-learning process that takes place in a unit of learning (e.g., a course, a lesson or any other designed learning event) (Koper, 2006). (2) A learning design is a reusable representation of a concrete learning opportunity. A learning design arranges teaching methods, assessment designs, learning content, and other elements of a learning environment such as learning tools towards learning outcome attainment. (Gutiérrez, Crespo, Totschnig, Leony, & Kloos, 2012).

Learning Outcomes (LO): (1) It is a statement of what a learner knows, understands, and is able to do on completion of a learning process. It covers knowledge, skills and competences that a learner should attain when successfully having finished a unit of learning. (Gutiérrez et al., 2012). (2) The set of knowledge, skills and/or competences an individual has acquired and/or is able to demonstrate after completion of a learning process, either formal, non-formal or informal. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Lifelong Learning (LLL): All learning activity undertaken throughout life, which results in improving knowledge, know-how, skills, competences and/or qualifications for personal, social and/or professional reasons. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

National Qualifications Framework: It means an instrument for the classification of qualifications according to a set of criteria for specified levels of learning achieved, which aims to integrate and coordinate national qualifications subsystems and improve the transparency, access, progression and quality of qualifications in relation to the labour market and civil society.

National Qualifications System: It means all aspects of a Member State’s activity related to the recognition of learning and other mechanisms that link education and training to the labour market and civil society. It includes the development and implementation of institutional arrangements and processes relating to quality assurance, assessment and the award of qualifications. A national qualifications system may be composed of several subsystems and may include a national qualifications framework;

Non-Formal Learning or Non-Formal Education: Learning which is embedded in planned activities not explicitly designated as learning (in terms of learning objectives, learning time or learning support). Non-formal learning is intentional from the learner’s point of view. Non-formal learning outcomes may be validated and lead to certification; Non-formal learning is sometimes described as semi-structured learning. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Outcome-Based Assessment: (1) Assessment process that must be aligned with the learning outcomes. In other words it should support learners in their progress (formative assessment) and validate the achievement of the intended learning outcomes at the end of the process (summative assessment). Also implies that the assessment process should be adapted depending on the kind of outcomes that it is aimed to appraise. (Gutiérrez et al., 2012). (2) The process of appraising knowledge, know-how, skills and/or competences of an individual against predefined criteria (learning expectations, measurement of learning outcomes). Assessment is typically followed by validation and certification. In the literature, ‘assessment’ generally refers to appraisal of individuals whereas 'evaluation' is more frequently used to describe appraisal of education and training methods or providers. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Project-Based Learning (PBL) or Project-Organized Learning (POL): Project-Based Learning (PBL) is a pedagogical approach that organizes learning around projects. According to the definitions found in PBL handbooks for teachers, projects are complex tasks based on challenging questions or problems. Thus, students are involved into designing, problem-solving, decision making, or investigative activities. These tasks provide students with an opportunity to work relatively autonomously over extended periods of time and allow them to elaborate a final realistic products or presentations. (Thomas, 2000)

Qualification Framework: An instrument for the development and classification of qualifications (e.g. at national or sectorial level) according to a set of criteria (e.g. using descriptors) applicable to specified levels of learning outcomes. A qualification framework can be used to: – establish national standards of knowledge, skills and competences; – promote the quality of education; – provide a system of coordination and/or integration of qualifications and enable comparison of qualifications by relating qualifications to each other; – promote access to learning. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Qualification: (1) It means a formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards. (European Communities, 2008b). (2) The term qualification covers different aspects: (a) Formal qualification: the formal outcome (certificate, diploma or title) of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards and/or possesses the necessary competence to do a job in a specific area of work. A qualification confers official recognition of the value of learning outcomes in the labour market and in education and training. A qualification can be a legal entitlement to practice a trade. (b) Job requirements: the knowledge, aptitudes and skills required to perform the specific tasks attached to a particular work position.(European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Reflection: Person's ability to reflect on her or his actions. It can be either past action or current actions. Reflection links previous knowledge with self-regulated actions to acquire new knowledge in a continuous process of planning, monitoring and evaluating. (Glahn, 2009)

Reflection Triggers: They refer to visual and verbose representations of multiple students' activity analyses for reflection purposes in formal education (Verpoorten, Westera, & Specht, 2012)

Scoring Rubric: -Education area-. The rubric is a standard of performance for a defined population. (National Committee on Science Education Standards and Assessment, 1996). A scoring rubric is a set of criteria and standards descriptors typically associated to learning objectives. It is used to assess or communicate about performance, behaviour, or quality.

Self-Directed Learning: In its broadest meaning, according to Malcolm Knowles is a process: ... "in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (Knowles, 1975).

Self-Regulated Learning: Is a process that implies motivation to learn, monitoring, reflecting, judging, planning, and evaluating personal progress against a standard. Self-regulation refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals. (Zimmerman, 2005)

Skills: (1) The ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments) (European Communities, 2008b). (2) The ability to perform tasks and solve problems. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

Smart-Indicator: Contextualised visualisations of interaction data for supporting informal learning that follows rule-based adaptation strategies. (Glahn, 2009)

Social Learning Analytics: They make visible, and in some cases potentially actionable, behaviours and patterns in the learning environment that signify effective process. In particular, the focus is on processes in which the learner is not solitary, and not necessarily 'doing work to be marked', but is engaged in 'social' activity either by virtue of interacting directly with peers (e.g. via messaging, friending, following), or using collaborative platforms in which their activity is leaving traces which will be experienced by others (e.g. by blogging, publishing media, searching, tagging, rating). (Shum & Ferguson, 2011)

Social Learning Context Analytics: They are analytic tools that expose, make use of, or seek to understand social context(s) where the learner is involved. (Shum & Ferguson, 2011)

Social Planes: The social plane is the level where individual representations disappear behind the culture that the community members jointly constructed. More practically, it has been discriminated collaborative (small groups (2-7)) versus collective activities (all the class students). It is often encounter the following five levels of activity: Individual plane, Group plane, Class Plane, Community Plane, and World Plane. (Dillenbourg, 2004a)

Standards and Specifications: Explicit set of requirements to be satisfied by a material, product, or service. A technical specification may be developed privately by a corporation, regulatory body, or military organization or it may be developed by standardized organizations. When a specification is issued by a standardization body, it becomes a standard. (Gutiérrez et al., 2012)

Technology-Enhanced Learning (TEL): It refers to the support of any learning activity through technology considering the workings of the human cognitive system to achieve learning objectives and maximise its potential (efficiency and effectiveness of learning). (Dror, 2008)

Virtual Learning Environment (VLE) or Learning Management System (LMS): It has the following characterises: It is a designed information space, a social space, a space explicitly represented, students are not only active but also actors, not restricted to distance education, it integrates heterogeneous technologies and multiple pedagogical approaches, most of them overlap with physical environments (Dillenbourg, Schneider, & Synteta, 2002).

Vocational Education and Training (VET): Education and training which aims to equip people with knowledge, know-how, skills and/or competences required in particular occupations or more broadly on the labour market. (European Centre for the Development of Vocational Training (CEDEFOP), 2008)

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ABSTRACT

A trace of lifelong-learning qualifications has become more and more mandatory at the European and even at world level. However, for higher education courses, the former could imply new complex learning designs and abundance of data to monitor, analyse, and report. Therefore, this implication has produced at least two challenges:

1. *How to help students and teachers to understand and trace the underlying competences in their courses according to the European standards?*
2. *How to engage them to use technology-enhanced tools and benefit from them?*

Personalised, competence-based, and social learning have been suggested as potential ways to address these problems.

This work combine the ideas of personalised, competence-based, and social learning by providing course lifecycle support through competence-based design, outcome-based assessment, social learning context analytics, and open student modelling visualisations. A series of studies using a virtual learning environment exploited the idea of the approach and revealed promising results. These results demonstrated personalised guidance, competence-based design, outcome-based assessment, and social context visualisation combined helped students and teachers to trace learning outcomes of the European Qualifications Framework (EQF) in higher education courses. Thus, this thesis extends the approach of higher education to a larger collection of learning objects for designing, assessing, and analysing courses. Moreover, this approach verifies its capability of supporting social context visualisation for online and blended personalised education.

Study results confirmed that when users worked with voluntarily given applications, learning quality was increased. Students raised it through their contextual awareness, reflection, and self-regulation while teachers increased it through contextual awareness and self-reflection with several possibilities for planning, monitoring and moderating of their courses. Later works, still in progress, will prove if different applications will help to improve learning results reached by students and also their impact in courses with pedagogical strategies of active learning. Extensions to add recommender systems for teachers and students were designed, their implementation and tests are still awaiting. Regarding subjective tests, these confirmed the interface usability while teachers and students suggestions were taken into consideration for consecutive system versions.

RESUMEN

Un rastreo de las cualificaciones del aprendizaje a lo largo de la vida es cada vez más obligatorio a nivel europeo, incluso a nivel mundial. Sin embargo, en lo que corresponde a los cursos en educación superior, esto puede derivar en diseños de cursos más complejos y adicionalmente abundancia de datos para rastrear, analizar e informar. Por tanto, esto ha producido al menos dos retos:

1. *¿Cómo ayudar a los estudiantes y maestros a entender y rastrear las competencias subyacentes en sus cursos?*
2. *¿Cómo involucrar a los estudiantes y profesores en el uso de herramientas de tecnología mejorada y beneficiarse de ellas?*

El aprendizaje personalizado, el aprendizaje basado en competencias y el aprendizaje social han sido sugeridos como posibles formas de abordar estos problemas.

Este trabajo combina las ideas de aprendizaje personalizado, basado en competencias y social mediante el apoyo a diferentes instantes del ciclo de vida de cursos universitarios a través de un diseño basado competencias, una evaluación basada en resultados de aprendizaje, analíticas del contexto social del aprendizaje y visualizaciones del modelo abierto del estudiante. Una serie de estudios usando un ambiente virtual de aprendizaje exploró la idea del enfoque revelando resultados prometedores. Estos resultados demostraron que la combinación de la orientación personalizada, un diseño basado en competencias, una evaluación basada en resultados de aprendizaje y la visualización del contexto social ayudaron a estudiantes y maestros a monitorizar resultados del aprendizaje según el Estándar Europeo de Cualificaciones (EQF, por sus siglas en inglés) en los cursos de educación superior. Por lo tanto, esta tesis extiende el enfoque de educación superior a una colección más grande de objetos de aprendizaje para el diseño, la evaluación y el análisis de cualificaciones en cursos. Por otra parte, este enfoque verifica su capacidad para soportar la visualización del contexto social para educación personalizada en ambientes de aprendizajes mixtos y en línea.

Los resultados de los estudios confirman que al trabajar con las herramientas voluntariamente proporcionadas, se realzó la calidad del aprendizaje aumentando por parte de los estudiantes la conciencia contextual, reflexión y auto-regulación y por parte de los profesores aumentando la conciencia contextual y reflexión con diversas, posibilidades de planeación, monitorización y moderación del curso. Estudios posteriores en progreso comprobarán si además ayudan a mejorar los resultados de aprendizaje alcanzados por los alumnos y el impacto en cursos con estrategias pedagógicas de aprendizaje activo. Extensiones para añadir sistemas recomendadores para docentes y alumnos fueron diseñadas y están a la espera de implementación y pruebas. Las pruebas subjetivas confirmaron la usabilidad de la interfaz y las sugerencias de docentes y estudiantes fueron tenidas en cuenta para las sucesivas versiones del sistema.

PART I

GENERAL INTRODUCTION

CHAPTER 1

GENERAL INTRODUCTION

The purpose of this chapter is to present the research work motivation, expose the tackled problem, identify the main research questions and provide an overview that will provide the structure to the document. The chapter is organized as follows: Initially, this chapter presents an overview of changes in higher education to consider lifelong learning. Then, drawbacks and challenges to support teachers and learners in this new ambit are exposed. After that, the main research areas are presented ending with the actual contributions in personalised learning, competence-based learning, and social learning as main antecedents of this thesis. Once the problem has been stated, the research questions and contributions of this thesis are listed. Finally, a section to describe the organization of the rest of the document is presented.

1.1 The Problem and Motivation

Higher Education is part of *Formal Education* and this is part of *Lifelong Learning (LLL)*. The emphasis on this fact affects higher education institutions both in its organization and pedagogy (Janssen, 2010). Some of changes in higher education that influence this thesis are:

- Changes in curriculums to adapt them to a competence-based learning and outcome-based assessment.
- Alignment with European agreements and standards in order that students' qualifications and credits could be interoperable in the LLL scenario. For instance the European Credit Transfer System (ECTS) (European Communities, 2009), and the European Qualifications Framework (EQF) (European Communities, 2008b).
- Increased emphasis on pedagogical approaches that contribute to students' active learning, e.g. *Project-Based Learning (PBL).*
- Greater use of technology that impacts the regular classroom courses and also allows greater delivery modes (online and blended courses).
- Increased synergy between formal education and informal learning.

Taking these changes into consideration, give us a more complex ambit of higher education, and research challenges in this environment. Nowadays, students and teachers in higher education struggle to create learning with new forms of: curriculums, assessments, communication technologies, virtual social interactions, data, software applications and devises. For instance, a blended course following the pedagogical approach PBL and with a learning design based on the EQF is a completely new scenario than a course imparted in a classroom that does not implement any active-learning pedagogical approach and without any alignment to an European agreement. In this enhanced higher education ambit, students and teachers need to develop new knowledge, skills and personal competences. Moreover, they need useful support to do so because they can be lost in the complexity of data models involved. The next paragraphs explore the desirable attitudes to develop in teachers and students for current higher education.

In *Personal Learning Environments (PLE)* a common practice is that students develop self-direction and self-regulation to achieve personal learning objectives in a highly personalised learning environment. The first term, *Self-directed learning*, in its broadest meaning, as explained by Malcolm Knowles refers to "a process ... in which individuals take the learning initiative, with or without the help of others. In this process, learners diagnose their learning needs, formulate learning goals, identify human and material resources for learning, choose and implement appropriate learning strategies, and evaluate learning outcomes" (Knowles, 1975). *Self-regulation*, on the other hand, is a process that implies motivation to learn, monitoring, reflecting, judging, planning, and evaluating personal progress against a standard. Self-regulation refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals. (Zimmerman, 2005). Self-direction and self-regulation are similar but self-direction has an additional premise of giving students a broader role in the selection and evaluation of learning materials. Self-direction can encompass self-regulation, but not the opposite (Loyens, Magda, & Rikers, 2008). Traditionally in higher education these students' characteristics (self-direction and self-regulation) were fewer required due to teacher-centred learning design and teacher's moderation of courses. Nevertheless, this situation is changing in higher education. The more technology and informal learning influence formal education, the more these characteristics are required in formal education. Consequently, as Jos Beishuizen and Karl Steffens state, even in formal education, self-regulatory skills are desirable assets (Carneiro, Lefrere, Steffens, & Underwood, 2011). Despite the fact that in higher education students are committed to a course design and teachers' moderation, nowadays there are some situations where students' self-direction and self-regulation are advantages. In this thesis, it is believed that in online and blended courses, online activities are opportunities to obtain feedback that come across from all individuals the student interact with (teacher, teammates, classmates, himself). This feedback then allows the student to trace personal learning paths within the general learning design of the course generated by the teacher. If so, this is an open window in higher education for self-direction and self-regulation. Another opportunity for students to develop self-regulation and self-direction is through management of incidental learning. *Incidental learning* is when learners lose focus on planed learning objectives and focus on unexpected learning objectives. In this thesis, it is believed that unexpected learning objectives can be accentuated in online and blended courses due to link connections of learning resources. This incidental learning is also an opportunity for self-regulation and self-direction in higher education. On the other hand, when implanting active learning pedagogical approaches in higher education courses such as PBL, students are able to perform self-regulation and self-direction in the practices and problems proposed in the course (Loyens et al., 2008). Moreover, in courses driven by PBL approach self-regulation and self-direction increase the students' performance (Bin, Abdul, Ariff, & Ibrahim, 2011).

Hence, *self-regulation* and *self-direction* are attitudes related to take actions to improve learning that can be used in the actual higher education. Nevertheless, it requires other previous abilities from students and teachers in order to go from thought to actions. They are for instance *awareness* and *reflection*. In the book Learning and Awareness authors define *awareness* as an understanding of a learning task and the phenomena that are relevant for the task (Marton & Booth, 1997). With the influence of technology in learning the awareness concept has been specialised in different types of awareness ranging from *group awareness*, *task awareness* and *workspace awareness* to *contextual awareness* and *peripheral awareness* (Liechti & Sumi, 2002), and even *social awareness* or *network awareness* (Steiny & Kukkonen, 2007). This thesis is more interested in the discussion of *contextual awareness* because of their relation with technology. It refers to the ability of a system to adapt its behaviour to dynamic situations such as the system itself, of its environment, and of its users. *Contextual awareness* is useful to adapt both what the users should be made aware of (i.e. to provide an information filtering mechanism), and how they should be made aware of it (e.g. prefer an auditory to a visual notification), depending on their situation (Liechti & Sumi, 2002). Then, reflection can be the bridge between to be aware of a context and take self-regulated actions. The steps of a student in this bridge of reflection could be planning, monitoring and moderation.

All in all, students and teachers need to be more aware of the context in higher education, reflect, and self-regulate their learning. New forms of curriculums, forms of assessment, standards to follow, and big datasets need to be understood and analysed by students and teachers. Furthermore, students and teachers need to be aware of the impact of formal education in LLL. In this thesis, it is believed that course learning design, and social context can be useful for teachers and students in the new ambit of higher education to encourage awareness and reflection on students' models.

To sum up to this point, the current scope of higher education presents big research challenges towards support and feedback development for students and teachers. Among those this work found: support to track online activities and practices in virtual scenarios, support to social learning, support to canalize the decisions of self-direction/ self-regulation of students, support to aggregate, analyse and visualise data, support to generate awareness and reflection about curriculums, students' performance and social comparatives.

The challenges in the higher education enhanced ambit require a fusion of social science contributions and technological contributions. That is, technological changes driven by human cognition and learning research (Dror, 2008). As a consequence, the methods, results and conclusions presented in this thesis are framed in the area of *Technology-Enhanced Learning (TEL).* The TEL community also known as the educational technology community is interested in providing support to improve teaching and learning by embracing areas such as: *Information Technology (IT)* on education, *Educational Data Mining (EDM)*, educational *Information and Communication Technology (ICT), TEL Recommender systems (TEL RecSys), Personalised Learning*, among others. Thus, TEL contributions can be found in the whole ambit of higher education in several ways. For instance, in online and blended courses the contributions can be traced as enrichments of the *Virtual Learning Environment (VLE)*. Another way to acknowledge TEL contributions is in traditional classrooms courses when technological tools that are independent from VLEs are suitably used in this environment. In higher education evidence showed by

Brooks strongly suggests that TEL environments, independent of all other factors, have a significant and positive impact on student learning (Brooks, 2011). Advantages and disadvantages arise depending on the good or bad foundation of this technology in human cognition and learning research (Dror, 2008). Thus, theoretical research needs to be translated in practical ways to use technology so as to enhance learning.

In this ambit (higher education as part of LLL) and in this meta-area of research (TEL) the aim is to enhance higher education virtual environments to connect curricular learning towards LLL. Nowadays more data are collected and need to be properly managed. On the other hand, as mentioned previously, there is a need to develop skills of self-regulation, awareness, and reflection among students. Also there is a need to support teachers in process of awareness and reflection. Last but not least important, European agreements boost the necessity of taking into account highly specialize knowledge in curriculums than before. This work attempts to combine thoughts of personalised, competence-based, and social learning by providing course lifecycle support through competence-based design, outcome-based assessment, open social learning analytics, and open student modelling visualisation in virtual environments. The next paragraphs discuss briefly the main contributions that motivated the proposal of this thesis.

Within the area of Personalised Educational Learning, this work is interested in contributions from Open Student Modelling, and Learning Analytics. Open student modelling and Learning Analytics are popular approaches that allow students to observe and reflect on their progress. Open student modelling is important to address the issue of self-regulation in learning. In particular, visual approaches for open student modelling have been proved to provide students with an useful and holistic view of their progress in a learning context (S. Bull, 2004; S. Bull & Mckay, 2004; Zapata-Rivera & Greer, 2004; S. Bull, Cooke, & Mabbott, 2007; Mitrovic & Martin, 2007; Conejo, Trella, Cruces, & Garcia, 2011; Bakalov, Hsiao, Brusilovsky, & König-Ries, 2011). Most of the open student modelling research focuses on a representation of an individual student ignoring the social aspect of learning. Learning Analytics imply select, capture, aggregate, report, predict, use, refine, and share data during the learning process for teachers and learners (Elias, 2011). Learning analytics are usually displayed in dashboard-like interfaces. The aim of these dashboards is to provide useful support for understanding and decision making in learning and teaching. Most of the learning analytics research focuses on study student's activity and student's progress but social perspectives of activities and complex new models of qualification are ignored. Thus, these two areas are tightly related in visualisation aspects although open student modelling is more centred on personalisation and learning context while learning analytics do more emphasis on semantic aggregation, statistical analyses, and results towards prediction and recommendation.

An overview of *Competence Based Learning (CBL)* will be explained here through two sets of projects that have inquired into this topic. The purpose is to show that in both types of projects, knowledge models and assessment models are tightly related in the learning scenarios. The first group of projects (TENCompetence, ICOPER, PALO, MACE among others) characterize for emphasizing on data models for outcome based assessment describing assessment resources. This type of projects focused insistently on interoperability of learning assessment resources. The second group of projects (LOCO Analyst) on the other hand, have insight regarding models of knowledge representation, activity monitoring and feedback for teachers. In the next list the main contributions for each project are detailed.

- In the TENCompetence project the TENCompetence Assessment Model was developed The TENCompetence Assessment Model aims to cover the lifecycle of the assessment process in five software packages namely: 1) Assessment design, 2) Item construction, 3) Assessment construction, 4) Assessment run, and 5) Response rating. It was described as a formal specification using *Unified Modelling Language (UML)* diagrams. Prototype tools show how to use the model to implement different assessment methods, and how to import and/or export assessment data between different tools and even using different pedagogical methods (Petrov, Aleksieva-Petrova, Stefanov, Schoonenboom, & Miao, 2008).
- The ICOPER project developed the *Open ICOPER Content Space (OICS)*, a centralised repository for VLEs of educational resources. The OICS manages instructional design resources (e.g. learning designs, teaching methods and assessment methods), learning outcome definitions, and learner assessment resources to learner's achieved learning outcomes. The OICS allows a centralized management of resources and the accessibility of them across platforms. Additionally, it simplifies the integration of different VLEs and interoperability. In the OICS the assessment resource described using the *IMS Question & Test Interoperability (IMS-QTI)* is optionally packaged by means of *IMS Content Package (IMS-CP)* and then the ICOPER LOM AP layer is attached (Gutiérrez et al., 2012).
- The *Personal Achieved Learning Outcomes (PALO)* data model is a simple schema proposed to capture information on learning outcomes (knowledge, skills, and wider competences) achieved by a learner, it also describes relations among those outcomes (Najjar et al., 2010). The model also contains information on the context where the learning outcomes are obtained or applied, assessment records and levels associated to the outcomes (e.g. proficiency level). The PALO data model covers (with some customization) data elements and concepts related to learning outcomes from other specifications such as: *IEEE Reusable Competency Definitions (IEEE-RCD),* and *ICOPER Learning Outcome Definitions (ICOPER-LOD).* These specifications describe the characteristics of learning outcomes, while *Human Resources eXtensible Markup Language (HR-XML)* describes evidence records of learning outcomes.
- The *Metadata for Architectural Contents in Europe project (MACE)* was a pan-european initiative to interconnect and disseminate digital information about architecture. MACE connects various repositories of architectural knowledge and enriches their contents with metadata. MACE portal has several services for searching and browsing architectural contents. For instance, the special service devoted to search by competence where a matrix of competences in architecture classifies resources according to the EQF learning outcomes levels. (The MACE Project, 2012)

- The *Learning Object Context Ontologies (LOCO-Analyst)* ontological framework was initially aimed to facilitate reusability of learning objects and learning designs. Later on it , was extended to also provide support for personalised learning (Jovanovic, 2008). The framework defines formal representation of learning object context and its principle building blocks such as: various kinds of learning-related activities, participants in the learning process (i.e. learners, teachers, teaching assistants, and the like), and the learning content. Accordingly, it integrates a number of learning-related ontologies.

Common aspects and lessons learned from the mentioned projects point out that knowledge models and assessment models are tightly related in the learning scenarios. Another key finding is that practice activities and learning activities are quite connected with developing of knowledge, skills, and wider competences. Many solutions with target in interoperability of data were delivered with these projects. Table 1-1 shows a summary of the mentioned projects in CBL.

Table 1-1 European projects related to competences development

New Models	Software Development	Standards / Specifications
TENCompetence Project: 1) A technical and organizational infrastructure for lifelong competence development, 2) Implement different assessment methods, 3) Import and/or export assessment data		
TENCompetence	Software prototypes	UML
ICOPER Project: 1) Centralized management of learning resources, 2) Interoperability across platforms		
Open ICOPER Content Space (OICS)	Centralised repository of educational resources	IMS-QTI, IMS-CP, and ICOPER LOM AP
PALO Project: Capture information on achieved learning outcomes and its relations		
PALO model	Mock-up prototypes	IEEE-RCD, ICOPER-LOD, and HR-XML
MACE Project: 1) Centralized management of resources, 2) Multiple search services		
	Web Portal with: Authoring Tool of Competences Centralised repository of architecture content Search Engines	EQF
LOCO Project : Facilitating reusability of learning objects and learning designs, and later extended to also provide support for personalised learning		
1) Learning Context ontology 2) User Model ontology 3) Learning Object Content Structure ontology 4) Quiz ontology 5) Domain ontology 6) Learning Design Ontology	LOCO-Analyst tool and several ontologies	IMS-LD IMS-CP KIM platform

It is important to note that it is still necessary to clarify how teachers and learners can adopt standards and specification in formal education during their courses' lifecycle. This adoption must take into account restrictions of time and cognitive effort of teachers and learners. Another open question is how this adoption can support possible active learning in formal education. Additionally, it is necessary to clarify how teachers and learners can take into account highly specialize knowledge in courses to help to formal institutions to provide traceable competence based and/or learning-outcome based curriculums.

Finally, in the area of *Social Learning*, this research is motivated by the success of social visualisation. *Social visualisation* approaches for learning focus mainly on student's communication and collaboration (Vassileva, 2008). Recently, other works in the area merge it with open student modelling and personalised learning to provide adaptive social visualisations of student's progress and personalised guidance in content repositories (Bakalov et al., 2011; I.-H. Hsiao et al., 2012; I.-H. Hsiao, 2012).

The proposal of this thesis to support higher education in the context of LLL is inspired in the next main ideas:

- It is necessary to use a qualification framework that works for all LLL scenarios where developing of knowledge, skill and wider competences is not separated from practice or activities.
- It is necessary to redefine the formal course lifecycle model as the union of several models: a competence model, an enhanced qualification model, an open student model, a monitoring technological model, and a technological feedback model. To do so this thesis provides the *Adaptive Evaluation Engine Architecture (AEEA)* and the *Activity-based Learner-models*.
- Novel software applications to support teachers and learners need to be developed to support each step of the course lifecycle model. In the mark of this thesis four web applications were constructed: ONTO-EQF, CC-DESIGN, RUBRICS-360 and SOLAR.
- Active learning characteristics need to be recognized and stimulated in formal education. Software applications of this thesis intent to raise contextual awareness, reflection, and self-regulation in a course lifecycle.
- Learning activities monitoring and semantic aggregation of this data are the base to adequate support responses in online and blended courses.
- Learning analytics and open user models offer new opportunities for services in VLE and support for teachers and students.

To sum up, the motivation of this thesis is focused on enhancing higher education environments to support and contribute properly to the LLL purposes. The current ambit of higher education is wider than before and personal learning skills are more required nowadays in higher education, especially for some didactical approaches to implement active learning strategies and methods. Recognizing that scientific and technological innovation has a profound effect on learning needs, methods and strategies; the cornerstones of this thesis are cognitive science and technology. The methods and proposals of this thesis bellow to the area of TEL, in particular to personalised, competence-based and social learning. The goal of this work is to bringing these three streams of research together to integrate personalised learning with social learning by extending learning analytics with open social visualisations. In addition, integrate competence-based and personalised learning through new methods of design, assessment and feedback in higher education. The aim is to bring personalised guidance to teachers and learners a in a large collection of educational content and engage them in doing educational activities using enhanced technology environments. Figure 1-1 depicts the contribution to the subareas of research.

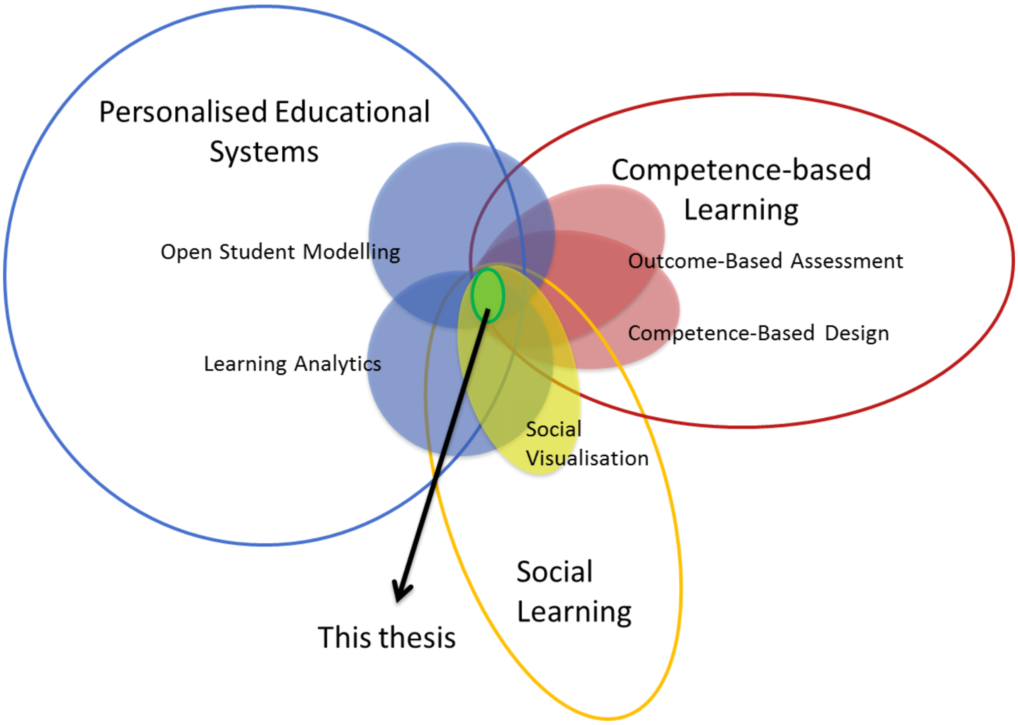


Figure 1-1 Contribution of this thesis to the subareas of research

Further sections expose the questions of research, the scope and contributions in TEL and the structures of this thesis.

1.2 Research Questions

The objective of this research is to explore new dimensions for teachers and learners support in online and blended university courses as part of the lifelong competence development path.

Formal education is just part of the LLL path of students. With this in mind and as a consequence, the exchange of qualifications between formal education institutions and other learning situations has become a necessity. On the side of formal education, higher education institutions are supposed to register not only regular students' marks or grades but also the underlying competences of courses. To do so, these competences must be enclosed in a framework of qualifications useful for all situations of LLL, including formal education.

Lifelong Learning needs from formal education supporting and managing the underlying competences in courses. Nowadays this support is still vague and unproductive. Formal education need to take advantage of lessons learned by informal learning and provide a bridge to LLL. With this scope the particular interest of this thesis is phrased by the following question.

> *How can appropriate support strategies be provided to competence development in higher education institutions for the lifelong learning process?*

To help answer the main research question (RQ) seven subordinate research questions were posed:

RQ.1 What antecedents exist of support of competence development for LLL, especially in higher education?

RQ.2 Which information elements, procedures and software applications are needed to build a technical and pedagogical architecture to support competences development?

RQ.3 How to introspect learning activities for competence assessment and recommendations?

RQ.4 How can teachers make effective use of European standards for designing, monitoring and moderating their lessons?

RQ.5 How can students and teachers be more aware and reflect about the underlying competences in university courses?

RQ.6 How can students make effective use of European standards for planning, monitoring and evaluating personal progress?

RQ.7 Will open and social visualisations provide successful personalised guidance within a rich collection of educational resources?

The answers of these questions should enable the identification of a concise set of information elements, procedures and software applications that inform competences development in online and blended courses.

In each chapter of this thesis one or more research questions are addressed. The questions do not map one-to-one to a chapter. The Section 1.4 explains how the design research relates to the research questions. It also describes how the content of each of the chapters relates to the research questions.

1.3 Scope and Contributions

Although several studies have been made in competence development for LLL the contributions presented in this thesis are focused on provide a methodology that purely provide a path to support teachers and students in overcome difficulties to monitor the progress of competences in University Courses. The majority of contributions in competences development for LLL are focus in solve the interchange of data across different services and platforms between institutions. How these data can be collected in a practical way inside formal education institutions is leaved aside. Teachers and students need a practical path to collect these data, to be aware and reflect about the competences development in their courses. They also need to be aware and reflect about how these competences are related in a LLL spectrum. Active learning pedagogical approaches in higher education need support to address self-direction and self-regulation of students.

On one hand, contributions take into account the requirements that teachers have to design learning activities and assessment resources linking the complexity that a competence framework adds to them. On the other hand, the contributions take into account the requirements of students to understand their underlying models of activities and competences development in VLEs.

The following list summarizes the general contributions made for supporting awareness and reflection of lifelong competences development in courses' lifecycle in higher education:

1. The first contribution is the definition of a technical architecture, the *Adaptive Engine Evaluation Architecture (AEEA)*, to support the cycle of online and blended courses. This architecture identifies concise elements, procedures and software applications to support competences development in VLEs of formal education institutions. The pillar of this architecture is the EQF.
2. The second contribution is a technical architecture called *Activity-based Learner-models*. This architecture allows monitoring learners' activities and learning outcomes, aggregates and controls the delivery of appropriated learning analytics responses to teachers and learners. This architecture allows introspecting learning activities and learning outcomes with different social planes (a student, teammates, or class). The cornerstones of this architecture are: 1) The Engeström´s Activity Theory from the cognitive aspect, 2) The EQF as European agreement and standard in qualification, and 3) The Actuator-indicator model from the technological aspect.
3. A third contribution is an authoring software application, the *ONTO-EQF application*, devoted to support teachers to define competences. Definitions are based on the EQF levels of qualification and the EQF learning outcomes. The creation of competences is made in a collaborative way by teachers. In the case of courses in computer science. *ONTO-EQF* also use *The ACM Computing Classification System* to frame competences in knowledge domains universally recognized by research community and formal education institutions.
4. A fourth contribution is a software application, the *CC-DESIGN application*, concentrated on support teachers in course design. This application introduces a novel concept to describe a script of learning outcomes assessment related to activities. The learning design that teachers can make with this application is oriented to evaluation activities and their relation with qualification of course´s competences. Other aspects related to learning design of courses must be done with the traditional VLE already used by the online or blended course.
5. A fifth contribution is a software assessment application, the *RUBRICS-360* application. This application manages the assessment tasks of teachers and students. *RUBRICS-360* implements a *360 degree feedback* to impulse a formative assessment. According to the script of assessment created before, the application produces a plan of assessment for each person. The user select a task of the plan and an automatic test using scoring rubrics is generated. A test inquires about the levels of qualification achieved by a student for the competences in an activity. This proposal is intentioned to reduce the time that teachers could spend in generate regular tests composed of items related to a one or many competences.
6. A sixth contribution is a social learning context analytics software application, the *SOLAR application*. SOLAR has at the moment three dashboards to show

different perspectives of the open user model of students. In the firsts two dashboards parallel views are displayed to contrast levels of qualification of a student against performance of her/his peers (teammates) and the whole class. The third dashboard introduces a novel sunburst visualisation in which the learning design of the course and the personal model of competence qualifications for a student are combined.

7. A final contribution is a set of different learning designs of courses based on the EQF with different pedagogical approaches. These designs were modelled during the evaluation process of the AEEA Software Suite.

Summarizing, the contribution of this thesis to the TEL domain is a framework that integrates cognitive and technological aspects to improve the effectiveness of VLEs in formal education. The effectiveness is improved through: 1) Effects on learning and teaching such as raise awareness, and reflection in teachers and students, 2) Allow teachers to work as the EQF expected they do. 3) Social effects as collaborative creation of competences, collaborative formative assessment based on the 360 Degree Feedback and social guidance.

The scenarios of evaluation mainly analyse three different situations in formal education: an online course, a blended course without active pedagogical approach and a blended course with the PBL pedagogical approach. Additionally, these scenarios are focus on engineering courses and the knowledge domains of the courses are framed in the ACM Classification in order to give a universal classification for them.

1.4 Design Research and Outline of the Thesis

This thesis documents the research process to bring learning cycle support in formal education for awareness and reflection of lifelong competence development. The thesis consists of five parts, each containing one to four chapters. Figure 1-2 presents an overview of the content and relations between the chapters of this thesis.

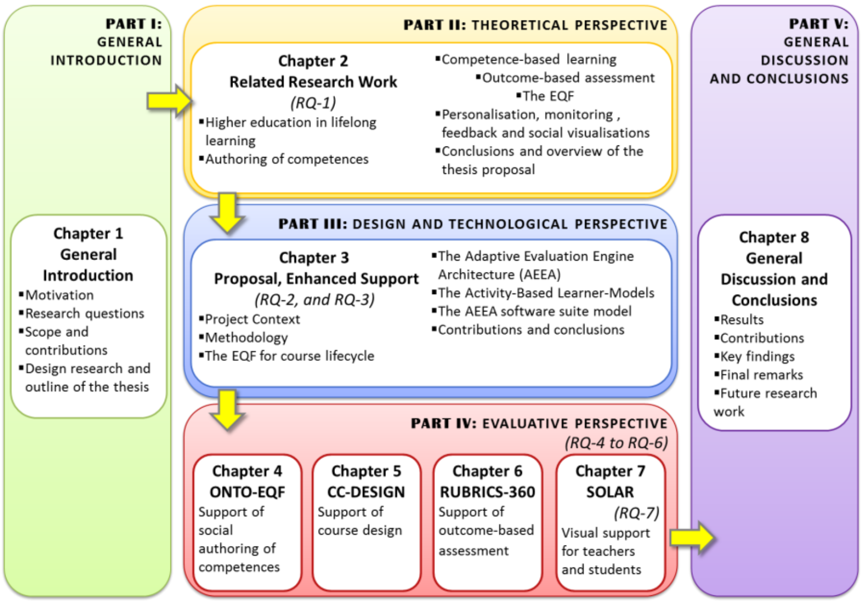


Figure 1-2 Overview of thesis structure

1.4.1 Part I: General Introduction

The first part is the general introduction that is ending with this section. The second part is theoretical; it presents the state of the art and characterizations of lines of research involved in this thesis. The third part is design-oriented and digs into the technological and pedagogical aspects of solutions. The fourth part evaluative in nature shows the studies and their results. The final part contains the conclusions which can be drawn from the studies, as well as a discussion of the results and directions for future research.

1.4.2 Part II: Theoretical Perspective

The theoretical part of this thesis aims to provide a framework in the wide process of competence development support. The antecedents of research are studied. This research does not start from scratch. Competence development has been subject of research in the domains of psychology, sociology, organizational science and, computer science. Research reported in this thesis builds on the results acquired in these domains.

- *Chapter 2* summarizes previous research work related with this thesis. It presents an overview on the theoretical foundations and models that were used in other chapters. The chapter elaborates the pillars of this research. It analyses the implications of previous studies to bring insights into the gaps. It derives a model for characterizing theoretical and technological aspects involved in this thesis. This chapter is completely dedicated to solve the first research question *(RQ-1)*.

1.4.3 Part III: Design and Technological Perspective

The design and technological part shows the proposed approaches to support competence development in formal education. The aim of this part is to determine the procedures, information elements, and software applications to support competence development in online and blended courses.

- *Chapter 3* presents a technological architecture called *Adaptive Evaluation Engine Architecture* (AEEA) is exposed. This architecture describes the process, information elements and software applications needed to support competences' development in formal education for online and blended courses. A second technological architecture called Activity-Based learner-Models is introduced within the AEEA to define process and the technological elements to monitor learners' activities and deliver learning analytics and recommendations. This chapter answers the second *(RQ-2)* and the third research questions *(RQ-3)*.

1.4.4 Part VI: Evaluative Perspective

The evaluative part of this thesis explores whether teachers and students are better supported with the implemented proposals. All chapters of this part concern with the research questions fourth *(RQ-4)* to seventh *(RQ-7)*. A big case study was performed with teachers' perspective in the fall semester of 2011 and a case study with students was performed in spring-summer semester of 2012. In order to show the research objectives at each step of the formal education process, the results are not presented by user perspective (teacher or student) but by software application of the AEEA Suite that support each step.

- *Chapter 4* describes the results related to support of authoring of competences by using the ONTO-EQF software application.
- *Chapter 5* describes the results related to support of course design by using the CC-DESIGN software application.
- *Chapter 6* describes the results related to support of competences´ assessment by using the RUBRICS-360 software
- *Chapter 7* describes the results related to visual analytics for teachers and learners by using the SOLAR software application.

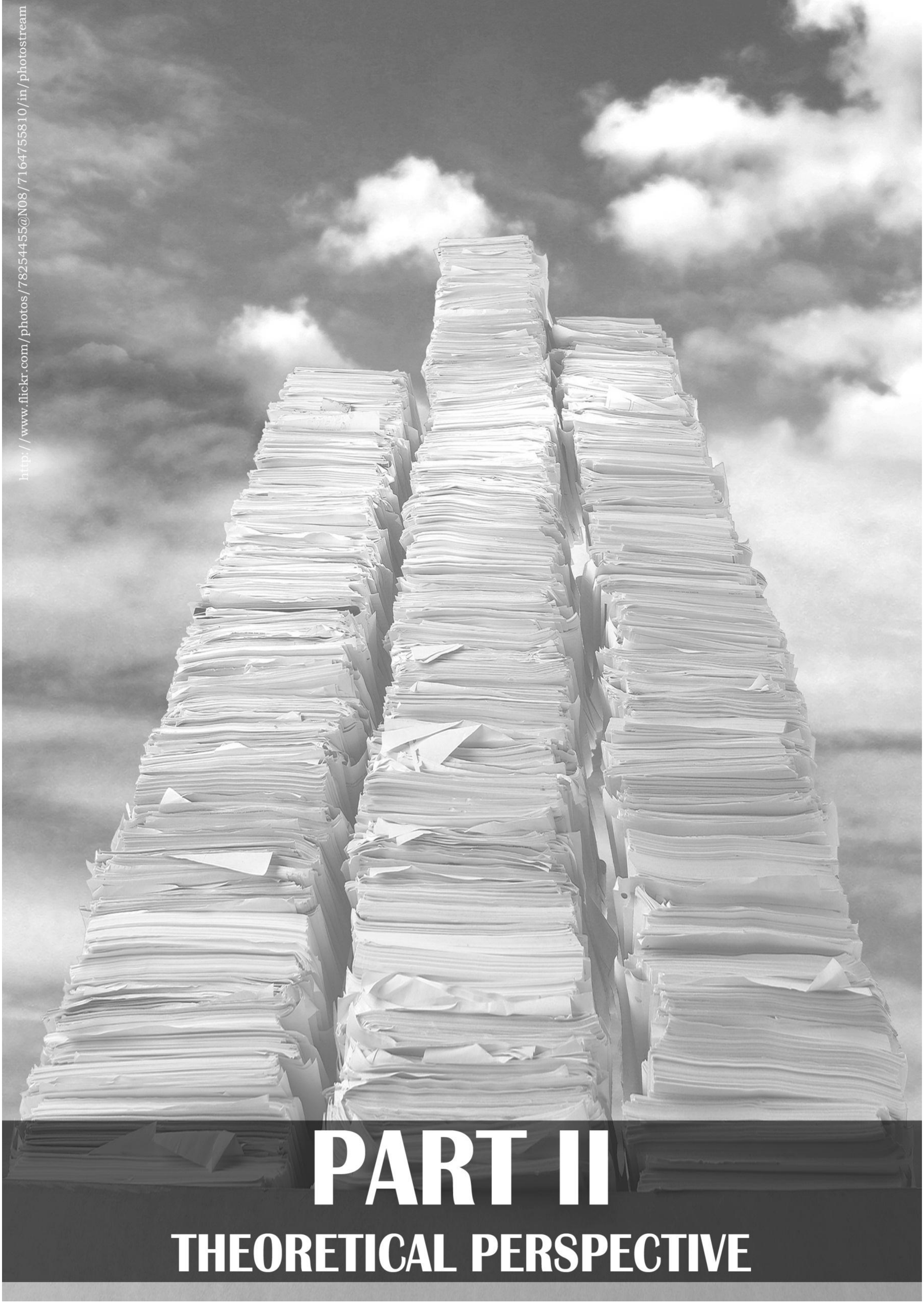
1.4.5 Part V: General Discussion and Conclusions

After concluding the evaluative part, it is important to summary the key findings and general conclusions of the whole research process. This is the intention of the last part of this thesis.

- *Chapter 8* summarizes the results, derives the central conclusions from the studies and reflects on the contributions of this thesis to the research domain of TEL in general and particularly to the lifelong competence development in higher education. Additionally, the chapter provides a general discussion of the limitations and boundaries of the studies, their practical relevance, transferability and implications. A preview of possible future research is given.

1.4.6 Appendices

The appendices contain a selection of the most important parts of the materials used within the studies reported in this thesis. The material in the appendices is referenced to various chapters of the thesis.



PART II
THEORETICAL PERSPECTIVE

http://www.flickr.com/photos/78254455@N08/7164755810/in/photostream

CHAPTER 2

RELATED RESEARCH WORK

This chapter describes the most relevant contributions regarding theoretical and technological concepts. It introduces the theoretical concepts in educational and multidisciplinary science that are pillars of this thesis. Additionally, the chapter introduces the technological models in which this thesis is grounded. The pros and cons of these contributions are discussed briefly while the main drawbacks are analysed. Moreover, some consequences of using such contributions are mentioned as well as justifications for particular selections in this thesis.

This chapter is organized as follows: Section 2.1 gives an overview of the ambit of formal education as part of the LLL, especially higher education. Some drawbacks in higher education to contribute LLL are pointed out here as well. Furthermore, new challenges in *TEL* and *competence-based learning* for higher education are summarized. Section 2.2 describes the big picture of competences' models in higher education with authoring of competences, competence-based learning design, and outcome-based assessment. Section 2.3 shows relevant contributions in social visualisations and personalised learning. Here, features of the emerging field of learning analytics are displayed as well as an open student models. Then, the section describes the Engeström's Activity theory as a social interaction foundation for further technological implementation. Finally, in this section, the Actuator-Indicator model is explained in order to introduce the technological pillar for monitoring and visualisation of learners' activities.

2.1 Overview of Higher Education in the Lifelong Learning Spectrum

As David Cofer illustrated the scope of learning involve two axes (Cofer, 2000). To begin with, there is the axis that answers the question: who is in charge of defining learning goals and objectives? This first axis covers from informal learning to formal education. *Informal learning* is when the learner sets the goals and learning objectives and it happens throughout learners' lives in a highly Personalised manner based on their particular needs and interests. *Formal education* is when trainers or learning specialists set the goals and objectives. It takes place in formal educative institutions such as schools, colleges or universities and within a teacher-student relationship. Close to formal education is *Non-formal education* defined as when someone outside of the learning department, such as a manager or supervisor, sets the goals or learning objectives. Non-formal education is often related to *Vocational Education and Training (VET)* and organizational learning. On the other hand, there is the axis that answers the question: what triggers the intention of setting learning objectives? This second axis covers from incidental learning to intentional learning. *Incidental learning* is when learners pick up something else in the learning environment that causes their loss of attention on the learning objectives or goals and focus on an unplanned learning objective. *Intentional learning* has a self-directed purpose because it has goals, learning objectives and a methodology (what and/or how to learn). Thus, the situations around learning can be summarized as formal education, non-formal education, informal learning, intentional learning, and also incidental learning. Figure 2-1 shows the scope of learning.

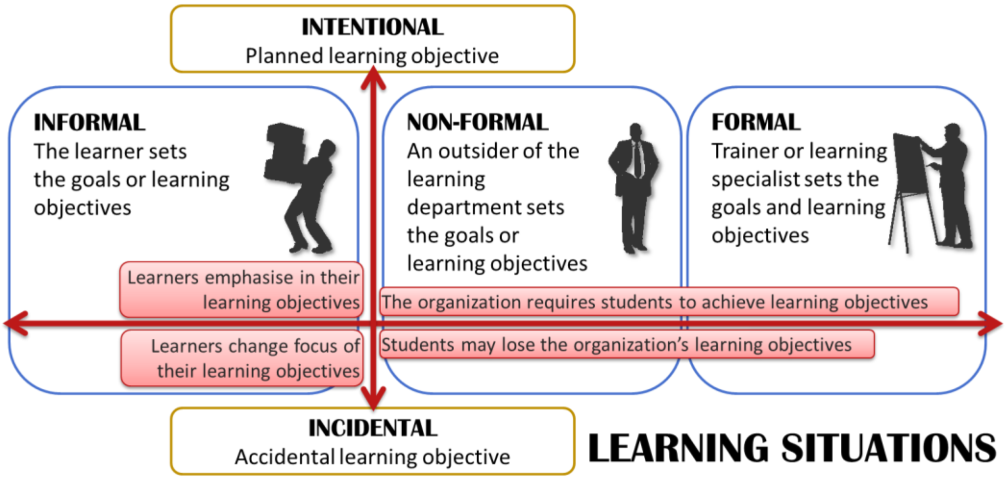


Figure 2-1 Learning situations, based on (Cofer, 2000)

Nowadays, the concept of learning has been enlarged to consider LLL. Lifelong Learning recognizes that learning is not only confined to the classroom, but it also takes place throughout life. Then, the former Cofer's definitions could be extended also for LLL. In this extended vision LLL can have a three-dimensional space considering 1) The moment in life of a learning experience, 2) Who set the objectives, and 3) The source of intentions. Figure 2-2 presents three-dimensional space of LLL.

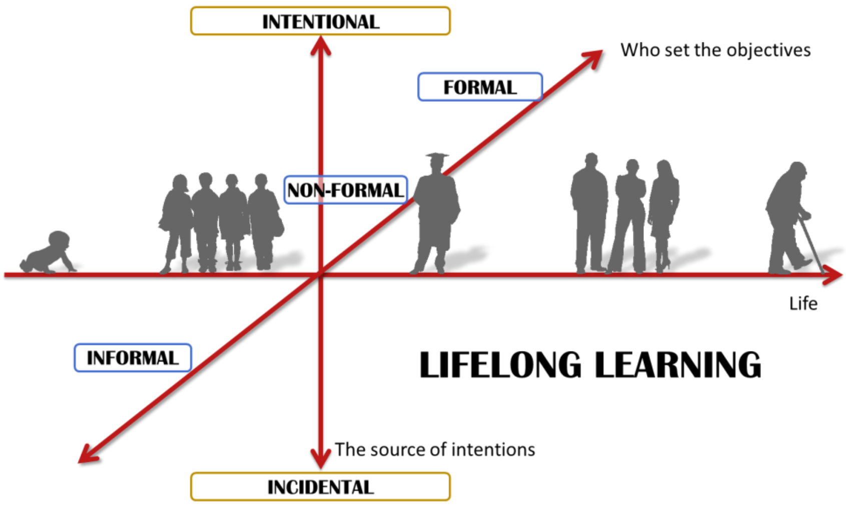


Figure 2-2 Three-dimensional space of lifelong learning

This thesis is focused on enhancing formal higher education environments to support and contribute properly to the LLL purposes. Thus, it is necessary to clarify the ambit of formal education environments as presented in Figure 2-3. The most traditional environment in formal education is the classroom where all learning activities are physically performed. A more contemporary environment, in formal education, is distance learning with online courses. In distance learning, a VLE is used to provide a Web-based system that models conventional real-world education by integrating a set of equivalent virtual concepts in web applications. Some examples of well-known VLEs are: Blackboard, Moodle, DotLRN, ATutor among others. Courses with mixed environments are called blended courses where some activities are performed in the classroom and some others on the VLE. Nowadays, VLEs have extensions through mobile applications; consequently, activities in blended courses can be situated in the classroom, in online systems (VLEs) or mobile systems.

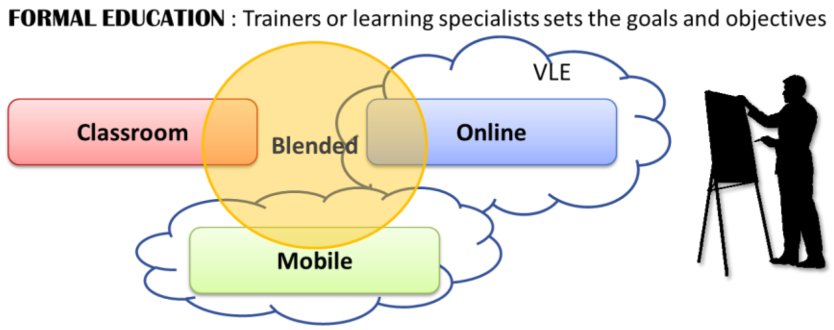


Figure 2-3 Formal education ambit

Despite the fact that the horizontal axis of learning (see Figure 2-1) gives a first impression of well separated types of scenarios between informal learning and formal education, currently the boundaries are blurred. Significant elements of formal education have been characterised in informal situations and vice versa (Malcolm, Hodkinson, & Colley, 2003). The more technology supports learning, the more boundaries between informal learning and formal education are blended. At the moment, it is a fact that PLE, used in informal learning, can influence formal education environments positively and negatively. In this sense it has been indicated that formal education can benefit from the active creation of personalised online content and fluid communication networks of informal learning (G. Bull et al., 2008). Nevertheless, the authors argument that sometimes a barrier is raised in formal education due to several causes such as an authoritative control of learning objectives and contents, limited access to technology in institutions, a general low level of effective use of technology, and reject of a more complex learning environment. Other authors went further stating that “the use of social networking tools helps to blur and blend the lines between formal and informal settings and where formal leaning fails, deliver emerging social technologies can bridge the gap” (Lucas & Moreira, 2009). From science education, some authors suggested that the provision of an effective education entails an enhanced complement between informal and formal sectors (Stocklmayer, Rennie, & Gilbert, 2010).

Thus, the future tendency is that informal learning influence much more formal education transforming its traditional nature. Strong assumptions related to formal education need to be revised nowadays. In this thesis, it is believed that formal education needs to take into consideration findings from informal learning strategies and exploit the benefits of synergy. Generally speaking, traditional formal education, in particular higher education, can be typified as Glahn in his PhD thesis well described as follows: 1) Explicit curriculums are provided, 2) There is a clear role distinction, and 3) Feedback is present (Glahn, 2009). In following paragraphs this document will goes through this characterization to expose current drawbacks in higher education. Moreover, special cases are pointed out to illustrate how these cases transform the traditional nature of higher education.

2.1.1 Curriculums

To start with, Glahn in his PhD thesis said that explicit curriculums are always provided in higher education (Glahn, 2009). Nevertheless, curriculums are "live systems" that evolve throughout time and this fact introduces some drawbacks in formal education.

On one hand, European, national, and institutional policies force to change curriculums. In somehow, during the last decades, these policies have intended to conciliate traditional knowledge-based curriculums with organizational needs. It has been remarked that competence-based curriculums fill the gap between knowledge-based curriculums and societal and organizational needs (Sampson & Fytros, 2008). Moreover, European agreements and standards such as the EQF (European Communities, 2008b) and the ECTS (European Communities, 2004) are driving the transformation of European curriculums to allow transference of learners' qualifications and credits in terms of competences.

On the other hand, different documents presents that technological opportunities also contribute to curriculums' evolutions. A report, for example, introduces two major programmes of research that inquire how the use of technology can help to make curriculum design processes more agile and responsive; and the experience of learning more engaging, inclusive, and rewarding (JISC Executive, 2009). A second report presents the key achievements, lessons learnt, benefits reported and strategies developed by 15 project teams in the programme (JISC Executive, 2011). Moreover, the impact of technology in higher education curriculums has been deeply analysed (Mayes, Morrison, Mellar, Bullen, & Oliver, 2009). Generally speaking, new ways of interaction raise and new programs can be offered. For instance, currently Open Universities around the world have a complete range of distance learning degrees which are more common today than some decades ago. It is clear that blended and mobile scenarios create new ways to introduce, deliver, and interchange information.

Despite the fact of this unstopped natural evolution of curriculums, these sets of policies, agreements, standards, and technologies are introduced faster than practical methodologies for teachers and students. Teachers and students need support to introduce changes in their practices. For example, teachers and students have not a clear vision of how to implement such rules in real practice and what instruments and process to apply. Teachers need tools for mapping knowledge-based curriculums to new regulations. Students need to be aware of the new forms of curriculums, and the learning outcomes to be achieved on them. Students also need to know how they will be measured and assessed through evaluation activities in their courses. In many cases institutions do not provide supportive tools to teachers, learning designers, and students to do such a change. Therefore, transformation is slowly implemented in higher education. The practice is always behind the agreements and standards, even behind of deadlines for voluntary or mandatory changes. Zahilas explains that the EQF has two main deadlines: 1) Year 2010 to refer their national qualifications levels to the EQF and 2) Year 2012 to introduce a reference to the EQF levels in all individual certificates and diplomas awarded at the national level (Zahilas, 2012). Zahilas also reports that for the first one, committed countries were slightly behind target. An official study report of the European Parliament reveals that for the first stage of reference, 12 countries presented their reference reports in 2011 and 19 countries are foreseen in 2012 (Broek, Buiskool, Van Oploo, & De Visser, 2012). That is to say, two years behind the deadline.

2.1.2 Role Distinction

Due to clear role distinction, traditional higher education created a division of responsibilities within courses. For instance, there is no doubt that general direction and moderation in higher education are in charge of the teacher. Nevertheless, when formal courses are implemented based on didactic approaches of active education (such as PBL, Solving Problem, Problem-Solving Learning, Scenario-Based Learning, Inquiry-Based Learning, Enquiry-Based Learning, Problem-Oriented Learning, Work-Based Learning, and Action Learning) some inputs of students can be related with self-direction. In Leach's thesis the author reports eight categories of self-directed experiences in formal education contexts (Leach, 2000). Moreover, Leach states that all formal education programmes need to include a diversity opportunities for both self and teacher-direction. Some authors highlight conditions under which self-directed learning can be promoted especially for programs with active learning approaches (Hout-Wolters, Simons, & Volet, 2002). Then, a course following an active didactic approach requires commitment of students to carry out tasks and solve problems to move forward in the course. Students need to plan and regulate their performance while the teachers' role is a more supportive than directive one. In brief, although it is true that self-direction is a characteristic more related to informal learning where learners are free to trace their own objectives and learning paths, it is not an exclusive characteristic of informal learning.

Furthermore, this traditional role distinction impacts also the assessment responsibility. In traditional higher education, assessment activities are rated by teachers. That is, the teacher is the only assessor of students. There is also limited support for new ways of assessment where students can play as assessors. For example, self-assessment, intra-group assessment, and inter-group assessment are rarely used in learning design for evaluation in higher education, but they can be assumed by students as assessors. These enriched ways of assessment would be easier to use with the support of technology in order to save, monitor, aggregate, compute, and display results of assessment from multiple sources. It is still necessary to enhance VLEs with evaluation engines to manage the complexity of new ways of assessment and new assessment data models.

2.1.3 Feedback

Feedback is boosted in higher education thanks to the close relationship teacher-student. However, in online and blended courses, feedback implemented in VLEs is usually limited to plain reports of activity logs and summative results. VLEs usually have a log function and they present an activity report to teachers (and not to the learners) but without aggregated semantic meaning or social perspectives. Furthermore, VLEs are not concerned with useful visualisations for teachers and learners. Thus, a lot of information is saved although valuable potential is ignored for feedback. De la Harpe & Radloff state that both teachers and students do not know much about them or their relationship to learning and assessment (De La Harpe & Radloff, 2000). In particular for assessment, formative feedback is not a default option in VLEs. Formative feedback could support teachers and students in moderation and direction of courses by encouraging students' self-regulation (Nicol & Macfarlane-Dick, 2006) and reflection (S. Bull, Quigley, & Mabbott, 2006). Research areas such as *Open user modelling*, and more recently, *Learning Analytics*, give some insight about useful feedback for monitoring of learning activities and understanding of learners' performance. However, in formal education there are few contributions of these research areas to aggregate, visualise, recommend, and predict based on learners monitoring and qualifications.

2.1.4 Summary of Characterization and Drawbacks

To sum up, higher education is part of the LLL process. Its scenarios go from traditional classroom sessions to online courses. Nowadays, these scenarios are influenced by PLEs created by learners in informal learning. The establishment of learning objectives can be either intentional (institutional origin) or incidental (casual origin). The TEL research community provides new enhanced scenarios including higher education scenarios. A preliminary review of a characterization of higher education points out some drawbacks: (1) Support for new ways of curriculums, (2) Support for moderation and direction, particularly when active learning strategies are applied to courses in higher education, (3) Support for assessment that comes from the students. (4) Feedback of VLEs. Table 2-1 summarizes the discussion around higher education characterization and pointed out drawbacks.

Table 2-1 Characterization of higher education and drawbacks for LLL support

Characterization of Higher Education	Fact	Drawback	
Explicit curriculums are provided	Curriculums change throughout time. Nowadays it is a necessity to conciliate knowledge-based curriculums with competence-based ones.	D1	Teachers and students are not supported with methodologies to introduce curriculums' changes on their teaching and learning processes.
Clear role distinction.	Learning design, direction, and moderation are traditionally limited to the role of teachers.	D2	Active learning strategies have limited support in higher education.
		D3	There is limited support for new ways of assessment where students can be part of assessors.
Feedback is present	In the VLEs, the types of feedback are traditionally limited to plain reports. Additionally, these reports are available for a single role perspective.	D4	Useful potential for feedback is ignored in VLEs
		D5	There is a lack of aggregation for semantic meaning in VLEs
		D6	The activity reports are not supported for multiple role perspectives
		D7	Formative assessment support is limited
		D8	There is a lack of useful visualisations

Before introducing any proposal of a technology-enhanced course lifecycle, an inspection regarding the state of art is necessary to answer the main research question of this chapter:

RQ-1. What are the existent antecedents towards competence development support for LLL, especially in higher education?

In this thesis the technological changes introduced to the course lifecycle impact the two first phases of the course lifecycle. The next subsections of this chapter highlight the theoretical and technological research works in the state of the art that were necessary to explore for turning this course lifecycle in a competence-based one. To enhance the Learning Design Phase it was necessary to characterize Technology-Enhanced Competence-Based learning (see Section 2.2). To enhance the Implementation Phase it was required on one hand to dig into new ways of support for assessment with Outcome-Based Assessment and Competency-Based Assessment (Section 2.2.1). On the other hand, a scrutiny of research works related with ways of monitoring activities it was needed as well as delivering appropriated feedback responses. For that purpose, Open User Models area and the novel area of Learning Analytics were explored (See Section 2.3.1 and Section 2.3.2). At the same time from multidisciplinary aspects, the Engeström´s Activity Theory was analysed (see Section 2.1.3). Finally, from the technological aspect the Actuator-Indicator model was retaken (see Section 2.3.4).

2.2 Technology-Enhanced Competence-Based Learning

Competence-Based Learning (CBL) refers to the formal and informal learning. Likewise, it alludes to training activities that individuals and/or groups perform to improve their competences in a particular field; given some personal, societal or employment related motives (C. Griffin, 1999; Aspin & Chapman, 2000; Field, 2001; Sampson & Fytros, 2008).

For a long time the mayor drawback in competence support for LLL was the lack of agreement in a commonly accepted definition of the term competence, resulting to multiple interpretations (Sampson & Fytros, 2008). Specifications and standards for competence description, such as the IMS RDCEO (IMS Reusable Definition of Competency or Educational Objective), the IEEE RCD (IEEE Reusable Competency Definitions) and the HR-XML Competencies (Human Resources eXtensible Markup Language) were proposed as candidates. Table 2-2 shows descriptions of them.

As was said in Chapter 1, several European projects were concern to enhance competence-based learning scenarios by means of technology (see Table 1-1). These projects focus intensively in modelling and representing competence-related information in a machine-readable meaningful way so as to allow its inter-exchange in a standard and consistent way between different system implementations. It was the basic idea to build technology-enhanced competence-based training systems.

The findings of European projects mentioned and the efforts of the European Communities have led to the *European Qualifications Framework (EQF)* that gives a common base of definitions and descriptors for qualifications of competences for LLL in Europe. The learning outcomes descriptors are the links of competence descriptions with qualifications. A competence description has a type of learning outcome and eight levels to appraise it. This framework is analysed in detail in section 2.2.1.1 of this chapter.

Table 2-2 Earliest specifications/standards for competence definitions

Standard/Specification	Description
IMS RDCEO By: IMS Global Learning Consortium Current Version: 1.0 Release: October 2002	Minimalist, but extensible competence and educational objectives specification. It considers basic elements such as competence title, description and also it offer the possibility of extend the competence information adding a general element <statement> in which can be added specific elements in the competence definition. The RDCEO Schema can be used in both academic and business contexts. It focus is to offer.
IEEE RCD By: Learning Technology Standards Committee of the IEEE Computer Society Current Version: 1.0 Release Date: 29/08/2008	"This standard defines a data model for describing, referencing and sharing competency definitions, primarily in the context of online and distributed learning. IEEE RCD specifies the mandatory and optional data elements that constitute a Competency Definition as used in a Learning Management System, or referenced in a Competency Profile. The purpose of this standard is to define a universally acceptable Competency Definition model to allow the creation, exchange and reuse of Competency Definition in applications such as Learning Management Systems, Competency or Skill Gap Analysis, Learner and other Competency profiles, etc." [1]
HR-XML Human Resources eXtensible Markup Language By: HR-XML Consortium Current Version: 3.0 Release Date: 23/09/2009	Standard XML schema to provide trading partners standardized and practical means to exchange information about competences within a variety of business contexts. Additionally to the general information in the IMS RDECO specification, this approach define explicitly two specifics elements in the competence definition, the evidence used to capture information to substantiate the existence, sufficiency, or level of a competence and the weight element to capture of information on the relative importance of the competency in different aspects.

Nevertheless, a number of open issues and challenges for technology-enhanced competence-based higher education do exist. Before inter-exchanging information this information need to be collected from higher education courses because they are the place where competences are developed in higher education. Few efforts have been made to provide VLE of course management in higher education with tools and a methodology to allow teachers and learners to adopt the European standard in qualifications for LLL competence development. Therefore, there are some open questions such as how can we model competences collaboratively in VLEs of higher education?; how can we do a course learning design whose activities and assessment resources target specific EQF competences representing course objectives?; how can we assess EQF competences for LLL with a formative feedback for learners and teachers in higher education?; how to deliver recommendations and analytics from the information of LLL competence development in higher education?; how to contrast expected EQF competences of a curriculum and the ones owned by a student in higher education courses; how to contrast personal student competence performance in different social contexts of a course?; and how to trace long-term analytics of LLL competence development in higher education?

Following this introduction, in further sub-sections of this section an attempt to a literature review on current outcome-based assessment is given.

2.2.1 Outcome-Based Assessment

Outcome-Based Assessment is a process that must be aligned with the learning outcomes. That is, it should support learners with formative assessment and summative assessment to measure their progress and validate the achievement of the intended learning

[1] http://www.cen-ltso.net/main.aspx?put=264&AspxAutoDetectCookieSupport=1

outcomes. It also implies that the assessment process should be adapted depending on the kind of outcomes that it is aimed to appraise. (Gutiérrez et al., 2012). Table 2-3 shows a taxonomy of assessment types.

Table 2-3 Taxonomy of assessment types

Assessment Name	Definition
Summative assessment	After a period of work, the learner takes a test and then the teacher marks the test and assigns a score. The test aims to summarize learning up to that point.
Formative assessment	Consider an assessment 'formative' when the feedback from learning activities is used to adapt the teaching to meet the learner's needs or to students take control of their own learning.
Portfolio assessment	Portfolio assessment is that it emphasizes and evidences the learning process as an active demonstration of knowledge. It is used for evaluating learning processes and learning outcomes. It is used to encourage student involvement in their assessment, their interaction with other students, teachers, parents and the larger community.
Self-Assessment	Assessment where students making judgments about their own work. Students critique their own work, and form judgments about its strengths and weaknesses.
Peer-Assessment	Student assessment of other students' work, both formative and summative. Peer-assessment intragroup: Students in a teamwork appraise their partners. Peer-Assessment extra group: Students appraise the collaborative work of other group.
360-Degree Feedback	Is feedback that comes from all around the student. The name refers to the 360 degrees in a circle, with the student in the centre of the circle. Feedback is provided by subordinates, peers, and teachers. It also includes a self-assessment and, in some cases, feedback from external sources.

Generally, assessment in e-learning is conducted independently from learning environment processes (Koper & Miao, 2008). Learning designers are concentrated in learning tasks, learning resources, and learning support tools. Consequently, they slightly forget assessment issues are integrated at the end of an e-learning process. This integration is not necessarily linked with the measurement of learning objectives during the student's learning process.

Approximately five years ago, educational researchers increased their interest in integrating assessment with the other key elements of learning design and the development of competences (Paquette, 2007; Koper & Miao, 2008). It has been raised that planning methods of assessing and evaluating learning implies answering many questions (Garzotto & Retalis, 2008; Bennett et al., 2010). For example, which learning activities will be graded? What types of evaluation methods are more appropriate for the educational objectives of a learning experience? How can these methods be customized to a specific learning context and to the expected benefits of a particular learning experience? What are the strategies for monitoring, assessment, and visualisation? What are the adaptive strategies to provide in assessment tools?

In order to integrate properly assessment within learning process, some proposals claim the following as main ideas: 1) Introduce assessment as another key element of leaning process and 2) Link each learning objective or competence with one or several kind of assessments (Paquette, 2007). In this way, assessment becomes a way of spiral measuring for student's learning achievement. Additionally, assessment turns into a good source for feedback and future recommendations.

In short, assessment becomes a way of spiral measuring for student's learning achievement or learning outcomes. Consequently, assessment turns into a good source of not only for feedback, but also for recommendation generation and drive adaptations in the learning environment.

2.2.1.1 *The European Qualifications Framework (EQF)*

The EQF is a common European reference system which link countries' qualifications systems and frameworks together. In practice, it functions as a translation device making qualifications more readable and understandable across different countries and systems in Europe.

The recommendation formally came into effect in April 2008. It's a voluntary framework, so there are no formal legal obligations for participant countries. Two main dates (2010 and 2012) were established as important deadlines regarding qualifications systems. For year 2010 participant countries were supposed to relate their qualifications systems to the EQF while year 2012 these countries should guarantee that individual qualification certificates bear a reference to the appropriate EQF level.

The EQF uses eight reference levels based on learning outcomes (defined in terms of knowledge, skills, and wider competences). Table 2-4 lists the learning outcomes for each EQF reference level. The EQF shifts the focus from input (lengths of a learning experience, type of institution) to learning results. In other words, the former emphasises on what a person holding a particular qualification actually knows and is able to do when completing a learning process. The EQF recognises that the European education and training systems are very diverse. Therefore, a shift to learning outcomes is necessary to make comparison and cooperation between countries and institutions as possible. This also signals that qualifications – in different combinations – capture a broad scope of learning outcomes including theoretical knowledge, practical and technical skills, and social competences where the ability to work with others will be crucial.

Table 2-4 EQF levels and the related learning outcomes, reported in (European Communities, 2008a)

	Knowledge	**Skill**	**Wider Competence**
	In the context of EQF, knowledge is described as theoretical and/or factual.	In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive, and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).	In the context of EQF, competence is described in terms of responsibility and autonomy.
Level 1 The learning outcomes relevant to Level 1 are	Basic general knowledge.	Basic skills required to carry out simple tasks.	Work or study under direct supervision in a structured context.
Level 2 The learning outcomes relevant to Level 2 are	Basic factual knowledge of a field of work or study.	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools.	Work or study under supervision with some autonomy.

Level 3 The learning outcomes relevant to Level 3 are	Knowledge of facts, principles, processes and general concepts, in a field of work or study.	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information.	Take responsibility for completion of tasks in work or study adapting own behaviour to circumstances in solving problems.
Level 4 The learning outcomes relevant to Level 4 are	Factual and theoretical knowledge in broad contexts within a field of work or study.	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study.	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change. Supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities.
Level 5 (*) The learning outcomes relevant to Level 5 are	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge.	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems.	Exercise management and supervision in contexts of work or study activities where there is unpredictable change. Review and develop performance of self and others.
Level 6 (**) The learning outcomes relevant to Level 6 are	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles.	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialized field of work or study.	Manage complex technical or professional activities or projects, taking responsibility for decision making in unpredictable work or study contexts take responsibility for managing professional development of individuals and groups.
Level 7 (***) The learning outcomes relevant to Level 7 are	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research. Critical awareness of knowledge issues in a field and at the interface between different fields.	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields.	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches. Take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams.
Level 8 (****) The learning outcomes relevant to Level 8 are	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields.	The most advanced and specialized skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice.	Demonstrate substantial authority, innovation, autonomy, scholarly as well as professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research.

Compatibility with the Framework for Qualifications of the European Higher Education Area
The Framework for Qualifications of the European Higher Education Area provides descriptors for cycles. Each cycle descriptor offers a generic statement of typical expectations of achievements and abilities associated with qualifications that represent the end of that cycle.

(*) The descriptor for the higher education short cycle (within or linked to the first cycle), developed by the Joint Quality Initiative as part of the Bologna process, corresponds to the learning outcomes for EQF level 5.

(**) The descriptor for the first cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 6.

(***) The descriptor for the second cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 7.

(****) The descriptor for the third cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 8.

Some benefits from shifting the focus to learning outcomes are presented below:

- Facilitates the transfer and use of qualifications across different countries and education and training systems. Using learning outcomes as a common reference point, the framework facilitate comparison and transfer of qualifications between countries, systems and institutions and will therefore be relevant to a wide range of users at European as well as at national level.

- Promotes citizens' mobility between countries. It will make easier for learners to describe their broad level of competence to recruiters in other countries. This will help employers interpret applicants 'qualifications and then support labour market mobility in Europe.

- Supports a better match between the needs of the labour market (for knowledge, skills and competences) and education and training provision. The EQF is an ambitious and far-reaching instrument which has implications for education, training systems, labour market, industry, commerce, and citizens.

- Facilitates the validation of non-formal and informal learning. The EQF can support individuals with extensive experience from work or other fields of activity. The focus on learning outcomes will make it easier to assess whether learning outcomes acquired in these settings are equivalent in content and relevance to formal qualifications. The EQF will support individual users , education providers, and learning trainers by increasing transparency of qualifications awarded outside of a particular national system (for example by sectors and multinational companies). The adoption of a common reference framework based on learning outcomes will facilitate the comparison and (potential) linking of traditional qualifications, awarded by national authorities, and the ones awarded by other stakeholders. Thus, the EQF will help sectors and individuals to take advantage of this growing internationalisation of qualifications.

- Facilitates the lifelong learning of persons. By establishing a common reference point, the EQF will indicate how learning outcomes may be combined from different settings (e.g. a formal study or work training taken in different countries) and thus the EQF will contribute to reduce barriers between education and training providers (e.g. between higher education and vocational education and training, which may operate in isolation from each other). Hence, the EQF will promote progression, so that learners do not have to repeat a specific learning again.

2.2.1.2 *The EQF Relation with Other Qualification Systems*

The EQF complement and reinforce existing European mobility instruments such as Europass, and ECTS (used in the Bologna process).

In the case of Europass, it introduced a portfolio of documents to be used by individuals. Those documents describe qualifications and competences from an individual; however, Europass does not compare levels of qualifications. In the future, all relevant Europass documents, in particular Europass diploma and Europass certificate supplements, should contain a clear reference to the appropriate EQF level.

Continuing, there is the case of Bologna process for higher education. This process has been outstanding due to highest rates of students' mobility and qualifications throughout Europe. The qualifications framework for Higher Education developed under the Bologna Process is fully compatible with EQF. Specifically, EQF descriptors at levels 5-8 refer to the ones of higher education agreed under the Bologna Process. Nevertheless, the formulation of the EQF level descriptors differs from the Bologna level descriptors that were developed specifically for higher education needs. Instead EQF as a lifelong learning framework not only implements levels descriptors for higher education, but also encompasses *vocational education and training* (VET) and work contexts, including at the highest levels.

As an instrument for the promotion of lifelong learning, the EQF encompasses general and adult education, vocational education and training as well as higher education. Its eight reference levels cover the entire span of qualifications from those achieved at the end of compulsory education (Level 1, for example school leaving certificates) to those awarded at the highest level of academic, professional or vocational education and training (Level 8, for example Doctorates). Each level should be attainable, in principle, to a variety of education and career paths.

Summing up, at a very practical level from 2012 all new qualifications should bear a reference to the appropriate EQF level. The EQF will thus complement and reinforce existing European mobility instruments.

2.3 Personalised Monitoring, Feedback and Social Visualisations

Personalised feedback related to monitoring of students activities and learning outcomes are possible using techniques such as learning analytics and open student models. Nevertheless it is necessary to construct technological frameworks to define how these visualisations will be produced. Engeström's Activity Theory and the Actuator-indicator model are the cornerstones of this research to that purpose. The aim of this research is generates learning analytics and open student models to give a clear vision of students actions and learning outcomes taking into account the social context of them. Next sections give a brief description of concepts and actual contributions in Learning Analytics, Open User Models, Engeström's Activity Theory and the Actuator-Indicator Model.

2.3.1 Learning Analytics

Learning Analytics (LA) have been defined as a variety of data-gathering tools and analytic techniques to study student engagement, performance, and progress in practice (explicit student actions and tacit actions), with the goal of using what is learned to tailor educational opportunities to each student, assess academic progress, predict future performance, spot potential issues, and revise curricula, teaching, and assessment in real time (Johnson et al. 2011).

For their relation with TEL in personalised learning this thesis is especially interested in *Social Learning Analytics*. A recent report state social learning analytics make visible, and in some cases potentially actionable, behaviours and patterns in the learning environment that signify effective process (Shum & Ferguson, 2011). In particular, the focus is on processes in which the learner is not solitary, and not necessarily 'doing work to be marked', but is engaged in 'social' activity either by virtue of interacting directly with peers (e.g. via messaging, friending, following), or using collaborative platforms in which their activity is leaving traces which will be experienced by others (e.g. by blogging, publishing media, searching, tagging, rating). In their publication the same authors also defines *Social Learning Context Analytics* as analytic tools that expose, make use of, or seek to understand social context(s) where the learner is involved.

Learning analytics is still a young area of research. Some works in the last two years have given insight into the gaps for characterizing this area or research (Elias, 2011; Shum & Ferguson, 2011; Ferguson, 2012; Drachsler & Greller, 2012). It was defined an early vision of learning analytics as foundation for visualisations and recommender systems (Duval, 2011), it was also recognized activity monitoring as good source for learning analytics production (Govaerts, Verbert, & Duval, 2011). Both ideas were also highlighted in the article (Florian-Gaviria et al., 2011). In a recent article the authors present the concept of *Reflection Triggers* that refers to visual and verbose representations of multiple students' activity analyses for reflection purposes in formal learning (Verpoorten et al., 2012).

In this thesis, it is believed that *social learning context analytics* are a very useful source of feedback for outcome-based assessment in order to generate awareness, reflection and even self-regulation in students and teachers about the statistical analyses of competence development in the social context of courses.

2.3.2 Open Learner/Student Models

The main purpose of a *learner model* is to provide information to enable an adaptive learning environment to personalise interfaces to a user's learning needs. Systems are now increasingly opening their learner models to the learner. Such *open learner/student models* allow the learners to view information about their self. Benefits of opening the user model to learners and teachers have been argued (Brusilovsky & Sosnovsky, 2005; Mitrovic & Martin, 2007; S. Bull & Kay, 2007; Van Labeke, Brna, & Morales, 2007; S. Bull & Gardner, 2010) among others.

A review of the literature (S. Bull & Kay, 2009) shows that an open learner/student model allows access to the user model content in a variety of forms such as: skill meters, interactive texts and tables, trees, Bayesian networks, and concept maps. Others include simulations, animations, and Fuzzy models.

In this thesis, it is believed that *open student models* are a very useful source of feedback for *outcome-based assessment* in order to generate awareness, reflection and even self-regulation in students and teachers about the competence development in relation with design of learning courses.

2.3.3 Engeström's Activity Theory

Engeström's Activity Theory has its origins in modelling and analysing business processes (Engeström, 1987, 1999). The underpinning core of the activity theory is that activity cannot be limited to "means of getting to results" but needs to be analysed at the level of actions. This Activity Theory provides a system model to describe actions and their contextual constraints. This model has six components: A subject, an object, instruments, rules, social planes (community), and co-operative processes (division of labour). The interplay of these components leads to an outcome of an activity. The activity system can be separated into action and context parts. The relations in the action part describe the observable interplay of the elements in an activity. The subject, the object, and the instruments are elements of the action part. The relations in the context part describe supporting and constraining factors for an activity. This part contains rules, social planes, and co-operative processes. Figure 2-4 shows the original Engeström's Activity Theory scheme.

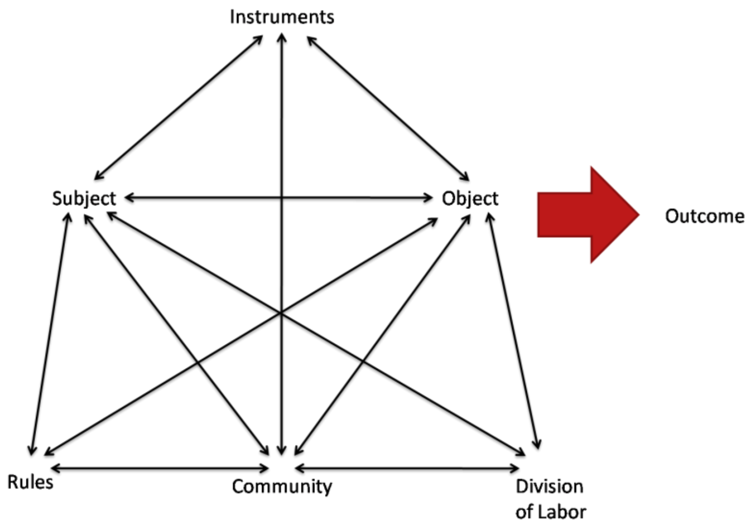


Figure 2-4 Engeström's Activity Theory reported in (Engeström, 1987)

This Activity Theory model describes the structural relations between the components of a single activity. Each element of this model may relate to individual activities that can be described with the model recursively. Additionally, the activity's outcome can trigger new activities. This allows the systematic description of complex processes. This model has been used to analyse the effectiveness and the efficiency of business processes for identifying potential improvements of work settings (Engeström, 2000; Mirel, 2003; Engeström, 2008; Lindgren, 2011).

The Activity Theory has received some attention by TEL research, most notably in the context of Computer Supported Collaborative Learning (CSCL) (Dillenbourg & Tchounikinew, 2007) and mobile learning (Isomursu, Kuutti, & Väinämö, 2004; Uden & Helo, 2008). The concepts of Activity Theory are attractive for educational-technology research because they share key aspects that have been identified by instructional design research (Reigeluth, 1983). The provided relationship model connects these aspects systematically. In educational settings the elements "teacher" and "learner" replace the elements "subject" and "object" of the original model.

Consecutive works argued that social planes require consideration for orchestrating TEL. These planes are bound to the social connectedness of learners on the activity level and can include individual, collaborative, or collective (class wide) activities (Dillenbourg, 2004a, 2008; Dillenbourg & Tchounikinew, 2007). Five (5) generic social planes have been identified. These social planes structure or influence the learning activities. They are known as individual, group, class, community, and world planes (Dillenbourg, 2004b). The individual plane refers to activities developed by the student him/herself and group plane refers to activities performed in small groups that allow direct collaboration among all participants. The class plane includes activities whose participants belong to the same course. The community plane comprises actors from other classes or courses on the same topic. Finally, the world plane refers to actions that involve unidentified actors, such as visitors of a public web-journal.

A more recent work has identified that activity information from other social planes influences awareness and self-regulation of learners (Glahn, Specht, & Koper, 2009a). They noticed that contrasting individual learning activities with the same information about activities on a different social plane enables learners to contextualize their own activities and stimulate the social awareness (with regard to the activities undertaken on the other plane). This finding indicates that information of different social planes can support self-assessment activities in TEL.

The second aspect of the Activity Theory is that rules define and constrain an activity. This aspect focuses on the contextualizing factors of an activity. In TEL rules on learning activities are commonly perceived as part of instructional design problems. This is due to rules are an integral part of every instructional design (Reigeluth, 1983), (Clark & Croock, 2002). However, it has been highlighted that rules in VLEs constraining learning activities can be located at several hierarchical control levels; namely, system, organizational, teacher, and learner levels (Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009). The hierarchy of these levels implies that rules at each level constrain the possible activities of the following levels. These levels also involve stakeholders such as system developers, technical administrators or organizational managers who are typically ignored by TEL research.

While in Engeström's original model instruments are considered as passive mediators in an activity, the different types of rules affect directly these instruments in the activity system. In interactive information systems, actors often do not apply these rules straight forward. More commonly external rules constrain the possible use of an instrument, such as a VLE. These external rules can be inherent to an instructional design, hardwired into the logic of an information system or configured as part of an organizational policy. Hence, these rules are included through the instruments that are used in an activity. In the same line of reasoning, the technology-related constraints can have a direct impact on collaboration and co-operation in learning processes. This technology-induced change suggests an extension of the original Activity Theory model that also considers the relations between procedural rules, instruments, and collaborative processes (see Figure 2-5).

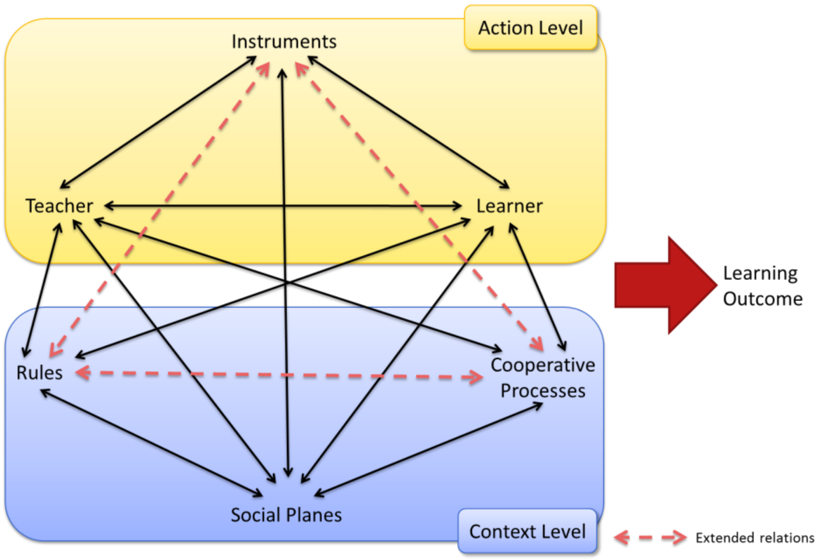


Figure 2-5 Extended Engeström's Activity Theory for TEL. (Florian-Gaviria et al., 2011)

Outcome-based assessment focuses on the results of an activity and tries to deduce the success of an activity by comparing expected and delivered learning outcomes (Crespo et al., 2010). The activity itself remains a black box for such approaches. Activity-based assessment changes this perspective towards assessing the activities that lead to the outcomes. This includes the assessment of the appropriate applications of external rules, the interactions on and across social planes, and (if present) collaboration and cooperation among learners. All aspects of this kind of assessment contribute to the evidence that learners achieved the targeted competence levels.

From the perspective of the extended Activity Theory model, the provisioning and exposure of analytical rules for accessing data in information systems remains a challenge. Advances in such a challenge will allow the effective application of learning analytics for supporting learners and teachers.

2.3.4 Actuator-Indicator Model

While the Activity Theory offers a well-structured model for analysing and conceptualising learning and its assessment, it does not provide guidelines for implementing services to support learning or assessment. A generic system architecture was proposed for adaptive and contextual systems (Zimmermann, Specht, & Lorenz, 2005). Further research extended this architecture with concepts of motivational research (Glahn et al., 2007, 2009a, 2009b). Then, this extension was applied to different application areas of TEL (Glahn & Specht, 2005; Glahn et al., 2009a; De Jong, Specht, & Koper, 2008). The Actuator-Indicator model not only has had its mayor impact as pillar of context-aware systems and ubiquitous computing, but also as cornerstone of recommender systems (Ballatore, McArdle, Kelly, & Bertolotto, 2010; Hella & Krogstie, 2011), and multimedia systems (Hornsby & Walsh, 2010).

The model proposed consists of an architecture with four functional layers. These core functional layers are sensor data management (sensor layer), context abstraction (semantic layer), control-actuator output (control layer), and output indication (indicator layer). Figure 2-6 shows the information flow of the actuator-indicator model.

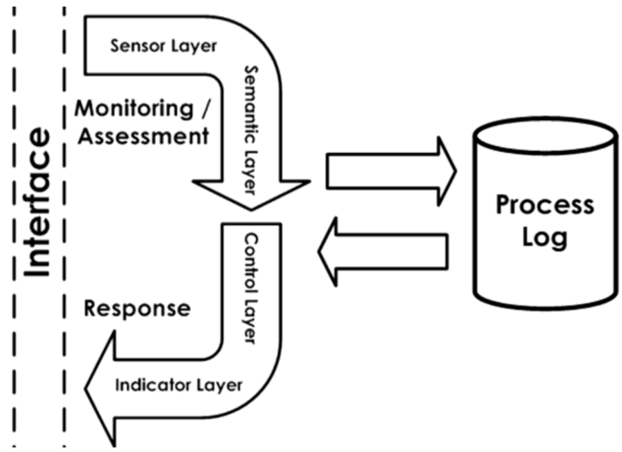


Figure 2-6 Actuator-Indicator model. (Zimmermann et al., 2005)

The sensor layer is responsible for logging information about traces of learners' interactions and other contextual information. The semantic layer collects the data from the log system and aggregates these data into higher-level information by using *aggregators*. The former is a function that transforms sensor data from the log system. An *activity aggregator* refers to how logs of a particular activity are semantically transformed. The aggregators respond differently depending on the context (social plane), in which they are called. The control layer is in charge of interpreting the response of aggregators through different strategies. A *strategy* determinates when and how to collect aggregator responses and how to present them to the user. In brief, the active strategy selects the representations and provides the aggregated information to them. To complement this definition, an *activity-based learner-model* integrates the output of several aggregators. Finally, the indicator layer is in charge of transforming the returned data of the control layer into representations that are interpretable by humans.

Integrating learning analytics capabilities to complex legacy systems is a challenge since existing functions and components should be identified along the information processing flow of this architecture.

2.4 Conclusions and Overview of the Thesis Proposal

In this thesis it is believed that *competence-based education*, *outcome-based assessment*, and *social visualisations* in higher education are possible ways to mitigate the mentioned drawbacks (see Table 2-1). Table 2-5 summarises the ideas of support to mitigate the drawbacks in support of LLL competence development in higher education mentioned before.

Table 2-5 Ideas of support in higher education to mitigate drawbacks

Drawbacks	Technology-Enhanced Support for LLL Competence Development	Area of Research
D1	Helping teachers to align higher education courses to curricular agreements. This could be done by providing support for teachers and students in adopting the European curricular agreements. Support for teachers to map the objectives of their courses to a competence-based learning and outcome-based assessment. Support for students to be aware of the expected learning outcomes and the relation of these learning outcomes with the course activities.	Competence-Based Learning Open User Models
D2	Providing support for self-direction and self-regulation by means of useful feedback that raise awareness and reflection.	Open User Models Learning Analytics Outcome-Based Assessment
D3 D7	Providing support for enriched forms of outcome-based assessment in VLEs. Providing support for teachers and students in taking part of formative assessment.	Outcome-Based Assessment 360-Degree Feedback
D4	Providing a technological framework to trace students' activities and learning outcomes with multiple perspectives. Providing support with a clear vision of the achieved learning outcomes.	Learning Analytics Open User Models
D5 D6	Providing a technological framework to aggregate information with multiple perspectives from VLEs.	Learning Analytics Open User Models
D8	Providing visualisations of open user models and social learning analytics for useful feedback.	Learning Analytics Open User Models

http://alxa.ru/2008/11/20/steel_puzzle_sphere_2.html

PART III

DESIGN AND TECHNICAL PERSPECTIVE

CHAPTER 3

PROPOSAL FOR ENHANCING COURSE LIFECYCLE IN HIGHER EDUCATION

This chapter is concerned with expose the analysis and design of the thesis proposal. Two research questions are answered here namely: *RQ-2. Which information elements, procedures and software applications are needed to build a technical and pedagogical architecture to support competences development?* and *RQ-3. How to introspect learning activities for competence assessment and recommendations?* To that end, the chapter starts with a description of the project context. Then, it follows the planned methodology for analysis and design. Afterwards, and successive results of design are described. Finally, contributions and chapter's conclusions are remarked.

3.1 Project Context

The objective of this thesis is to validate the framework (Personalised, competence-based, and social learning) by a suite of software applications supporting authoring of competences, learning design, assessment, open student modelling interfaces and social learning analytics for teachers and learners. Scalable educational content collections are expected from the rich data models behind applications. This kind of study requires a considerable preparation. Sufficient volume of learning content should be developed, a set of studies to determine the critical features of the target framework should be performed (Chapter 4 to Chapter 7), and finally, on the basis of these studies, the suite itself should be promoted to the last stable version as final development of the framework. This chapter covers all software analysis and design and provides a complete picture of the project context.

3.2 Methodology

The first stage of analysis was to inquiry about a competence-based course lifecycle. A generic characterization for online and blended course lifecycle was taken into account to discuss possibilities for adding a competence-based European agreement such as the EQF. As result, a competence-based course lifecycle was proposed for higher education.

In order to implement this course lifecycle, a technological architecture was designed, the *Adaptive Evaluation Engine Architecture (AEEA).* The AEEA propose several steps of support for competence-based learning in higher education through a set of applications and data models. In addition, a second technological architecture design, the

Activity-based Learner-models, supports also personalised learning and social visualisations through tracing students' activities with social perspectives and delivering open social learning analytics and open student model of competences progress. This second architecture is also intended to deliver personalised guidance through recommendations for teachers and students. Preliminary studies for recommender systems were made (Florian-Gaviria & Fabregat, 2011). They will be implemented as future work.

Finally, a software suite was implemented and several case studies performed with teachers and students in order to validate the framework. The next sections describe the results of each stage of this methodology.

3.3 The EQF for Course Lifecycle

This section describes how a generic characterization of a lifecycle for online and blended courses can be undertaken based on the EQF in order to allow a CBL in higher education.

The generic process characterization of a course lifecycle has been used in higher education for blended (and online) courses. Figure 3-1 illustrates this characterization and its related phases. Supports on technology-enhanced ways are going to be introduced in this course lifecycle to turn it in a competence-based process. Here in Chapter 3, the ideas summarized in Table 2-5 are going to be introduced as different technology-enhanced forms of support.

Basically the lifecycle of online courses has three main phases. The first stage is the *Learning Design Phase* better known among practitioners as "preparation". The second one is the *Implementation Phase* that for many, it concerns with the actual teaching. The third phase is the *Evaluation Phase* of the learning process and the results of this phase are used to improve future iterations of a course. However, in open and distance learning the teaching process has a greater emphasis of the preparation phase than traditional educational approaches. This focus shift also concerns online and blended learning. Further, many VLEs do not actively support the final phase of the online course life cycle. Some possible explanation for this situation are the limitations of the selected technical platform or due to organizational or administrative restrictions of a VLE's use (Verpoorten et al., 2009).

Most educational design theories follow a common pattern for conceptualizing this process (Reigeluth, 1999). This pattern consists of seven educational activities as follow:

1) Definition of learning prerequisites
2) Definition of learning outcomes
3) Definition and alignment of learning activities
4) Rules for assessing the learning performance
5) Monitoring of the learning process
6) Moderation of the learning process
7) Evaluation of the learning process

Particularly the first six activities directly influence the quality and effectiveness of a single learning unit (Reigeluth, 1999). A structured evaluation phase contributes to the quality and effectiveness of long running educational and training offers and programs.

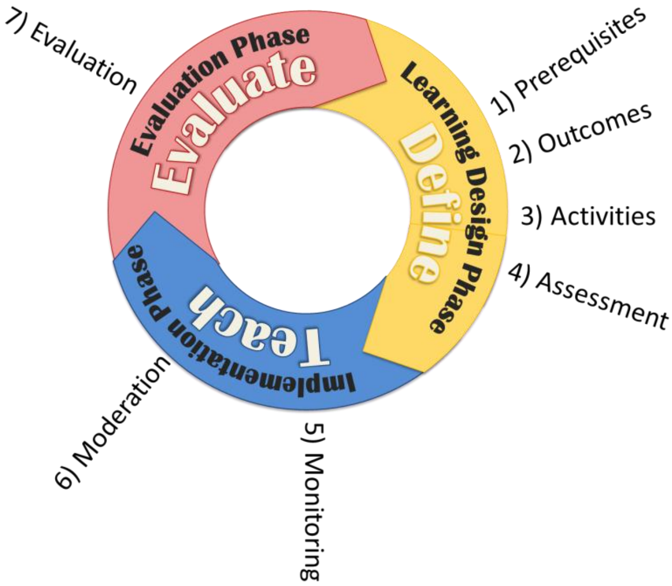


Figure 3-1 Online or blended course lifecycle (Florian-Gaviria et al., 2011)

The EQF is an instrument of the European Union for supporting the mobility of citizens across Europe. Traditionally, mobility was hindered by different educational and qualification systems. Each national system has its specifications that make a direct comparison of academic and professional degrees difficult. The Bologna Process reduced the mobility thresholds for academics by unification of the academic degrees in Europe (Murphy, Loveland, Foley, & Stableski, 2007; Hunter, 2010). Despite the unification of the academic degrees (titles), the Bologna Process did not include homogenization of the academic programs (content). Early criticism to the Bologna Process was made towards this standardization protocol. Mainly, Bologna Process used to standardise titles but not the content of the qualification, creating a disadvantage among candidates that take part in studies with more nourished curriculums within the constraints of years per cycles (Mencinger, 2004; Cuesta, 2010). Fortunately, the Bologna Process is now moving away from a strict convergence in terms of time spent on qualifications, towards a competence-based system. Therefore, it is necessary even for academic degrees to document the actual competences that have been achieved during the education.

Although from 2012 onwards the EQF is considered as mandatory for documenting academic and professional education, training, and learning throughout the European Union (European Parliament Council, 2008). Nevertheless, there is little progress for integrating EQF into academic education and training on a large scale. One of the causes of this situation is the lack of supporting tools to use the EQF into the education and training practices.

Current approaches to supporting the educational activities through learning design emphasize on the design and arrangement of learning activities (Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2005; Verpoorten, Poumay, & Leclercq, 2007; Masson, Macneill, Murphy, & Ross, 2008) and assessment rules (Joosten-ten Brinke et al., 2007; Miao, Sloep, & Koper, 2008; Florian-Gaviria, Baldiris, Fabregat, & De la Hoz-Manotas, 2010) while the relation between learning activities, learning prerequisites and learning outcomes received limited attention by contemporary research (Gruber, Glahn, Specht, & Koper, 2010). This gap is also visible in current approaches and specifications for the technical support of the educational design process (Hernández-Leo et al., 2005; IMS Global, 2002).

The learning objectives have been discussed as a central element of any learning design process. However, given that practitioners seem to have difficulties defining good learning objectives, prerequisites and learning outcomes are often optional elements or absent in the interfaces of learning design software. Educational design research has highlighted in the past that abstract learning objectives and learning goals should be replaced by quantifiable learning outcomes (Reigeluth, 1999). These learning outcomes are directly related to the prerequisites and the learning activities of a learning unit. The learning activities in a learning unit can be considered as the means that bridge the gap between the prerequisites and the learning outcomes. Ideally, each learning activity in a learning unit contributes to the assessment of at least one learning outcome.

Similar to Sue Bennett's thirty (30) activity verbs and the 8 learning activities (Verpoorten et al., 2007) that can be used for patterning the learning activity descriptions (Masson et al., 2008), the EQF provides structure to defining quantifiable prerequisites and outcomes for learning. For competence building the EQF levels provide clear and easy-to-understand descriptors of what a person needs to show if this level has been achieved. These achievements are distinguished by "knowledge", "skills", and "wider competences". From this perspective, the prerequisites define the capabilities of learners in a selected target area, while the target level in the EQF terminology defines the learning outcomes. As EQF provides quantifiable reference points for prerequisites and learning outcomes (see Table 2-4), it provides structure for planning the assessment of a learning unit.

A similar approach is used for standardized language learning in Europe using the six levels of the European Language Pass. This framework distinguishes the competences "listening", "reading", "spoken interaction", "spoken production", and "writing" (CEDEFOP, 2008). For each competence, this framework provides a set of capabilities that need to be proven for each level. This framework enables language learning providers to tailor their offers towards these capabilities and certify learning outcomes accordingly.

For many domains, the EQF has been not as worked out in the same fashion as for the language-learning domain. Educators and teachers are required to specify a suitable competence model for their courses based. However, classifications on the domain knowledge and on competences do exist for many domains.

Based on a given competence model, the first activity of the instructional design process is to define the prerequisites and the outcomes for a learning unit. This definition explains the gap between prerequisites and the learning outcomes. Moreover, it includes selecting learning activities, defining assessment rules, monitoring the students' learning progress, and providing appropriate feedback.

The learning design phase arranges learning activities and resources within the learning unit. Any suitable learning activity is directly related to at least one learning outcome. A learning activity has the following elements:

1) A task for the student to be completed.

2) Resources needed for the task to be performed.
3) At least one associated competence.
4) Assessment rules for task completion and competence development progress.

Each learning activity is a step for bridging the gap between the prerequisites for learning and the learning outcomes. The arrangement of learning activities provides a script for moderating and guiding the learning process.

During the implementation of a course, two activities are concurrent. First, educators need to moderate the students' learning processes aligned to the previously defined script. Secondly, educators need to monitor the learning progress in order to provide meaningful feedback to learners. Both activities are tightly interwoven and influence one another.

The moderation and feedback support provision orient learners in the learning process. There are two ways to perform the former activities. The first one is providing task support (Van Merrienboer & Kirschner, 2007) which in online courses has been discussed in the context of scaffolding (Davis & Miyake, 2004). In instructional scaffolding teachers help students to master a task or a concept by providing support. This can take many forms such as outlines, recommendations, storyboards, or key questions. Task support is primarily activity centred to model a task, give advice or providing coaching. The second way of moderation is guidance through feedback. This type of support tackles orientation problems by providing learners an external view of their performance (marks, grades, or qualification of competences). Therefore, such learning support is primarily outcome centred and relates to the assessment procedures that are defined for a course.

The monitoring activity engages educators with the overall progress analysis within a learning unit. This activity provides insights of the overall learning process by observing students' relationship with resources, time, peers, and teacher. Monitoring enables educators to track the pace appropriateness of the learning course and to identify learners with specific needs to be supported. While in classroom settings, the monitoring activity is often implicitly performed; the online, blended, and distance learning environments need to provide educators with specific means. In this way, teachers can observe the different social and process dynamics of a course. Consequently, monitoring activity enables practitioners to select suitable moderation and support strategies.

The additional competence specification during the design phase allows adapting the monitoring and moderation activities based on the predefined EQF levels. This adaptation selects appropriate analytical approaches and information for feedback depending on the different complexity and intellectual challenges of the preselected EQF levels.

3.4 The Adaptive Evaluation Engine Architecture (AEEA)

Once the course lifecycle has been defined and the benefits of using the EQF have been justified, the next step concerns with the technical architecture to support this enhanced course lifecycle. This section outlines the *Adaptive Evaluation Engine Architecture (AEEA)*. This architecture is the fundamental framework to implement a software suite based on the EQF to support educational design, assessment, and feedback oriented by competences qualification.

AEEA is *Adaptive* because Personalised interfaces are delivered for each student and also because the system provides different navigation and functions for teachers and students. It is an *Evaluation Engine* because a novel proposal for assess competences progressively using a 360 degree feedback is provided. Finally, it is *Architecture* because the AEEA is a framework for research, teaching and learning.

This architecture is a technical design that characterizes a methodology for competence driven LLL in higher education. The architecture describes the online course lifecycle supported in data models. The course is carried out by teachers and students through software applications. The AEEA was initially reported in the articles (Florian-Gaviria, Baldiris, & Fabregat, 2009b; Florian-Gaviria et al., 2009a). In the AEEA, the first two phases of the online course lifecycle are modelled, namely: 1) The *Learning Design Phase* and 2) The *Implementation Phase*, (see Section 3.3). Figure 3-2 shows the AEEA design which is structured into two packages: the *Design Package* and the *Run-time Package*. The *Design Package* is in charge of the educational activities of the *Learning Design Phase* such as defining prerequisites, learning outcomes, activities, and assessment rules of the course lifecycle. The *Run-time Package* runs the educational activities of the *Implementation Phase* such as monitoring and moderation of the course.

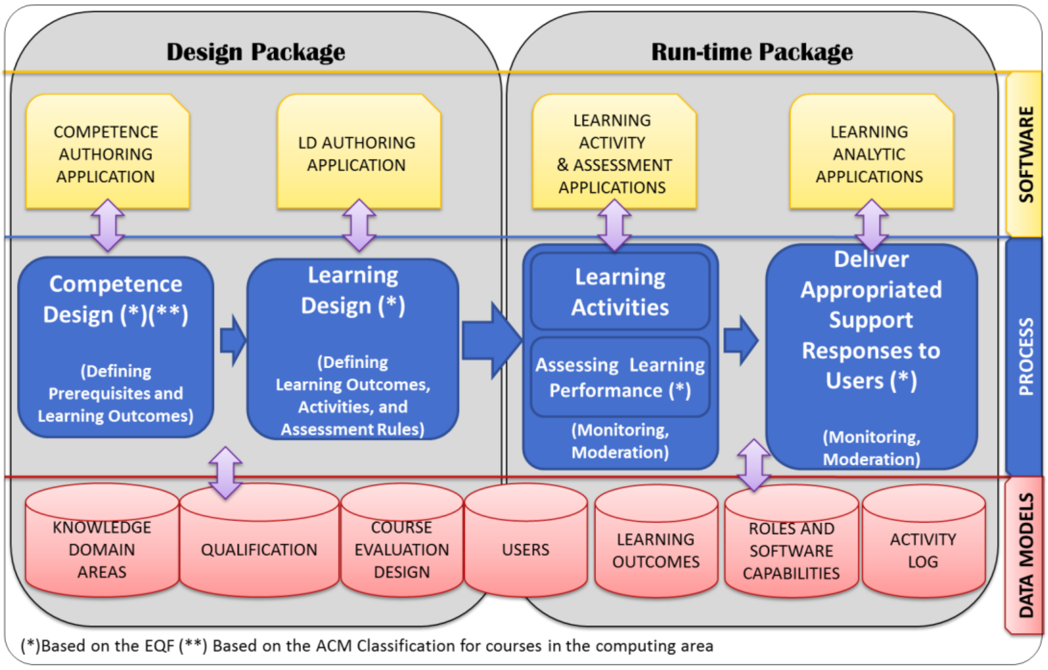


Figure 3-2 The Adaptive Evaluation Engine Architecture (AEEA)

The AEEA is divided in three layers namely data models, process, and software. The lower layer frames the data models of the architecture. The middle layer contains the logical internal procedures of the architecture. The upper layer shows the proposed software applications to be employed by users (teachers and learners). Next paragraphs describe each one of the steps in the educational process that are supported by the AEEA. To do so, the data model layer, examples of data, and mock-ups of the software layer are presented. A complete presentation of the final software interfaces and case studies are detailed from Chapter 4 to Chapter 7.

The first step supported in the design package is the competences´ design. The *Competence Authoring Application* is proposed to support this step. In this software application teachers can select *knowledge domains* (a branch of knowledge in a discipline) related to their courses. Then teachers can select existent competences or create new ones for each knowledge domain selected. Educators in higher education require authoring tools that allow them to search, define, and share metadata competences under universally recognized domain classification systems. Since higher education has a wide range of degrees and it is a fact that each degree has different knowledge domains; then, a lot of domain classification systems need to be taken into consideration. For instance, the MACE project supports an integration of repositories and several search engines, in the Architecture area, unifying information with metadata in a set of domain classification systems (The MACE Project, 2012). Thus, isomorphic and homogenous information schemas are generated. In the case of the AEEA the domain classification system selected was the ACM Computing Classification System (Association for Computing Machinery, 1998) because courses used to test were in the area of computing and the ACM system is widely accepted as reference classification system in computing education and computing research (Vessey, Ramesh, & Glass, 2005; Mirkin, Nascimento, & Pereira, 2008) .

Thereby, the *Competence Authoring Application* is grounded on a set of data models. There is a competences qualification model based on the EQF and there is also a model of course competences ordered by knowledge domains. Figure 3-3 shows a detailed view of united data models behind the *Competence Authoring Application*.

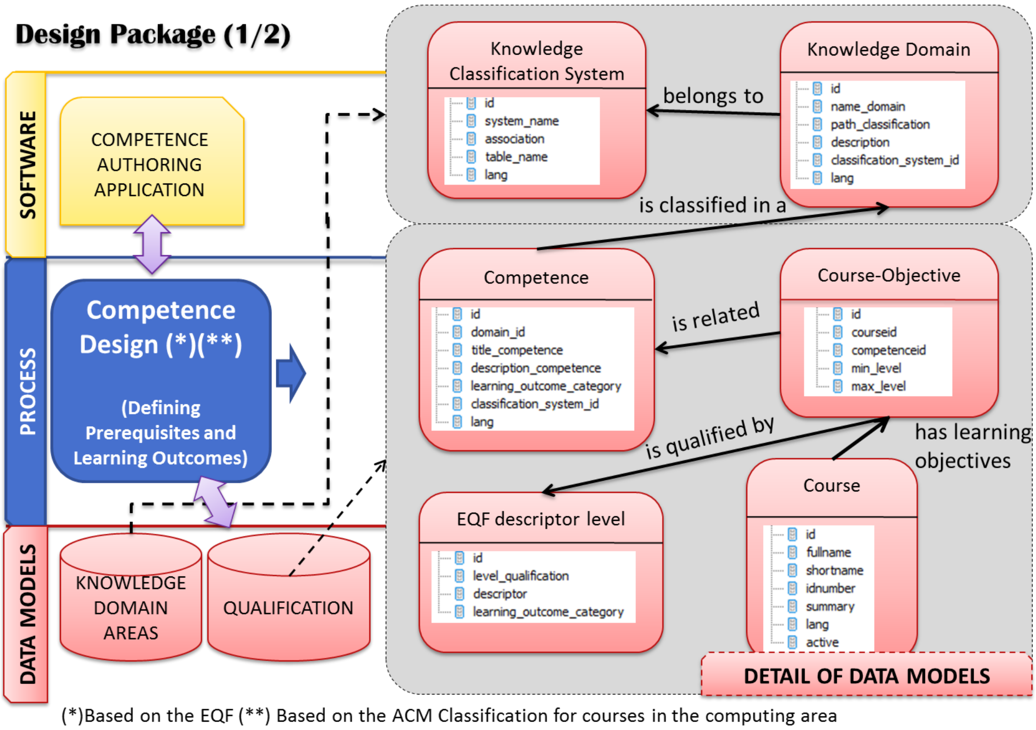


Figure 3-3 Detail of data models in competence authoring application

To give an example of possible competences, there is the course Fundaments of Lineal Control Systems, a summary of its competences are presented in Table 3-1. Appendix A, B and C hold complete learning designs of some courses that participated in the case studies.

Table 3-1 Example of competences in a course

C.3 Computer Systems Organization / Special-purpose and application-based systems / Process control systems	
Ability to define problems of lineal systems	Skill
Ability to solve problems of lineal systems	Skill
Do and evaluate technical information in control systems	Skill
Knowledge in control of lineal systems	Knowledge
G.4 Mathematical logic and formal languages / Mathematical Software / Documentation	
Expose results of analysis and design of control systems	Communication and social competence
I.2.8 Computing Methodologies / Artificial Intelligence / Problem solving, control methods, and search / Control theory	
Ability to design block diagrams	Skill
Knowledge in digital and analogical control systems	Knowledge
Knowledge in typical loop of analogical and digital control	Knowledge
I.6.4 Computing Methodologies / Simulation and Modelling / Model Validation and Analysis / Model Validation and Analysis	
Ability to model discrete dynamical systems	Skill
I.6.5 Computing Methodologies / Simulation and Modelling / Model Development / Modelling methodologies	
Ability to analyse interrelations	Skill
Ability to analyse the effect of feedback in control systems	Skill
Ability to calculate responses through time	Skill
Ability to describe control system mathematical model	Skill
I.6.8 Computing Methodologies / Simulation and modelling / Types of simulation / Continuous	
Ability to determine effects of control actions	Skill
J.7 Computer Applications / Computers in other systems / Industrial control	
Ability to implement the control action PID	Skill
K.7.4 Computing Milieus / The Computing Profession / Professional Ethics / Codes of ethics	
Respect copyright	Autonomy and responsibility competence
Respect the real authoring in teamwork	Autonomy and responsibility competence
K.7.4 Computing Milieus / The Computing Profession / Professional Ethics / Codes of good practice	
Ability to do public presentation of project progress	Communication and social competence
Disposition to self-learning in PBL	Learning competence
Good team relationships	Communication and social competence
Punctuality with assigned tasks	Autonomy and responsibility competence
Use appropriated technical file templates	Communication and social competence

After authoring of competences, a *Learning Design (LD) Authoring Application* supports teachers to define learning activity elements (defining prerequisites, learning outcomes, evaluation activities, and assessment rules of the course lifecycle). This application only set up evaluation activities, other learning activities must be supported by other VLE.

The learning design proposed is a complex activity for teachers because they are not used to competence-based leaning designs. Therefore, the learning design task was divided in three steps; 1) The first step is to define prerequisites and learning outcomes. 2) A second step is to determine types of assessments to be performed in an evaluation activity. 3) A final step is to delineate a script of qualifications for assessment activities. Let’s take a deeper look for these steps.

For each competence added to the course, an initial EQF level states the prerequisite and a final EQF level defines an expected learning outcome. Table 3-2 shows a mock-up of a part of the *LD Authoring Application* with a list of learning prerequisites and learning outcomes in a course. In this thesis the concept *EQF competence* refers to a competence (knowledge, skill or wider competence) with an associated expected EQF level of qualification that is either a prerequisite or a learning outcome of a course.

Table 3-2 Mock-up of interface to show learning prerequisites and learning outcomes in a course

Knowledge Domain: Area / Subarea /						
Competence Description	**Prerequisite (based on the EQF)**			**Learning Outcome (based on the EQF)**		
Knowledge in ...	Knowledge	Level	1	Knowledge	Level	3
...		...	...		...	...
Knowledge in ...		Level	2		Level	4
Ability to ...	Skill	Level	2	Skill	Level	3
...		...	...		...	...
Ability to ...		Level	1		Level	3
Responsibility to ...	Responsibility competence	Level	3	Responsibility competence	Level	4
...						
Responsibility to...		Level	2		Level	3
Instructions: For each Knowledge Domain selected 1. Add a row for each Knowledge to develop in this knowledge domain 2. Add a row for each Skill to develop in this knowledge domain 3. Add a row for each Wider competence to develop in this knowledge domain Select the initial EQF level and the final EQF level for each competence added						

In order to provide support guided by feedback, defined in the previous section, the AEEA demands applications implementing a 360-degree feedback such as (Petrov & Aleksieva-Petrova, 2008). Consequently, a 360-degree evaluation is proposed and teachers need to take this into account during learning design to determine which kind of assessments will be performed in an evaluation activity. Four kinds of assessment can be selected: self-assessment, teacher-assessment, intragroup peer-assessment and intergroup peer-assessment. Table 3-3 illustrates a mock-up of how teachers select assessments to be performed in evaluation activities of a course.

Table 3-3 Mock-up of interface to associate activities and assessments.

Activity	**Self Assessment**	**Intragroup Peer Assessment**	**Intergroup Peer Assessment**	**Teacher Assessment**
Final peer evaluation	-	100%	-	-
Final self evaluation	100%	-	-	-
Oral Presentation	-	-	-	100%
Practical evaluation	-	-	-	100%
Report 1	-	-	10%	90%
Report 2	-	-	10%	90%
Report 3	-	-	-	100%
Writing evaluation 1	-	-	-	100%
Writing evaluation 2	-	-	-	100%
Writing evaluation 3	-	-	-	100%
Writing evaluation 4	-	-	-	100%

The course learning design model is completed by collecting learning activities elements. In this model, the gap between the prerequisites and the learning outcomes is detailed in a set of rules. These rules define the competence development progress in terms of expected qualification levels in activities. Therefore, the script to moderate and guide the learning process can be visualised as a matrix between learning activities and competences that reports expected qualifications. Table 3-4 expresses a mock-up to define the script of competences' qualification. A cell of this matrix represents an expected level of qualification for a competence in an activity. The row defines the qualification steps of a competence from the initial qualification level (prerequisite) to the final expected qualification level (learning outcome) through one or more assessment activities. The first version of the competence and qualification model for the Design Package was presented in the article (Florian-Gaviria, Baldiris, & Fabregat, 2010). This data model was modified later to adopt the EQF. Figure 3-4 shows in detail last unified data models behind this application.

Table 3-4 Mock-up to define an script of qualifications

Competence Description	EQF Level in Evaluation Activity 1	EQF Level in Evaluation Activity 2	...	EQF Level in Evaluation Activity N
Knowledge Domain: Area / Subarea /				
Knowledge in ...	[1 -8]	[1 -8]	[1 -8]	[1 -8]
...	[1 -8]	[1 -8]	[1 -8]	[1 -8]
Ability to	[1 -8]	[1 -8]	[1 -8]	[1 -8]
...	[1 -8]	[1 -8]	[1 -8]	[1 -8]
Responsibility to ...	[1 -8]	[1 -8]	[1 -8]	[1 -8]
...				

Instructions:
For each competence added, select the evaluation activities that assess the competence and mark the EQF level expected for the competence for each evaluation activity.
A competence can be assessed in one or more evaluation activities at different levels.
At least one of the evaluation activities must assess de final level (learning outcome) of the competence.

Regarding the *Run-time Package* design, *Assessment applications* of the suite were designed for a 360-degree evaluation, an individual is given feedback by everyone in his/her circle. For an educational lifecycle the circle of students is formed by the teacher, their classmates or peers, and him/herself. Therefore, to obtain a 360-degree feedback in evaluation the assessment applications must provide teacher assessment as well as peer assessment and self-assessment. The first versions of the 360-degree assessment applications were presented at (Florian-Gaviria, Baldiris, Fabregat, et al., 2010). Figure 3-5 illustrates the last core of data models for *Assessment applications.*

With the aim of providing a simple and automatic way of building tests for competences' qualification, tests using *scoring rubrics* were selected in this thesis as the best option (McKenzie, 2005; M. Griffin, 2009; Walser, 2011). Findings of the ICOPER project suggested to turn the competences qualification model to a more simple but useful one, that is, to take an alternative path from the IMS-QTI and IMS-RDCO specifications which aimed to link test's items (questions of summative assessment tests) with competences (Simon & Mirja, 2010; Rojas, Crespo, Totschnig, Leony, & Delgado Kloos, 2012). The models illustrated in Figure 3-4 and Figure 3-5 links a series of competences with a test not with summative test's items. This decision allows to cover many kinds of assessment and to build automatic tests with scoring rubrics from the script of qualifications. The EQF descriptors are used as descriptors of categories of the scoring rubric. The script of qualifications gives the rules of competences to be included in an evaluation and the expected level of qualification for each one. Thus, a matrix of descriptors and competences is built as a test with scoring rubrics for each evaluation. Table 3-5 gives an example of a test with a scoring rubric to assess knowledge competences of a particular evaluation.

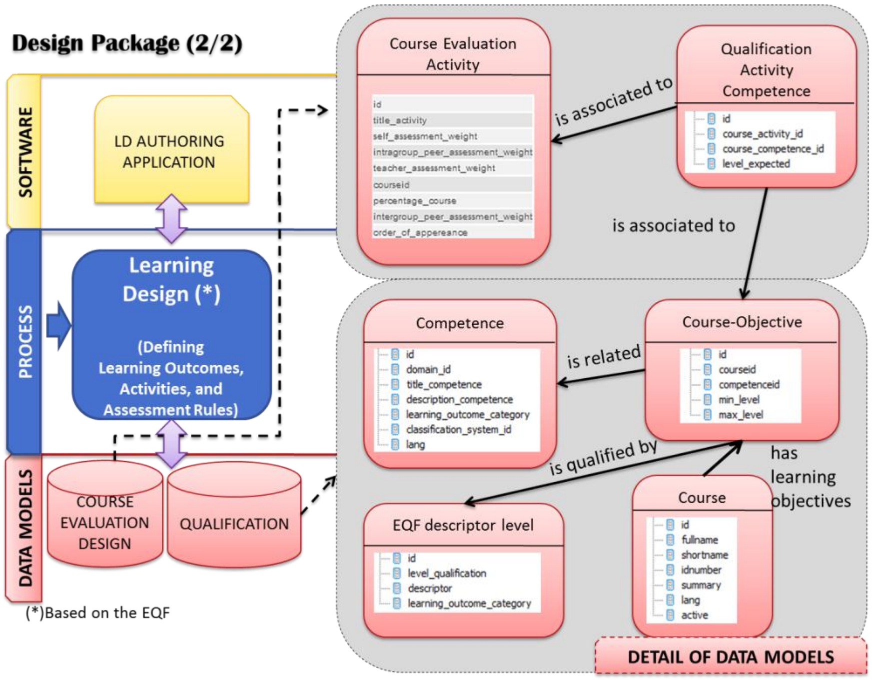


Figure 3-4 Detail of data models in LD authoring application

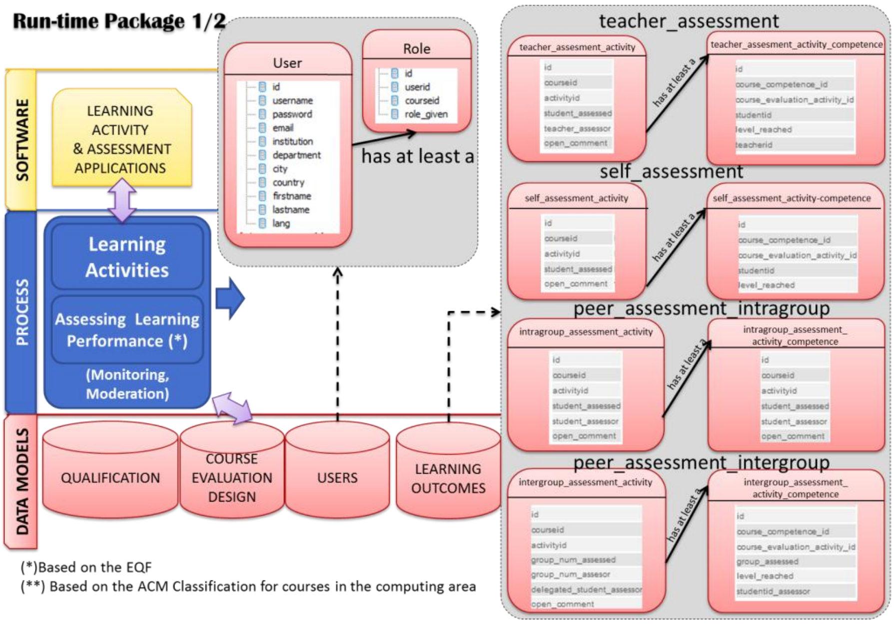


Figure 3-5 Detail of data models in assessment applications

Table 3-5 Mock-up of a qualification test for knowledge competences.

Competence	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Knowledge Descriptors of EQF Levels									
	Below level 1	Recall basic general knowledge	Recall and comprehend basic knowledge of a field, the range of knowledge involved is limited to facts and main ideas	Knowledge of facts, principles, processes and general concepts, in a field of work or study	Factual and theoretical knowledge in broad contexts within a field of work or study	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields
Knowledge in control of lineal systems	○	○	○	○	◉	○	○	○	○
Knowledge in digital and analogical control systems	○	○	○	◉	○	○	○	○	○
Knowledge in typical loop of analogical and digital control	○	○	◉	○	○	○	○	○	○

The *Learning Analytics Applications* allow monitor the learning progress and meaningful feedback. Its design was treated as special case with a separated technical architecture called Activity-based learner-models, detailed in the next section.

3.5 The Activity-Based Learner-Models

Most VLEs already provide functions that can be used for supporting activity-centred learning, but the related information is commonly unavailable in a structured form. Semantically structured learner models are required in order to provide technological support for more activity-centred assessment and feedback types. An activity-based learner model creates a semantic structure of dynamically generated learner properties that reflect observed actions of a learner. Activity-based learner-models are a prerequisite for activity-centred assessment and process support for competence development.

Contemporary competence models such as PALO (Najjar et al., 2010) and EQF (European Communities, 2008a; European Communities, 2008c; Zahilas, 2012) describe proficiency levels of competences according to types of activities that learners are capable to perform. Previous research proposed (Florian-Gaviria et al., 2009a) and implemented (Florian-Gaviria, Baldiris, Fabregat, et al., 2010) the *AEEA* for competence assessment. This architecture emphasizes the process factors for assessing competence developments over content-centred factors of conventional outcome-based assessment approaches.

Cheetham and Chivers (Cheetham & Chivers, 2005) define a competence as knowledge or theory-guided practice. This implies that a competence can be recognized only if it is demonstrated, reflected and used for guiding practice. In contrast to a skill that focuses on instrumental actions such as handling a specific tool, a competence requires more profound conceptual understanding of the underpinnings of the related practices as well as experiences in applying this understanding. Furthermore, a competence differs from a competency in so far that the former refers to the ability of linking knowledge with practices whereas the latter refers to knowledge about practice (Cheetham & Chivers, 2005).

The assessment of competence development relies on evidence that learners are able to perform actions that are related to a competence. This perspective emphasizes the relevance of the process for its results. Previous research suggested outcome centred testing as formative assessment of competence developments (Crespo et al., 2010). However, these approaches appear to be limited, because of the active nature of competence development.

The present design is grounded on two models: the Engeström's Activity Theory (see Section 2.3.2) and the Actuator-Indicator model (see Section 2.3.4) as pillars to implement an activity-based learner model in a VLE.

Outcome-based assessment focuses on the results of an activity and tries to deduce the success of an activity by comparing expected and delivered learning outcomes (Crespo et al., 2010). The activity itself remains a black box for such approaches. Activity-based assessment changes this perspective towards assessing the activities that lead to the outcomes. This includes the assessment of the appropriate applications of external rules, the interactions on and across social planes, and (if present) collaboration and co-operation among learners. All aspects of this kind of assessment contribute to the evidence that learners achieved the targeted competence levels.

From the perspective of the extended Activity Theory model the provisioning and exposure of analytical rules for accessing data in information systems remains a challenge for the effective application of learning analytics for supporting learners and teachers.

The main research question of this section addresses the need for structuring complex data resulting from activities in a learning environment. Moodle, like other VLEs, has only limited built-in support for learning analytics. The core components and extensions related to assessment focus on outcomes rather than the activities. Therefore, the question is: how to introspect learning activities for competence assessment and recommendations?

Integrating the concepts of the actuator-indicator model (see Section 2.3.4) with the Activity Theory (see Section 2.3.2) approaches this question. This integration is an attempt of structuring learning analytics techniques for designing solutions for activity-based assessment and recommendations that can be used by teachers and instructional designers in TEL.

The core of this question is primarily related to the semantic layer of the actuator-indicator model. An aggregator in this layer can be defined in terms of the Activity Theory as a rule that enables perspectives on activities that are performed on one or many social planes. As such every aggregator can be verified regarding its meaning for a perspective on a social plane. Figure 3-6 highlights the previous concepts within the extended Activity Theory model.

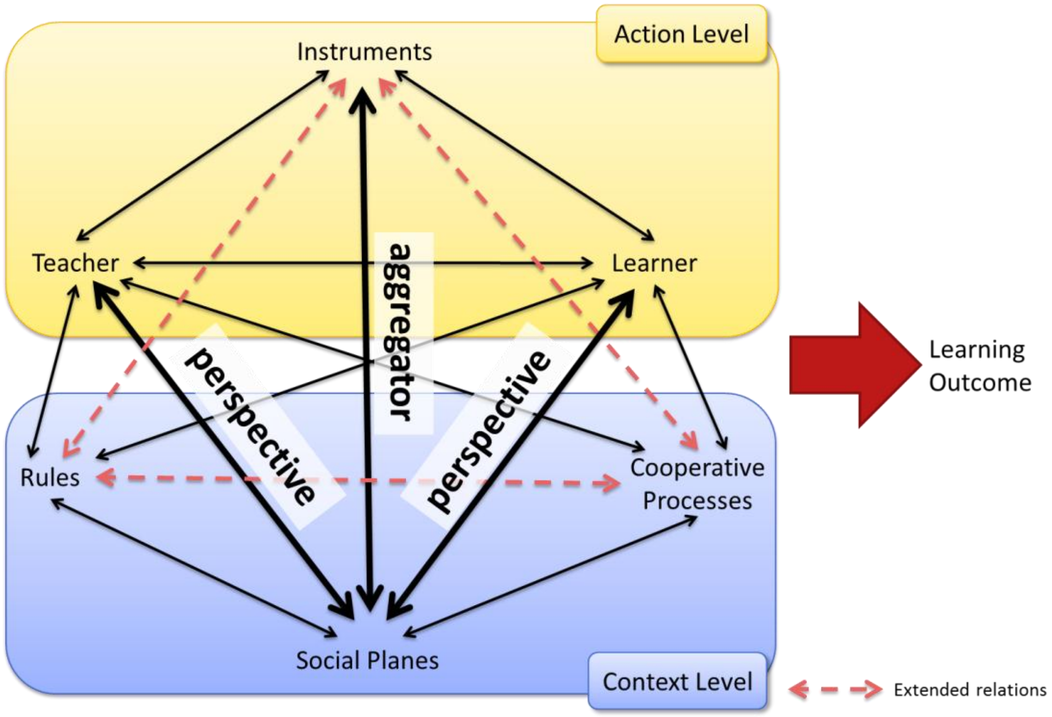


Figure 3-6 Research scope in relation to the extended Activity Theory Model (Florian-Gaviria et al., 2011)

The translation of Engeström's model (Engeström, 1999) to TEL, described in section 2.3.3 along with the layered structure (Zimmermann et al., 2005) described in section 2.3.4, are permeated in this section to propose an architecture to support learning analytics and recommendations. Figure 3-7 shows the layout of the overall architecture. The architecture uses the context information present in a VLE and adds some other components. The architecture allows the construction of dynamic learner models based on perspectives over social planes in activities. The models need to be capable of reacting to actions during the learning process.

The proposed architecture builds on the layers proposed by Zimmermann et al. (2005): Sensor layer, semantic layer, control layer and indicator layer. The activity-based learner model is related to the first two layers and the learning analytics solutions to the last two layers. In this section the components of the architecture are explained in relation to these two parts.

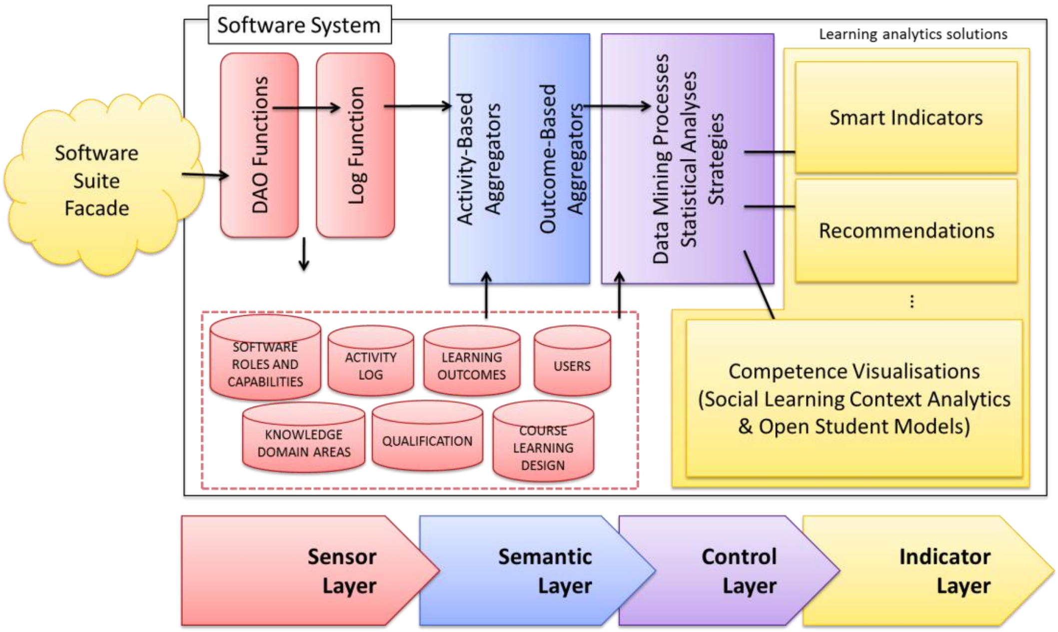


Figure 3-7 The Activity-Based Learner-Models technical framework (Florian-Gaviria et al., 2011)

The Sensor Layer. The purpose of this layer is to collect and to store traces of actions. Learners perform activities in the VLE. A VLE implements a detailed activity logging in its services. Consequently, it is not necessary to implement a separate sensor layer for tracking learner actions in a VLE, because the system already stores sufficient context information about the learners' interactions. Logs in VLE are created by a Log Function and stored in a database, which stores all interactions and allows structured querying and filtering of these data. These data can be used for identifying complex activities by integrating the access time, the active user, and the performed action.

By default only system administrators and teachers have access to activity reports and basic statistics in the most of VLE. For instance, some research about the use of Moodle Log Function were made previously (Verpoorten et al., 2009; Glahn & Specht, 2005). The former delineated and documented a perspective on personalisation based on the mirroring of personal tracked data to the user; the latter is a conceptual paper which analyses the underlying concepts for a system-architecture for device adaption for mobile learning, integrating a VLE into ubiquitous computing. In addition, tools for teachers and administrators feedback in VLEs are usually the report logs and the report statistics. The log reporting and statistics are drawn from the database.

The Semantic Layer. This layer processes the data collected by the sensor layer into semantically meaningful information. At the level of the semantic layer several aggregators can be active to process the traces of learning activities and learning outcomes. Aggregators are the engine to implement the extended Engeström's Activity Theory with role perspectives over social planes (see Figure 3-6). The following aspects constitute an aggregator.

- An Aggregation rule represents an SQL query that processes user tracking database. Each aggregation rule returns the result data to the JSON format that can be easily interpreted by web-frontends. Each aggregation rule can get accessed through a distinct name that represents the analytic function of the rule.

- The context is used for filtering a social plane of the learners. The social planes implemented so far are: a student, teammates, and class. The context "a student" includes only the data of the learner, who requests the data from the system. The context "teammates" includes either the data of peers in a collaborative group or all other learners who are enrolled in the same courses as the learner excluding the data of the current user. The context "class" includes all learners who are enrolled and active in the course. The context is passed as a parameter to the aggregation rule.
- Role-based perspective on the data is automatically applied based on the current role of the requesting user. Students have only access to the contexts 'self' and – anonymous – to those of the 'teammates' context. Teachers have access to all details of the aggregated information. When teachers make a request using the context 'self' or 'peer' an extra parameter is required for identifying the related student for whom this context will be applied.

In summary, each aggregation rule can be limited to a perspective over a different social plane of the learner and to a specific course.

Other semantic information is stored in the VLE database. For instance, in order to support competence development and competence assessment, the semantic layer requires a competence model and an assessment plan. Database tables to express the competence model based on the EQF were created for the semantic layer. Similarly, tables to express the assessment plan were integrated. The competence model defines the ontology of competences, their levels of qualification and activities related to each level of competence. The assessment plan defines how actions in a course relate to the competence model and how they contribute to the evidence on the competence development of a learner. Other examples of semantic information stored in the VLE database are the structure of roles and capabilities to classify the type of users and theirs permissions in the system. The capabilities in VLEs can be applied to many levels such as: activity, course, system and so on.

The Control Layer. This layer defines the arrangement of the aggregators and the visualisations that are used for mirroring. The control layer is implemented as a plug in that provides several widgets that can be independently integrated into the user interface of a course. Each widget contains a set of aggregators and visualisations, which can be configured by the instructor of a course. Through a context parameter an instructor can define the scope of the data that is returned by the selected aggregator. In the case of recommendations an aggregator implements the data mining algorithms. In this layer the competence model and the assessment plan are data inputs to process the recommendation strategies and the indicators of competence analytics. A recommender system is planned for further research. Using this architecture, these recommender systems will be based on learning analytics.

The Indicator Layer. This layer provides different presentation modes for the data of the control layer. The indicator chooses the presentation mode based on the configuration of the indicator layer and receives the data from the control layer. So far the indicator layer shows smart indicators, competence analytics and an open user model whose parameters are the context and the tracked activity. The indicator layer is embedded into the user interface through a JavaScript (JQuery).

Figure 3-8 illustrates the technology behind the implementation of activity-based learner-models.

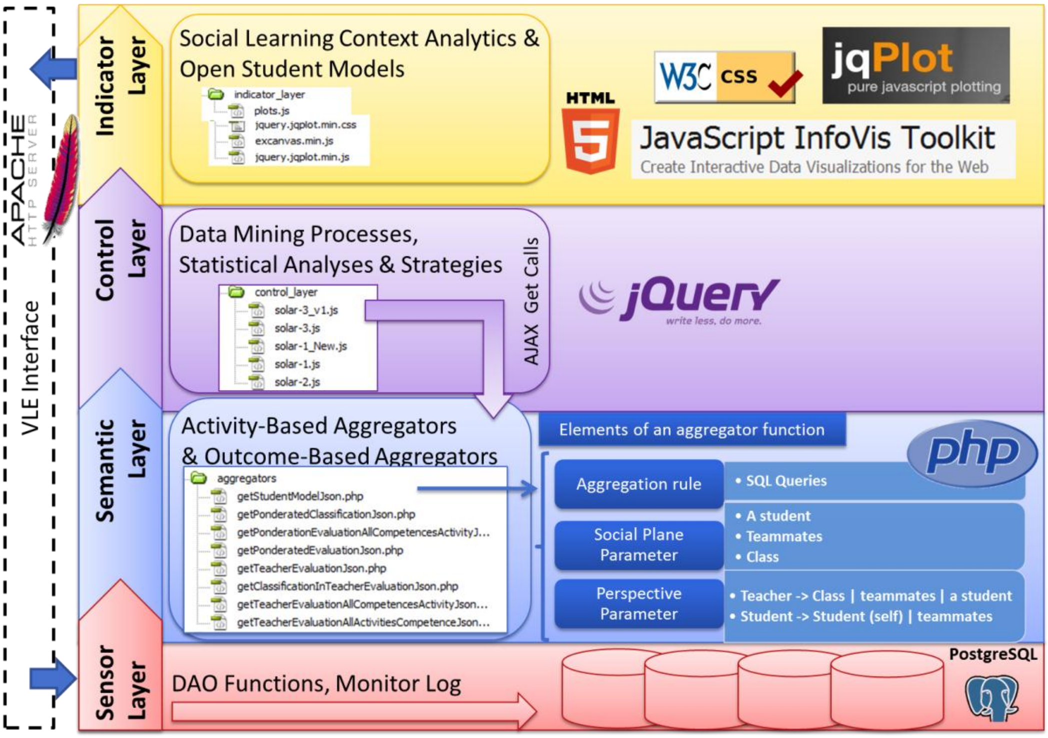


Figure 3-8 Technology behind activity-based learner-models

3.6 The AEEA Software Suite Model

This section shows the final design made for a software suite that allows educators in higher education to embed the EQF into their learning design and educational practice of online and blended teaching. Moreover, this suite supports teachers and students in monitoring and moderating competences' development during a university course lifecycle. The definition of competences and learning outcomes is based on the EQF.

This software suite is based on the AEEA framework and activity-based learner-models explained in preceding sections. Thus, the AEEA Software Suite (at this moment) is a set of four fully implemented Web 2.0 applications:

1. ONTO-EQF
2. CC-DESIGN
3. RUBRICS-360
4. SOLAR

These applications are independent of any learning environment. This software suite is the materialisation of the general proposed framework of this thesis that combines

Personalised, competence-based, and social learning. Figure 3-9 depicts the architecture of the overall software suite.

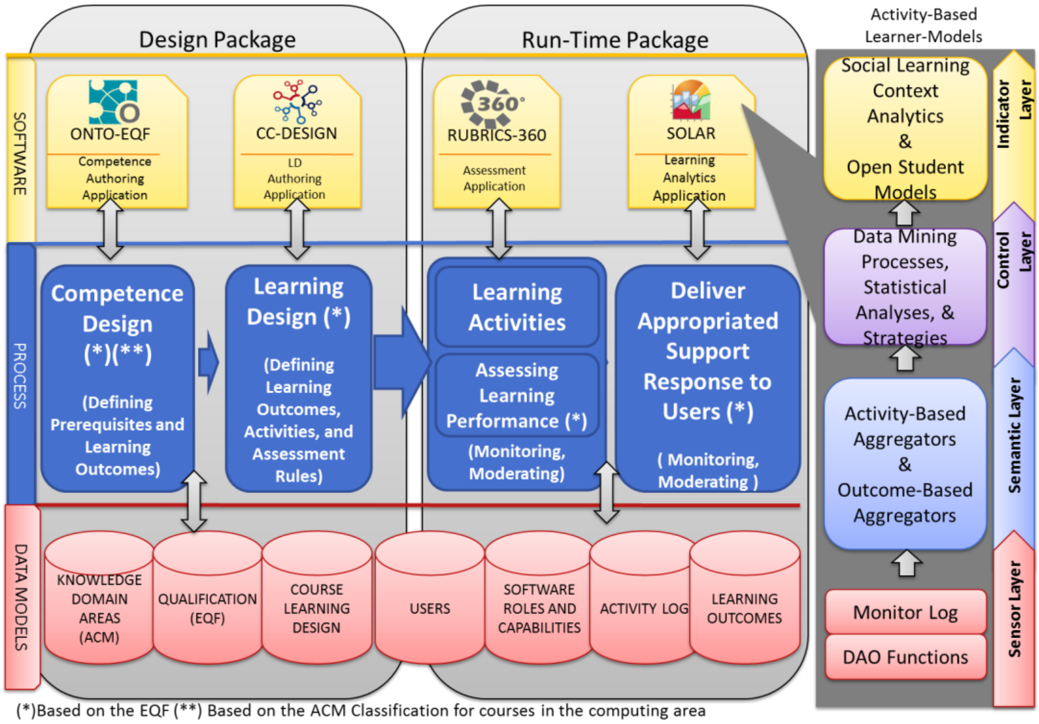


Figure 3-9 The AEEA software suite

General speaking, the AEEA Suite was built with the aim of provide suitable support for:

a) Mapping of learning objectives of a study course to the EQF.
b) Understanding how certain user activities are related to EQF competences.
c) Facilitating assessment of competences in higher education.
d) Triggering awareness, reflection and self-regulation during the learning process.
e) Detecting failure and success of students in development of competences. Moreover, good students and bad students. In addition, possible learning-design errors in a course.

To do so, the AEEA Suite implements some mechanisms, as mentioned in former sections, such as: authoring of EQF competences, learning design for competences qualification, a 360-degree assessment, competences' development monitoring, activity-based learner-models, open social learning analytics, and open social student model.

Table 3-6 gives a brief description of AEEA Suite applications. Currently, the AEEA Suite is being tested on computing courses where the ACM Computing Classification System is used to select knowledge domains. Chapters 4 to 7 are dedicated to explain the implementation of the AEEA Suite and case studies.

Table 3-6 Brief description of AEEA Suite applications

Application	General Description
Design Time Applications	
ONTO-EQF	It is an authoring tool of competences. To set, edit, and share a repository of competences for courses based on the EQF.
CC-DESIGN	It is a design course tool. To design a plan of activities and the expected level of qualification for competences involved in these activities.
Run-Time Applications	
RUBRICS-360	To provide a 360° formative assessment of competences (self-assessment, peer-assessment and teacher-formative-assessment) for courses. The assessment tool is based on scoring rubrics.
SOLAR	To provide Social Learning Context Analytics Research about learning outcomes and performance of students. The analytics are showed for different social perspectives (teacher, student) with different social planes (a student, teammates, class).

3.7 Contributions and Conclusions

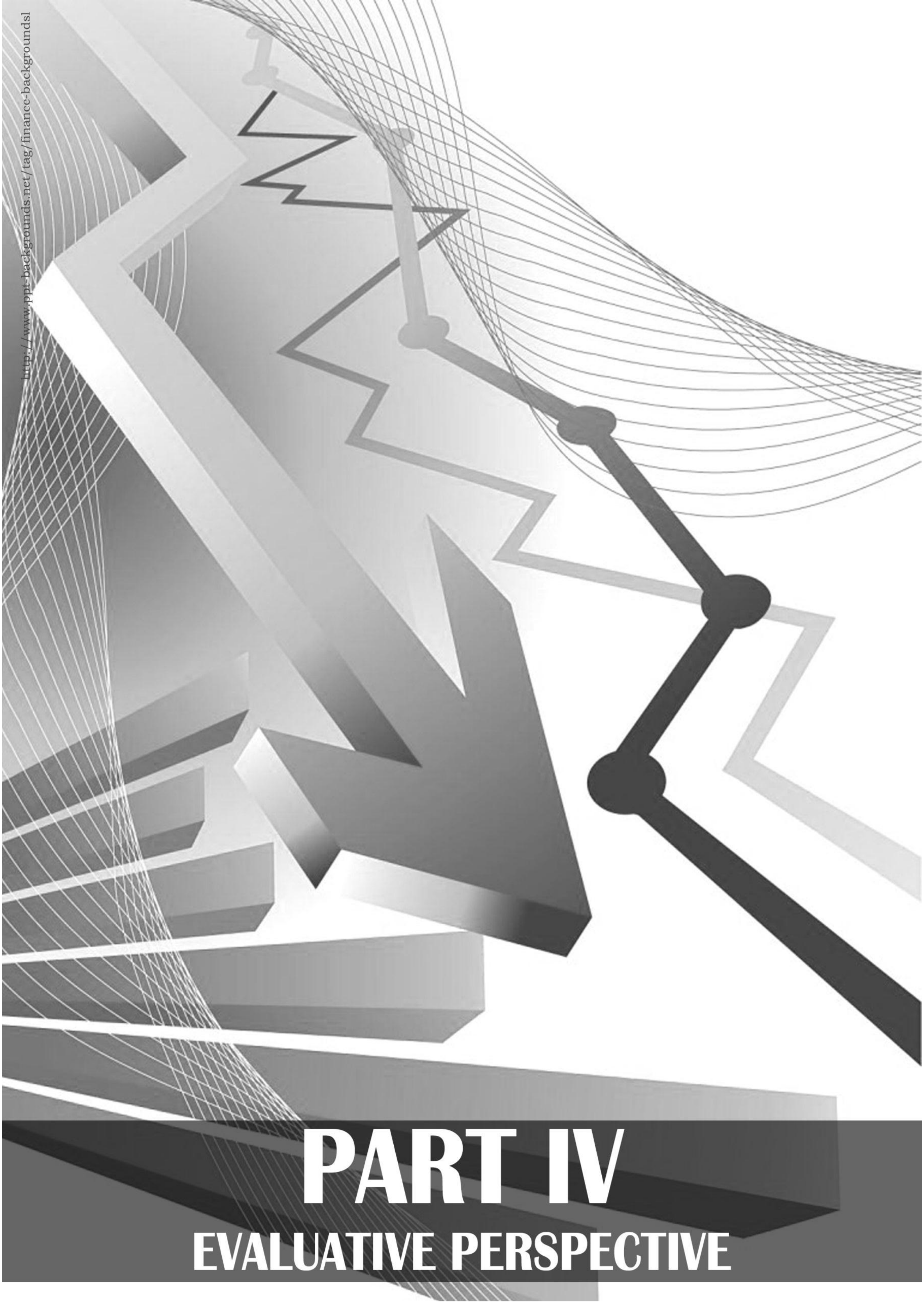
In this chapter was exposed mainly the analysis and design of the thesis proposal.

The first task was concern with the definition of a course life cycle for online and blended courses. The course's lifecycle proposed introduces the EQF as base for each step of design time and run-time. Thus, a personalised and competence-based course lifecycle would be performed in higher education.

Regarding to the first research question to be answered here, two technological frameworks were designed to clarify information elements, procedures and software applications that are needed to build a technical and pedagogical architecture to support competence development in higher education. The *AEEA* clarifies a general framework for personalised and competence-based courses while the *Activity-Based Learner-Models* dig more onto perspectives for social learning.

On the other hand, the second research question was answered through the design of the *Activity-Based Learner-Models*. In particular, the semantic layer of this framework clarifies how to collect data from the database and logs of VLEs and how to build aggregators taking into account different perspectives on social planes. That is, a way to implement the Engeström's activity theory within an educational technological framework for semantic enrichment of the data. Further layers, clarifies how to deliver any semantic enriched information to layers in charge of data analyses and visual representations. Some of the proposed visualisations are social learning analytics, open student models, and recommendations.

Although analyses and usability tests have been performed in order to build TEL recommender systems (Florian-Gaviria & Fabregat, 2011), implementations for those are let as future research work.



PART IV

EVALUATIVE PERSPECTIVE

CHAPTER 4

SUPPORT OF SOCIAL AUTHORING OF EQF COMPETENCES IN HIGHER EDUCATION

This chapter is dedicated to present the findings of a teacher's case study and survey related to support of EQF competences authoring in higher education courses. The case study was carried out using the software application called ONTO-EQF. ONTO-EQF is the first web application of the AEEA Suite developed with research purposes for this thesis. The case study was performed in the fall semester of 2011 using three courses in programming. In total, 20 teaching persons participated. Six of these teaching persons were females and the other fourteen males. The range of age was between 24 and 48-year-old. The number of enrolled students for the first course was 100, for the second and third course 20 students each one.

This chapter is organized as follow. First, and introduction and the research questions to be answered in the case study are presented. After that, the research scope is clarified. Once research questions and research scope of this chapter are outlined, the user objectives (teacher's objectives) are presented. Before describing the case study, a section presents an overview of ONTO-EQF application highlighting justifications for some decisions. Then, the case study with teacher's perspective is described. Finally the results, discussion and conclusions are pointed out.

4.1 Introduction

Technology-enhanced competence-based education attracted the interest of the TEL research community. Several European projects have inquired in how to model and represent competences in a way so as to allow its interchange in a standard and consistent way between different systems (see previous Table 1-1).

Nevertheless, new agreements for LLL in Europe such as the EQF need to be taken into account generating a number of open issues and challenges for technology-enhanced competence-based education modelling. For instance, *How to cover the whole range of knowledge areas needed to model EQF competences in higher education? How to support teachers to adopt perspectives towards the EQF in their teaching design?*

Some authors argued that competence-related information may refer not only to student's competence profile, but also to education curricula that were developed (Sampson & Fytros, 2008). In this way, efforts have been done with the standardization of European curriculums at national level. Countries of the *European Higher Education Area*

(EHEA) develop their NQF to translate their curriculums to EQF competences. Even, it is expected for the future that instruments such as the Europass references not only EQF competences but also EQF levels of qualifications attained by a student. However, inside of European higher education institutions, the management of EQF competences is not supported at course level. That is, European teachers are not really concerned with referencing EQF competences in their courses. Thus, important learning outcomes are not taken into consideration for the lifelong student's portfolio. It is worth noting the vision of referencing EQF levels of qualification for Europass and other instruments would be better supported with a monitoring of EQF competence development at course level.

4.2 Research Questions

The main research question of this chapter addresses the need for structuring a suitable methodology for teachers to carry out authoring of EQF competences in their courses for a competence driven LLL. As was said in Chapter 3, teachers need data models and applications to support their work in a process from authoring of EQF competences to complex data analyses and feedback according to the EQF. Therefore, for the first step of this process the research questions are:

> *How can teachers make effective use of European standards for designing their lessons? More precisely, How teachers can make effective use of the EQF for map the objectives of their courses to a competence-based model? (Contribution to answer RQ-4 of this thesis)*
>
> *How can teachers be more aware and reflect about the underlying competences in university courses? (Contribution to answer RQ-.5 of this thesis)*

Integrating the concepts of 1) The AEEA to define a competence driven learning process, 2) The competence qualification framework EQF as base model in designing and implementing of ONTO-EQF application, and 3) The ACM Computing Classification System to select universally recognized knowledge domains in computing, approaches this question. This integration (see Figure 3-3) is an attempt of structuring a software application to support a methodology in authoring of competences that can be used by teachers and instructional designers in TEL. This integration is based on a unified definition of competence, which serve as the basis for developing a common competence model within for authoring of competences in the competence development lifecycle.

4.3 Scope of Research

ONTO-EQF application was made with the purpose of support a wide range of teachers in higher education; nevertheless test processes with teachers involve several difficulties that in somehow constrained the research scope of this chapter. The next paragraphs describe the difficulties and constrains of research for this chapter.

The first difficulty in the test process were university policies that forbidden installation of new plugins in the institutional Moodle. Two universities were involved in this case study namely: UdG and UNIVALLE. Both of them raise this barrier. Due to this restriction, the final version of ONTO-EQF was developed as an independent web application from the Moodle systems of UdG and UNIVALLE and, it was deployed in a server of the BCDS research group of UdG. Thus, teachers of UdG and UNIVALLE could use the institutional Moodle and perform the competence authoring tasks in ONTO-EQF application of the AEEA Suite. The technology used to construct ONTO-EQF and, its architecture is compatible with Moodle's development directives. Thus, it will allow in a future to have a version of ONTO-EQF as plug-in of the Moodle system.

The second difficulty was to involve teachers in the case study. Without a fully institutional support, the invitation to participate in the case study was limited to some courses of the Polytechnic School of UdG and the Engineering Faculty of UNIVALLE. Both institutions offer engineering courses. In consequence, courses used in the case study belonged to engineering curriculums.

The third difficulty was to involve teachers for a long period of time. The case study with the ONTO-EQF application require at least a semester or a year in the study. Throughout 2011, only 20 teachers from two countries and three different engineering courses were willing to participate doing the extra work.

Last but not least, there is an extra difficulty to face with teachers case studies. Not all involved teachers taught the same subject. As consequence, several courses need to be mapped to the proposed EQF competence-based framework, the former implied big resources of time in order to assist teachers in design tasks.

Other teacher and courses with different pedagogical strategies joined to the case studies during the 2012. Nevertheless, until now, a comparative study with the perspective of teachers using different pedagogical strategies is not viable due to little number of teachers for each pedagogical strategy.

The perspective of students is not explored for the ONTO-EQF application because they do not need to perform authoring of competences. ONTO-EQF application is devoted to the teachers' perspective.

4.4 User's Objectives in Authoring of Competences

4.4.1 Teachers' Objectives

The AEEA Suite supports the use of the EQF throughout the lifecycle of higher education courses. A first challenge that teachers face is how to map the objectives of their course to the EQF. The vision of this thesis is that mapping starts with the task of authoring of suitable EQF competences for lessons of a course. In particular, for authoring of EQF competences, the ONTO-EQF application and background data models are integrated to achieve the next teachers' objectives:

1) Teachers were invited to define a core of competences based on the EQF for their lessons. Moreover, in order to have a collaborative software application, the competences need to be classified by universally recognized knowledge domain areas.

2) Teachers were also invited to define prerequisites and learning outcomes for their courses.

4.5 The ONTO-EQF Application

The first application of the AEEA Suite that teachers used was ONTO-EQF. This is an authoring application of competences to set, edit and share a set of competences based on the EQF. Figure 4-1 shows the overview of the ONTO-EQF interface. This interface layout is inspired in the one successfully used for the authoring tool of the MACE project.

Teachers surf the knowledge domain areas in the upper left table. See Figure 4-1a and Figure 4-2. For this case study in the area of Programming the knowledge domain areas were organized based on the ACM Computing Classification System (Association for Computing Machinery, 1998). For other knowledge domains the system allows to add more classification systems. Thus, the whole range of knowledge domain can be supported in this application. When a knowledge domain area is selected, the associated competences are displayed above. See Figure 4-1b and Figure 4-3, Here, more competences can be added, edited or deleted (see Figure 4-4 and Figure 4-5). After selecting a competence the corresponding EQF qualification descriptors are displayed at the rightmost table (see Figure 4-1d and Figure 4-6). These descriptors define eight levels of qualification for the type of learning outcome of the competence (knowledge, skill, or wider competence). The selected competence can be added to the course using the button “Add to course” (Figure 4-1c). After clicking the “Add to course” button an emerging window ask to the teacher the initial level (prerequisite) and the final level (learning outcome) of qualification expected.

In Figure 4-1 the knowledge domain area selected is Object-Oriented Programming; the competence selected is Knowledge in characterization of object-oriented programming; the learning outcomes of this competence are “knowledge”, that is why the descriptors showed at the rightmost table are the eight EQF descriptors of knowledge.

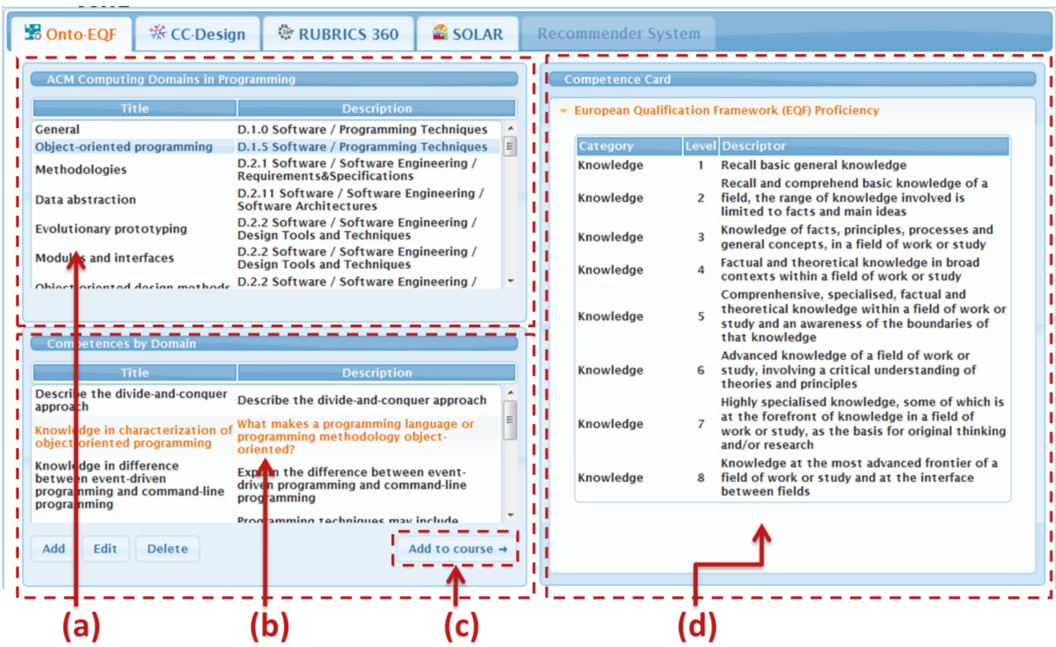


Figure 4-1 Overview of ONTO-EQF application

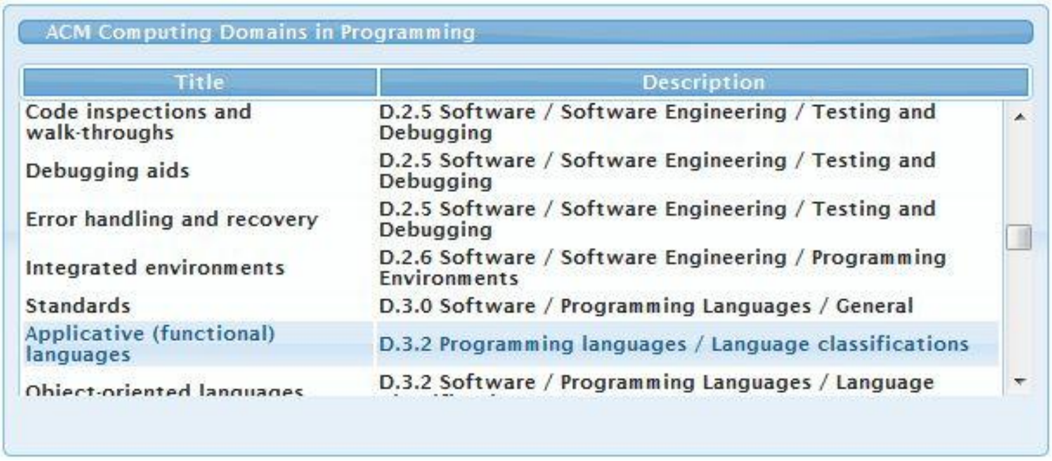


Figure 4-2 Detail of interface to select knowledge domains

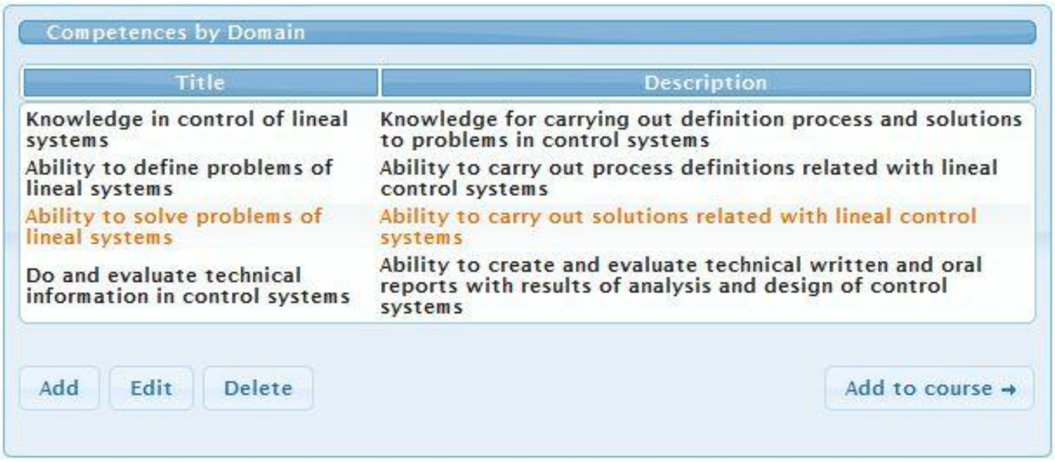


Figure 4-3 Detail of interface to manage competences

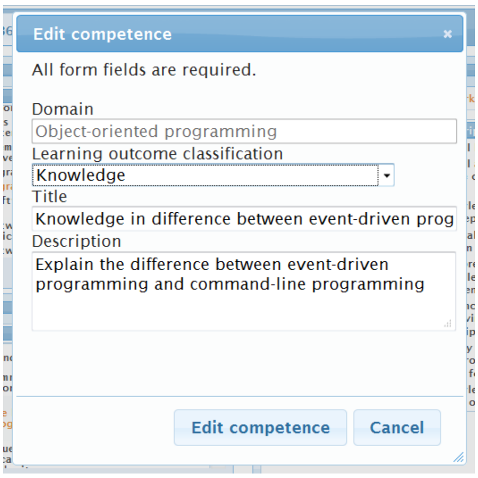


Figure 4-4 Dialog window to edit a competence

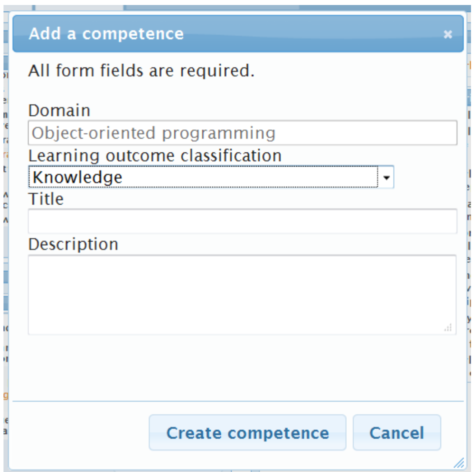
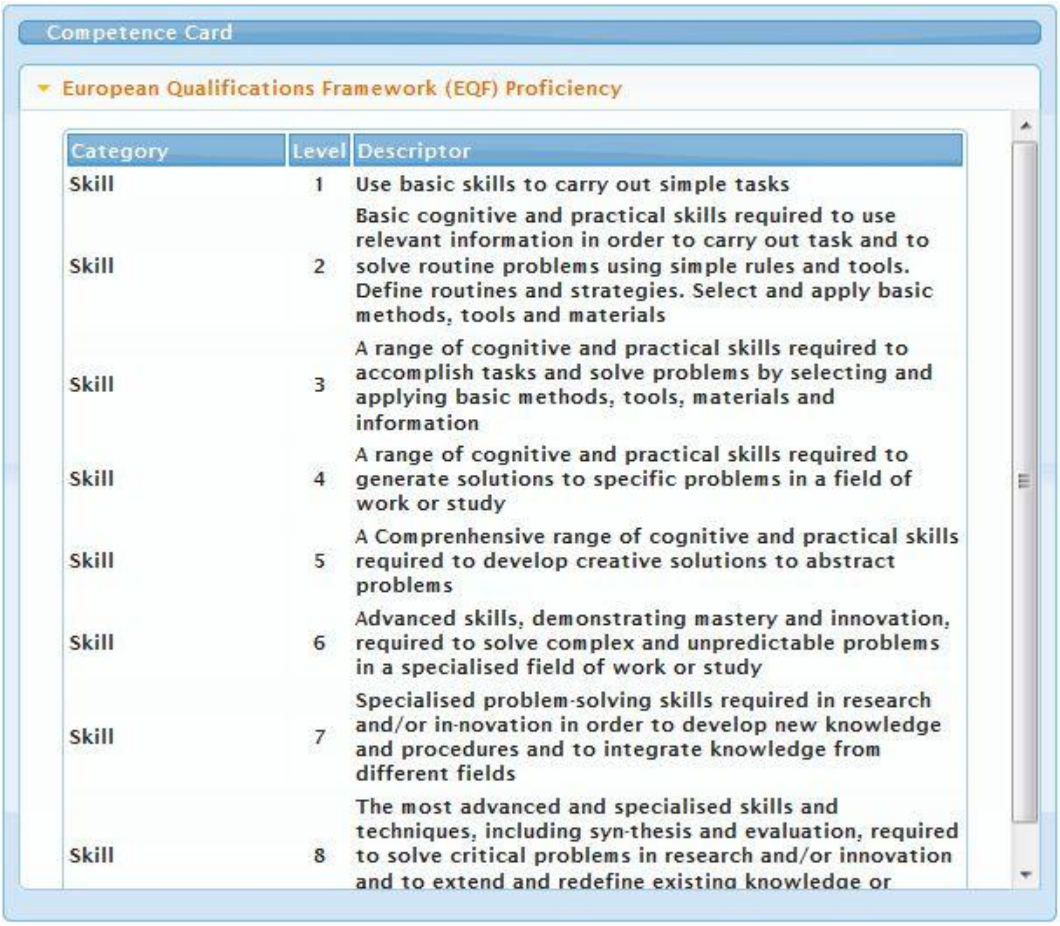


Figure 4-5 Dialog window to add a new competence



Category	Level	Descriptor
Skill	1	Use basic skills to carry out simple tasks
Skill	2	Basic cognitive and practical skills required to use relevant information in order to carry out task and to solve routine problems using simple rules and tools. Define routines and strategies. Select and apply basic methods, tools and materials
Skill	3	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information
Skill	4	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study
Skill	5	A Comprenhensive range of cognitive and practical skills required to develop creative solutions to abstract problems
Skill	6	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Skill	7	Specialised problem-solving skills required in research and/or in-novation in order to develop new knowledge and procedures and to integrate knowledge from different fields
Skill	8	The most advanced and specialised skills and techniques, including syn-thesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or

Figure 4-6 Detail of interface of competence card

4.6 Teachers Case Study and Survey

This case study explores the social perspective of teachers. It was performed in the fall semester of 2011 using three courses in programming[1]. In total, 20 teaching persons participated: 12 computer science teachers (4 of them were coordinator-teachers. A coordinator-teacher is who oversee the rest of teachers in courses with massive students distributed in multiple groups), 8 computer science teaching assistants. Six of these teaching persons were females and the other fourteen males. The range of age was between 24 and 48-year-old. The number of enrolled students for the first course was 100, for the second and third course 20 students each one.

Teachers were asked to use ONTO-EQF during a complete semester to evaluate whether this application could assist them in to be more aware and reflect about the

[1] *Fundaments of Programming*. Course UNIVALLE. Description available on:
http://eisc.univalle.edu.co/archivos/programas/programafp.pdf
Interactive Programming. Course UNIVALLE. Description available on:
http://eisc.univalle.edu.co/archivos/programas/750085M%20-%20ProgramacionInteractiva.pdf
Data Structures and Algorithms. Course UdG (3105G07010/2011). Description available on :
http://www.udg.edu/Guiadematricula/Dissenyassignatura/tabid/15700/Default.aspx?curs=2011&codia=3105G07010&codip=

underlying competences in their courses. The usefulness of the ONTO-EQF in order to include the perspectives of the EQF in authoring of competences was also evaluated.

Teachers needed a previous training to learn how to authoring EQF competences and they also required preliminary instructions regarding ONTO-EQF. To do so, several sessions of one-hour meeting were conducted for each course. In the case of Colombian courses, meetings were performed via Skype. In the case of Spain courses, face meetings were arranged. At least two sessions for each course were needed to complete the mapping of course's objectives to the EQF competences and levels of qualification. In these meetings a cognitive overcharge was revealed in teachers because they were not familiarised with the EQF and the ACM Classification System. So, they needed to understand these models and also they needed to learn how to work with ONO-EQF. Thus, the task of describe course objectives was completely different from the way teachers used to do it.

To give an example of results Figure 4-7 gives an overview of EQF competences authored for course *Data Structures and Algorithms*.

A survey was designed to measure teachers' opinion. The survey was divided in seven sections, one section to collect demographic data. Then five section to inquire about: usefulness, easy of using, easy of learning, satisfaction, and issues of privacy and data sharing. Finally, it was a section to give the opportunity for open comments. Questions were mainly designed to measure opinion of teachers after the test period. The questions were formulated in a variety of types, including open questions and 5-point Likert scales with single choice questions. In the case of 5-point Likert scales, 1 always means *Strongly Disagree* and 5 *Strongly Agree*. The question items of the survey are presented in APPENDIX D.

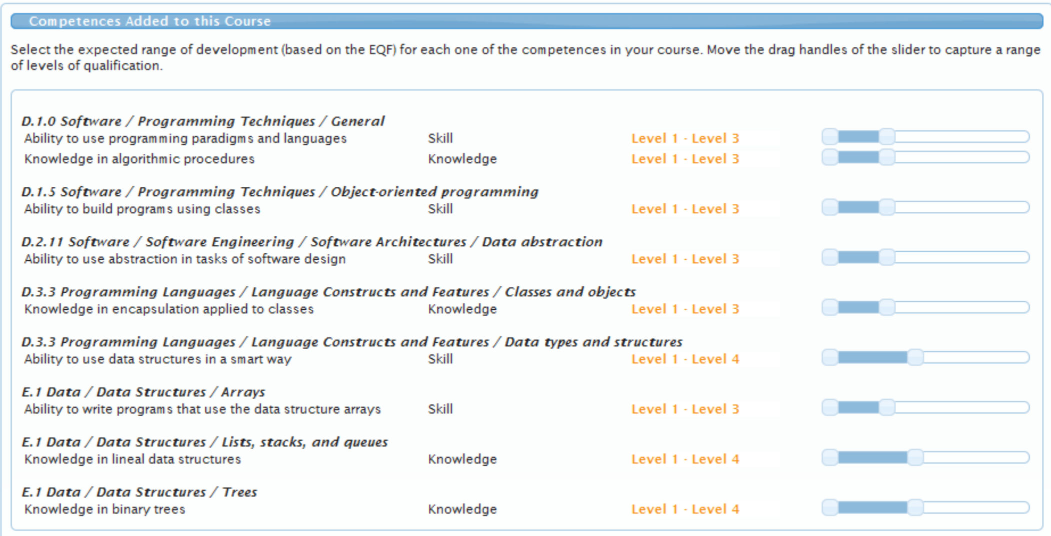


Figure 4-7 Knowledge Domains, EQF competences, prerequisites and learning outcomes for the course "Data Structures and Algorithms"

4.7 Results

Once teachers completed the courses, they filled in the designed survey to evaluate their opinion about ONTO-EQF. In this survey, teachers answered open questions about how well they understood the application and tasks, if they used some strategies to complete the process, how they achieved the proposed objectives, if they had some advice to improve the application, if they had suggestions for new ways of interaction, if they needed extra information or new abilities to perform the proposed tasks. In addition, in order to know how many teachers were pleased, they answered a series of questions where they had to choose the most appropriate response of a 5-point Likert scale from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). Finally, at the end of the survey a space was left to additional comments. The report on the results is organized along the lines of five segments namely: usefulness, easy of using, easy of learning, satisfaction, and issues of privacy and data sharing. Table 4-1 summarizes frequencies (n) and percentages (%) for ONTO-EQF evaluation.

Table 4-1 Frequencies and percentages for ONTO-EQF evaluation

Strongly Disagree (1)		Disagree (2)		Neutral (3)		Agree (4)		Strongly Agree (5)		Total	
n	%	n	%	n	%	n	%	n	%	n	%
Usefulness											
B1) ONTO-EQF helps me to design how the class objectives are described in terms of EQF competences											
0	0%	0	0%	3	15%	9	45%	8	40%	20	100%
B3) Defining course objectives in this way provides useful enriched information than the way I used to do it											
0	0%	0	0%	8	40%	10	50%	2	10%	20	100%
B4) ONTO-EQF helps me to be aware of the underlying EQF competences of my course											
0	0%	0	0%	4	20%	7	35%	9	45%	20	100%
B6) ONTO-EQF helps me to reflect about the underlying EQF competences of my course											
0	0%	0	0%	4	20%	9	45%	7	35%	20	100%
B8) ONTO-EQF helps me to start my teaching work plan											
0	0%	0	0%	8	40%	11	55%	1	5%	20	100%
B10) ONTO-EQF helps me to access other teachers' competence definitions											
0	0%	0	0%	4	20%	12	60%	4	20%	20	100%
B12) ONTO-EQF helps me to understand levels of qualification (Level 1 to Level 8) related to learning outcomes (Knowledge, Skill, Wider Competence)											
0	0%	0	0%	2	10%	9	45%	9	45%	20	100%
B14) The EQF is suitable as framework for authoring of competences in higher education											
0	0%	0	0%	2	10%	16	80%	2	10%	20	100%
B15) Higher education European teachers need authoring tools for EQF competences											
0	0%	2	10%	5	25%	10	50%	3	15%	20	100%
B16) It is good idea to classify competences in universal knowledge domains											
0	0%	3	15%	9	45%	8	40%	0	0%	20	100%
B17) The ACM classification system is appropriated to browse computing knowledge areas											
0	0%	0	0%	2	10%	18	90%	0	0%	20	100%
B.18) It was easy to accomplish de task of authoring of competences for a course											
0	0%	3	15%	4	20%	13	65%	0	0%	20	100%
Ease of Use											
C1.The instructions to perform authoring tasks were clear											
0	0%	0	0%	5	25%	11	55%	4	20%	20	100%
C2. The interface is easy to use											
0	0%	0	0%	2	10%	12	60%	6	30%	20	100%
C3. The interface is user friendly											
0	0%	0	0%	2	10%	10	50%	8	40%	20	100%

C4. The interface requires the fewest steps possible to accomplish what I need to do with it											
0	0%	0	0%	2	10%	14	70%	4	20%	20	100%
C5. I prefer a graphical visualisation of the competence classification, like a network graph											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%
Ease of Learning											
D1) I learned how to use the interface quickly.											
0	0%	0	0%	2	10%	10	50%	8	40%	20	100%
D2) I easily remember how to use the interface.											
0	0%	0	0%	2	10%	11	55%	7	35%	20	100%
D3) It is easy to learn how to use the interface.											
0	0%	0	0%	1	5%	13	65%	6	30%	20	100%
Satisfaction											
E1. I am satisfied with the interface.											
0	0%	0	0%	1	5%	14	70%	5	25%	20	100%
E2. The interface is pleasant to use											
0	0%	0	0%	2	10%	16	80%	2	10%	20	100%
E3. ONTO-EQF supports the EQF in an appropriate way											
0	0%	0	0%	2	10%	14	70%	4	20%	20	100%
E4. I would recommend ONTO-EQF to my colleagues.											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%
E5. I am satisfied with the sharing capabilities for design competences											
0	0%	0	0%	5	25%	9	45%	6	30%	20	100%
E6. I would like a recommender system that suggests competences based on selections of teachers with similar courses											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%
Privacy and Data Sharing											
F1. I like the idea of comparing my design with other teachers with similar courses											
0	0%	0	0%	6	30%	9	45%	5	25%	20	100%
F2. I feel comfortable sharing my competence definitions with others.											
0	0%	2	10%	3	15%	10	50%	5	25%	20	100%
F3. I do not mind that my course design be anonymously share with other teachers											
0	0%	2	10%	9	45%	7	35%	2	10%	20	100%

Regarding usefulness results show teachers thought ONTO-EQF supports them to reach planned objectives, namely:

- Design how the class objectives are described in terms of EQF competences with a percentage of 85% (see QB.1:.Agree 40% + Strongly Agree 45%). Open answers about how teachers felt they did this mapping (QB.2), all agreed to mention they did it by transforming course objectives into competence development ranges.
- To be aware of the underlying EQF competences of a course with a percentage of 80% (see QB.4: Agree 35%+ Strongly Agree 45%). Open answers about how teachers felt they did it (QB.5) indicate they gain awareness by completing their courses competence authoring.
- Reflect about the underlying EQF competences of a course with a percentage of 80% (see Q.B6: Agree 45% + Strongly Agree 35%). Open answers about how teachers felt they did it (QB.7) specify they reflect during the competence authoring because teachers needed to think carefully about the semantic context (ACM classification and EQF framework) to set each competence. Another way of reflection mentioned was when teachers analyse competences authored by other teacher that could be valuable for their own courses.

With respect to underground models teachers found the EQF (see QB.14: Agree 80% + Strongly Agree 10%) and the ACM Computing Classification System (see QB.17: Agree

90%) as good bases for the purposes of ONTO-EQF, the both questions with a high agreement of 90%. In addition, teachers thought ONTO-EQF help them to understand clearly the EQF learning outcomes with a percentage of 90% (see QB.12: Agree 45% + Strongly Agree 45%).

Taking note of lower ratings, the task of authoring competences was not so easy for teachers with results with only 65% in the category of Agree (see QB.18: Agree 65%).

Focusing on contrast ratings, it is important to note differences between satisfaction with sharing information and the desire of privacy. It was notorious that teachers were satisfied with the sharing capabilities with a percentage of 75% (QE.5: Agree 45% + Strongly Agree 25%) and they were willing to share their competences definitions with a percentage of 75% (QF.2: Agree 50% + Strongly Agree 25%) but they were not interested in share the entire course design with a percentage of 45% (QF.3: Agree 35% + Strongly Agree 10%).

In connection with future proposals, a specific recommender system idea was well received by teachers with a percentage of 80% (QE.6: Agree 40% + Strongly Agree 40%). Likewise, the indication of transforming the user navigation to a visual representation was keen reception with a percentage of 80% (QC.5: Agree 40% + Strongly Agree 40%).

4.8 Discussion

This research was conducted with the aim of fill the gaps between the EQF objectives in higher education and the practical way of link them in online and blended courses. Therefore, the interest is to validate not only ONTO-EQF but also the whole united models proposed to the competence authoring process for a course based on the EQF. It is pleasant to find out high satisfaction between teachers with the process and the united models. Moreover, teachers suggest building this kind of software as institutional applications in Universities. It is also satisfactory that the objectives for teachers in ONTO-EQF were achieved by them. Additionally, according with the results the application seems to be well implemented and with a suitable theoretical background. Therefore the ONTO-EQF supports a methodology for designing competences for courses in higher education using both the EQF, and a social collaboration strategy among teachers.

Although authoring design task was reported as difficult, teachers reported enriched useful information as outcome of authoring of EQF competences with ONTO-EQF. Maybe they found design tasks difficult because this case study was the first experience, for many of them, with a course based on the EQF. Even, it was the first experience in the area of competence-based education. It is necessary to carry out a second case study with the same teachers to find out if the cognitive overload decreases or remains. In any case, it is notorious that teachers need a previous training in competence authoring tasks, especially competence authoring based on the EQF.

As a consequence of the above, teachers want the benefits of inspecting colleague's information but they are reticent to share their entire information. Most teachers expressed their willingness to share their definitions of EQF competences. On the other hand, they only wanted to share their course competence designs with selected teachers.

A further ONTO-EQF version will personalise levels of information to share. Thus, a personalised navigation to respect teachers willing will be delivered.

Maybe, it is a good idea for future versions of ONTO-EQF to develop recommender systems to assist teacher in competence authoring tasks. The survey asked about a specific recommender and teachers marked as high this possible one 80% (see QE.6).

4.9 Contributions and Conclusions

The ONTO-EQF application was presented. The application allows teachers to integrate EQF perspectives in competence modelling for higher education. A EQF competence bank is shared and manage by teachers with access to the application. A case study with teachers and a survey were presented.

Focusing on the underlying information models, they seem to be solid pillars for this implementation. Moreover, the united conception of data models was well received by teachers.

With respect to authoring of EQF competences, this task demands time for preparing the course. The results show cognitive overcharge for teachers in the task, more than expected from researchers. On the other hand, teachers appreciate the useful extra information generated for their courses during the authoring process. Some strategies such as net visualisations of information and a recommender system have been planned to decrease this problem.

The case study revealed that in practice teachers are not so familiarized in higher education with competence-based education and the EQF. Despite the fact of the simplicity of the EQF framework, in practice it is necessary a deep level of conceptualization to map course objectives to the EQF. The former seem to suggest that adoption of the EQF at course level in higher education is a big challenge that requires important time resources in authoring of EQF competences and more contributions from TEL.

Regarding to the research question *how teachers can make effective use of the EQF for authoring competences for their lessons?* ONTO-EQF brings a methodology to set, manage, and share EQF competences in higher education. A united collaboration of standardised models such as a knowledge domain areas model (ACM Computing Classification System) and a qualification model (EQF) are the cornerstones of the proposal. A simple interface of three hierarchical tables that change their information according to the actions of the teacher in the parent table has been useful to develop the objectives of teachers in authoring of EQF competences for their lessons. A support to share competences definitions was included in ONTO-EQF. Overall teachers were able to reach the objectives and perform designed tasks.

For research question *"how can teachers be more aware and reflect about the underlying competences in university courses?"* teachers reported in open responses that they gained awareness by completing their authoring of competences for a course. They also state different opportunities for reflection. First, they reflect during the competence authoring because they think carefully about the semantic context (ACM classification and EQF framework) to set each competence. Another way of reflection mentioned was to analyse competences authored by other teacher that could be valuable for their own courses.

Thus, looking for the best result in authoring became a trigger of reflection and a method to be aware of the underlying competences in university courses.

Finally, some comments and suggestion of the case study and the survey will take into account to produce a further version of ONTO-EQF. The recommender system and net visualisation ideas that were well received for teachers are also in the line of future research work. It is also necessary to dig into adaptive navigation support to generate levels of personalisation in shared information regarding teachers' competence definitions and teachers' course competence designs.

CHAPTER 5

SUPPORT FOR ENHANCING COURSE DESIGN WITHIN AN EUROPEAN PERSPECTIVE FOR LIFELONG COMPETENCE DEVELOPMENT

The purpose of this chapter is to present results from case study and surveys related to support a course design based on the EQF for higher education. The case study were carried out by teachers using the software application called CC-DESIGN. This is the second application of the AEEA Suite developed with research purposes for this thesis. Teachers' case study is joined to the previous one presented in Chapter 4. Thus, the current teachers' case study was also carried out in the fall semester of 2011 using the same courses and teachers.

This chapter is organized as follow. First, and introduction and the research questions to be answered in the case studies are presented. After that, the research scope is clarified. Once research questions and research scope of this chapter are outlined, the user objectives (teacher's objectives) are presented. Before describing the case study, a section presents an overview of CC-DESIGN application. This description is accompanied with justifications of decisions taken for CC-DESIGN implementation. Then, the case study for teacher perspective is described. Finally results, discussion and conclusions are pointed out.

5.1 Introduction

Competence models are used to inform the design of appropriate learning activities so as to minimize the gap between the expected competences of a given curriculum and the ones owned by an individual learner (Sampson & Fytros, 2008).

5.2 Research Question

The main research question of this chapter addresses the need for structuring a suitable methodology for teachers in higher education to carry out a learning design including EQF competences in competence driven LLL. Therefore, for teacher's perspective the research questions are:

This chapter is based on:
(Florian-Gaviria et al., 2013)

How can teachers make effective use of European standards for designing their lessons? More precisely, How teachers can make effective use of the EQF for learning activities design and assessment design on well-defined core of learning outcomes? (Contribution to answer RQ-4 of this thesis)

How can teachers be more aware and reflect about the underlying EQF competences in university courses? (Contribution to answer RQ-5 of this thesis)

5.3 Scope of Research

The previous chapter gives justification of why tools of this thesis were constructed as independent web applications from the official VLEs of testing universities (Moodle). There it was also mentioned why test courses were only in the area of engineering. In addition to such limitations, it is important to note that for this chapter, the scope in learning design is to give a complementary and enhanced support to the traditional learning design tools used for teachers in their VLEs. Therefore CC-DESIGN is not a substitute but a complement of VLE tools for learning design.

5.4 Users' Objectives in Course Design

5.4.1 Teachers' Objectives

The teachers' objective with the CC-DESIGN application is to focus their learning activities design and assessment design on well-defined core of learning outcomes. By doing so; teachers can align the course design to the EQF competence levels. Teachers define a script for moderating and guiding learning process through a matrix of expected qualification levels for activity/competence. In other words, steps for assess a competence are defined through progressive learning outcomes in different activities.

5.5 The CC-DESIGN Application

The second Web application that teachers used was CC-DESIGN; this is an instructional design application. CC-DESIGN is used to design a plan of activities and the expected level of qualification for each one of the EQF competences involved in these activities. Figure 5-1 shows an overview of CC-DESIGN interface for teachers. This application is divided in three sections: 1) Competences added to this course, 2) Evaluation activities, and assessment weighting, and 3) Script for qualification of competences through the evaluation activities of the course.

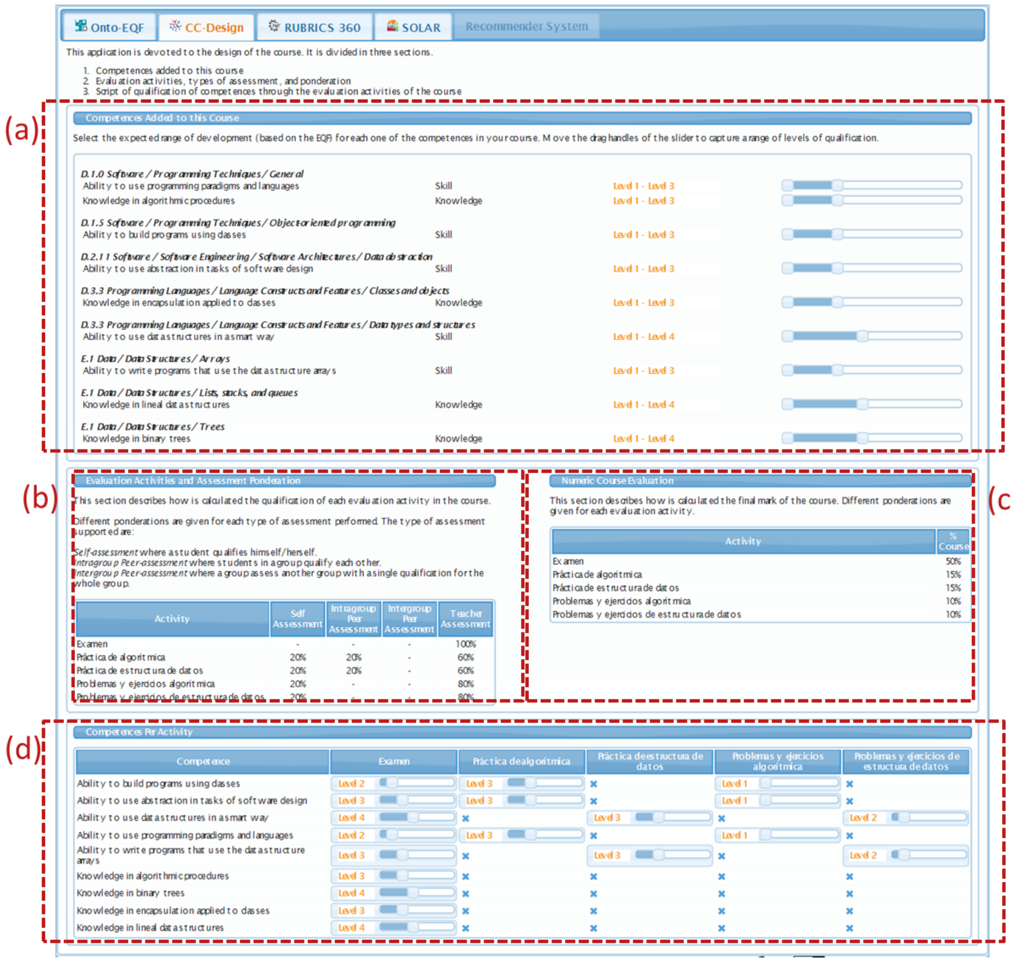


Figure 5-1 Overview of CC-DESIGN interface for teachers

In CC-DESIGN interface the upper box shows (Figure 5-1a) competences already added to the course ordered by knowledge domains areas. Using a slider widget, teachers can edit the minimum and maximum level they expect to develop each competence in their courses, from the eight levels of qualification of the EQF. The middle boxes show information related to evaluation activities of the course. For assessment of competences percentages of self-assessment, intragroup peer-assessment, intergroup peer-assessment, and teacher-assessment are defined in the left table (Figure 5-1b) for each evaluation activity; percentages of evaluations for the final course score are defined in the right table (Figure 5-1c). In the final box (Figure 5-1d) teachers can set up in detail the levels of qualification expected by activity/competence using a slide bar. A competence can be evaluated at several activities in a progression of levels of qualification. If the competence is not evaluated in a particular activity the slide bar is replaced by an icon which expresses "negative".

To give an example, in Figure 5-1 the first competences added to the course is *Ability to use programming paradigms and languages* (a skill). The prerequisite for this competence is the EQF Skill level 1 and the final learning outcome expected is the EQF Skill level 3. This competence is assessed with three evaluation activities: 1) Algorithmic problems and exercises at EQF Skill level 1, 2) Exam at EQF Skill level 2, and 3) Practice of algorithmic at EQF Skill level 3. 20% of the Algorithmic problems and exercises evaluation is a student self-assessment, the remainder 80% is the teacher evaluation.

On the other hand, CC-DESIGN is presented to students without editing privileges in order to offer a visualisation of teacher's learning design. Figure 5-2 illustrates an overview of CC-DESIGN interface for students. In the student's interface sliders are removed and any evaluation activity can be managed.

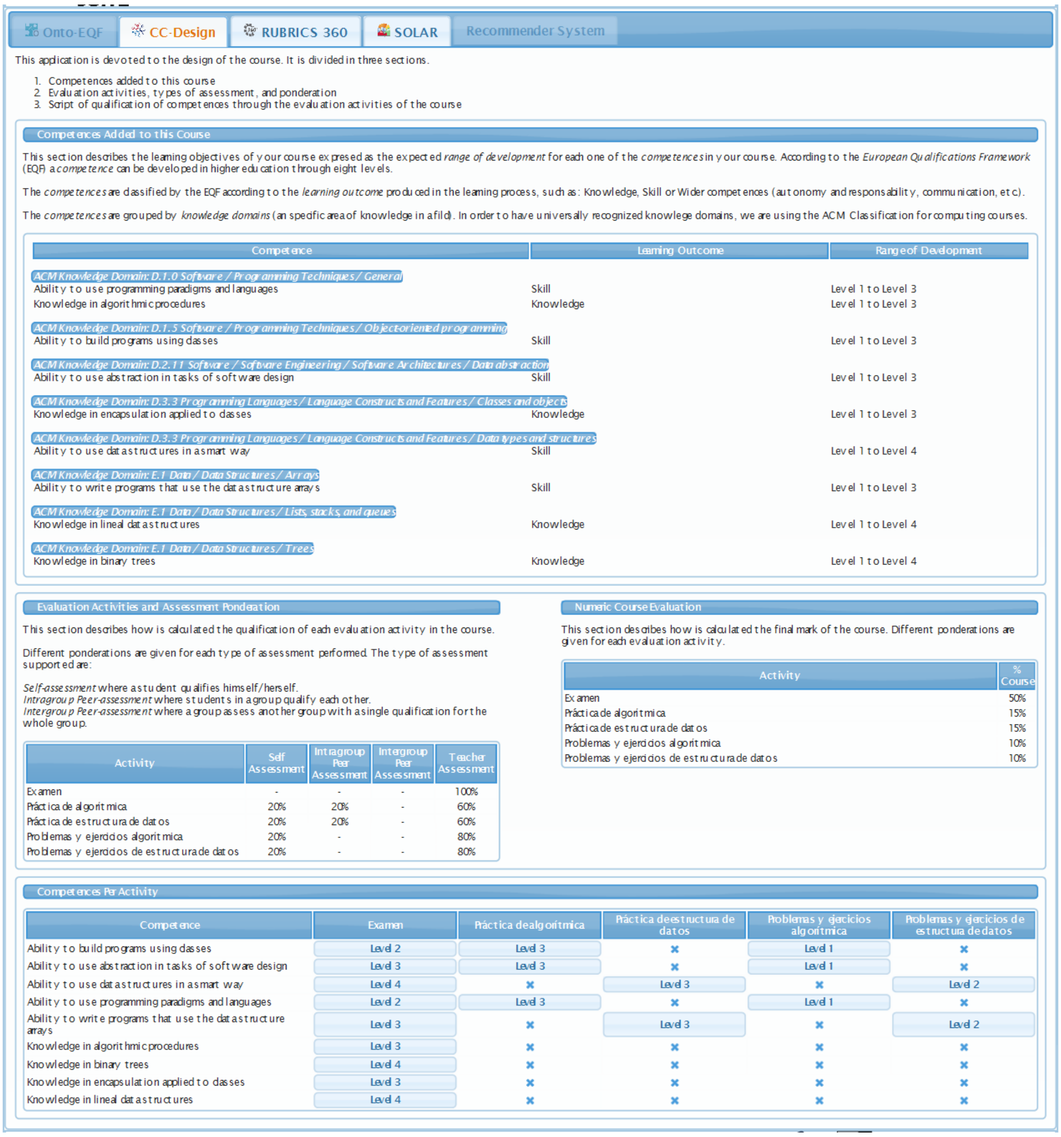


Figure 5-2 Overview of CC-DESIGN interface for students

5.6 Teachers' Case Study and Survey

As was said before, this case study was carried out with the same population of teachers and courses than the case study reported in Chapter 4, that is, 20 teaching persons (six females and fourteen males), between 24 and 48-year-old. Eleven teachers in the study did not have previous experience in this type of design. Nine of the twenty teachers had some experience designing a course with competences but none of them had used before EQF levels of qualification for competences.

In this context, teachers were asked to use CC-DESIGN during a complete semester to evaluate whether this application could assist them in to be more aware and reflect about the underlying competences in their courses. The usefulness of CC-DESIGN in order to include the perspectives of the EQF in course design was also evaluated.

Here, teachers needed a previous training to specify the relation between course activities and the learning objectives in terms of EQF competences. They also required preliminary instructions regarding CC-DESIGN. To do so, several sessions of one-hour meeting were conducted for each course. Skype meetings or face meetings were arranged. At least two sessions for each course were needed to complete the learning activities design and assessment design. In these meetings a cognitive overcharge was revealed in teachers because they were not familiarised with the EQF and the 360-degree feedback. So, they needed to understand these models and also they needed to learn how to work with CC-DESIGN. Thus, the task of describe learning activities and assessment was completely different from the way teachers used to do it.

Continuing with outcomes of proposed task, APPENDIX A, APPENDIX B, and APPENDIX C hold complete learning designs of courses that were modelled using the AEEA Suite. From the six courses modelled during May 2011 to June 2012, the ones in the appendixes were selected because they used different pedagogical approaches.

For evaluating purposes, a survey was designed to measure teachers' opinion. The survey was divided in seven sections, one section to collect demographic data. Then five section to inquire about: usefulness, easy of using, easy of learning, satisfaction, and issues of privacy and data sharing. Finally, it was a section to give the opportunity for open comments. Questions were mainly designed to measure opinion of teachers after the test period. The questions were formulated in a variety of types, including open questions and 5-point Likert scales with single choice questions. In the case of 5-point Likert scales, 1 always means *Strongly Disagree* and 5 *Strongly Agree*. The question items of the survey are presented in APPENDIX E.

5.7 Results

Once teachers completed the courses, they filled in the designed survey to evaluate their opinion about CC-DESIGN. In this survey, teachers answered open questions about how well they understood the application and tasks, if they used some strategies to complete the process, how they achieved the proposed objectives, if they had some advice to improve the application, if they had suggestions for new ways of interaction, if they needed extra information or new abilities to perform the proposed tasks. In addition, in order to know how many teachers were pleased, they answered a series of questions where they had to choose the most appropriate response of a 5-point Likert scale from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). Finally, at the end of the survey a space was left for additional comments. The report on the results is organized along the lines of five segments namely: usefulness, easy of using, easy of learning, satisfaction, and issues of privacy and data sharing. Table 5-1 summarizes frequencies (n) and percentages (%) for CC-DESIGN evaluation.

Table 5-1 Frequencies and percentages for CC-DESIGN evaluation

Strongly Disagree (1)		Disagree (2)		Neutral (3)		Agree (4)		Strongly Agree (5)		Total	
n	%	n	%	n	%	n	%	n	%	n	%
Usefulness											
B1) CC-DESIGN helps me to focus my learning activities design and assessment design on well-defined core of learning outcomes											
0	0%	0	0%	2	10%	8	40%	10	50%	20	100%
B3) Defining course design in this way provides useful enriched information than the way I used to do it											
0	0%	0	0%	5	25%	13	65%	2	10%	20	100%
B4) CC-DESIGN helps me to be aware of the underlying EQF competences of my course											
0	0%	0	0%	3	15%	7	35%	10	50%	20	100%
B6) CC-DESIGN helps me to reflect about the underlying EQF competences of my course											
0	0%	0	0%	4	20%	9	45%	7	35%	20	100%
B8) CC-DESIGN helps me to plan my teaching work											
0	0%	0	0%	7	35%	11	55%	2	10%	20	100%
B10) CC-DESIGN helps me to design a 360-degree feedback for competence assessment											
0	0%	0	0%	5	25%	10	50%	5	25%	20	100%
B12) CC-DESIGN helps me to set levels of qualification (Level 1 to Level 8) for learning outcomes of activities (Knowledge, Skill, Wider Competence)											
0	0%	0	0%	0	0%	10	50%	10	50%	20	100%
B14) The EQF is suitable as framework for a competence-based course design in higher education											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%
B15) Higher education European teachers need learning design tools that includes perspectives of EQF competences											
0	0%	2	10%	5	30%	10	50%	2	10%	20	100%
B16) It is good idea to support a 360-degree feedback for competence assessment design											
0	0%	0	0%	5	25%	9	45%	6	30%	20	100%
B17) It was easy to accomplish de tasks of assessment design and learning activities design for my course											
0	0%	3	15%	5	25%	12	60%	0	0%	20	100%
Ease of Use											
C1.The instructions to perform learning design tasks were clear											
0	0%	0	0%	5	30%	11	55%	3	15%	20	100%
C2. The interface is easy to use											
0	0%	0	0%	2	10%	12	60%	6	30%	20	100%
C3. The interface is user friendly											
0	0%	0	0%	2	10%	10	50%	8	40%	20	100%
C4. The interface requires the fewest steps possible to accomplish what I need to do with it											
0	0%	0	0%	3	15%	14	70%	3	15%	20	100%
Ease of Learning											
D1) I learned how to use the interface quickly.											
0	0%	0	0%	2	10%	10	50%	8	40%	20	100%
D2) I easily remember how to use the interface.											
0	0%	0	0%	2	10%	11	55%	7	35%	20	100%
D3) It is easy to learn how to use the interface.											
0	0%	0	0%	1	5%	13	65%	6	30%	20	100%
Satisfaction											
E1. I am satisfied with the interface.											
0	0%	0	0%	1	5%	14	70%	5	25%	20	100%
E2. The interface is pleasant to use											
0	0%	0	0%	2	10%	16	80%	2	10%	20	100%
E3. CC-DESIGN supports the EQF in an appropriate way											
0	0%	0	0%	4	20%	10	50%	6	30%	20	100%
E4. I would recommend CC-DESIGN to my colleagues											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%

E5. I am satisfied with CC-DESIGN to align prerequisites to the EQF											
0	0%	0	0%	5	25%	9	45%	6	30%	20	100%
E7. I am satisfied with CC-DESIGN to align learning activities to the EQF											
0	0%	0	0%	3	15%	9	45%	8	40%	20	100%
E9. I am satisfied with CC-DESIGN to align assessment to the EQF											
0	0%	0	0%	4	20%	12	60%	4	20%	20	100%
E11. I am satisfied with CC-DESIGN to align learning outcomes to the EQF											
0	0%	0	0%	4	20%	14	70%	2	10%	20	100%
E13. I would like a recommender system that suggests possible activities based on added competences of my course											
0	0%	0	0%	3	20%	14	70%	3	15%	20	100%
Privacy and Data Sharing											
F1. I would like to comparing my design with other teachers with similar courses											
0	0%	2	10%	5	25%	9	45%	2	10%	20	100%
F2. I would feel comfortable sharing my plan for competence qualifications with others.											
0	0%	2	10%	3	15%	10	50%	5	25%	20	100%
F3. I would not mind that my course design be anonymously share with other teachers											
0	0%	4	20%	7	35%	7	35%	2	10%	20	100%

Results about CC-DESIGN show that the instructional design task was difficult for teachers with an agreement of 60% (see QB.17: Agree 60%). Nevertheless, they were pleased to carry out this task based on the EQF with a percentage of 80% (see QB.14: Agree 40% + Strongly Agree 40%). Moreover, 75% of teachers report as more convenience the new way of complementing course design (see QB.3: Agree 65% + Strongly Agree 10%).

Regarding to teachers' objectives using CC-DESIGN, results seem to give evidence that teachers reached such objectives. For instance, being aware of the underlying EQF competences in courses was perceived for teachers with a percentage of 85% (see QB.4). Besides, in a percentage of 80%, teachers felt they did reflection about these competences (see QB.6). Most important, 90% of teachers were able focus their learning activities design and assessment design on well-defined core of learning outcomes (see QB.1). The responses to open questions give insight into the way teachers were capable of reach the earlier objectives. In the open answers teachers reported reflection in two situations, first when they established prerequisites and learning outcomes because they needed to think carefully in implications of the dimension of competence development for the course; the second situation was when they needed to set the script of qualifications, reflection was necessary to analyse the best way to develop each competence through time and activities. Teachers reported that consequently these two situations of reflection were triggers of awareness in a general level (contextualise prerequisites and learning outcomes) and in a deep level (contextualise an script of qualifications) respectively regarding to the underlying EQF competences of their courses.

Focusing on usability aspects, CC-DESIGN seems easy to use from the results with percentages of agreement between 85% and 90% for the series of questions in this aspect. The only little problem was the instructions to perform design tasks, with an agreement percentage of 70%.

In connection with ease of learning, teachers were greatly with percentages between 90% and 95%.

Regarding satisfaction, teachers perceived the application as well implemented with a satisfaction 80% (see QE.3: Agree 50% + Strongly Agree 30%). Furthermore, open answers to QE.6, QE.8, QE.10, and QE.12 show that teachers thought they aligned course elements to the EQF through mapping of progressive achievement of learning objectives in students' actions. Thus the definition of the matrix of qualifications for a course is the final materialization of course elements mapped to the EQF.

Although sharing capabilities were not implemented yet for CC-DESIG, the survey inquired about the perception of teachers with privacy and data sharing for future. Similar to the previous case study, teachers expressed lower rates of agreement (45% to 75%) for sharing the entire course design, even anonymous sharing.

5.8 Discussion

Perhaps teachers found design tasks difficult because this case study was the first experience, for many of them, with a course based on the EQF. It is necessary to carry out a second case study with the same teachers to find out if the cognitive overload decreases or remains. In addition, it is a fact that time inverted in support meetings exceeded expectations of researches, so as for change the outlook of time required to design a new course with new teachers. In any case, it is notorious that teachers need a previous formation in instructional design tasks, especially instructional design based on the EQF. Teachers struggle between learn a new way of course design and unlearn the old one. Nevertheless, teachers were able to align course design to the EQF competence levels using the CC-DESIGN application. It is expected to increase levels of motivation in teachers for competence-based course design with the use of further applications of the AEEA Suite. Thus, efforts in design will be rewarded by means of automatic generation of assessments, learning analytics and open student models.

Focus on value added and achieved objectives results are promising. Teachers reached all proposed objectives, were able to perform the overall design tasks, and finally reported enriched information from the new process. In addition, more contextual awareness and reflection of the underlying EQF competences of their courses was also stated. All in all, from usefulness the balance is quite positive.

In connection with usability, the main aspect to take care in future versions of CC-DESIGN is clarifying instructions for each step. Maybe it is a good idea to add contextual menus for instructions. Layout of CC-DESIGN has been updated twice attending suggestions of teachers. More efforts to improve layout and instructions will be valuable.

With respect to satisfaction the overall evaluation was positive. For course elements, teachers reported satisfaction aligning them to the EQF. Open responses of survey exposes that proposed interface constitutes a method to progressive enhancing of course design taking into account EQF perspectives.

Similar to the previous case study, maybe it is a good idea for future versions of CC-DESIGN to develop recommender systems to assist teacher in tasks of course design. The survey asked about a specific recommender system and teachers mark as high this possible one 85% (see QE.13).

Last remark is for privacy and data sharing issue, the case study and survey expose that teachers consider as highly private and personal their course designs. In consequence, the expectations of adding future capabilities to adaptive navigation are less important in CC-DESIGN than the ones revealed for ONTO-EQF.

5.9 Contributions and Conclusions

It has been presented the CC-DESIGN application, the second one of the AEEA Suite. This application allows teachers to enhance course design using the competence-based framework EQF in three steps, namely: managing prerequisites and learning outcomes, defining evaluation activities in a 360-degree feedback for assessment, and defining a script of qualifications. A case study and survey with teachers was presented. Another case study and survey with students was also exposed.

In a broader perspective, united information models were well received by teachers. Teachers were able to relate students' actions with underlying competences and assessment.

To accomplish the extended learning design it was necessary some extra steps of instructional design. This process demands significant time for preparing the course. The results show cognitive overcharge for teachers in tasks of design. Some strategies such as possible recommender systems have been planned to decrease this problem.

The proposal for assessment of competences introduce a 360-degree feedback evaluation, this proposal allows a practical way to support active learning strategies in higher education due to active participation of students in self and peers evaluation. Given that, some teachers were willing to adopt new ways of assessment for their courses. This willingness was more notorious in courses with massive students, continuous evaluation, and project-based activities. Therefore, CC-DESIGN impact in teaching and learning could depend on the type of pedagogical strategies of the course and the willingness of teachers to explore new types of assessment.

This case study seems to show that in practice teacher in higher education are not so familiarized with the EQF and competence-based education. It will be a good idea to explore more on this topic and its implications for the EQF adoption at course level in higher education. Although run-time applications of the AEEA suite could help to motivate teachers to invest extra time in design, an institutional policy to demand qualification of competence levels in courses would be more effective towards monitoring competences development in higher education.

Regarding to the research question *how teachers can make effective use of the EQF for learning activities design and assessment design on well-defined core of learning outcomes?* CC-DESIGN brings a methodology to set and manage elements of course design based on the EQF. Learning outcomes are expressed in a large scope as the final qualification expended in the course for each competence. On the other hand, they are also expressed in a detailed manner for each evaluation activity.

For research question *how can teachers be more aware and reflect about the underlying EQF competences in university courses?* teachers reported several stages of reflection during the learning design: a) thinking carefully in the general range of competence development, b) thinking carefully in the assessment opportunities and percentages to evaluate competences, and c) thinking carefully the script of qualifications. The new generated information gives an open model to be aware of the EQF competences process of qualification in the course.

Finally, for future research, it is necessary to test CC-DESIGN in other knowledge domains and different pedagogical strategies to analyse the entire possibilities. Some comments and suggestion of the case study will take into account to produce a further version of CC-DESIGN, especially layout and instructions. Exploring possibilities to add recommender systems to CC-DESIGN is also in the line of future research. As was mentioned before, a possible recommender would suggest activities according to the EQF levels selected; the EQF descriptors can bring light to the kind of evidences and activities to achieve a particular level.

CHAPTER 6

SUPPORT OF EQF COMPETENCE ASSESSMENT IN HIGHER EDUCATION COURSES

The purpose of this chapter is to present results from case study and survey related to support of outcome-based assessment in university courses. The assessment proposal is based on the EQF and a 360-degree feedback for blended courses in higher education. The case studies were carried out by teachers using the software application called RUBRICS-360. This is the third application of the AEEA Suite developed during the thesis process. The teachers' case study belongs to the series of evaluations in the fall semester of 2011.

This chapter is organized in a similar way than the previous two chapters. First, an introduction and the research questions concerning to this chapter are presented. Then, restrictions that constrain the research scope are described. Section four of this chapter is reserved to the objectives for teacher perspective. An overview of the RUBRICS-360 is presented in section five. Followed, a section is devoted to the case study. Results, discussion of results, and general conclusions of the chapter complete the last three sections of the chapter.

6.1 Introduction

A novel aspect of this proposal is to give a mechanism to generate several automatic tests for EQF competence assessment in higher education. Another novelty is to bring a 360-degree feedback for formative feedback at different social planes of guidance in competence development. Finally the case studies presented are examples of the earliest efforts for implanting the EQF in assessment at course level in higher education.

After exposing briefly novel aspects of the proposal in this chapter, the next sections are concern to the research process carried out for this subject.

6.2 Research Questions

The main research question of this chapter addresses the need for structuring a suitable methodology for teachers to carry out an outcome-based assessment using EQF competences in competence driven LLL. As a result, for teacher's perspective the research questions are:

How can teachers make effective use of European standards for monitoring and moderate their lessons? (Contribution to answer RQ-4 of this thesis)

How can teachers be more aware and reflect about the underlying competences in university courses? (Contribution to answer RQ-5 of this thesis)

6.3 Scope of Research

Constrains mentioned in previous chapters are also applicable to this chapter of Evaluative Perspective. So, the same restrictions to research are also applicable in this chapter with the mentioned consequences such as: 1) Implementation of RUBRICS-360 as an independent web application. 2) Testing only with courses that belong to engineering curriculums, 3) A sample of 20 teachers for case study with them, and 4) A maximum of three courses.

In addition to the previous restrictions, it is important to note that the evaluation of the impact of the assessment approach proposed (a 360-degree feedback in higher education) is in somehow constrains due to the willing of teachers to include all kind of assessment possibilities in their learning designs. Only one of the three courses used the entire possibilities of evaluation.

Finally, the teacher's design determines also the number of EQF competences to include, the number of activities to assess and the number of evaluations per activity. That is why some course designs were more enhanced than others.

6.4 User's Objectives in Formative Competence Assessment

6.4.1 Teachers' Objectives

The teachers' purpose with the RUBRICS-360 application is to perform assessment of EQF competences based on scoring rubrics (descriptions of rating values) and to provide feedback to learners as part of a 360-degree feedback. The assessment of competences is not registered in terms of grades but in terms of EQF qualification levels achieved by student for each EQF competence in an activity. The monitoring and moderating provided by RUBRICS-360 support teachers to be aware and reflect about performance of their students as well as control their progress in assessment tasks.

6.5 The RUBRICS-360 Application

RUBRICS-360 gets its name because of the assessment approaches that it implements, namely rubrics score tests and a 360-degree feedback implementation. In RUBRICS-360 the user interface is divided in two regions. A first region presents the personalised plan of assessment for the current user to select tests. A second region displays a selected test. A brief explanation of these regions is given below.

To start with, the plan of assessment is expressed with a series of buttons to select evaluations. This plan is built automatically for each user from the course design made earlier. The course design determines the social planes that should be valued by the current user. That is, a single user for self-assessment, a group of students in the class for peer assessment, and all students for teacher-assessment. The course design also determines what activities must be evaluated by the user. The activities are the ones where the user has the role of appraiser. Teachers can be appraisers of their students for many evaluation activities. Figure 6-1 displays a cutting view of an assessment plan for a teacher. A button with an alert icon represents a pending evaluation. For instance, in Figure 6-1a the teacher's evaluation of the activity *Report 3* is pending for the student *Carmen Yohana*. Besides, a button with a pencil icon means an assessment already performed and editable. For example, in Figure 6-1b the editable button indicates that the test to assess the *Writing Evaluation 3* of *Sebastian* has been done. Thus, teachers can have a graphical representation of the progress in their evaluation plan.

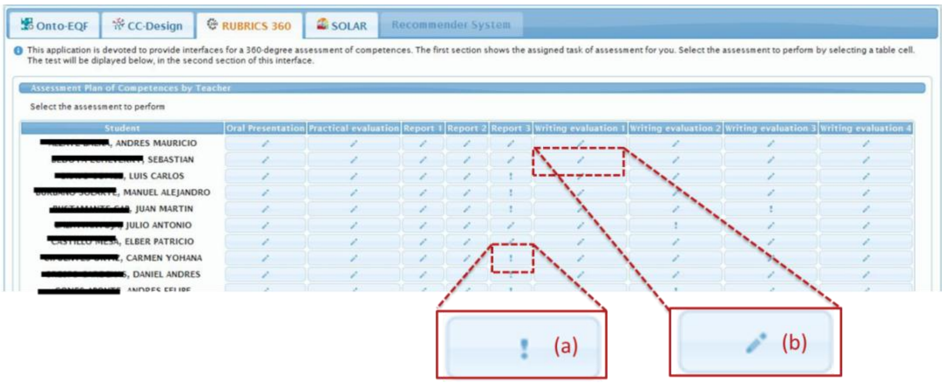


Figure 6-1 Detail of an assessment plan for teacher

The same strategy is used for displaying the assessment plan for students. The difference is that a student has three different opportunities to be appraiser, namely self-assessment (to appraise himself/herself), peer-assessment intragroup (to appraise peers that work with him/her in a group task), and peer-assessment intergroup (to appraise peers that work in other group of the same course). Therefore, the student's plan of assessment is divided in three sections instead of one. Figure 6-2 shows an overview of the assessment plan for a student. Here, the student *Andrés Mauricio* must be appraiser of himself for the *Final Self Evaluation* (see Figure 6-2*a)*. In addition, he must appraise her partners *Brian* and *Jhoan Sebastian*, the ones who helped him to make the course project, for the *Final Peer Evaluation (See* Figure 6-2*b)*. Finally, he must evaluate the *Report 1* and *Report 2* of *Group 8* (another group in the course). In these final cases, the appraiser student evaluates to all students that belong to *Group 8* with the same qualifications of EQF competences (See Figure 6-2c).

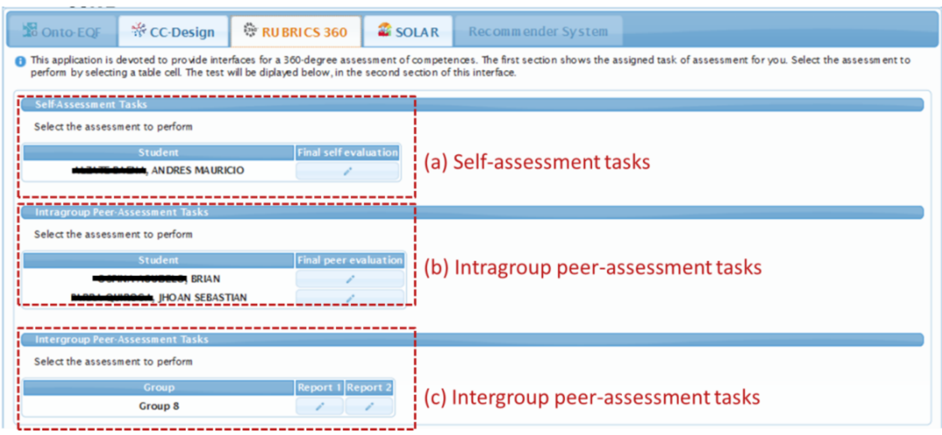


Figure 6-2 Detail of an assessment plan for student

Continuing with the second region, a corresponding test is automatically generated after selecting a button in the first region (See Figure 6-3a) Tests are composed of scoring rubrics to qualify EQF competences. Tests are based on the learning design arranged by teacher previously. That is, a test includes the EQF competences to be assessed in the activity according to the script of qualifications made by teacher using CC-DESIGN. Thus, although unlimited automatic test can be generated for a course, the limit for the number of automatic tests generated depends on the teacher's design. It is important to note also that the automatic generation is made for teacher-assessment, self-assessment, intragroup peer-assessment, and intergroup peer-assessment. Figure 6-3 gives an example of a test for teacher-assessment. In this example, ten EQF competences are evaluated for the activity *Writing Evaluation 1*. Here, three EQF competences are classified as *Knowledge* (see Figure 6-3b), the next six EQF competences produce learning outcomes of type *Skill* (See Figure 6-3c), and the last one is a *wider competence* (see Figure 6-3d). The EQF descriptors of learning outcomes are used as descriptors of categories for scoring rubrics. Figure 6-3e shows descriptors for Knowledge learning outcomes. Figure 6-3f illustrates descriptors for skills learning outcomes. Figure 6-3g exemplifies descriptors for wider competences in terms of learning competences. This strategy allows that teachers and students in higher education have a mechanism to qualify EQF competences contributing to monitoring a part of lifelong learning using a common and European standardized base. A final space for comments is left at the end of test (See Figure Figure 6-3h).

To conclude this exposition of the second region of the RUBRICS-360 interface, Figure 6-4 displays an example of a peer-assessment intergroup test. In this example, the student must give a single evaluation of the activity Report 1 for all students that belong to Group 8 in the course. In this case, there are several categories of wider competences such as: autonomy and responsibility, learning competences, and communication and social competence. The same final space for comments is left at the end of test.

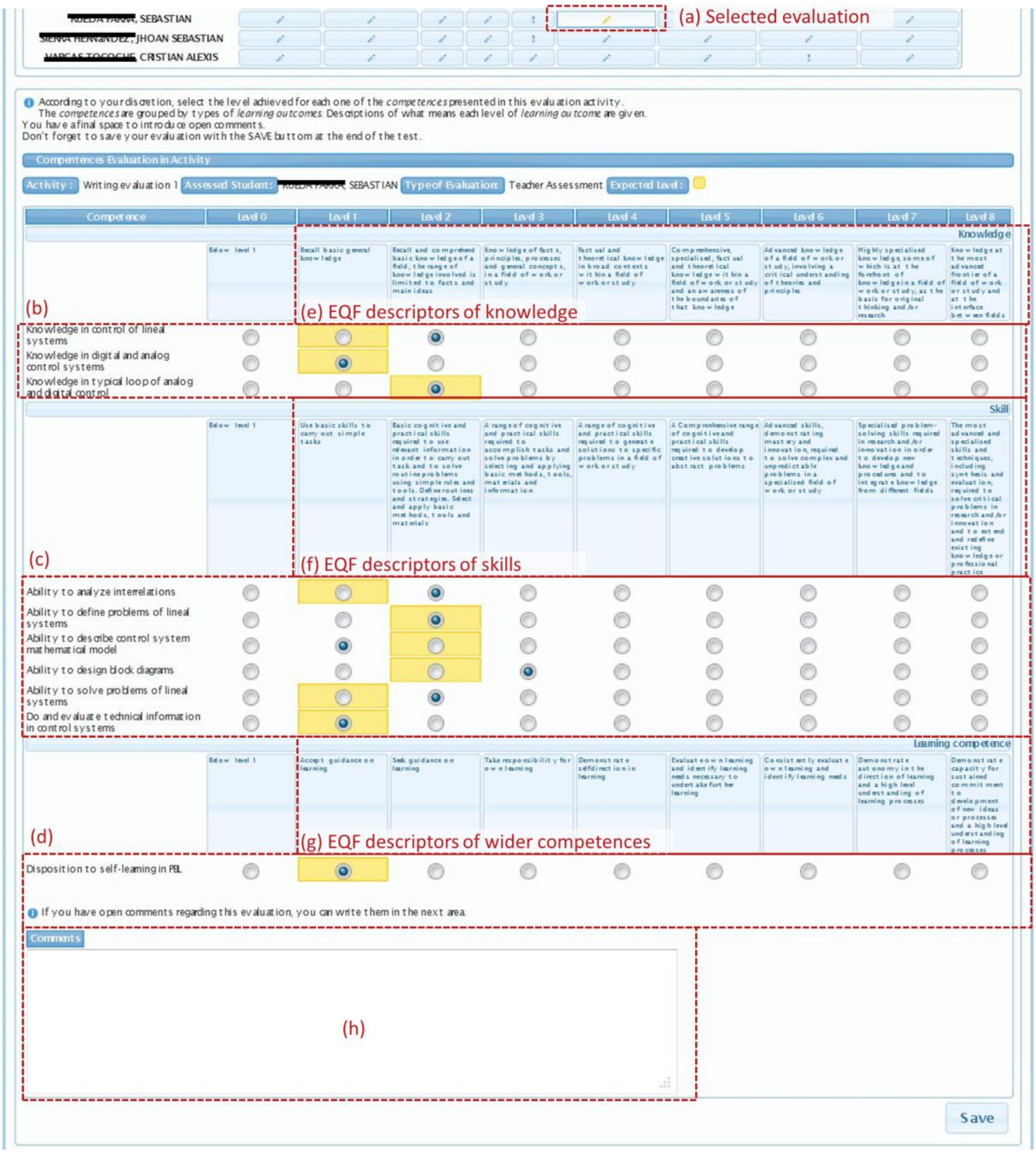
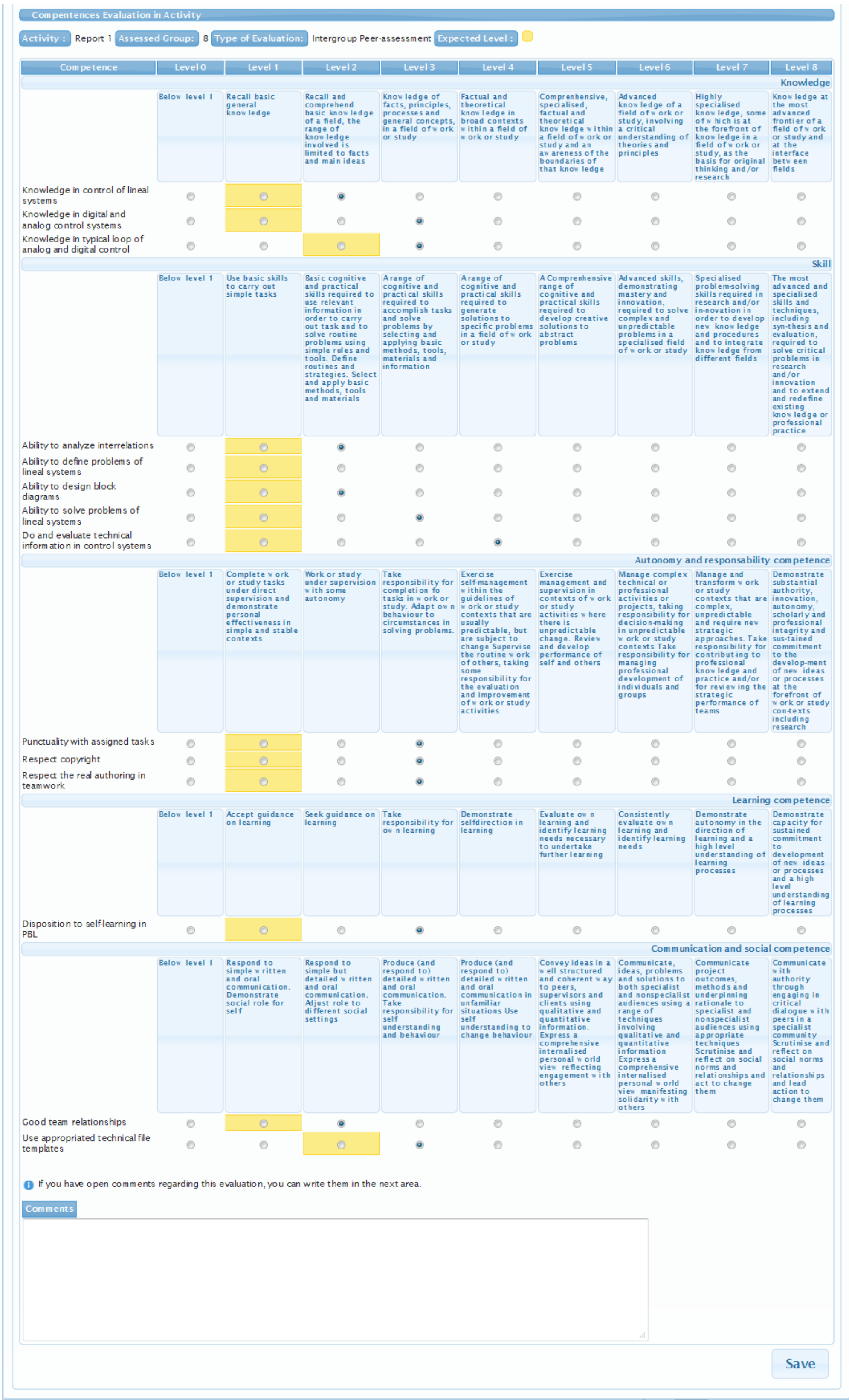


Figure 6-3 *Example of an automatic scoring rubric test for teacher*



Compentences Evaluation in Activity

Activity : Report 1 Assessed Group: 8 Type of Evaluation: Intergroup Peer-assessment Expected Level :

Competence	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Knowledge									
	Below level 1	Recall basic general knowledge	Recall and comprehend basic knowledge of a field, the range of knowledge involved is limited to facts and main ideas	Knowledge of facts, principles, processes and general concepts, in a field of work or study	Factual and theoretical knowledge in broad contexts within a field of work or study	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields
Knowledge in control of lineal systems									
Knowledge in digital and analog control systems									
Knowledge in typical loop of analog and digital control									
Skill									
	Below level 1	Use basic skills to carry out simple tasks	Basic cognitive and practical skills required to use relevant information in order to carry out task and to solve routine problems using simple rules and tools. Define routines and strategies. Select and apply basic methods, tools and materials	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	A Comprenhensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Specialised problem-solving skills required in research and/or in-novation in order to develop new knowledge and procedures and to integrate knowledge from different fields	The most advanced and specialised skills and techniques, including syn-thesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice
Ability to analyze interrelations									
Ability to define problems of lineal systems									
Ability to design block diagrams									
Ability to solve problems of lineal systems									
Do and evaluate technical information in control systems									
Autonomy and responsability competence									
	Below level 1	Complete work or study tasks under direct supervision and demonstrate personal effectiveness in simple and stable contexts	Work or study under supervision with some autonomy	Take responsibility for completion fo tasks in work or study. Adapt own behaviour to circumstances in solving problems.	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change Supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities	Exercise management and supervision in contexts of work or study activities where there is unpredictable change. Review and develop performance of self and others	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts Take responsibility for managing professional development of individuals and groups	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches. Take responsibility for contribut-ing to professional knowledge and practice and/or for reviewing the strategic performance of teams	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sus-tained commitment to the develop-ment of new ideas or processes at the forefront of work or study con-texts including research
Punctuality with assigned tasks									
Respect copyright									
Respect the real authoring in teamwork									
Learning competence									
	Below level 1	Accept guidance on learning	Seek guidance on learning	Take responsibility for own learning	Demonstrate selfdirection in learning	Evaluate own learning and identify learning needs necessary to undertake further learning	Consistently evaluate own learning and identify learning needs	Demonstrate autonomy in the direction of learning and a high level understanding of learning processes	Demonstrate capacity for sustained commitment to development of new ideas or processes and a high level understanding of learning processes
Disposition to self-learning in PBL									
Communication and social competence									
	Below level 1	Respond to simple written and oral communication. Demonstrate social role for self	Respond to simple but detailed written and oral communication. Adjust role to different social settings	Produce (and respond to) detailed written and oral communication. Take responsibility for self understanding and behaviour	Produce (and respond to) detailed written and oral communication in unfamiliar situations Use self understanding to change behaviour	Convey ideas in a well structured and coherent way to peers, supervisors and clients using qualitative and quantitative information. Express a comprehensive internalised personal world view reflecting engagement with others	Communicate, ideas, problems and solutions to both specialist and nonspecialist audiences using a range of techniques involving qualitative and quantitative information Express a comprehensive internalised personal world view manifesting solidarity with others	Communicate project outcomes, methods and underpinning rationale to specialist and nonspecialist audiences using appropriate techniques Scrutinise and reflect on social norms and relationships and act to change them	Communicate with authority through engaging in critical dialogue with peers in a specialist community Scrutinise and reflect on social norms and relationships and lead action to change them
Good team relationships									
Use appropriated technical file templates									

If you have open comments regarding this evaluation, you can write them in the next area.

Comments

Save

Figure 6-4 Example of test with scoring rubrics for intergroup peer assessment

6.6 Teachers' Case Study and Survey

Continuing with the series of teachers' case studies, the present one was carried out with the same population of teachers and courses than the case studies reported in Chapter 4 and Chapter 5. So, 20 computer science teachers (six females and fourteen males) between 24 and 48-year-old participated. None of them have used teaching-strategies with outcome-based assessment. Moreover, at the beginning of the series of case studies none of them were abreast either the EQF or the 360-degree feedback theory. At this point, after evaluating ONTO-EQF and CC-DESIGN, they were more familiarised with the EQF and the 360-degree feedback because of their learning in the previous case studies.

In this context, teachers were asked to use RUBRICS-360 during a complete semester to evaluate whether this application could assist them in to be more aware and reflect about the underlying competences in their courses. The usefulness of RUBRICS-360 to help teachers to monitor and moderate their lessons including the perspectives of the EQF in assessment was also evaluated.

To start the study teachers required preliminary instructions regarding RUBRICS-360. To do so, a manual of instructions and a one-hour meeting were conducted for each course via Skype.

After the brief training period, teachers started the assessment period. Initially, teachers asked for a mechanism to bind their traditional marks (or grades) to the new framework of qualifications of competences. RUBRICS-360 was not designed to translate valuations between an assignment/test mark (or grade) to qualifications of competences. Moreover it is not the intention to qualify all competences related to an assignment/test with the same qualification level (1 to 8) or level of performance (below expected, successful, or above expected). Nevertheless, this kind of request pointed out that teachers in higher education are used to quantitative valuations and they are required to give a mark (or grade) for each evaluation. In consequence, and taking into account that the proposed approach to evaluate an activity involve several qualifications of competences, researchers concluded that it would be more adequate to have a mechanism to translate valuations in the other way around. That is, to convert the set of qualifications of competences to a mark (or grade) for the assignment/test. Thus, teachers would be rewarded to assess using an outcome-based evaluation since they will be delivering two kinds of valuations: a set of qualifications of competences for the activity and the traditional mark (or grade) automatically generated. It is thought that with this feature in a future version teachers would be more motivated with this outcome-based evaluation. Consequently, in this case study, teachers performed assessment tasks without an automatic translation mechanism. The outcome-based evaluation was completely different for teachers from the way they are used to assessing.

For evaluating purposes, a survey was designed to measure teachers' opinion. The survey was divided in seven sections. A section to collect demographic data, then five sections to inquire about: Usefulness, Ease of using, Ease of learning, Satisfaction, and issues of Privacy & Data Sharing. Finally, it was a section to give the opportunity for open comments. Questions were mainly designed to measure opinion of teachers after the test period. The questions were formulated in a variety of types, including open questions and 5-point Likert scales with single choice questions. In the case of 5-point

Likert scales, 1 always means the worse option and 5 the best option. The question items of the survey are presented in APPENDIX F.

6.7 Results

At the end of courses, teachers were invited to fill the designed survey in. The purpose was to evaluate the opinion of teachers about the support of outcome-based assessment for their courses using RUBRICS-360. In this survey a combination of open questions and 5-point Likert scale questions from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*) were presented. As was said before, the survey was organized in seven segment. Table 6-1 summarizes the report of frequencies (n) and percentages (%) for teachers' evaluation of RUBRICS-360. For usefulness segment, 5-point Likert scale questions inquired about the agreement in the achievement of proposed objectives whereas open questions inquired about how teachers perceived they attained these objectives and what strategies they used. Open questions also collected data of teaching-skills required, comments, and finally, suggestions to improve the support.

Table 6-1 Frequencies and percentages for teachers' evaluation of RUBRICS-360

Strongly Disagree (1)		**Disagree (2)**		**Neutral (3)**		**Agree (4)**		**Strongly Agree (5)**		**Total**	
n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Usefulness											
B1. RUBRICS-360 helps me to perform assessment of competences on well-defined core of descriptors for learning outcomes.											
0	0%	0	0%	3	15%	7	35%	10	50%	20	100%
B3. Performing assessment in this way provides enriched useful information than the way I used to do it											
0	0%	0	0%	3	15%	9	45%	8	40%	20	100%
B5. Performing assessment in this way provides enriched useful learning resources than the way I used to do it											
0	0%	0	0%	2	10%	6	30%	12	60%	20	100%
B7. RUBRICS-360 helps me to monitor the performance of my students											
0	0%	0	0%	3	15%	4	20%	13	65%	20	100%
B9. Monitoring students' performance with RUBRICS-360 was easier than the way I used to do it.											
0	0%	1	5%	2	10%	5	25%	12	60%	20	100%
B10. RUBRICS-360 helps me to monitor my progress to complete assessment tasks											
0	0%	0	0%	2	10%	2	10%	14	80%	20	100%
B12. RUBRICS-360 helps me to moderate course activities											
0	0%	0	0%	3	15%	5	25%	12	60%	20	100%
B14. RUBRICS-360 helps me to be aware of the underlying EQF competences of my course											
0	0%	0	0%	2	10%	2	10%	16	80%	20	100%
B16. RUBRICS-360 helps me to reflect about the underlying EQF competences of my course											
0	0%	0	0%	2	10%	4	20%	14	70%	20	100%
B18. RUBRICS-360 helps me to plan my teaching work											
0	0%		5%	3	15%	6	30%	10	50%	20	100%
B20. RUBRICS-360 helps me to bring formative feedback for different social planes (a single student, a group of students, the class) in competence assessment of my course											
0	0%	0	0%	3	15%	11	55%	6	30%	20	100%
B22. RUBRICS-360 helps me to assess levels of qualification (Level 1 to Level 8) for learning outcomes of course activities (Knowledge, Skill, Wider Competence)											
0	0%	0	0%	2	10%	5	25%	13	65%	20	100%
B24. Higher education European teachers need assessment tools that includes perspectives of EQF competences											
0	0%	0	0%	4	20%	12	60%	4	20%	20	100%
B25. It was easy to accomplish de tasks of assessment for my course											
0	0%	0	0%	3	15%	11	55%	6	30%	20	100%
B26. The interface helps me to access the content (tests and qualifications)											

0	0%	0	0%	0	0%	6	30%	14	70%	20	100%
Ease of Use											
C1.The instructions to perform learning design tasks were clear											
0	0%	0	0%	5	25%	11	55%	4	20%	20	100%
C2. The interface is easy to use											
0	0%	0	0%	3	15%	9	45%	8	40%	20	100%
C3. The interface is user friendly											
0	0%	0	0%	1	5%	9	45%	10	50%	20	100%
C4. The interface requires the fewest steps possible to accomplish what I need to do with it											
0	0%	0	0%	1	5%	10	50%	9	45%	20	100%
Ease of Learning											
D1) I learned how to use the interface quickly.											
0	0%	0	0%	3	15%	13	65%	4	20%	20	100%
D2) I easily remember how to use the interface.											
0	0%	0	0%	0	0%	6	30%	14	70%	20	100%
D3) It is easy to learn how to use the interface.											
0	0%	0	0%	3	15%	13	65%	4	20%	20	100%
Satisfaction											
E1. I am satisfied with the interface.											
0	0%	0	0%	2	10%	6	30%	12	60%	20	100%
E2. The interface is pleasant to use											
0	0%	0	0%	2	10%	6	30%	12	60%	20	100%
E3. RUBRICS-360 supports the EQF in an appropriate way											
0	0%	0	0%	2	10%	8	40%	10	50%	20	100%
E4. RUBRICS-360 supports the 360-degree feedback theory in an appropriate way											
0	0%	0	0%	3	15%	9	45%	8	40%	20	100%
E5. I would recommend RUBRICS-360 to my classmates											
0	0%	0	0%	4	20%	8	40%	8	40%	20	100%
E6. It is a good idea to use EQF descriptors as scoring rubric descriptors											
0	0%	0	0%	5	25%	11	55%	4	20%	20	100%
E7. It is good idea to support a 360-degree feedback for EQF competence assessment											
0	0%	0	0%	2	10%	10	50%	8	40%	20	100%
E8. The EQF is suitable as framework for an outcome-based assessment in higher education											
0	0%	0	0%	1	5%	7	35%	12	60%	20	100%
E9. It was worth the effort of design in order to produce automatic assessment tests											
0	0%	0	0%	1	5%	7	35%	10	50%	20	100%
E10. Is it a good idea to qualify levels achieved by students for each competence involved in an activity											
0	0%	0	0%	5	25%	10	50%	5	25%	20	100%
E11. I would like a recommender system that suggests actions for detected students in danger of dropout.											
0	0%	0	0%	6	30%	10	50%	4	20%	20	100%
Privacy and Data Sharing											
F1. I like directives of privacy applied to evaluations. In particular, privacy in personalised plans of assessment that are displayed for each system user.											
0	0%	0	0%	0	0%	6	30%	14	70%	20	100%
F2. I like directives of privacy applied to evaluations. In particular, privacy in personalised results that are displayed for each student.											
0	0%	0	0%	0	0%	6	30%	14	70%	20	100%

The results description is presented along the lines of the survey sections. Frequencies and percentages are taken into account as well as the open comments to clarify why teachers agree on an opinion, and how they perceived evidences of the attained objectives.

To start with results description, *usefulness* section is of main interest. In this section teachers reported to have attained proposed objectives. Next paragraphs describe details of results for these objectives achieved.

The first objective for teachers was to perform assessment of EQF competences based on scoring rubrics; in this sense, results to question Q.B1 show that 85% of teachers thought they performed this assessment on well-defined core of descriptors (raking values of rubric) for learning outcomes; in addition, they agreed in a 85% (see Q.B3 and Q.B5) that this process gave them enriched useful information and resources. From the open comments to Q.B2 is deduced that the well–defined core of descriptors were the EQF descriptors used in assessment tests. From the open comments to Q.B4, and Q.B6 a summary list of teachers' comments regarding useful enriched information and new learning resources are summarized in Table 6-2.

Table 6-2 Summary of highlighted teachers' comments regarding enriched elements in RUBRICS-360

Enriched elements	Highlighted teachers' comments
Enriched useful information	"With RUBRICS-360 it is possible to have more assessment data from different actors in the learning process". "The amount of EQF qualifications collected is a new source of enriched useful information than ever". "I can realise the expected performance for each EQF competence during the assessment. The former is useful to reflect about the real performance for each student". "Formative comments are found from different actors in the learning process. This extra information is useful to the target student".
Enriched useful learning resources	"The automatic tests are valuable learning resources that help me to assess in many ways course's activities." "I felt rewarded with the automatic generation of test. It is worth the effort of design time to have this mechanism of assessment." "The plan of assessment is a clear instrument to be aware of my progress in the assessment activities."

The second teachers' objective was to realise the ways to monitor and moderate courses with RUBRICS-360. The proposed mechanism of assessment seems to help teachers in monitoring performance of students. Thus, in a percentage of 85% teachers agree on the help that the application proportioned (see Q.B7). Moreover, they reported that monitoring students' performance was easier than ever before. 85% (see Q.B9). There is another form of monitoring teachers agree have found, it is the monitoring of assessment task progress with a percentage of 90% of agreement (see Q.B10). Regarding course moderation teachers reported some ways with an agreement of 85% (see Q.B12). These percentages are better understood taking a look of Table 6-3 in which a summary of open comments highlight the evidences of monitoring and moderation for teachers. This summary was extracted from the open answers to Q.B8, Q.B11 and Q.B13.

Table 6-3 Summary of highlighted teachers' comments regarding monitoring and moderation using RUBRICS-360

Evidences	Highlighted teachers' comments
Evidences of monitoring	"To monitor the performance of a student was possible going over the accomplished tests that assessed the student." "I have never been able to monitor any kind of competence development in my courses. With RUBRICS-360 was easy to monitoring a big bunch of qualifications regarding EQF competence development." "Besides the students' monitoring another kind of monitoring was possible with this application. I was able to monitor my own tasks of assessment. I had a clear vision of what have been done and what was pendent." "I could realise the progress of a student by checking the sequence of evaluations in which an EQF competence had to be developed."
Evidences of course moderation	"The space for open comments at the end of tests was an instrument to make bad qualifications less harsh and more formative for students. It was a space to give reasons of lower qualifications and to give advice in order to improve performance." "Thanks to the big picture of qualifications from all over the student, I was able to guide discussions and to direct meetings for each group of students during the final course project."

An important objective with RUBRICS-360 was raise contextual awareness and reflection about the underling EQF competences in courses. Teachers agreed in report this kind of awareness with a percentage of 90% (see Q.B14). In addition, the mentioned reflection was agreed for 90% of teachers (see Q.B16). Table 6-4 enlightens the moments reported by teachers regarding contextual awareness and reflection of EQF competences in their courses.

Table 6-4 Summary of highlighted teachers' comments regarding contextual awareness and reflection using RUBRICS-360

Evidences	Highlighted teachers' comments
Contextual Awareness	"With the plan of assessment presented it is easy to explore tests and thus to have a broad picture of the EQF competences involved in the course activities". "The interface allowed me to realise points of good and bad learning designs in the script of qualifications for the underlying EQF competences of my course. The former was possible detecting lower performance for the most of students in an activity"
Reflection	"An analysis of the expected learning outcomes of EQF competences in a test was necessary to judge the real achieved levels of each student." "It was necessary to match real evidences in activities with evidences defined by EQF descriptors to qualify the correct level of an EQF competence for a student." "I was able to think in future repercussions in the course for students with lower performance and also for students with good performance. This reflection was made in terms of prediction of the final development of the EQF competences for each student"

Other benefits reported for teachers using RUBRICS-360 were: they planned the teaching work (80% of agreement on Q.B18) by adjusting either course design or teaching resources to EQF competences with lower students' performance (open question Q.B19); they brought formative feedback for social planes (85% of agreement on Q.B20) by given the opportunity to students to appraise a single student, or a group of students (open question Q.B21); perform a wider plan of assessment tasks (90% of agreement on Q.B22); and they had access to the assessment content, that is tests and qualifications (100% of agreement on Q.B26)

As final results regarding usefulness, teachers agree in a percentage of 80% on the necessity of tools that includes perspectives of EQF competences for their courses (see Q.B24). In contrast with design tasks, the assessment tasks were reported as easy for teachers with an agreement of 85% (see Q.B25).

For the section of ease of use and easy of learning, teachers' answers seem to show agreement with percentages between 85% and 95%. The only exception was the question regarding instructions to perform tasks with a slightly less agreement of 75% (see Q.C1).

For satisfaction section, results reflect highest scores for 9 of 11 questions with percentages between 80% and 95% of satisfaction with RUBRICS-360. For Q.E6, 25% of teachers were neutral with the idea of using EQF descriptors as scoring rubric descriptors. The remaining 75% of teachers agreed on the former question. A similar result was for satisfaction with intensive qualification of EQF competences in activities (see Q.E10). It is important to notice results for question Q.E9. Here, with a percentage of 85%, teachers agreed on that it was worth the effort of design in order to produce automatic assessment tests.

Last but not least, results of section Privacy and Data Sharing evidence high agreement for teachers in the policies implemented in RUBRICS-360. Some open comments to Q.F3 revealed that teachers desire a mechanism to use RUBRICS-360 taking the role of a particular student, similar to the functionality of Moodle VLE.

6.8 Discussion

The greatest finding of the study with RUBRIS-360 is that teachers feel rewarded with the generation of personalised automatic plans and tests of assessment for teachers and students. Joined to the previous reward in term of new resources generated, it is also reported as enhanced benefit the new information produced from the proposed outcome-based assessment process such as: formative feedback introduced for social planes in the course (a single student, a group of students in a project). Thus, it worth the effort of course design. As future work would be valuable a better support of formative feedback for the social plane class. That is, to introduce functionalities for assessments and comments directed to the all class.

Another important finding is that teachers have the necessity of transforming EQF competence qualifications of an activity with a traditional mark (or grade) for it. Thus, teachers expected as result of a competence test: a) the results of EQF competence qualifications, and b) a final mark (or grade) for the activity. Strategies to introduce personalised metrics for teachers are necessary in order to generate an automatic mark from the set of EQF competence qualifications. The study pointed out that teachers transform in a subjective manner a student´s performance to a mark (or grade). Furthermore, Colombian teachers tend to be more conservatives transforming competence performance to marks than Spanish teachers. All in all, this is an issue to be analysed with precaution because the EQF levels are not correspond necessarily with an ascendant order. So, a superior level of qualification not necessarily means a better performance for the all cases.

The research team feel pleased that teachers achieved the proposed objectives using RUBRICS-360. Teachers reported evidences of contextual awareness and reflection about the underlying EQF competences of their courses. They also reported to be able to monitor and moderate their courses from the information gathered.

From the overall results, RUBRICS-360 seems to be useful, easy to use, and easy to learn. However, some improvements are in the line of future work. For instance, some teachers claim the necessity of introducing personalised additional comments to clarify the EQF descriptors in the context of their own courses. The former would be formative information for students. So, it is good idea to take this into account for a further version of RUBRICS-360. Another improvement would be to introduce a palette of colours, additional to the metaphor of icons, to represent the progress of a user in the assessment plan. A final functionality to introduce is to allow teachers change their interfaces to the interface of a particular student.

It is thought that teachers found assessment tasks easy due in part to prior experience with ONTO-EQF and CC-DESING. This experience gave them adequate knowledge about the EQF. It would be a sign that decreasing cognitive overload increases levels of agreement in the new tasks.

To conclude this discussion it is important to note that this type of assessment proposal for university courses increase the commitment of teachers and students in the process of assessment. Consequently, some teachers are not so willing to accept in a first instance the new challenge. From the case study observation it is important to say that teacher´s motivation is important as referent for student´s enthusiasm.

6.9 Contributions and Conclusions

A web application called RUBRICS-360 for assessment of EQF competences in higher education courses has been presented. A case study and survey with the perspective of teachers was also described. With RUBRICS-360 teachers and students were involved in a new approach of assessment for their courses. This new method generates automatic tests from the script of qualifications designed previously by the teacher. Hence, self-assessment, peer-assessment intragroup, peer-assessment intergroup, and teacher-assessment are possible to qualify EQF competences of an activity. With the student as the centre of feedback, RUBRICS-360 is an example of a 360-degree feedback implementation in higher education for outcome-based assessment.

Teachers were able to reach proposed objectives using RUBRICS-360; even they found assessment tasks as easy to carry out. More important, although design tasks were reported as difficult before, at the end of the process teachers felt rewarded with the automatic generation of tests for assessment and the formative information collected. From the results, it seems that teachers can make effective use of the EQF for monitoring. They reported follow an EQF competence development by inspection of the set of evaluations of a student. With the plan of assessment they were able to monitor pendent qualifications to be assessed. On the other hand, effective use of the EQF for moderation has been the case when teachers use comments to explain lower qualifications and give advice within the process of outcome-based assessment. Previous assessment results were useful to moderate group meetings because they were a tangible base for discussion of group performance. As for contextual awareness and reflection teachers also reported some strategies such as: managing tests as pieces of a puzzle reporting EQF competences in the course, predicting errors in course design according to a considerable number of students that failed, analysing expected learning outcomes to judge students, matching real evidence with evidence described in EQF descriptors, and thinking in repercussion of the monitored qualifications for each student.

Implications with the traditional ways of assessment were found so as to conclude that the outcome-based assessment must provide a bridge to produce metrics in order to calculate a mark or grade per activity. The conciliation between the traditional evaluation and the assessment of EQF competences is vital to the willingness of higher education teachers in the adoption of the EQF for their courses. In short, teachers want that their efforts for a deep analysis in outcome-based assessment be rewarded in formative assessment as well as in summative assessment.

An objective of this chapter was to contribute with a mechanism to monitor lifelong competence development from higher education assessment. The ideal of national and European qualifications reported as learning outcome levels of the EQF could be better supported if these qualifications come from the source where the outcomes were attained. A detailed quantity of standardized qualifications can be monitored from courses in higher education. The call for European education and qualification from this chapter is to take advantage of technology to monitor competence development in the heart of learning institutions. Thus, conciliation between European instruments such as the Europass, the EQF and ECTS could have a common point of data gathering.

CHAPTER 7

VISUAL SUPPORT OF COURSE MONITORING AND MODERATION FOR EQF COMPETENCE DEVELOPMENT

This chapter is organized as follow. Section 7.1 gives a brief introduction of main contributions that motivated this research. It also brings a final vision of how these ideas are combined to promote. Section 7.2 presents the research questions related with this chapter. Section 7.3 introduces the teachers′ objectives using visual learning analytics. In the same way Section 7.4 shows the students′ objectives through visual analytics. Section 7.5 describes the SOLAR application emphasizing in possible consequences for teachers and students. Adaptations of interfaces are explained as well. Additionally, usability decisions are documented and justified. After that, Section 7.6 and Section 7.7 explain the case studies for different roles that used the application, mainly teachers and students. The results from the case studies are showed in Section 7.8 followed by a discussion of those in Section 7.9. The chapter ends with a summary and descriptions of the conclusions and key findings in section 7.10.

7.1 Introduction

With the increase of available educational data and the emerging learning analytics research field (Govaerts et al., 2011; Drachsler & Greller, 2012; Ferguson, 2012) there are potentials to support the visualisation of course objectives mapped to EQF competences. To reach such objective, data aggregation of learners' evaluation activity is needed in web-based learning environments. Moreover, recent work on open student models (Bakalov et al., 2011; I.-H. Hsiao et al., 2012; I.-H. Hsiao, 2012) seems to be supportive for the above mentioned issues. Open student models can express the rather complex dependencies between study behaviour, EQF competences, and the underlying learner model. For instance, Hsiao, Bakalov & Brusilovsky use open student models in their research to present the student progress in self-assessment tasks with parallel and introspective views. Inspired by their approach, this thesis applied a sunburst representation to visualise the dependencies of the AEEA student model to the EQF competence framework. The visualisation aims to support students in order to gain contextual awareness of their underlying learner model. Consequently, the support of learning activities may help to improve their competence development in an easy and comprehensive manner.

To sum up, learning analytics and open student models can assist students in creating contextual awareness, supporting reflection, and understanding where their success and failure in EQF competences development are. This thesis combined these approaches in the SOLAR suite to support the uptake of EQF at the university level by offering a series of dashboards with analyses and a visual representation of an open student model of EQF competence development during the course. SOLAR displays to students their individual learning outcomes according to EQF by comparing them to the overall class performance, teammate's performance and the expected teacher performance. The SOLAR application aggregates information from the data produced by the previous RUBRICS-360 application. The SOLAR application aims to trigger reflection and contextual awareness processes about EQF competences development for both students and teachers.

SOLAR combines learning analytics, open student model, personalised content, social visualisations, and outcome-based assessment results to deliver personalised visualisations of EQF competence development with parallel views of social plane perspectives.

7.2 Research Questions

Several thesis questions are addressed in this chapter from the learning analytics and open user models areas. Here, complementary answers are expected to the ones found out in previous chapters for similar or equal questions. Moreover, separated case studies were performed in order to divide research focus on a single user perspective and the research questions attained to a particular viewpoint. The first case study was carried out for the teacher perspective while the second one was for the student. Different courses in the area of Engineering were used throughout 2011 and 2012. Research questions are presented below by user perspective.

Teacher´s Perspective Research Questions

> *How teachers can make effective use of European standards for monitoring and moderate their lessons? (Contribution to answer RQ-4 of this thesis)*
>
> *How can teachers be more aware and reflect about the underlying competences in university courses? (Contribution to answer RQ-5 of this thesis)*

On the other hand, from students' viewpoint the main research question of this chapter address the need for structuring a mechanism for students to take notice of EQF competences in their higher education. Consequently, for the student's perspective research questions are:

> *How can students be more aware and reflect about the underlying competences in university courses? (Contribution to answer RQ-5 of this thesis)*
>
> *How can students make effective use of European standards for planning, monitoring and evaluating personal progress? (Contribution to answer RQ-6 of this thesis)*
>
> *RQ.7 Will open and social visualisations provide successful Personalised guidance within a rich collection of educational resources?*

7.3 Users Objectives

7.3.1 Teachers' Objectives with Visual Analytics in SOLAR

The SOLAR application provides visual overviews of the learners' progress against what designed by the teacher. It provides performance parallel views of individual student, his/her peers, and all as a class. The teachers' goal with SOLAR is to monitor the progress of a course and of individual learners on relevant dimensions. Another objective is to create contextual awareness and reflection for teachers on how learners are developing or not, the competences related with the course. For teachers, other purposes are to identify good and bad students according to failure and success in competences´ performance. One last objective is to identify potential problems in the course design.

7.3.2 Students' Objectives with Visual Analytics in SOLAR

This application allows students to explore visual representations of their study progress in terms of qualification of EQF competences. The analyses are made according to the EQF competence mapping of the teacher for each activity and assessments of the students. SOLAR, then; provides parallel views as was said previously. Regarding the student perspective, the parallel views show only anonymous summary of teammates and class performance. The application aims to support contextual awareness and reflection of the learning process of the students. SOLAR stimulate their self-regulation processes as well. Therefore, the application wants to support students to recognize success and failures in their learning process and competence development.

7.4 The SOLAR Application

As mentioned previously, SOLAR application mainly provides visual access to student performance. It also provides *social open student model* about learning outcomes and the development of competences in a course.

Thus, the visualisations are showed with parallel social planes (a student, teammates, and, class). The student social plane shows data of a single student. Peers social plane can mean either the whole class minus the current student (when the course has not subdivision of students in groups) or the group of students that work together for collaborative activities. Finally the class social plane shows data of the whole class. The motor that produce visual analytics take into account the 360 degree evaluation made with RUBRICS-360 to deliver weighted qualifications. Figure 7-1 shows an overview of SOLAR application for teachers.

The left column shows results for the student social plane, the middle column displays results for the peers social plane, and the right column illustrates results for the social plane class. Students have a similar layout for their interface but without marks of the other students, just summary results and details of their own results. Figure 7-2 shows an overview of the students interface. The following paragraphs and figures detail the learning analytics showed by SOLAR. The figures exemplify the perspective of the teacher role. If any difference exists with the perspectives of the student, the student adaptation is described.

The performance is contrasted against the expected levels of qualification defined by the teacher. The former is presented in the charts by different colours. *Green* indicates successful performance, in other words, the student achieved the projected level. *Orange* designate below performance, that is to say, the student has a lower level than the expected. *Blue* specifies that student has a level beyond the projected. Figure 7-3a shows general results of a single evaluation activity for a student. A bar and a coloured label are plotted for each competence evaluated. Figure 7-3b displays general results of a single competence for a student. A bar and a label are marked for each evaluation activity that assesses the competence. For Figures 7-4a and 7-4b use stacked bars to represent each student. Figure 7-4a illustrates the results of a group of peers in competences of a particular evaluation activity, summarizing the student's competences in terms of below, success or above the expected level. Figure 7-4b shows the results of a group of peers in activities that evaluate a particular competence, summarizing this time the number of activities in terms of below, success or above the expected level as well.

The visual analytics for the class social plane is also display using stacked bars as the ones employed for the peers social plane. Figure 7-5a shows the results of the whole class in competences of a particular evaluation activity. Figure 7-5b displays the results of the whole class in activities which evaluate a particular competence.

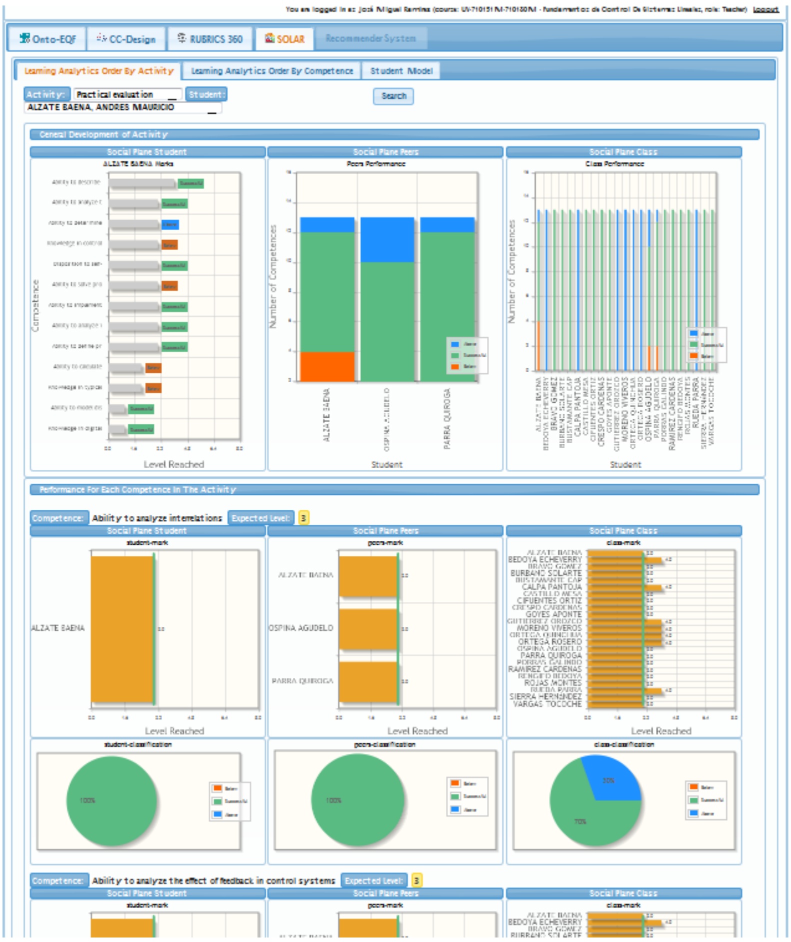


Figure 7-1 Overview of SOLAR application for teachers

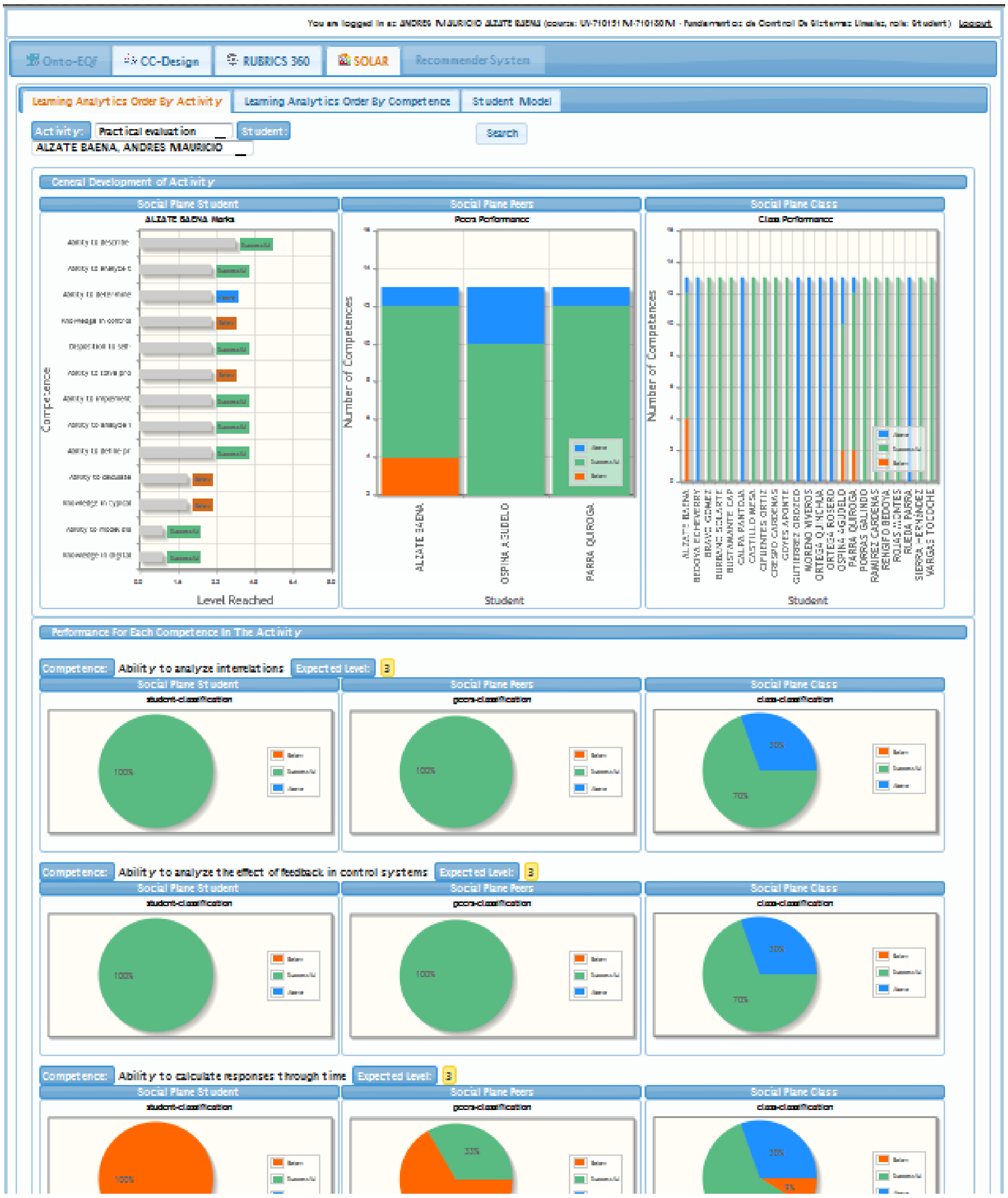


Figure 7-2 Overview of SOLAR application for students

a) b)

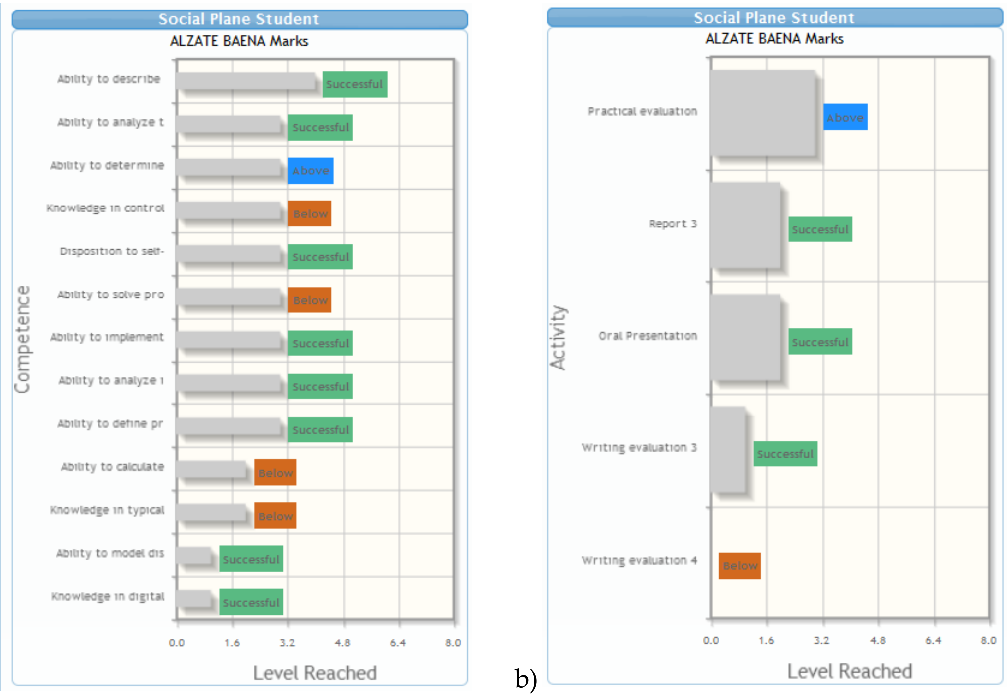


Figure 7-3 General performance for student social plane. a) Detail of general performance in competences related to a single activity. b) Detail of general performance in activities that assess a competence.

a) b)

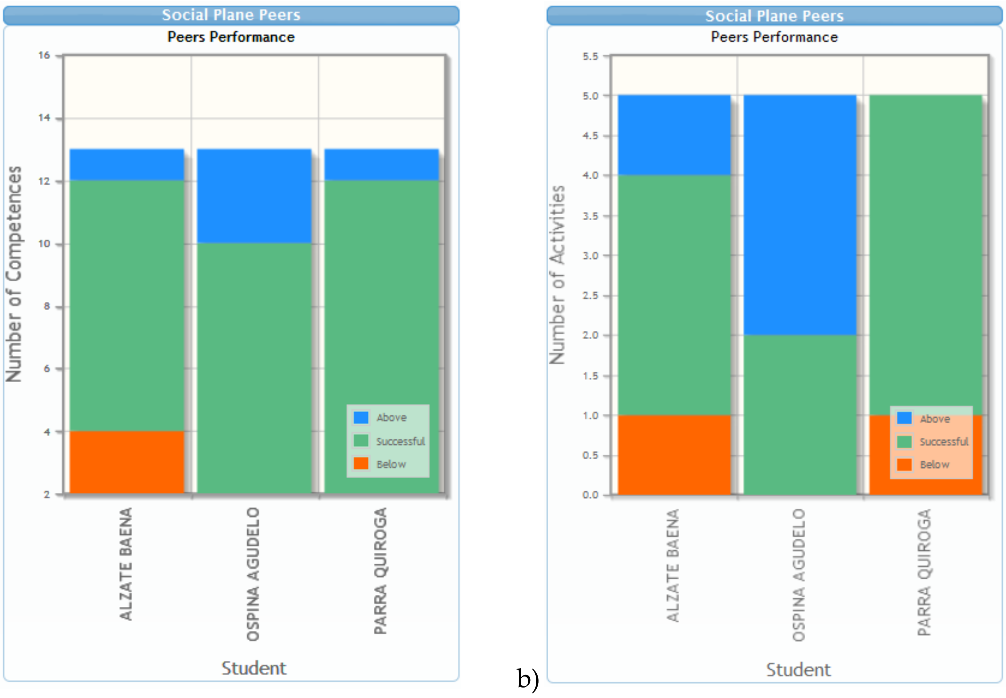


Figure 7-4 General performance for teammate social plane. a) Detail of general performance in an activity. b) Detail of general performance in a competence.

a) b)

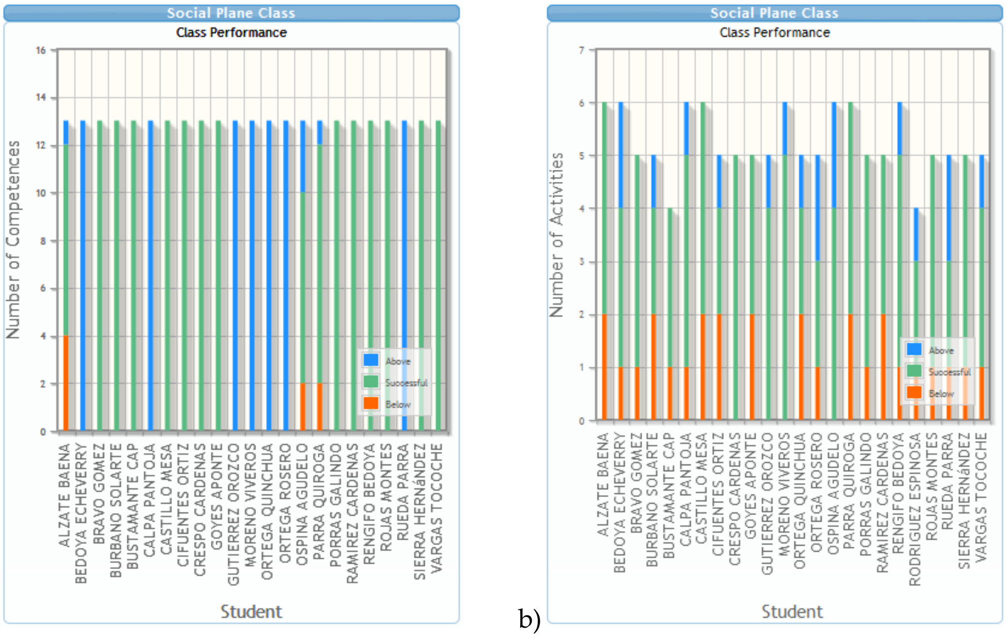


Figure 7-5 General performance for class social plane. a) Detail of general performance in an activity. b) Detail of general performance in a competence.

Detailed plots are generated selecting a particular competence and activity. Figures of each social plane contains two plots namely, a bar chart and a pie. Figure 7-6a corresponds to student social plane, Figure 7-6b displays peers social plane while Figure 7-6c shows the class social plane. Bar-charts exhibit the level achieved for each student in contrast with the expected one (green line). Pie charts instead show the percentage of students that achieve a performance level in terms of success, below, or above. Figure 7-6d shows the adaptation for the student interface in the class social plane (the personalisation is similar for the other social planes). Due to university policies, students are not allowed to visualise bar-charts with the result of their peers or classmates. Marks, grades or even competence qualifications of their colleagues are considered personal information to not be shared by default.

Figure 7-7 shows the open student model representation added to SOLAR. It is a sunburst visualisation that combines the allocated competences model defined by the teacher model with the overall performance of the student. The sunburst is built upon consecutive concentric circles that explain the dependency from projected competence, evaluation activities, to the final student learning outcomes. The first circle (from the centre of this sunburst) shows the Knowledge Domains applied in the course. The second circle shows the competences available within each Knowledge Domain, brown colours discriminate the type of learning outcome (Skill, Knowledge, or Wider Competence). The third cycle shows the assessment activities and their EQF levels defined by the teacher using purple colours. The forth circle shows the student's performance in the activity (in terms of success, below, or above). For instance, this sunburst illustrates the user model of a particular student in the course Lineal Control Systems. The knowledge domain *I.2.8 Computing Methodologies / Artificial Intelligence / Problem solving, control methods, and search / Control theory* has three competences to be evaluated: 1) *Ability to design block diagrams*, 2) *Knowledge in digital and analogue control systems*, and 3) *Knowledge in typical loop of analogue* *and digital control*. Competence 2 is evaluated through the activities: *2.1) Oral Presentation, 2.2) Practical evaluation, 2.3) Report 1, 2.4) Report 2, 2.5) Report 3, 2.6) Writing evaluation 1, 2.7) Writing evaluation 2, 2.8) Writing evaluation 3, and 2.9) Writing evaluation 4*. The performance of this student in the previous activities is: Successful, Successful, Above, Successful, Successful, Successful, Above, Successful, and Below respectively.

Figure 7-6 *Detailed plots for performance of a pair competence-activity. a) Results for student social plane. b) Results for teammate social plane. c) Results for class social plane. d) Adaption in student´s interface for the class social plane.*

Some interactions are possible with the sunburst. When the mouse is passed over the visualisation, tooltips shows up to provide some extra information and the sector is turned red to distinguish it. Figure 7-8a displays an example of tooltip over a knowledge domain sector, Figure 7-8b over a competence, Figure 7-8c over an evaluation activity, and Figure 7-8d shows a tooltip over a learning outcome. Tooltips are always displayed horizontally; no matter in what sector of the sunburst the user is passing the mouse. Then, the idea is to avoid unnecessary user head rotation when reading. Another interaction is choosing a sector with a mouse click. After clicking, the whole sunburst rotates to position it horizontally at the right of the circle. The same usability principle remains, to allow a comfortable reading for the user. The active sector is turned *cyan* colour in order to distinguish it. A fixed box in the top-right corner explains the active sector chosen in the sunburst. The outer chosen sector is, the more information appear in the box since data from the previous circles are added. For example, if the active sector selected is in the last circle, the box shows data from the underlying knowledge domain to the achieved learning outcome. Figure 7-8e is an example of this box with a full path.

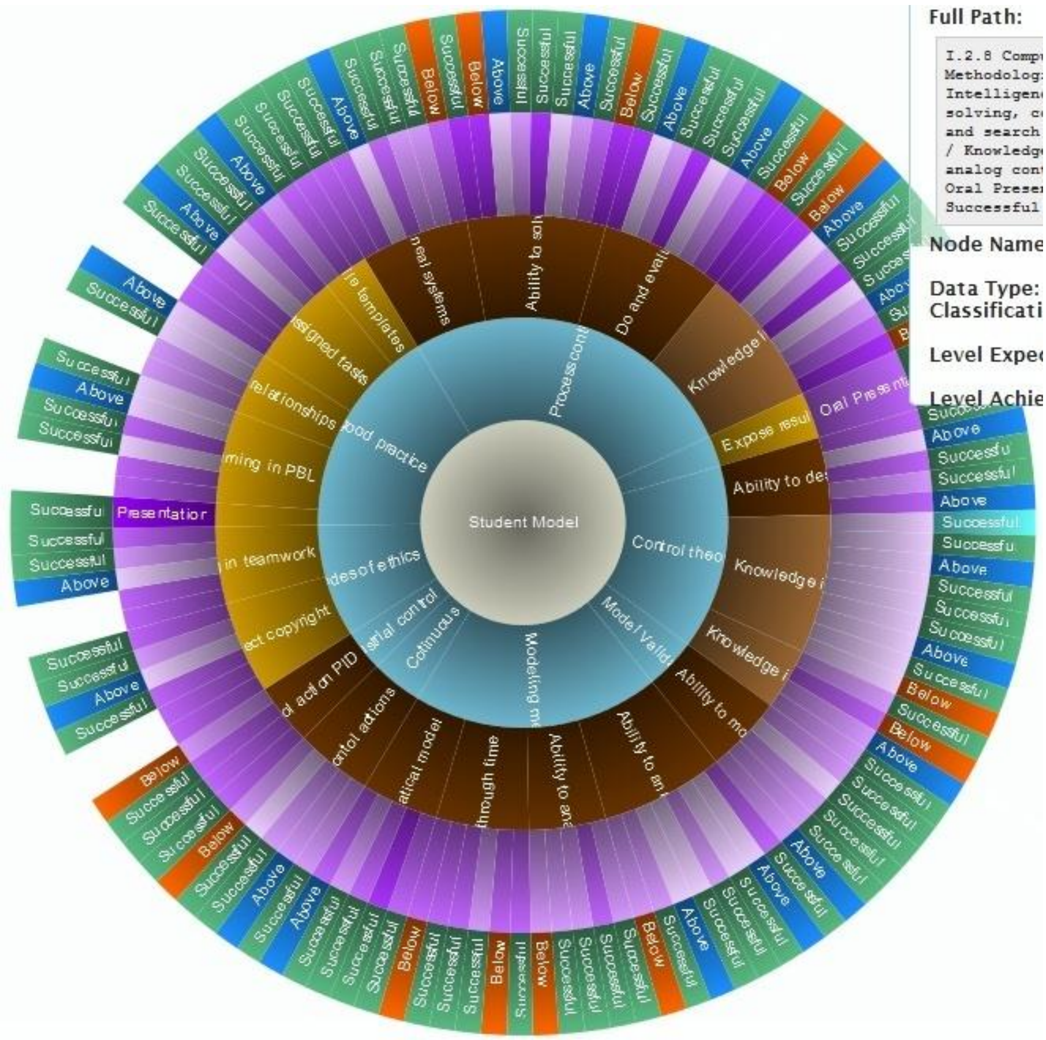


Figure 7-7 Sunburst representation of instructional design and student's qualification

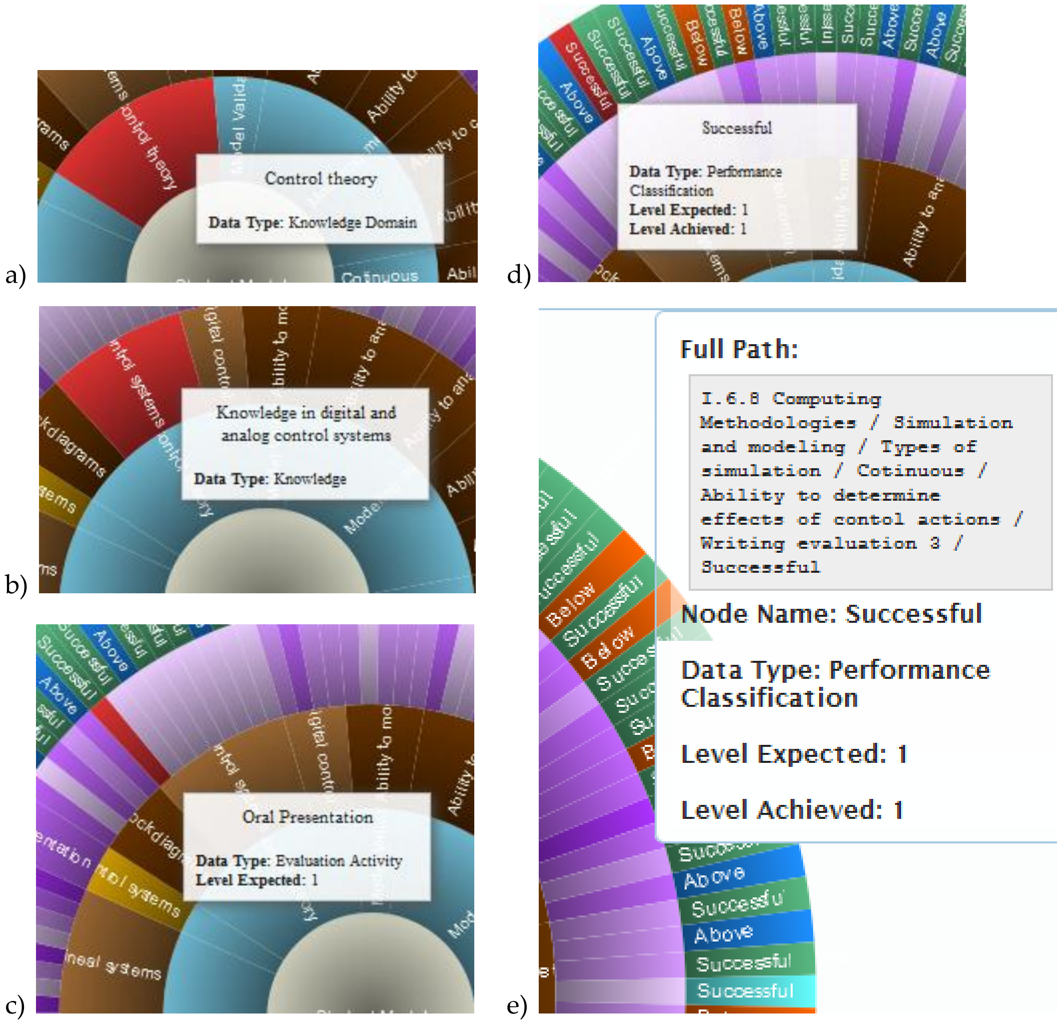


Figure 7-8 Sunburst's tooltips with contextual information at each level of the open student model. a) Tooltip with additional information of knowledge domain. b) Tooltip with additional competence information. c) Tooltip with additional information of the evaluation activity. d) Tooltip with additional information of evaluation result. e) Detailed box information for active selection.

7.5 Case Studies

7.5.1 Case Study with Teachers

This case study explores the social perspective of teachers. It was performed in fall semester 2011 using three courses in programming. In total, 20 teaching persons participated: 12 computer science teachers (4 of them were coordinator) and 8 computer science teaching assistants. Six of these teaching persons were females and the other fourteen males. Regarding range ages were between 24 and 48-year-old. The total number of enrolled students for the first course was 100 while the second and third had 20 students each.

Teachers were asked to use SOLAR application to evaluate whether this could assist them in understanding student models and development of competences.

Usefulness of SOLAR application to include EQF perspectives in the course design was also evaluated.

A survey was designed with four sections dedicated to evaluate SOLAR application and the AEEA Suite. First section collected demographic data, the second one inquired only about SOLAR application, the third corresponded to the AEEA Suite and, finally the last section was for open comments. Questions were mainly designed to measure the satisfaction, usefulness, and opinion of teachers during the test period. The survey contained several types of questions including open questions, 5-point Likert scales with single choice questions, and matrix tables with single choice questions. In the case of 5-point Likert scales, one (1) always meant the worse option and five (5) the best option. The question items of the second section of survey are presented in Table 7-1.

Table 7-1 Overview survey teachers´ case study

Evaluation questions about SOLAR	Answer types and data range
Q2.1 Was it easy for you to understand the meaning of visualisations?	Single choice. 5-point Likert Scale Very difficult (1) - Very Easy (5)
Q2.2 Was the overall appearance of SOLAR elements (colours, plots, etc.) suitable for you?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
Q2.3 How satisfied are you with the SOLAR application for course's monitoring?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
Q2.4 How satisfied are you with the SOLAR application for course's moderation?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
Q2.5 * Was SOLAR useful for you to detect failure and success of students?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.7 Was it easier to understand students' failures and successes with SOLAR than without it?	Single choice. 5-point Likert Scale Very difficult (1) - Very Easy (5)
Q2.8 * Was SOLAR useful for you to detect potential problems in course design?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.10 * Was it useful for your teaching-work the learning analytics presented?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.12 * Do you think SOLAR can assist teachers in raising contextual awareness about performance of students in terms of EQF competence development?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.14 * Do you think SOLAR can assist teachers in raising reflection about performance of students in terms of EQF competence development?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.16* Do you think that this kind of dashboards can assist teacher in understanding performance of students in social planes?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.18* Did SOLAR application allows you to classify students in terms of excellent, good, average and failing?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.20 Was it easier to classify students with SOLAR than without it?	Single choice. 5-point Likert Scale Very difficult (1) - Very Easy (5)
Q2.21 * Was SOLAR useful for you to bring personalised guidance to students within the collection of assessment resources?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
Q2.23 * Was SOLAR useful for you to bring personalised guidance to students within the collection of learning outcomes reports?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)

7.5.2 Case Study with Students

Following the teachers' case study (Florian-Gaviria, Glahn, & Fabregat, 2013) it was conducted the one for students. After some improvements to AEEA Suite and the addition of an open student model as a sunburst visualisation, the research focussed on the student perspectives evaluation on AEEA Suite and more specifically SOLAR application.

This research emphasise on the evaluation of the approach to explain the complex dependencies between course objectives, study behaviour, and competence development according to EQF. It is the belief of this study that students need tools to understand: how their study performance is related to the EQF qualifications and to be aware on how they can improve their competence development. Therefore, this work had two main research questions (see Section 7.2)

An online survey was designed to gain further insights from the student target group regarding the benefits and shortcomings of the AEEA suite and SOLAR. The participating students were supported first with an one-hour meeting where they were taught EQF, general aspects of AEEA suite, and SOLAR application. Afterwards, students received their login credentials to sign into AEEA suite. The enrolment process to the course "Data Structures and Algorithmic" took one week. After the study course was completed the online survey was provided to them. The study took five weeks in total.

Method: The survey was designed and hosted using the free limited version of Qualtrics (qualtrics.com). This tool provides several practical question-answer types. The survey is divided in four sections. First one collected demographic data, then a larger section gathered specific information about SOLAR application a third one is dedicated to AEEA Suite, and the final section focused on open comments.

Table 7-2 shows the overview of question items, answer types, and data range of the survey's second section.

Questions were mainly designed to measure satisfaction, usefulness, and opinion of students during the test period. The questions were formulated in a variety of types, including prioritization lists (rank order), 5-point Likert scales with single choice questions, and matrix tables with single choice questions. In the case of 5-point Likert scales, one (1) always means the worse option and five (5) the best option. On the contrary, in the case of rating scales the more punctuation the less desired option.

Participants: The idea was to promote the interviews and questionnaires equally to students enrolled in college degrees, master studies, and doctoral studies in the Polytechnic School of the University of Girona. It was received higher response from master students with a 40% of the enrolment rate (n=10). The Ph.D students were the less involved counting 4% of the enrolment rate (n=1). The youngest group of students, the 2nd-year college students, sum 20% of the enrolment rate (n=5). The remaining 36% (n=9) comes from 4th-year college students. In total, 25 surveys were collected from students where 32% (n=8) were females and 68% (n=17) males. The age range reported was between 18-34 years old. A first cluster between 18-year to 25-years reached the 44% (n=11). A second cluster between 26-years to 34-years reached 56% (n=14).

Table 7-2 Overview of student´s case study survey

Question	Answer types and data range
QB.1 How satisfied are you with SOLAR application to trigger reflection and contextual awareness about your learning processes?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
QB.2 How satisfied are you with SOLAR application to understand your qualification of competences?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
QB.3 How satisfied are you with SOLAR application to understand your learning progress?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
QB.4 How satisfied are you with SOLAR application to understand your performance versus the performance of your classmates?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
QB.5. How satisfied are you with SOLAR application regarding time response to generate plots and visualisations?	Single choice. 5-point Likert Scale Very dissatisfied (1) - Very satisfied (5)
QB.6. Was it easy for you to understand the meaning of visualisations?	Single choice. 5-point Likert Scale Very difficult (1) - Very Easy (5)
QB.7. Did it take you long to understand the meaning of visualisations when using SOLAR for the first time?	Single choice. 5-point Likert Scale Very Slow (1) – Very Fast (5)
QB.9 Was it possible for you to detect your failures and successes in development of competences?	Single choice. 5-point Likert Scale Definitely not (1) – Definitely yes (5)
QB.10 Was it possible for you to be aware of your academic strengths and weaknesses in terms of EQF competences?	Single choice. 5-point Likert Scale Definitely not (1) – Definitely yes (5)
QB.11a Was it helpful for your reflection process to observe your qualifications versus the performance of others (“teammates” and “class”)?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.11b Was it helpful for your contextual awareness process to observe your qualifications versus the performance of others (“teammates” and “class”)?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.12. Were the presented learning analytics useful for your evaluation of learning activities?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.13. Were the presented learning analytics useful for your evaluation of EQF competences?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.14. Were the presented student model representation (Sunburst Visualisation) useful to understand your user model?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.15a. Do you think is useful to use SOLAR application throughout course lifecycle?	Single choice. 5-point Likert Scale Strongly disagree (1) – Strongly Agree (5)
QB.15b. Do you think is useful to use SOLAR application only at the end of the course lifecycle?	Single choice. 5-point Likert Scale Strongly disagree (1) – Strongly Agree (5)
QB.16 Do you think this kind of dashboards can support students to perform self-regulated learning (planning, monitoring, and evaluating personal progress against a standard)?	Single choice. 5-point Likert Scale Strongly disagree (1) – Strongly Agree (5)
QB.17 Was SOLAR useful for your personalised guidance within the collection of assessment resources?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)
QB.18 Was SOLAR useful for your personalised guidance within the collection of learning outcomes reports?	Single choice. 5-point Likert Scale Very useless (1) – Very useful (5)

7.6 Results

7.6.1 Results of Teacher’s Perspective

Once teachers completed the courses, the designed survey was filled out to evaluate the usefulness and satisfaction of SOLAR application for them. In this survey, teachers answered open questions about several items such as how well they understood the application and tasks; if they used some strategies to complete the process; how they achieved the proposed objectives (especially after questions with * in Table 7-1); if they had some advice to improve the suite; if they had suggestions for new learning analytics, and if they needed extra information or new abilities to perform the proposed tasks. In addition, to find out how many teachers were satisfied, they answered a series of questions (see Table 7-1) where they had to choose the most appropriate response of a 5-point Likert scale from 1 (Very dissatisfied or similar) to 5 (Very satisfied or similar). Finally, at the end of the survey a space was left for additional comments.

Table 7-3 summarizes the agreement percentages and frequencies for each question in the second section of survey. Figure 7-9 and Figure 7-10 show the summary of the subjective evaluation for each itemized survey question of the same section.

Table 7-3 Frequencies and percentages of Teachers´ survey results for SOLAR

Question	1 (worse)		2		3 (neutral)		4		5 (best)	
	n	%	n	%	n	%	n	%	n	%
Q2.1	0	0%	4	20%	2	10%	14	70%	0	0%
Q2.2	0	0%	1	5%	2	10%	8	40%	9	45%
Q2.3	0	0%	0	0%	2	10%	7	35%	11	55%
Q2.4	0	0%	0	0%	2	10%	8	40%	10	50%
Q2.5 *	0	0%	0	0%	4	20%	12	60%	4	20%
Q2.7	0	0%	0	0%	2	10%	7	35%	11	55%
Q2.8 *	0	0%	0	0%	4	20%	12	60%	4	20%
Q2.10*	0	0%	0	0%	5	25%	15	75%	0	0%
Q2.12 *	0	0%	0	0%	4	20%	10	50%	6	30%
Q2.14 *	0	0%	0	0%	4	20%	10	50%	6	30%
Q2.16*	0	0%	0	0%	3	15%	9	45%	8	40%
Q2.18*	0	0%	0	0%	4	20%	13	65%	3	15%
Q2.20	0	0%	0	0%	2	10%	9	45%	8	40%
Q2.21*	0	0%	0	0%	3	15%	9	45%	8	40%
Q2.23*	0	0%	0	0%	3	15%	9	45%	8	40%

Regarding meaning of visualisations (see Q2.1), teachers satisfaction was moderately rated with a 70%. The appearance of SOLAR was suitable for teachers (see Q2.2) reflected by an 85% satisfaction rate. The support for monitoring and moderation with SOLAR was perceived with a 90% high satisfaction (see Q2.3 and Q2.4). Teachers, in an 80% could identify student’s failures and successes in EQF competence development using SOLAR (see Q2.5). In open answers of question Q2.6, teachers said that they could identify failures and successes for each student by understanding the set of visualisations of EQF competence performance. They suggested implementing complementary visualisations in two ways. One that shows a summary of a sole student performance model and another that shows the summary of the class performance model. More importantly, teachers manifested that using SOLAR, they could identify successes and failures in EQF competence development. Something they have never been able to monitor before. Teachers could identify (80%) possible problems in the course design using SOLAR (see Q2.8). In open answers of Q2.9, they said these possible problems were revealed when teachers noticed, in the visualisations, a high percentage of the students with performance either bellow or beyond expected level. The learning analytics presented were useful (75%) for the teaching-work (see Q2.10). In open answers of Q2.11 teachers reported SOLAR was useful for their teaching work because was an instrument to monitor course performance, to realise areas of knowledge that need more teaching work, to realise students in danger of dropouts, and to realise students’ opinions that could be difficult in other way. In the opinion of teachers, 80%, SOLAR application triggers reflection and contextual awareness (see Q2.12 and Q2.14). The summary of open answers to Q2.13 and Q2.15 revelled that contextual awareness and reflection were raised in teachers when they endeavoured in understanding the set of visualisations for each student against their other classmates. Parallel views of social planes (see Q2.16) seemed to be well received by teachers in order to understand social student's behaviour (85%). The open answers to Q2.17 showed that teachers could understand the performance of a particular student against other social planes when they analysed the parallel visualisations. They could identify students more committed in team groups (they were better valuated by teammates), students with high performance in the class, and also students with lower performance in the class. Teachers reported in a 80% they could classify students in four categories (see Q2.18). In open answers to Q2.19 teachers suggested to generate automatically a visual model of these four categories for the class because they spent many time to figured out the general model of students classification. Moreover teachers suggested including more ranges of performance to classify students EQF competence performance. Anyway, teachers agreed in a 80% that this task of student's classification was easier with SOLAR than without it (see Q2.20). For personalised guidance, teachers agreed in an 85% that SOLAR helped students to manage enriched assessment resources (see Q2.21) and EQF learning outcomes reports (see Q2.23). In open answers to Q2.22 and Q2.23 teachers reported as evidences of personalised guidance that students realise they own model of EQF competence performance with a detailed specification of assessment resources involved in the gathering of valuations.

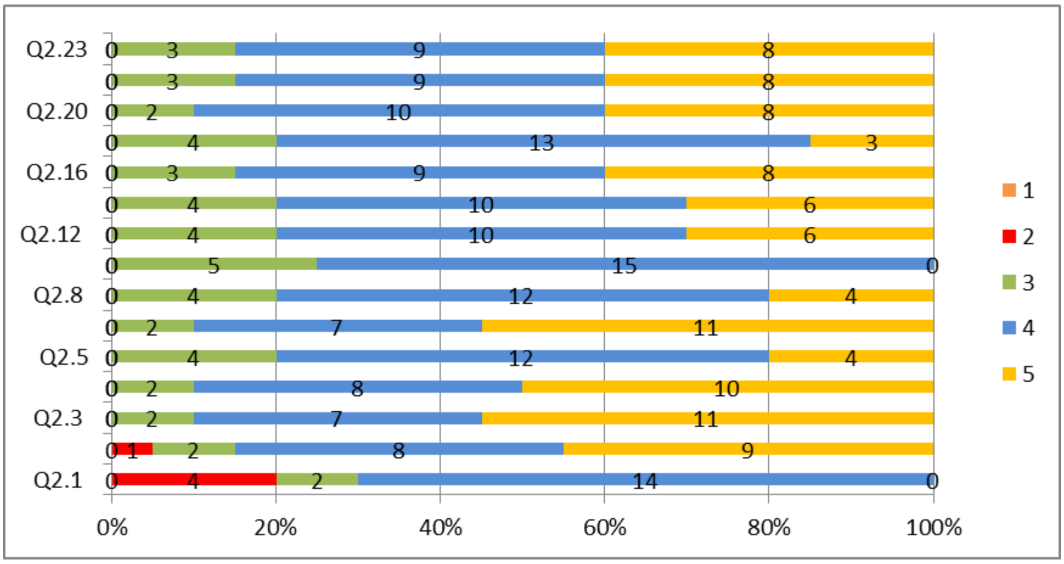


Figure 7-9 Summary of the subjective teachers' evaluation for each itemized survey question

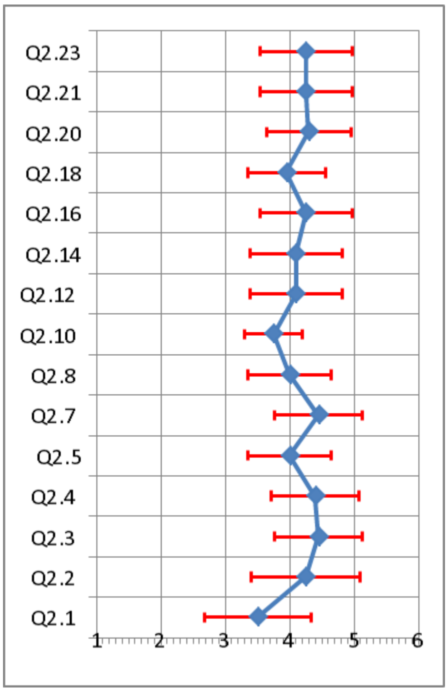


Figure 7-10 Another summary of the subjective teachers' evaluation for each itemized survey question

7.6.2 Results of Student's Perspective

The aim of the survey was to evaluate the satisfaction, usefulness, and opinion of students about AEEA suite, especially SOLAR application. Table 7-4 summarises result percentages (%) and frequencies (n) for each question of the second section of survey.

Table 7-4 Students´ survey results for SOLAR

Question	1 (worse)		2		3 (neutral)		4		5 (best)	
	%	n	%	n	%	n	%	n	%	n
QB.1	0%	0	0%	0	4%	1	64%	16	32%	8
QB.2	0%	0	4%	1	0%	0	72%	18	24%	6
QB.3	0%	0	0%	0	16%	4	64%	16	20%	5
Q5.4	0%	0	0%	0	20%	5	44%	11	36%	9
QB.5	0%	0	0%	0	12%	3	40%	10	48%	12
QB.6	0%	0	4%	1	40%	10	44%	11	12%	3
QB.7	0%	0	24%	6	32%	8	40%	10	4%	1
Q5.9	0%	0	0%	0	4%	1	40%	10	56%	14
QB.10	0%	0	0%	0	0%	0	44%	11	56%	14
QB.11a	0%	0	4%	1	16%	4	56%	14	24%	6
QB.11b	0%	0	4%	1	16%	4	56%	14	24%	6
QB.12	4%	1	0%	0	4%	1	72%	18	20%	5
QB.13	0%	0	0%	0	8%	2	64%	16	20%	7
QB.14	4%	1	0%	0	16%	4	52%	13	28%	7
QB.15a	0%	0	0%	0	4%	1	32%	8	64%	16
QB.15b	0%	0	0%	0	4%	1	32%	8	64%	16
QB.16	0%	0	0%	0	0%	0	76%	19	24%	6
QB.17	0%	0	0%	0	12%	3	60%	15	28%	7
QB.18	0%	0	0%	0	12%	3	60%	15	28%	7

As described earlier SOLAR application was designed to support self-regulation, contextual awareness, and auto-reflection process of students. Two strategies were applied mainly here: 1.Visualisation of the qualification model designed by teacher against the EQF learning outcomes achieved by student and 2.Visualisation of student grades compared to an anonymous summary of their peers' performance (teammates and classmates). Results showed in the case of students that SOLAR supported self-reflection and contextual awareness on a 96% (n=24) satisfaction level (see QB.1). Figure 7-11 shows a graphical representation of this result. Furthermore, the students rated the dual representation of their own performance, compared to the one of their peers, as very useful (80% n=20) for reflection and contextual awareness of their own study progress (see QB.11a and QB.11b).

They agreed unanimously, 100% (n=25), that this kind of dashboards can support students in their self-regulation process (see QB.16). Nevertheless, it is necessary to perform more tests to ascertain this fact in long-term courses. Figure 7-12 shows a graphical representation of this opinion.

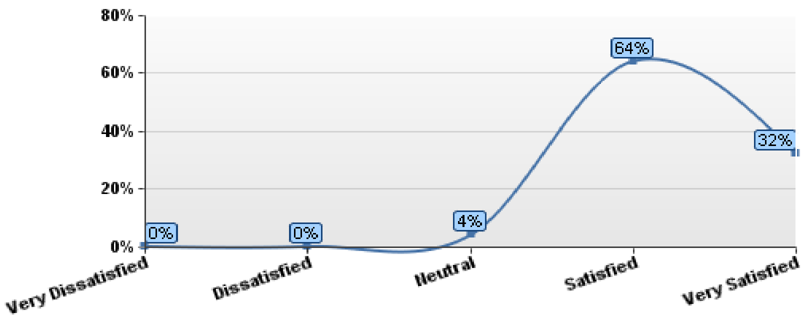


Figure 7-11 Student's rating towards reflection and contextual awareness with SOLAR

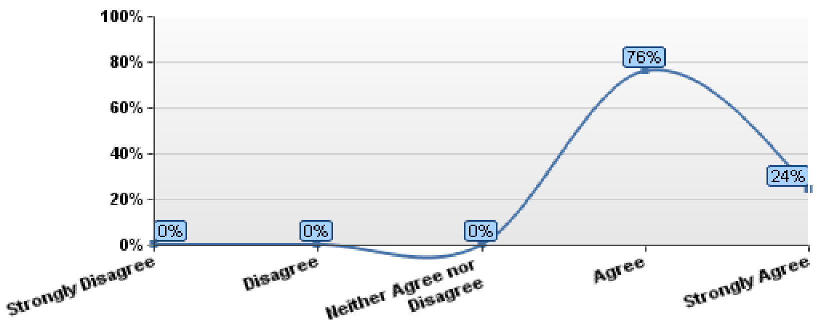


Figure 7-12 Student's opinion about self-regulation support

Another aim was to find out the students satisfaction with data related to EQF competences presented in SOLAR application. Figure 7-13 shows satisfaction results related to satisfaction with data a) Qualification (96% n=24) (see QB.2), b) Student's learning progress (84% n=21) (see QB.3), c) Individual Performance vs. Peers Performance (80% n=20) (see QB.4).

The three SOLAR's dashboards were well evaluated in terms of usefulness. The highest rated dashboard was the competence qualification dashboard (92% n=23) (see QB.12).

Finally, let's remember this study has two purposes. One is to know if the students could identify failure and success in their EQF competence development with SOLAR application and the other is to see if they could recognize their academic strengths and weaknesses in terms of EQF competences. Students reported that they were very satisfied with SOLAR application support and that it helped them in both dimension. First to identify failures and successes (96% n=24) (see QB.9) and second to recognize competence development according to EQF (100% n=25) (see QB.10).

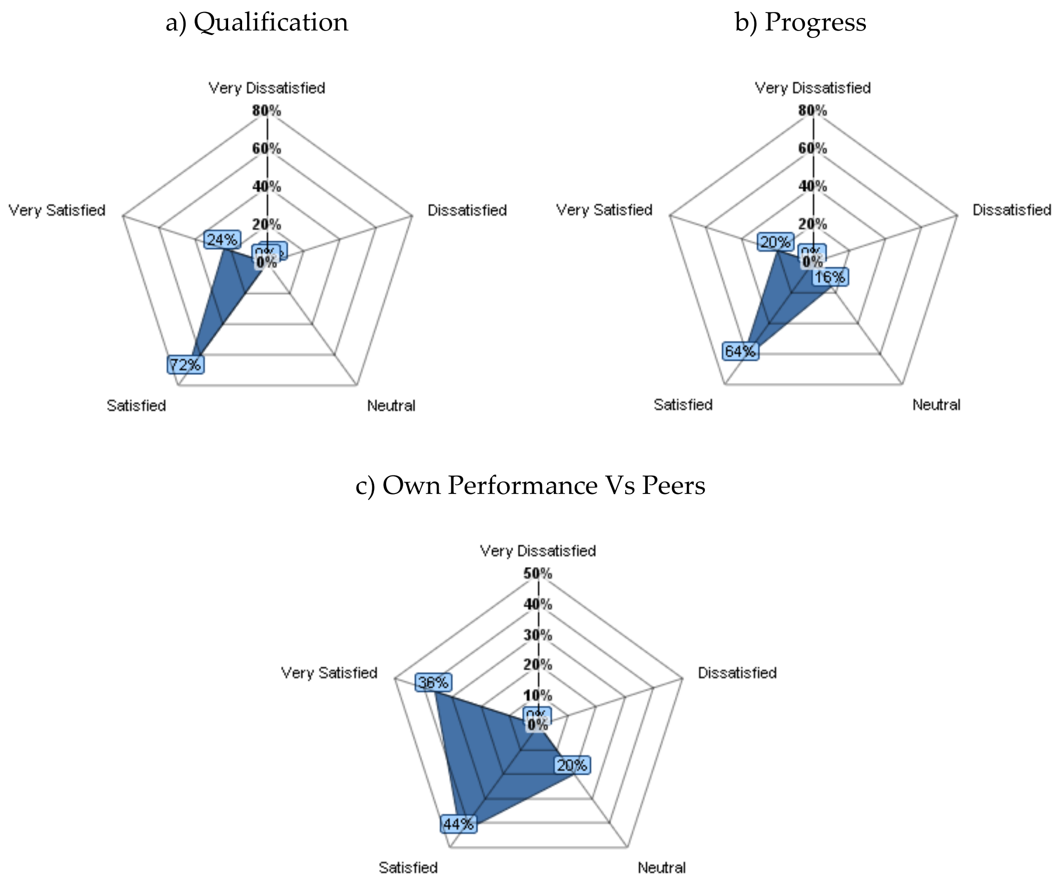


Figure 7-13 Perception about dashboards information

For personalised guidance, students felt they were well supported in an 88% to understand new assessment resources and new reports of EQF competence performance (see QB.17 and QB.18).

Figure 7-14 and Figure 7-15 show the summary of the subjective evaluation for each itemized survey question of the second section of students' survey.

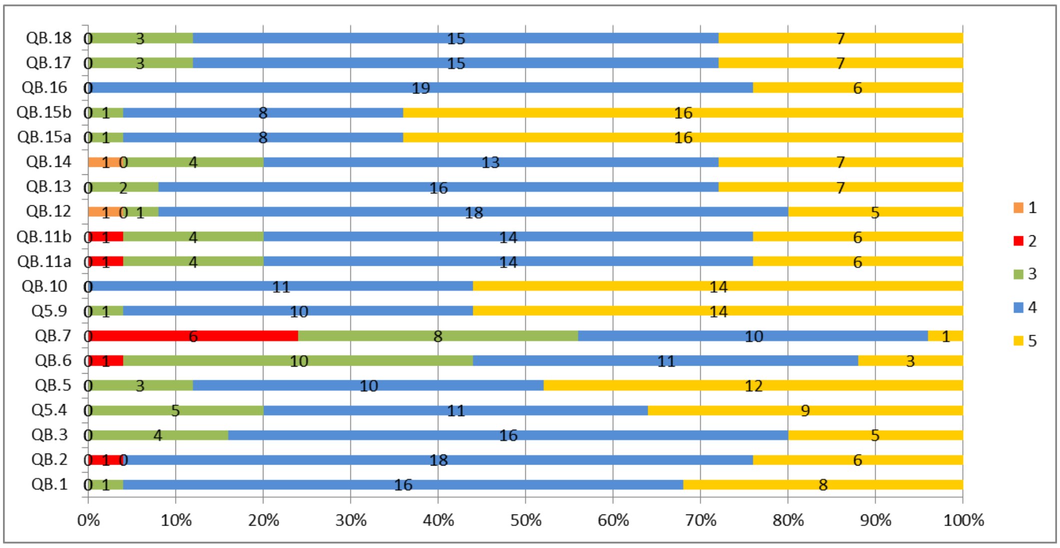


Figure 7-14 Summary of the subjective evaluation for each itemized student's survey question

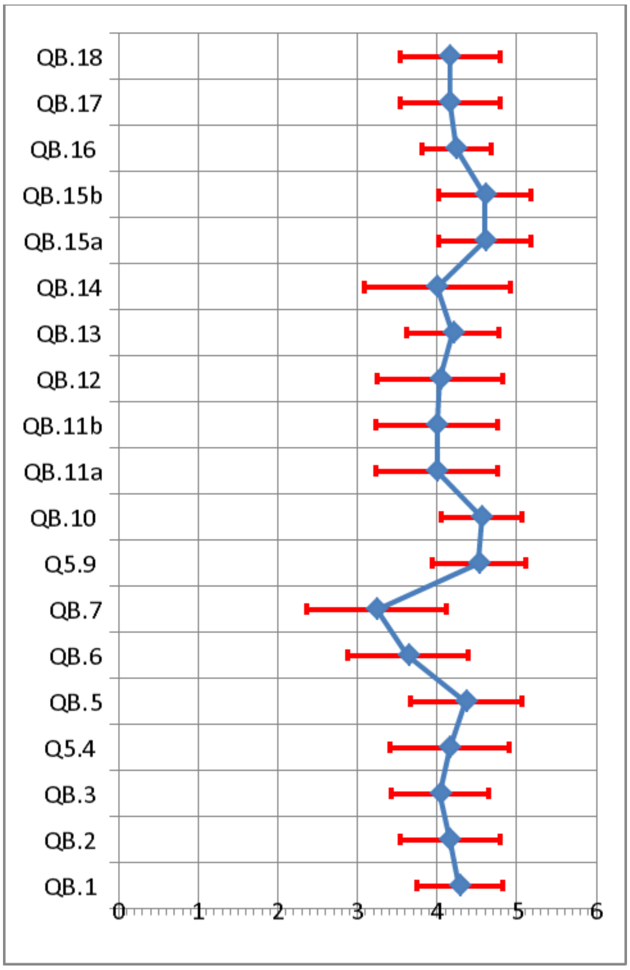


Figure 7-15 Another summary of the subjective evaluation for each itemized student's survey question

7.7 Discussion

Discussion is presented below to represent the teacher and student perspectives.

7.7.1 Discussion of Teacher's Perspective

According to the results, SOLAR application seems to be well implemented.

On the other hand, from teachers' difficulties some findings arose. First, the task of analysing visualisations (understand the meaning) performed by teachers creates cognitive overload. Although teachers manifested an acceptable satisfaction in the easiness of this task and their like for the visualisations; teachers also indicated they spent more time with the assigned task than expected. Maybe, it is because this case study was their first experience with learning analytics of competence development. Even, for most of teachers it was the first experience with learning analytics.

Taking into consideration teachers' suggestions, collected from the open questions and the final comments section of the survey, a set of improvements were implemented and new functionalities in the dashboards to allow personalisation for teachers. The proposal of parallel views of perspectives in social planes can be extended with the concept of introspective views of (Bakalov et al., 2011; I. Hsiao, Bakalov, Brusilovsky, & König-ries, 2011). In other words, to include a navigation mechanism to offer an overview of all items present in the model; to allow zooming into different parts of the model, to filter according to different criteria, and to provide details on demand. Another way to extend these dashboards is to include visualisations of progress in number of tasks performed through time (Glahn et al., 2007; Govaerts et al., 2011; I. Hsiao et al., 2011). The concept of progress visualisation in development of competences could provide a better idea of learning progress through time.

In SOLAR application teachers could identify, with an acceptable satisfaction, failures and successes in students. A complementary option of visualisations for this purpose should be: A net-visualisation of students according to their performance (class performance model), and a radial representation of student performance (the sole student performance model). The open comments related to SOLAR application showed that teachers were able to monitor student progress and also to be aware and reflect about performance of students.

7.7.2 Discussion of Student's Perspective

Similar to the outcomes of the teachers study, students also reported that it took them quite some time to understand what is presented in the different visualisations. Consequently, it is concluded that this phenomenon is due to the novelty of the approach since students are not used to these kinds of representations and EQF competence data. They require new skills to interpret the visualisations in the right way.

It was found that the sunburst representation looks nice but it can be overwhelming for small student groups. For them, a simple classical representation of qualifications in a table would be more efficient. Two observations were received regarding this point in the open questions. In addition, the sunburst visualisation was rated by 16% of the students as 'neutral'. Therefore, the dashboard needs to be provided in two versions for students (graphical and textual).

According to results proposed objectives for students with SOLAR seem to have achieved (contextual awareness, self-reflection, self-regulation). Personalised guidance allows students to recognize and navigate data of assessment resources and EQF learning outcomes reports

Some other statistical analyses were requested by students. These suggestions will be taken into account for further versions of SOLAR.

7.8 Contributions and Conclusions

SOLAR application was presented aiming to support students and teachers in contextual awareness and reflection of the learning process. The suite containing SOLAR allows an integrated process of modelling, assessing, monitoring and visualisations of development of competences. Social perspectives for teachers and students define capacities to request information from the system. The monitored information can be aggregated using different social planes (a student, teammates, classmates). In particular, SOLAR application is innovative because it presents learning analytics about competence development for different social perspectives (student, and teacher) through parallel social planes (a student, teammates, classmates).

Considering the results, SOLAR application can assist teachers in creating contextual awareness, kindling reflection, understanding students’ behaviour in social planes, and understanding successful and failure in competences development. It was notorious in the teachers’ case study that they need a dynamic visualisation of global classroom performance with more ranges of classification than above, successful and bellow.

Students´ study supports the findings of a previous study that was conducted with a teacher group. Thus, regarding the allocation and mapping of EQF competences to university courses, similar satisfaction tendencies were found in both studies.

Particularly SOLAR could visualise students’ study progress during the course through two strategies. First, an open student model visualisation of the qualification model, designed by teacher against the learning outcomes achieved by student, followed by detailed learning analytic visualisations of student’s performance compared to an anonymous summary of their peers’ performance (classmates). Learning Analytics proved to be useful to support students not only for future iterations and final assessment but also in real time during the study process. Students believe SOLAR could help them to self-regulate their learning process.

Personalised guidance within new enhanced learning resources was agreed for both users’ perspectives students and teachers. Nevertheless, more efforts could be done in order to provide navigation support within learning resources.

For future research, some findings and suggestion of the case studies will be taken into consideration to improve SOLAR application. Furthermore, combinations of the current learning analytics with introspective views in open student models are going to be made. Although more comprehensive study with both target groups (students and teachers) to explore the impact of the AEEA Suite is needed, the preliminary results are very promising. Finally, it is the aim to transfer the AEEA Suite into Moodle plug-ins to broaden and attract other research units to join to the research efforts on learning analytics and open student models.

PART V

GENERAL DISCUSSION AND CONCLUSIONS

CHAPTER 8

General Discussion and Conclusions

In this chapter, a summary of the main contributions of this research work is given together with possible directions for future research. First, the results are summarized in the following section. Followed, in Section 8.2 are discussed the scientific contributions extracted from the proposals and case studies carried out. Then, in Section 8.3 are summarised restrictions and limitations to findings of this thesis. This summary is bound to each one of the developed applications and reported findings. Finally, in Section 8.4 some interesting future research issues are discussed.

8.1 Summary of Results

The main goal for this thesis was to find an approach for course lifecycle support that merged the benefits of personalised, competence-based, and social learning to provide better context information for teachers and students in order to trace EQF competences in higher education courses. Thus, this research was conducted with the aim of filling the gaps between the EQF objectives in higher education and the practical way of carrying out them in online and blended courses.

It was proposed an integration of: *competence-based design*, *outcome-based assessment*, *social learning context analytics*, and *open student modelling visualisations*. Two technical architectures were designed as frameworks to develop this approach. Then these architectures were materialised with the implementation and deployment of a software suite called AEEA Suite. This suite has four web applications namely ONTO-EQF, CC-DESIGN, RUBRICS-360, and SOLAR. Consequently, the interest was to validate each software application of AEEA Suite, the strategies of support proposed for them, and the learning process for online and blended courses based on the EQF. To inspect usefulness, usability, ease of learning, satisfaction, and aspects of privacy and data sharing for teachers and students, a series of case studies were carried out throughout 2011 and 2012 using this software suite. These were thorough studies in blended and online higher education courses of Spain and Colombia.

In the next subsections, it is presented first the summary results of this thesis. Then, it is revisited the research questions formulated in the first chapter.

8.1.1 Results

In the first place, for teacher's perspective, it is pleasant to find out high satisfaction between them with the process and the united software applications. Moreover, teachers suggested building this kind of software suites as institutional applications in Universities. It is also satisfactory that the target objectives for teachers in each application were achieved by them.

In the second place, for student's perspective, it is agreeable to find out high satisfaction between them with the run-time applications and the EQF framework. It is also satisfactory that the objectives for students in each application were achieved by them.

Teachers were able to map the objectives of their courses to the EQF using the ONTO-EQF application. Then, teachers were able to align course design to the EQF learning outcomes levels using the CC-DESIGN application. Teachers and students were able to assess EQF learning outcomes of activities using RUBRICS-360, the social planes involved in the activities were taken in to account for these assessments. Following the progress in assessment tasks was also possible using with SOLAR. Besides, context awareness and reflection about the underlying EQF competences in the course were also possible with SOLAR. Finally, social context awareness and reflection of students' performance were possible with SOLAR application. The former took into account the social context were the EQF competences of them were attained.

Although design tasks were reported as difficult, at the end of the process teachers felt rewarded with the automatic generation of tests for assessment and the visual feedback provided (social learning context analytics and an open student model). It is thought that they found design tasks difficult because these studies were the first experience, for many of them, with a course based on the EQF. In any case, it is notorious that teachers need a previous training in competence-based design, especially learning design based on the EQF. It is also notorious that more efforts in support this kind of learning design will be helpful for teachers. Two types of recommender systems were suggested for future, and more levels of sharing capabilities for authoring of competences.

The social planes such as a student, teammates, and classmates were used to assess activities as well as to do activities' introspection in order to generate social learning context analytics. Although analyses of visualisations were reported as a big task in time consuming, teachers and students stated satisfaction and usefulness of the new resources generated.

Additionally, generally speaking, according with the results the software suite seems to be well implemented and with a suitable theoretical background. The evaluations showed that users generally felt positively about all aspects of the Suite, particularly the appreciation on ease of use, ease of learning and privacy and data sharing. Therefore the AEEA software suite supports a methodology for designing, monitoring and moderating lessons using the EQF.

8.1.2 Reexamining Research Questions

This section provides a summary of research questions and answers of this thesis.

RQ.1 What antecedents exist of support of competence development for LLL, especially in higher education?

In Chapter 1 a characterization of European projects related to LLL that were motivators of this research are exposed namely TENCompetence project, ICOPER project, PALO project, MACE projet and LOCO project. Then, in Chapter 2, the state of the art for LLL in higher education was inspected from the aspects of earliest specifications/standards for competence definitions, the EQF, authoring of competences, competence-based learning design, and outcome-based assessment. In addition, personalised education aspects were also reviewed in order to enhance the approach with social learning contextual analytics, open student models, and contextual awareness and reflection.

RQ.2 Which information elements, procedures and software applications are needed to build a technical and pedagogical architecture to support competences development?

In Chapter 3 was characterized a set of features for lifelong competence development in online and blended courses of higher education. Two phases of an online/blended course lifecycle where characterized namely the Design Phase and the Teach Phase. Then, data models, procedures and software applications where described in a technical architecture of two packages, and three layers. Four stages of course development where considered specifically competence design, learning design, monitoring learning activities & assessment, and delivering of appropriate support responses to users. Based on this technical architecture three software applications were constructed namely ONTO-EQF, CC-DESIGN, and RUBRICS-360.

RQ.3 How to introspect learning activities for competence assessment and recommendations?

In Chapter 3, a set of features was characterized in the technical architecture called activity-based learner-models. This architecture allows building learning analytics and recommender systems with a wider perspective view of social planes on the learning process. In the semantic layer of this architecture, activity-based and outcome-based aggregators were constructed to allow a technological implementation of the extended Engeström's Activity Theory with perspectives over social planes. An aggregator has an aggregation rule, a social plane parameter, and a role perspective parameter. For Sensor Layer it was shown evidence that such wider perspective on learning processes is available in the databases and especially in logging data of VLEs. Based on this technical architecture the software application SOLAR was constructed. SOLAR Sensor Layer was constructed using PostgreSQL and Function Log of VLEs. SOLAR aggregators in the Semantic Layer were implemented in PHP language. SOLAR Control Layer elements such as data mining processes and statistical analyses were codified with jQuery library and intensive AJAX Get calls to the server. SOLAR Indicator Layer elements such as Social learning context analytics and open student models used InfoVis Toolkit and jqPlot libraries and the classical languages for Web Interfaces CSS and HTML 5.

RQ.4 How can teachers make effective use of European standards for designing, monitoring and moderating their lessons?

For design aspects, the question was answered in two parts. First, how can teachers authoring EQF competences and include them in courses? then, how can teachers design courses based on the EQF?. The former was answered in Chapter 4 while the latter was answered in Chapter 5. In Chapter 4 a social application to authoring EQF competences collaboratively was evaluated, social mechanism to share EQF competences definitions and to add EQF competences to courses were provided. In Chapter 5 a web application to tailor course elements based on the EQF was validated. The course elements designed are: prerequisites, learning outcomes, activities, and a visual representation of a script of EQF qualifications.

For the aspects of monitor and moderation, two chapters gave complementary answers. Chapter 6 exposes evidences of teachers' monitor and moderation, during the assessment of EQF learning outcomes. Chapter 7 point out evidences of teachers' monitor and moderation, during the analysis of visual feedback.

RQ.5 How can students and teachers be more aware and reflect about the underlying competences in university courses?

In Chapter 6 and Chapter 7 contextual awareness and reflection was inquired for the teacher perspective. The agreement with the achievement of these objectives in assessment of EQF learning outcomes and analysis of visual feedback was appraised by teachers. Moreover, a summary of evidences were reported. Besides, the earlier evidences of planning, monitoring and moderating are collectively evidences of reflection.

In Chapter 7 contextual awareness and reflection was studied for the student perspective. The agreement with the achievement of these objectives in analysis of visual feedback was appraised by students. Moreover, a summary of proofs were reported.

RQ.6 How can students make effective use of European standards for planning, monitoring and evaluating personal progress?

In Chapter 7 student perspective for planning, monitoring, and evaluating was questioned. Students were ask to monitor their progress during the course, give opinions of their individual performance and their performance in the social context, and take actions to improve further evaluations. The agreement with the achievement of these objectives in analysis of visual feedback was appraised by students. Moreover, a summary of proofs were reported.

RQ.7 Will open and social visualisations provide successful personalised guidance within a rich collection of educational resources?

Yes. A wider collection of educational resources for learning design, assessment, and visual feedback in higher education was promoted with this thesis. A more deep level of semantic meaning is behind of details of course design. A diversity of new tasks in assessment is promoted as well. Visual guidance allows teachers and learners to follow their progress in task of assessment as reported in Chapter 6. An open student model and social learning context analytics in Chapter 7 allowed teachers and learners to understand the semantic complexity of the course model and their performance within this model and the social context of learning they were immersed.

8.2 Contributions

Considering the results condensed in this thesis, the goal of combine the ideas of personalised, competence-based, and social learning by providing course lifecycle support through competence-based design, outcome based assessment, social learning context analytics, and open student modelling visualisations has been accomplished. In the development of this goal, the following research contributions are listed below:

- A definition of a technical architecture, the Adaptive Engine Evaluation Architecture (AEEA), to support the cycle of online and blended courses with perspectives of LLL competence development. This architecture identifies concise elements, procedures and software applications to support EQF competences development in higher education.
- A technical architecture called Activity-based Learner-models. This architecture allows delivering of social learning context analytics and an open student model from monitoring students' activities and their learning outcomes, semantic aggregation and control of displayed visualisations. This architecture allows introspecting learning activities and learning outcomes with different social planes perspectives (a student, teammates, or class). The cornerstones of this architecture are: 1) The Engeström´s Activity Theory 2) The EQF, and 3) The Actuator-Indicator model.
- A third contribution is an authoring software application, the ONTO-EQF application, devoted to support teachers to define EQF competences in higher education with social sharing capacities. In the case of courses in computer science the application uses the ACM Computing Classification System to frame EQF competences in knowledge domains universally recognized by this community.
- A fourth contribution is a software application, the CC-DESIGN application that enhances the course design by introducing new elements to map course objectives to the EQF. This application introduces a novel concept to describe a script of EQF qualifications to be executed throughout the course run-time.
- A fifth contribution is a software application to assess EQF learning outcomes in higher education courses, the RUBRICS-360 application. Teachers and students use the application to perform a 360 degree feedback to promote formative outcome-based assessment. According to the script of assessment created before, the application produces a personalised plan of assessment for each user. Automatic tests with scoring rubrics are generated according to the user selections in the plan. Multiple EQF learning outcomes are appraised within each test.
- A sixth contribution is a social learning context analytics software application, the SOLAR application. SOLAR has at the moment three dashboards to show social learning context analytics and an open student model. In the firsts two dashboards parallel views are displayed to contrast performance of a single student against performance of her/his teammates and the whole class. The third dashboard introduces a novel sunburst visualisation in which the learning design

of the course and the personal model of EQF competence qualifications for a student are combined.

- A final contribution is an initial dataset of different learning designs of courses based on the EQF for higher education. These designs are based on different pedagogical approaches. Besides, there is an initial dataset of EQF competences defined in higher education in the area of computing.

On the whole, the contribution of this thesis to the TEL domain is a framework that integrates personalised, competence-based, and social learning to improve the effectiveness of VLEs in higher education. The effectiveness is improved through: 1) Allowing perspectives of LLL competence development in courses. Teachers and students have now a methodology to work according to how the EQF expects learning outcomes being qualified in higher education; 2) Effects on learning and teaching such as raise contextual awareness, and reflection in teachers and students; 3) Social effects such as collaborative creation of competences, collaborative formative assessment based on the 360 Degree Feedback, and social context awareness.

8.3 Key Findings

Considerations to social framing were worked in many of the tools developed. For instance, ONTO-EQF allows teachers from different universities to share and define EQF competences and a preliminary competence-based course-design. It was notorious that social applications required more efforts to personalise levels of navigation, even in a virtual higher education environment. Then, in RUBRICS-360 a 360-degree consideration in higher education gave the opportunity to social appraisals of students. A key finding here was that teachers need a mechanism to link EQF competence qualifications with marks (or grades) of appraised activities. The most intensive application in social framing was SOLAR which delivered social learning context analytics using perspectives for three social planes (student, teammates, and classmates) and personalised interfaces for two role users (student and teacher). During case studies some other social planes were revealed that are not mentioned in the theories of learning orchestration. For instance, those students that were enrolled but then left the course. Needed perspectives for other roles that are not mentioned in the extended Engeström's Activity theory were also revealed. For example, roles used in VLEs such as *invited teacher*, and *system administrator*. These social planes and role perspectives must be taking into account to produce greater and accurate learning analytics solutions.

Another interesting finding was that teacher presented a cognitive overhead in all design tasks and they need more support to face these tasks.

From these findings it is expected that new institutional and organizational strategies change in order to create better conditions for teachers and learners in the new ambit of higher education and with a competence-centred learning. For instance, policies to keep historical data of learning designs, assessments, qualifications, and learning analyses would facilitate the construction of recommender systems by inquiring patterns of failure and success. Another idea is to build a mechanism where students and teachers can express their willingness to share different types of new learning resources such as learning design resources, evaluations, and reports of learning outcomes. Maybe some teachers and learners could be less strict than institutional policies. An important policy would be encouraging higher education teachers to be involved in TEL research by means of awards and/or salary bonus. This would facilitate researchers to test more easily their proposals and with a major quantity of users.

8.4 Final Remarks

Before finishing the thesis, this section remarks some limitations of the project that impacted the proposed approach and findings.

As was said in Chapter 3 this thesis do not actively support the final phase of the online or blended course lifecycle, that is, the *Evaluation Phase* of the course. Some ideas to attend this issue are mentioned in the next section.

There were limitations that constrain the scope of this thesis in support of social authoring of EQF competences in higher education. First, university policies that forbidden installation of new plugins in the institutional Moodle. Due to this restriction, the final version of ONTO EQF was developed as an independent web application from the Moodle system. Second, the invitation to participate in the case study was limited to some courses of the Polytechnic School of UdG and the Engineering Faculty of UNIVALLE. Both institutions offer engineering courses. In consequence, courses used in the case study belonged to engineering curriculums. Third, was difficult to involve teachers for a long period of time doing extra work, only 20 teachers participated throughout 2011 and 2012. Then, several courses need to be mapped to the proposed EQF competence-based framework, the former implied big resources of time in order to assist teachers in design tasks. A comparative study with the perspective of teachers using different pedagogical strategies is not viable due to little number of teachers for each pedagogical strategy. ONTO-EQF application is devoted to the teachers' perspective and not to the student's perspective because of its objectives.

There were limitations that constrain the scope of this thesis in support for enhancing course design within a European perspective for lifelong competence development. The first four limitations described for the previous tool are also related with CC-DESIGN tool. In addition, the scope in learning design in this thesis is to give a complementary and enhanced support to the traditional learning design tools used for teachers in their VLEs. Therefore CC-DESIGN is not a substitute but a complement of VLE tools for learning design. CC-DESIGN is not an authoring tool or player for holistic instructional designs.

There were limitations that constrain the scope of this thesis in support of EQF competence assessment in higher education courses. In addition to the common previous restrictions, it is important to note that the evaluation of the impact of the assessment approach proposed (a 360-degree feedback in higher education) is in somehow constrains due to the willing of teachers to include all kind of assessment possibilities in their learning designs. Only one of the three courses used the entire possibilities of evaluation. The teacher's design determines also the number of EQF competences to include, the number of activities to assess and the number of evaluations per activity. That is why some course designs were more enhanced than others.

There were limitations that constrain the scope of this thesis in visual support of monitoring and moderating courses for EQF competence development. University policies forbidden open publication of students' qualifications. It constrains the perspectives of learning analytics for the role student. Only wide personal data visualisations and anonymous visualisations of teammates and classmates data with summative analyses were allowed for students.

As the case studies were only with courses in engineering, it is necessary to validate findings in other knowledge domains.

The study is not able to capture the possible gradual engagement of teachers and students due to external sources to the system. For instance, the evolution of social and educational technologies could have influenced them during the test period.

Due to the lack of historical data related to attained EQF qualifications of students in higher education courses, nowadays it is hard to validate the accuracy of possible algorithms that spot patterns of failure and success to predict dropouts. For this purpose, a dataset is being constructed with the monitored information of courses that used the AEEA Suite throughout 2011 and 2012. It is also the case of historical data needed to validate the accuracy of some future recommender systems for teachers. It is needed to increase the dataset of designed courses based on the EQF and historical data related to attained EQF qualifications of students in higher education courses.

8.5 Future Research Work

This section concludes the thesis with the vision for future research. There are several issues that have been left as future work throughout this thesis. I want to highlight some of them in three directions: ideas to enlarge the research scope, further improvement and new functionalities of the current implementations, and long-term research in Colombia. The next subsections present these three mentioned aspects.

8.5.1 Enlarge the Research Scope

It would be valuable to explore the significance of this approach in a wider scope of research. For instance, explore the approach in other knowledge domains. Due to university policies and resource limitations it was not possible to test the approach with courses in other knowledge domains different from the engineering field. How this approach would be received in other areas of knowledge and practice remains unknown.

Another possible expansion for the research scope is to inquire about the effects of this approach in higher education learning results. It will be necessary to conduct controlled and comparative experiments in order to measure the impact of this technology-enhanced approach in the improvement or not of success rates.

A third conceivable line of extension is to validate the approach in courses with different pedagogical approaches; in this sense, during the writing of this thesis the approach has been tested in university courses that follows the Project-Based Learning pedagogical approach, the results could confirm the hypothesis of better adoption of the approach in courses with this active learning pedagogical approach.

A final kind of interesting expansion is a long-term study with consecutive courses of a curriculum in order to dig into long-term analytics of learning trajectories.

After reflecting the findings of this work, some hypothesis and statements for the future use of the EQF are presented as follows:

- If there was an institutional support to the EQF at the level of European higher education courses, European university institutions would present their students´ portfolios describing achieved competences as a summary of attained EQF levels in learning outcomes (knowledge, skills, and personal competences). Moreover, these portfolios would include a clear monitoring of how the learning outcome levels were developed through the curriculum of a particular student.
- Thanks to historical data it would also possible to analyse patterns of success or failure of students for each professional and academic program. Thus, these and other learning analytics with perspectives on the social planes "study program" and "university community" would be possible.
- I think better learning analytics for the "study program" and "university community" social planes regarding EQF competence development would aid curriculum design and quality assurance in higher education.
- If there was a European support to the EQF at the level of European higher education courses, National and International services of education and training would benefit from it by means of complementing and reinforcing existing European mobility instruments such as the Europass, and the ECTS. Credits and qualifications would be better expressed in terms of levels of learning outcomes attained in higher education than hours spent in a learning process.
- I think that based on these mobility-enhanced instruments, It will be a good idea to develop learning analytics with perspectives of the social plane "European community" so as to selecting the best students for awards, mobility aids (grants, scholarships, and internships), and jobs with a solid foundation on EQF levels of learning outcomes attained.
- If there was a European support to the EQF at the level of European higher education courses, enhances to common VLEs would constitute new research projects to have a common methodology to create, design, assess and report EQF levels of learning outcomes in European courses. Moreover, if the contributions of this thesis were taken as a clear mechanism to the first step of collecting EQF qualifications and enhanced learning resources in higher education courses, the findings and contributions of past European projects related to interoperability and interchange of learning resources and assessment data in competence-based learning (TENCompentence, MACE, ICOPER among others) would be retaken as a second step.
- I think that students have a better idea of their EQF competences with the theoretical and technological tools developed in this thesis. I also think that students will be able to trace their own paths of learning, combining formal education and informal learning with the idea of monitoring their EQF competences. The student, then professional, and further employee could trace their lifelong learning using this strategy.

- A necessity for teacher was revealed. Teachers need a mechanism to link EQF competence qualifications with marks (or grades) of appraised activities. Initial implications of this idea were discussed in Chapter 6. A more exhaustive analysis is needed in order to design and construct a mathematically and educational suitable model and software tools for that purpose.
- It is necessary to inquire about other tools for competence-based learning that could help connecting higher education and other aspects of lifelong learning. For instance, teachers need to classify their learning resources and all types of students' learning activities (beyond assessment activities) according to EQF levels of learning outcomes. These resources and student activities could be internal or external to the current VLE used in the course. Therefore, match-up tools are required to blend formal resources and activities with the informal ones. Another possibility is that VLEs should allow import and export resources and qualifications based on the EQF. Data importations could have diverse sources such as historical data from higher education portfolios, historical data from non-formal institutions, or data from PLE. Data exportations could be directed to the individual student, national or international learning systems.
- I think that courses using an active learning pedagogical approach could be more engaged and recompensed with the overall proposal of this thesis because students of these courses need tools to helps them to self-direct their learning. And also because with a 360-degree evaluation they can appraise teammates in collaborative tasks.

In order to support the third phase of online or blended course lifecycle new research is possible to provide teachers with a dashboard of social learning context analytics regarding course design failures and successes. Generally speaking, more social learning context analytics are required for this phase with perspectives of the "course" social plane.

Finally, going beyond of the adopted technology for this thesis, it is a good idea to have versions of assessment tools and social learning context analytics for mobile devices. Thus, it will be possible to validate the approach with a highly enhanced environment of blended learning. It is also thought that it will be a mechanism to engage more students and teachers.

8.5.2 Improvements of Functionalities

To start with, the ideas left behind during the process of this thesis are described first. First, in the earliest stages of this thesis the aim was to construct software applications as plug-ins of the well-known VLE Moodle. Indeed, the first version of the assessment package was made for Moodle 1.9 (the official version at that time). Due to university policies, the idea was later altered to turn applications as web independent applications. Nevertheless, all the efforts were made to use compatible languages and the same database structure during the construction of the AEEA Software Suite so as to leave an easy way to transform the applications into Moodle plug-ins. It is thought that this kind of implementation would attract more research community to this proposal and also that teachers, at least teachers of UNIVALLE and UdG, would be more willing to use the applications in the same VLE they are used to develop their courses. Another set of functionalities awaiting for be part of the AEEA Suite are TEL recommender systems, especially the ones planned for purposes of teachers' design. Hand in hand with the former, it is necessary to enlarge the dataset of courses and historical data of EQF competences development of the Suite.

To follow, this paragraph takes into account ideas raised from the findings of research. During the case studies new ideas for other types of social learning context analytics were given for teachers and learners, it is important to focus especially in take priority for those which give more understanding of the patterns of failure and success in the learning process as well as some others to realise the social network context of the students. From the case studies and comments it was also revealed that teachers wanted more ranges to distinguish the performance of a learner. The three ranges used, (below, successful, and above) can be subdivided to consider a more granular measure of performance.

8.5.3 Long-term Research in Colombia

The process of doctoral studies will finalise with the defence of this thesis. Logically, far from be the end of my research days, it is just the beginning of a new stage of research journey. I must return to my country and my work as assistant professor in UNIVALLE. Bringing new ideas to the curriculum and technology evolution in the Colombian higher education is one of my first main goals. As the director's right hand of the Centre for Educative Regional Innovation of the Colombian South West from February 2013 I will be in position to the former. Opening a specific line of research in TEL within my Colombian group, GEDI[1], and working in the laboratory CEDESOFT[2], it is going to be the place from I am going to develop my future research, at least in regard to visible horizon.

I look forward to strengthening ties with European research groups that have opened their doors for me such as BCDS in Spain where I did my PhD studies, and CELSTEC in The Netherlands where I did a research stay during 2011.

[1] http://posgradosingenieria.univalle.edu.co/posgrados/?q=node/89

[2] http://cedesoft.univalle.edu.co/index.php?option=com_content&view=article&id=12&Itemid=10

APPENDIX A

LEARNING DESIGN OF THE BLENDED COURSE "DATA STRUCTURES AND ALGORITHMS"

Course Meta-Data

Course	:	Data structures and algorithms
Type of technology	:	Blended Course
Teacher	:	Josep Surrell
University	:	University of Girona, Spain
Test Period	:	Sep-Dec, 2012
Number of enrolled students	:	34

EQF Competences: Prerequisites, and Learning Outcomes

Competences Added to this Course

Select the expected range of development (based on the EQF) for each one of the competences in your course. Move the drag handles of the slider to capture a range of levels of qualification.

Competence	Type	Range
D.1.0 Software / Programming Techniques / General		
Ability to use programming paradigms and languages	Skill	Level 1 - Level 3
Knowledge in algorithmic procedures	Knowledge	Level 1 - Level 3
D.1.5 Software / Programming Techniques / Object-oriented programming		
Ability to build programs using classes	Skill	Level 1 - Level 3
D.2.11 Software / Software Engineering / Software Architectures / Data abstraction		
Ability to use abstraction in tasks of software design	Skill	Level 1 - Level 3
D.3.3 Programming Languages / Language Constructs and Features / Classes and objects		
Knowledge in encapsulation applied to classes	Knowledge	Level 1 - Level 3
D.3.3 Programming Languages / Language Constructs and Features / Data types and structures		
Ability to use data structures in a smart way	Skill	Level 1 - Level 4
E.1 Data / Data Structures / Arrays		
Ability to write programs that use the data structure arrays	Skill	Level 1 - Level 3
E.1 Data / Data Structures / Lists, stacks, and queues		
Knowledge in lineal data structures	Knowledge	Level 1 - Level 4
E.1 Data / Data Structures / Trees		
Knowledge in binary trees	Knowledge	Level 1 - Level 4

Activities and 360-Degree Script

Evaluation Activities and Assessment Ponderation

This section describes how is calculated the qualification of each evaluation activity in the course.

Different ponderations are given for each type of assessment performed. The type of assessment supported are:

Self-assessment where a student qualifies himself/herself.
Intragroup Peer-assessment where students in a group qualify each other.
Intergroup Peer-assessment where a group assess another group with a single qualification for the whole group.

Activity	Self Assessment	Intragroup Peer Assessment	Intergroup Peer Assessment	Teacher Assessment
Examen	-	-	-	100%
Práctica de algorítmica	20%	20%	-	60%
Práctica de estructura de datos	20%	20%	-	60%
Problemas y ejercicios algorítmica	20%	-	-	80%
Problemas y ejercicios de estructura de datos	20%	-	-	80%

Numeric Course Evaluation

This section describes how is calculated the final mark of the course. Different ponderations are given for each evaluation activity.

Activity	% Course
Examen	50%
Práctica de algorítmica	15%
Práctica de estructura de datos	15%
Problemas y ejercicios algorítmica	10%
Problemas y ejercicios de estructura de datos	10%

Script of EQF Qualifications

Competences Per Activity

Competence	Examen	Práctica de algorítmica	Práctica de estructura de datos	Problemas y ejercicios algorítmica	Problemas y ejercicios de estructura de datos
Ability to build programs using classes	Level 2	Level 3	✖	Level 1	✖
Ability to use abstraction in tasks of software design	Level 3	Level 3	✖	Level 1	✖
Ability to use data structures in a smart way	Level 4	✖	Level 3	✖	Level 2
Ability to use programming paradigms and languages	Level 2	Level 3	✖	Level 1	✖
Ability to write programs that use the data structure arrays	Level 3	✖	Level 3	✖	Level 2
Knowledge in algorithmic procedures	Level 3	✖	✖	✖	✖
Knowledge in binary trees	Level 4	✖	✖	✖	✖
Knowledge in encapsulation applied to classes	Level 3	✖	✖	✖	✖
Knowledge in lineal data structures	Level 4	✖	✖	✖	✖

APPENDIX B

LEARNING DESIGN OF THE ONLINE COURSE "NEW PROTOCOLS IN INTERNET"

Course Meta-Data

Course	:	New Protocols in Internet
Type of technology	:	Online Course
Teacher	:	Jose Luis Marzo
University	:	University of Girona, Spain
Test Period	:	Mar-Jul 2012
Number of enrolled students	:	34

EQF Competences: Prerequisites, and Learning Outcomes

Competences Added to this Course

Select the expected range of development (based on the EQF) for each one of the competences in your course. Move the drag handles of the slider to capture a range of levels of qualification.

C.2.0 Computer Systems Organization / Computer-Communication Networks / General / Data communications		
Knowledge in data communications	Knowledge	Level 4 - Level 6
C.2.1 Computer Systems Organization / Computer-communication Networks / Network Architecture and Design / Asynchronous Transfer Mode (ATM)		
Knowledge in IP over ATM	Knowledge	Level 2 - Level 3
C.2.1 Computer Systems Organization / Computer-communication Networks / Network Architecture and Design / Packet-switching networks		
Knowledge in MPLS	Knowledge	Level 1 - Level 3
C.2.2 Computer Systems Organization / Computer-communication Networks / Network Protocols / Applications		
Knowledge in applications based on client-server model	Knowledge	Level 3 - Level 5
C.2.2 Computer Systems Organization / Computer-communication Networks / Network Protocols / Protocol verification		
Knowledge of quality of service parameters (TCP)	Knowledge	Level 1 - Level 2
C.2.2 Computer Systems Organization / Computer-communication Networks / Network Protocols / Routing protocols		
Ability to solve basic routing problems	Skill	Level 2 - Level 3
Knowledge in routing algorithms	Knowledge	Level 2 - Level 4
C.2.3 Computer Systems Organization / Computer-communication Networks / Network Operations / Network management		
Knowledge in Differentiated Services (DiffServ)	Knowledge	Level 2 - Level 4
C.2.4 Computer Systems Organization / Computer-communication Networks / Distributed Systems / Distributed applications		
Knowledge of the client-server model	Knowledge	Level 2 - Level 4
C.2.5 Computer Systems Organization / Computer-communication Networks / Local and Wide-Area Networks / Internet		
Knowledge in TCP/IP and Internet	Knowledge	Level 3 - Level 5
C.2.6 Computer Systems Organization / Computer-communication Networks / Internetworking / Routers		
Knowledge in multicast routing	Knowledge	Level 2 - Level 4
C.2.6 Computer Systems Organization / Computer-Communication Networks / Internetworking / Standards		
Knowledge of TCP/IP suite protocols	Knowledge	Level 2 - Level 5
D.3.0 Software / Programming Languages / General / Standards		
Knowledge of standards for web services	Knowledge	Level 3 - Level 5
D.3.2 Software / Programming Languages / Language Classifications / Specialized application languages		
Ability to select the most appropriate language in web environments	Skill	Level 2 - Level 3
K.7.0 Computing Milieux / The Computing Profession / General / General		
Ability to search information concerning a specific topic	Autonomy and responsability competence	Level 1 - Level 3

Activities and 360-Degree Script

Evaluation Activities and Assessment Ponderation

This section describes how is calculated the qualification of each evaluation activity in the course.

Different ponderations are given for each type of assessment performed. The type of assessment supported are:

Self-assessment where a student qualifies himself/herself.
Intragroup Peer-assessment where students in a group qualify each other.
Intergroup Peer-assessment where a group assess another group with a single qualification for the whole group.

Activity	Self Assessment	Intragroup Peer Assessment	Intergroup Peer Assessment	Teacher Assessment
Forum "1"	60%	-	-	40%
Forum "Peer to Peer"	60%	-	-	40%
Practical work # 1	20%	-	-	80%
Practical work # 2	20%	-	-	80%
Propagation times exercises	30%	-	-	70%
Routing Exercises	30%	-	-	70%

Numeric Course Evaluation

This section describes how is calculated the final mark of the course. Different ponderations are given for each evaluation activity.

Activity	% Course
Forum "1"	-
Forum "Peer to Peer"	-
Practical work # 1	50%
Practical work # 2	50%
Propagation times exercises	10%
Routing Exercises	-

Script of EQF Qualifications

Competences Per Activity

Competence	Forum "1"	Forum "Peer to Peer"	Practical work # 1	Practical work # 2	Propagation times exercises	Routing Exercises
Ability to search information concerning a specific topic	Level 1	Level 1	Level 2	Level 2	Level 2	Level 2
Ability to select the most appropriate language in web environments	✖	✖	Level 2	Level 2	✖	✖
Ability to solve basic routing problems	✖	✖	✖	✖	Level 3	Level 3
Knowledge in applications based on client-server model	✖	Level 3	Level 5	✖	✖	✖
Knowledge in data communications	✖	✖	Level 4	Level 6	✖	✖
Knowledge in Differentiated Services (DiffServ)	✖	✖	✖	✖	✖	✖
Knowledge in IP over ATM	✖	✖	✖	✖	✖	✖
Knowledge in MPLS	✖	✖	✖	Level 1	✖	✖
Knowledge in multicast routing	✖	✖	✖	✖	✖	✖
Knowledge in routing algorithms	✖	Level 2	✖	Level 4	✖	Level 4
Knowledge in TCP/IP and Internet	Level 3	Level 3	Level 5	✖	✖	✖
Knowledge of quality of service parameters (TCP)	✖	Level 1	Level 1	✖	Level 2	✖
Knowledge of standards for web services	Level 3	✖	Level 3	Level 4	✖	✖
Knowledge of TCP/IP suite protocols	✖	Level 2	Level 3	✖	✖	✖
Knowledge of the client-server model	✖	✖	Level 2	Level 4	✖	✖

APPENDIX C

LEARNING DESIGN OF THE BLENDED COURSE "FUNDAMENTS IN CONTROL OF LINEAL SYSTEMS"

Course Meta-Data

Course	:	Fundamentos de Control De Sistemas Lineales
Methodology	:	Blended Course. Moodle and AEEA Suite were used
Teacher	:	José Miguel Ramirez
University	:	Universidad del Valle, Colombia
Test Period	:	Mar-Ago 2012
Number of enrolled students	:	22

EQF Competences: Prerequisites, and Learning Outcomes

Competences Added to this Course

Select the expected range of development (based on the EQF) for each one of the competences in your course. Move the drag handles of the slider to capture a range of levels of qualification.

C.3 Computer Systems Organization / Special-purpose and pplication-based systems / Process control systems			
Ability to define problems of lineal systems	Skill	Level 1 - Level 3	
Ability to solve problems of lineal systems	Skill	Level 1 - Level 4	
Do and evaluate technical information in control systems	Skill	Level 1 - Level 4	
Knowledge in control of lineal systems	Knowledge	Level 1 - Level 4	
G.4 Mathematical logic and formal languages / Mathematical Software / Documentation			
Expose results of analysis and design of control systems	Communication and social competence	Level 2 - Level 3	
I.2.8 Computing Methodologies / Artificial Intelligence / Problem solving, control methods, and search / Control theory			
Ability to design block diagrams	Skill	Level 1 - Level 3	
Knowledge in digital and analog control systems	Knowledge	Level 1 - Level 3	
Knowledge in typical loop of analog and digital control	Knowledge	Level 1 - Level 3	
I.6.4 Computing Methodologies / Simulation and Modeling / Model Validation and Analysis / Model Validation and Analysis			
Ability to model discrete dynamical systems	Skill	Level 1 - Level 2	
I.6.5 Computing Methodologies / Simulation and Modeling / Model Develpment / Modeling methodologies			
Ability to analyze interrelations	Skill	Level 1 - Level 3	
Ability to analyze the effect of feedback in control systems	Skill	Level 1 - Level 3	
Ability to calculate responses through time	Skill	Level 1 - Level 3	
Ability to describe control system mathematical model	Skill	Level 1 - Level 4	
I.6.8 Computing Methodologies / Simulation and modeling / Types of simulation / Cotinuous			
Ability to determine effects of contol actions	Skill	Level 1 - Level 2	
J.7 Computer Applications / Computers in other systems / Industrial control			
Ability to implement the control action PID	Skill	Level 1 - Level 3	

(Continuation)

K.7.4 Computing Milieux / The Computing Profession / Professional Ethics / Codes of ethics			
Respect copyright	Autonomy and responsability competence	Level 1 - Level 3	
Respect the real authoring in teamwork	Autonomy and responsability competence	Level 1 - Level 3	
K.7.4 Computing Milieux / The Computing Profession / Professional Ethics / Codes of good practice			
Ability to do public presentation of project progress	Communication and social competence	Level 2 - Level 5	
Disposition to self-learning in PBL	Learning competence	Level 1 - Level 3	
Good team relationships	Communication and social competence	Level 1 - Level 2	
Punctuality with assigned tasks	Autonomy and responsability competence	Level 1 - Level 3	
Use appropriated technical file templates	Communication and social competence	Level 2 - Level 3	

Activities and 360-Degree Script

Evaluation Activities and Assessment Ponderation

This section describes how is calculated the qualification of each evaluation activity in the course.

Different ponderations are given for each type of assessment performed. The type of assessment supported are:

Self-assessment where a student qualifies himself/herself.
Intragroup Peer-assessment where students in a group qualify each other.
Intergroup Peer-assessment where a group assess another group with a single qualification for the whole group.

Activity	Self Assessment	Intragroup Peer Assessment	Intergroup Peer Assessment	Teacher Assessment
Final peer evaluation	-	100%	-	-
Final self evaluation	100%	-	-	-
Oral Presentation	-	-	-	100%
Practical evaluation	-	-	-	100%
Report 1	-	-	10%	90%
Report 2	-	-	10%	90%
Report 3	-	-	-	100%
Writing evaluation 1	-	-	-	100%
Writing evaluation 2	-	-	-	100%
Writing evaluation 3	-	-	-	100%
Writing evaluation 4	-	-	-	100%

Numeric Course Evaluation

This section describes how is calculated the final mark of the course. Different ponderations are given for each evaluation activity.

Activity	% Course
Final peer evaluation	5%
Final self evaluation	5%
Oral Presentation	-
Practical evaluation	5%
Report 1	11.67%
Report 2	11.67%
Report 3	11.67%
Writing evaluation 1	12.5%
Writing evaluation 2	12.5%
Writing evaluation 3	12.5%
Writing evaluation 4	12.5%

Script of EQF Qualifications

Competences Per Activity

Competence	Final peer evaluation	Final self evaluation	Oral Presentation	Practical evaluation	Report 1	Report 2	Report 3	Writing evaluation 1	Writing evaluation 2	Writing evaluation 3	Writing evaluation 4
Ability to analyze interrelations	✖	✖	✖	Level 3	Level 1	Level 1	Level 2	Level 1	Level 1	Level 2	Level 2
Ability to analyze the effect of feedback in control systems	✖	✖	Level 2	Level 3	✖	✖	Level 2	✖	✖	Level 2	Level 2
Ability to calculate responses through time	✖	✖	Level 3	Level 3	✖	Level 2	Level 3	✖	✖	Level 3	Level 3
Ability to define problems of lineal systems	✖	✖	Level 3	Level 3	Level 1	✖	Level 3	Level 2	✖	Level 2	Level 3
Ability to describe control system mathematical model	✖	✖	Level 3	Level 4	✖	Level 3	✖	Level 2	Level 3	✖	✖
Ability to design block diagrams	✖	✖	Level 3	✖	Level 1	Level 3	✖	Level 2	Level 3	✖	✖
Ability to determine effects of contol actions	✖	✖	Level 2	Level 2	✖	✖	Level 2	✖	✖	Level 1	Level 2
Ability to do public presentation of project progress	✖	✖	Level 5	✖	✖	✖	✖	✖	✖	✖	✖
Ability to implement the control action PID	✖	✖	Level 3	Level 3	✖	✖	Level 3	✖	✖	✖	Level 2
Ability to model discrete dynamical systems	✖	✖	Level 2	Level 1	✖	Level 2	Level 2	✖	Level 2	✖	✖
Ability to solve problems of lineal systems	✖	✖	Level 4	Level 4	Level 1	Level 2	Level 4	Level 1	Level 2	Level 3	Level 4
Disposition to self-learning in PBL	Level 3	Level 3	Level 1	Level 3	Level 1	✖	✖	Level 1	✖	✖	✖
Do and evaluate technical information in control systems	✖	✖	Level 4	✖	Level 1	Level 2	Level 4	Level 1	Level 2	Level 3	Level 4
Expose results of analysis and design of control systems	✖	✖	Level 3	✖	✖	✖	✖	✖	✖	✖	✖
Good team relationships	Level 2	Level 2	Level 1	✖	Level 1	✖	✖	✖	✖	✖	✖
Knowledge in control of lineal systems	✖	✖	Level 4	Level 4	Level 1	Level 2	Level 4	Level 1	Level 2	Level 3	Level 4
Knowledge in digital and analog control systems	✖	✖	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1
Knowledge in typical loop of analog and digital control	✖	✖	Level 2	Level 3	Level 2	✖	✖	Level 2	✖	✖	✖
Punctuality with assigned tasks	Level 3	Level 3	Level 3	✖	Level 1	Level 2	Level 3	✖	✖	✖	✖
Respect copyright	Level 3	Level 3	Level 3	✖	Level 1	Level 2	Level 3	✖	✖	✖	✖
Respect the real authoring in teamwork	Level 3	Level 3	✖	✖	Level 1	Level 2	Level 3	✖	✖	✖	✖
Use appropriated technical file templates	✖	✖	✖	✖	Level 2	Level 3	Level 3	✖	✖	✖	✖

APPENDIX D

Survey for Evaluating ONTO-EQF from Teacher's Perspective

If any different is presented, use the following rating scale to interpret item questions:
Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5)

Item Question		Valuation
A. Demographic Data		
1. How old are you?	(1) 18-25 (2) 26-34 (3) 35-49 (4) 50-59 (5) 60-75	
2. What is your gender?	(1) Female (2) Male	
3. What is your level of education?	(1) 4-year College Degree (2) Master Degree (3) Doctoral Degree	
4. What is your teacher category?	(1) Lecture (2) Research assistant (3) Auxiliary Professor (4) Assistant Professor (5) Associate Professor (6) Titular Professor (7) Other	
5. In addition to my teaching work I am in charge of coordination of other teachers for this course.		(1) Yes (2) No
6. I used to design my courses using a competence-based education		(1 2 3 4 5)
7. I am abreast of the European Qualifications Framework (EQF)		(1 2 3 4 5)
8. I am abreast of ACM Computing Classification System		(1 2 3 4 5)
B. Usefulness		
1. ONTO-EQF helps me to design how the class objectives are described in terms of EQF competences		(1 2 3 4 5)
2. The former was possible by means of		Open question
3. Defining course objectives in this way provides useful enriched information than the way I used to do it		(1 2 3 4 5)
4. ONTO-EQF helps me to be aware of the underlying EQF competences of my course		(1 2 3 4 5)
5. The former was possible by means of		Open question
6. ONTO-EQF helps me to reflect about the underlying EQF competences of my course		(1 2 3 4 5)
7. The former was possible by means of		Open question
8. ONTO-EQF helps me to plan my teaching work		(1 2 3 4 5)
9. The former was possible by means of		Open question
10. ONTO-EQF helps me to access other teachers' competence definitions		(1 2 3 4 5)
11. The former was possible by means of		Open question
12. ONTO-EQF helps me to understand levels of qualification (Level 1 to Level 8) related to learning outcomes (Knowledge, Skill, Wider Competence)		(1 2 3 4 5)
13. The former was possible by means of		Open question
14. The EQF is suitable as framework for authoring of competences in higher education		(1 2 3 4 5)
15. Higher education European teachers need authoring tools for EQF competences		(1 2 3 4 5)
16. It is good idea to classify competences in universal knowledge domains		(1 2 3 4 5)
17. The ACM classification system is appropriated to browse computing knowledge areas		(1 2 3 4 5)
18. It was easy to accomplish de task of authoring of competences for a course		(1 2 3 4 5)
C. Ease of Use		
1.The instructions to perform authoring tasks were clear		(1 2 3 4 5)
2. The interface is easy to use		(1 2 3 4 5)
3. The interface is user friendly		(1 2 3 4 5)
4. The interface requires the fewest steps possible to accomplish what I need to do with it		(1 2 3 4 5)

5. I prefer a graphical visualisation of the competence classification, like a network graph	(1 2 3 4 5)
6. Please suggest new ways of interaction that you consider more easier	Open question
D. Ease of Learning	
1. I learned how to use the interface quickly.	(1 2 3 4 5)
2. I easily remember how to use the interface.	(1 2 3 4 5)
3. It is easy to learn how to use the interface.	(1 2 3 4 5)
4. Register strategies or patterns you follow to work with ONTO-EQF if any	Open Question
5.Register if you needed extra information or new abilities to learn to use ONTO-EQF	Open Question
E. Satisfaction	
1. I am satisfied with the interface.	(1 2 3 4 5)
2. The interface is pleasant to use.	(1 2 3 4 5)
3. ONTO-EQF supports the EQF in an appropriate way	(1 2 3 4 5)
4. I would recommend ONTO-EQF to my colleagues.	(1 2 3 4 5)
5. I am satisfied with the sharing capabilities for design competences	(1 2 3 4 5)
6. I would like a recommender system that suggests competences based on selections of teachers with similar courses	(1 2 3 4 5)
F. Privacy and Data Sharing	
1. I like the idea of comparing my design with other teachers with similar courses	(1 2 3 4 5)
2. I feel comfortable sharing my competence definitions with others.	(1 2 3 4 5)
3. I do not mind that my course design be anonymously shared with other teachers	(1 2 3 4 5)
G. Other Comments and Suggestions for Improvement	

APPENDIX E

SURVEY FOR EVALUATING CC-DESIGN FROM TEACHER'S PERSPECTIVE

If any different is presented, use the following rating scale to interpret item questions:
Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5)

Item Question		Valuation
A. Demographic Data		
1. How old are you?	(1) 18-25 (2) 26-34 (3) 35-49 (4) 50-59 (5) 60-75	
2. What is your gender?	(1) Female (2) Male	
3. What is your level of education?	(1) 4-year College Degree (2) Master Degree (3) Doctoral Degree	
4. What is your teacher category?	(1) Lecture (2) Research assistant (3) Auxiliary Professor (4) Assistant Professor (5) Associate Professor (6) Titular Professor (7) Other	
5. In addition to my teaching work I am in charge of coordination of other teachers for this course.		(1) Yes (2) No
6. I used to design my courses using a competence-based education		(1 2 3 4 5)
7. I am abreast of the European Qualifications Framework (EQF)		(1 2 3 4 5)
8. I am abreast of ACM Computing Classification System		(1 2 3 4 5)
B. Usefulness		
1. CC-DESIGN helps me to focus my learning activities design and assessment design on well-defined core of learning outcomes		(1 2 3 4 5)
2. The former was possible by means of		Open question
3. Defining course design in this way provides useful enriched information than the way I used to do it		(1 2 3 4 5)
4. CC-DESIGN helps me to be aware of the underlying EQF competences of my course		(1 2 3 4 5)
5. The former was possible by means of		Open question
6. CC-DESIGN helps me to reflect about the underlying EQF competences of my course		(1 2 3 4 5)
7. The former was possible by means of		Open question
8. CC-DESIGN helps me to plan my teaching work		(1 2 3 4 5)
9. The former was possible by means of		Open question
10. CC-DESIGN helps me to design a 360-degree feedback for competence assessment		(1 2 3 4 5)
11. The former was possible by means of		Open question
12. CC-DESIGN helps me to set levels of qualification (Level 1 to Level 8) for learning outcomes of activities (Knowledge, Skill, Wider Competence)		(1 2 3 4 5)
13. The former was possible by means of		Open question
14. The EQF is suitable as framework for a competence-based course design in higher education		(1 2 3 4 5)
15. Higher education European teachers need learning design tools that includes perspectives of EQF competences		(1 2 3 4 5)
16. It is good idea to support a 360-degree feedback for competence assessment design.		(1 2 3 4 5)
17. It was easy to accomplish de tasks of assessment design and learning activities design for my course		(1 2 3 4 5)
C. Ease of Use		
1.The instructions to perform learning design tasks were clear		(1 2 3 4 5)

2. The interface is easy to use	(1 2 3 4 5)
3. The interface is user friendly	(1 2 3 4 5)
4. The interface requires the fewest steps possible to accomplish what I need to do with it	(1 2 3 4 5)
5. Please suggest new ways of interaction that you consider more easier	Open question
D. Ease of Learning	
1. I learned how to use the interface quickly.	(1 2 3 4 5)
2. I easily remember how to use the interface.	(1 2 3 4 5)
3. It is easy to learn how to use the interface.	(1 2 3 4 5)
4. Register strategies or patterns you follow to work with CC-DESIGN if any	Open Question
5. Register if you needed extra information or new abilities to learn to use CC-DESIGN	Open Question
E. Satisfaction	
1. I am satisfied with the interface.	(1 2 3 4 5)
2. The interface is pleasant to use.	(1 2 3 4 5)
3. CC-DESIGN supports the EQF in an appropriate way	(1 2 3 4 5)
4. I would recommend CC-DESIGN to my colleagues	(1 2 3 4 5)
5. I am satisfied with CC-DESIGN to align prerequisites to the EQF	(1 2 3 4 5)
6. This prerequisite aligning was possible by means of	Open question
7. I am satisfied with CC-DESIGN to align learning activities to the EQF	(1 2 3 4 5)
8. This learning activities aligning was possible by means of	Open question
9. I am satisfied with CC-DESIGN to align assessment to the EQF	(1 2 3 4 5)
10. This assessment aligning was possible by means of	Open question
11. I am satisfied with CC-DESIGN to align learning outcomes to the EQF	(1 2 3 4 5)
12. This learning outcomes aligning was possible by means of	Open question
13. I would like a recommender system that suggests possible activities based on added competences of my course	(1 2 3 4 5)
F. Privacy and Data Sharing	
1. I would like to comparing my design with other teachers with similar courses	(1 2 3 4 5)
2. I would feel comfortable sharing my plan for competence qualifications with others.	(1 2 3 4 5)
3. I would not mind that my course design be anonymously shared with other teachers	(1 2 3 4 5)
G. Other Comments and Suggestions for Improvement	

APPENDIX F

SURVEY FOR EVALUATING RUBRICS-360 FROM TEACHER'S PERSPECTIVE

If any different is presented, use the following rating scale to interpret item questions:
Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5)

Item Question		Valuation
A. Demographic Data		
1. How old are you?	(1) 18-25 (2) 26-34 (3) 35-49 (4) 50-59 (5) 60-75	
2. What is your gender?	(1) Female (2) Male	
3. What is your level of education?	(1) 4-year College Degree (2) Master Degree (3) Doctoral Degree	
4. What is your teacher category?	(1) Lecture (2) Research assistant (3) Auxiliary Professor (4) Assistant Professor (5) Associate Professor (6) Titular Professor (7) Other	
5. In addition to my teaching work I am in charge of coordination of other teachers for this course.		(1) Yes (2) No
6. I am used to designing my courses using an outcome-based assessment		(1 2 3 4 5)
7. I am abreast of the European Qualifications Framework (EQF)		(1 2 3 4 5)
8. I am abreast of the 360-degree feedback theory		(1 2 3 4 5)
B. Usefulness		
1. RUBRICS-360 helps me to perform assessment of competences on well-defined core of descriptors for learning outcomes.		(1 2 3 4 5)
2. The former was possible by means of		Open question
3. Performing assessment in this way provides enriched useful information than the way I used to do it		(1 2 3 4 5)
4. Describe enriched information that you obtain from the assessment process		Open question
5. Performing assessment in this way provides enriched useful learning resources than the way I used to do it		(1 2 3 4 5)
6. Describe enriched learning resources that you obtain from the assessment process		Open question
7. RUBRICS-360 helps me to monitor the performance of my students		(1 2 3 4 5)
8. The former was possible by means of		Open question
9. Monitoring students' performance with RUBRICS-360 was easier than the way I used to do it.		(1 2 3 4 5)
10. RUBRICS-360 helps me to monitor my progress in assessment tasks		(1 2 3 4 5)
11. The former was possible by means of		Open question
12. RUBRICS-360 helps me to moderate course activities		(1 2 3 4 5)
13. The former was possible by means of		Open question
14. RUBRICS-360 helps me to be aware of the underlying EQF competences of my course		(1 2 3 4 5)
15. The former was possible by means of		Open question
16. RUBRICS-360 helps me to reflect about the underlying EQF competences of my course		(1 2 3 4 5)
17. The former was possible by means of		Open question
18. RUBRICS-360 helps me to plan my teaching work		(1 2 3 4 5)
19. The former was possible by means of		Open question
20. RUBRICS-360 helps me to bring a 360-degree feedback for different social planes (a student, teammates, class) in competence assessment of my course		(1 2 3 4 5)
21. The former was possible by means of		Open question

22. RUBRICS-360 helps me to assess levels of qualification (Level 1 to Level 8) for learning outcomes of course activities (Knowledge, Skill, Wider Competence)	(1 2 3 4 5)
23. The former was possible by means of	Open question
24. Higher education European teachers need assessment tools that includes perspectives of EQF competences	(1 2 3 4 5)
25. It was easy to accomplish de tasks of assessment for my course	(1 2 3 4 5)
26. The interface helps me to access the content (tests and qualifications)	(1 2 3 4 5)
C. Ease of Use	
1.The instructions to perform learning design tasks were clear	(1 2 3 4 5)
2. The interface is easy to use	(1 2 3 4 5)
3. The interface is user friendly	(1 2 3 4 5)
4. The interface requires the fewest steps possible to accomplish what I need to do with it	(1 2 3 4 5)
5. Please suggest new ways of interaction that you consider more easier	Open question
D. Ease of Learning	
1. I learned how to use the interface quickly.	(1 2 3 4 5)
2. I easily remember how to use the interface.	(1 2 3 4 5)
3. It is easy to learn how to use the interface.	(1 2 3 4 5)
4. Register strategies or patterns you follow to work with RUBRICS-360 if any	Open Question
5. Register if you needed extra information or new abilities to learn to use RUBRICS-360	Open Question
E. Satisfaction	
1. I am satisfied with the interface.	(1 2 3 4 5)
2. The interface is pleasant to use.	(1 2 3 4 5)
3. RUBRICS-360 supports the EQF in an appropriate way	(1 2 3 4 5)
4. RUBRICS-360 supports the 360-degree feedback theory in an appropriate way	(1 2 3 4 5)
5. I would recommend RUBRICS-360 to my colleagues	(1 2 3 4 5)
6. It is a good idea to use EQF descriptors as scoring rubric descriptors	(1 2 3 4 5)
7. It is good idea to support a 360-degree feedback for EQF competence assessment	(1 2 3 4 5)
8. The EQF is suitable as framework for an outcome-based assessment in higher education	(1 2 3 4 5)
9. It was worth the effort of design in order to produce automatic assessment tests	(1 2 3 4 5)
10. Is it a good idea to qualify levels achieved by students for each competence involved in an activity	(1 2 3 4 5)
11. I would like a recommender system that suggests actions for detected students in danger of dropout.	(1 2 3 4 5)
F. Privacy and Data Sharing	
1. I like directives of privacy applied to evaluations. In particular, privacy in personalised plans of assessment that are displayed for each system user.	(1 2 3 4 5)
2. I like directives of privacy applied to evaluations. In particular, privacy in personalised results that are displayed for each student.	(1 2 3 4 5)
3. What data sharing policies you would be comfortable with?	Open Question
G. Other Comments and Suggestions for Improvement	

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A trace of lifelong-learning qualifications has become more and more mandatory at the European and even at world level. However, for higher education courses, the former could imply new complex learning designs and abundance of data to monitor, analyse, and report. Therefore, this implication has produced at least two challenges:

1. How to help students and teachers to understand and trace the underlying competences in their courses according to the European standards?

2. How to engage them to use technology enhanced tools and benefit from them?

Personalised, competence-based, and social learning have been suggested as potential ways to address these problems.

This work combine the ideas of personalised, competence-based, and social learning by providing course lifecycle support through competence-based design, outcome based assessment, social learning context analytics, and open student modelling visualisations. A series of studies using a virtual learning environment exploited the idea of the approach and revealed promising results. These results demonstrated personalised guidance, competence based design, outcome-based assessment, and social context visualisation combined helped students and teachers to trace learning outcomes of the European Qualifications Framework (EQF) in higher education courses. Thus, this thesis extends the approach of higher education to a larger collection of learning objects for designing, assessing, and analysing courses. Moreover, this approach verifies its capability of supporting social context visualisation for online and blended personalised education.

Study results confirmed that when users worked with voluntarily given applications, learning quality was increased. Students raised it through their contextual awareness, reflection, and self-regulation while teachers increased it through contextual awareness and self-reflection with several possibilities for planning, monitoring and moderating of their courses. Later works, still in progress, will prove if different applications will help to improve learning results reached by students and also their impact in courses with pedagogical strategies of active learning. Extensions to add recommender systems for teachers and students were designed, their implementation and tests are still awaiting. Regarding subjective tests, these confirmed the interface usability while teachers and students suggestions were taken into consideration for consecutive system versions.

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