A Software Suite for Efficient Use of the European Qualifications Framework in Online and Blended Courses

Beatriz Florian-Gaviria, Christian Glahn, and Ramon Fabregat Gesa

Abstract—Since introduction of the European qualifications framework (EQF) as one instrument to bridge from learning institutions to competence driven lifelong learning, it remains a challenge for instructors and teachers in higher education to make efficient use of this framework for designing, monitoring, and managing their lessons. This paper presents a software suite for enabling teachers to make better use of EQF in their teaching. The software suite extends course design based on well-defined learning outcomes, monitoring performance and competence acquisition according to the EQF levels, assessment using scoring rubrics of EQF levels and competences in a 360-degree feedback, as well as visualizations of learning analytics and open student models in dashboards for different social perspectives in social planes. This paper includes a case study with 20 teachers who used the software suite in all phases of the course lifecycle for three programming courses. The results show that integrated applications for adopting the EQF in teaching practice are strongly needed. These results also show that the suite can assist teachers in creating contextual awareness, kindling reflection, understanding students and course progress, and inferring patterns of success and failure in competences development.

Index Terms—Instructor interfaces, systems specification methodology, system architectures, integration and modeling, social learning techniques, personalized e-learning, EQF, 360-degree feedback, learning analytics

1 Introduction

Traditionally, academic and professional mobility was hindered by different educational and qualification systems. Each national system has its specifics that make a direct comparison of academic and professional degrees difficult. The Bologna process with the *European credit transfer and accumulation system* (ECTS) [1] reduced the mobility thresholds for academics by unification of academic degrees' credits in Europe. Despite the unifying of the academic degrees, the Bologna process did not include homogenizing the academic programs [2]. Mainly, the Bologna process is used to standardize 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 [3]. Fortunately, the Bologna process is now moving toward a competence-based system in addition to the study time centred ECTS approach. Therefore, it is necessary even for academic degrees to document the actual competences that have been achieved during the education. The *European qualifications framework* (EQF) is a European communities' recommendation and common reference system that links the countries' qualifications systems and frameworks [4]. Thus, the EQF complements and reinforces existing European mobility instruments such as Europass and ECTS. Moreover, the EQF is driving the transformation of European curriculums to allow transparency of the learners' qualifications and credits in terms of the acquired competences.

Although from 2012 onwards, it is expected to introduce references to the EQF levels in all individual certificates and diplomas awarded at the national level in academic and professional education, training, and learning throughout the European Communities [4], [5], there is little progress for integrating EQF into academic education and training on a large scale. For instance, Zahilas [5] reported that for the 2010 deadline to refer national qualifications levels to the EQF, committed countries were slightly behind. This is supported by an official report by the European Parliament that reveals that for the first stage only 12 countries presented their reference reports in 2011 and 19 countries were expected to report in 2012 [6], which is 2 years behind the original deadline. This is partially due to the lack of supporting tools for integrating the EQF into the education and training practice. Teachers can be overwhelmed mapping and monitoring course objectives according to the EQF.

This paper presents a software suite that allows educators to embed the EQF into their course designs and educational practice of online and blended teaching. Although the objective of this suite is to cover all domains of higher education (HE), its evaluation had a limited scope due to difficulties of recruiting innovative teachers for it.

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Thus, the scope of the evaluation presented by this paper is restricted to computing engineering courses using the ACM Computing Classification System as reference for classification of competences.

This paper is structured as follows: Section 2 outlines the architecture of the software suite and describes its relation to the EQF as well as to educational design and assessment. Furthermore, it refers to related research that was relevant for the software suite's design. Moreover, it presents the research question pertinent for the evaluation study reported in this paper. Section 3 exposes the objectives to test the practical feasibility and constraints of integrating competence-based research into academic education and training. Section 4 describes how the software suite has been evaluated in university courses in Colombia and Spain. Section 5 shows the results of evaluation study. Section 6 discusses the findings. Based on this discussion the challenges for further research are identified in the concluding Section 7.

2 Related Work and Final Architectures

This section describes the evolution of technical architectures behind the software suite presented until their current versions. The new additions to these architectures are analyzed in relation to previous publications. First, this section introduces the EQF as part of the course lifecycle in HE, and then it presents a technical architecture for enhanced support within course lifecycle. This architecture has been further extended into a more advanced second technical architecture. This architecture clarifies how to introspect learning activities and learning outcomes for learning analytics and recommendations. Thus, the second technical architecture complements the first architecture. This section concludes with the research question based on the complete technical architecture.

2.1 EQF for Online/Blended Course Lifecycle

The lifecycle of online courses has three main phases. The first phase is the *learning design phase*. Practitioners typically call this phase "preparation." The second phase is the *implementation phase*. For many, this phase concerns the actual teaching. The third phase is the *evaluation* of the learning process 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 virtual learning environments (VLE) do not actively support the final phase of the online course life cycle. This can be due to the limitations of the selected technical platform or due to organizational or administrative restrictions of a VLE's use [7].

Most educational design theories follow a common pattern for conceptualizing this process [8]. This pattern consists of seven educational activities:

1. definition of learning prerequisites,
2. definition of learning outcomes,
3. definition and alignment of learning activities,
4. rules for assessing the learning performance,

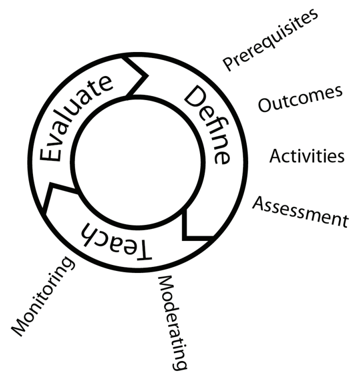

Fig. 1. Online course lifecycle with the related phases.

5. monitoring of the learning process,
6. moderation of the learning process, and
7. evaluation of the learning process.

Particularly the first six activities directly influence the quality and effectiveness of a single learning unit [8]. A structured evaluation phase contributes to the quality and effectiveness of long running educational and training offers and programs. Fig. 1 illustrates the online/blended course lifecycle and related phases.

Current learning design approaches for supporting educational activities emphasize on the design and arrangement of learning activities and assessment rules [9], [10], [11], while the relation between learning activities and the learning prerequisites and outcomes received limited attention by contemporary research. This gap is also visible in current specifications for the technical support of the educational design process such as the IMS learning design (IMS-LD) [9], [12].

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 objectives are often optional elements or absent in the interfaces of learning design software. Educational design research [8] has highlighted in the past that abstract learning objectives and learning goals should be replaced by quantifiable learning outcomes. 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 Bennet's activity verbs of and the eight learning activities [11] that can be used for patterning the learning activity descriptions [10], the EQF provides structure to defining quantifiable prerequisites and outcomes for learning and competence development. The EQF levels provide clear and easy-to-understand descriptions of what a person needs to show at the respective levels. These achievements are distinguished by "knowledge," "skills," and "personal 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. The EQF provides structure for planning the assessment of a unit of learning through

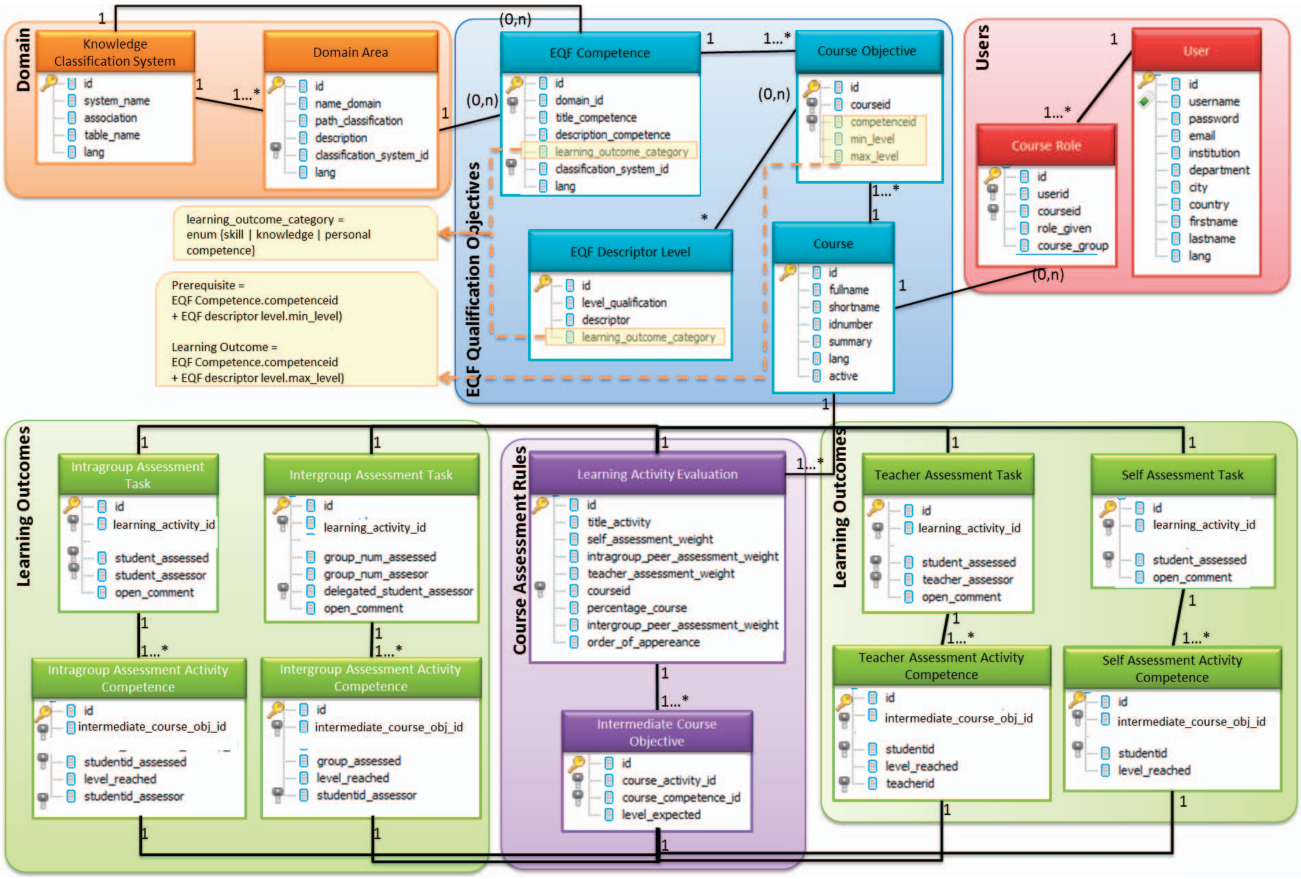

Fig. 2. Partial entity relationship diagram of data model to enhance course lifecycle based on the EQF.

quantifiable reference points for prerequisites and learning outcomes. The report [12] lists the learning outcomes for each EQF level.

A similar approach is used for standardized language learning in Europe using the six levels of the European framework of reference for languages (CEF) [14]. This framework distinguishes the competences "listening," "reading," "spoken interaction," "spoken production," and "writing" [14]. 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 toward these capabilities and certify learning outcomes accordingly.

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

In the following, the data model for enhancing the learning design of courses-based education through the EQF is presented for the first time. The scope in learning design with this proposal is to bring a complementary and enhanced support to the traditional learning design specifications and tools used for teachers in their VLEs. Therefore, our data model does not substitute but complements existing specifications for learning design.

Based on a competence model, the first activity of the instructional design process is defining the prerequisites and the outcomes for a learning unit. This definition states the gap between prerequisites and the learning outcomes. It frames selecting learning activities, defining assessment rules, monitoring the students' learning progress, and providing appropriate feedback.

Traditionally, learning design phase arranges learning activities and resources within the learning unit. In the present proposal, any suitable learning activity is directly related to at least one EQF learning outcome. A learning activity has the following elements:

1. a task for the student to complete,
2. the resources,
3. at least an associated competence, and
4. assessment rules for task completion and for 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.

Fig. 2 illustrates the data model proposed to enhance a learning design of a course.

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, and second, they need to monitor the learning progress to provide meaningful feedback to the learners. Both activities are tightly interwoven and influence one another.

The moderating and providing feedback support learners to orient them in the learning process. There are two types of moderating such processes. The first type is *providing task support* [13]. This type of learning support in online courses has been discussed in the context of scaffolding [14]. In instructional scaffolding teachers help students to master a task or a concept by providing support. The support can take many forms such as outlines, recommendations, storyboards, or key questions. This type of support is primarily activity centred to model a task, give advice or provide coaching. The second type of moderation is *guiding by feedback*. This type of learning support tackles the problem solving skills of learners by providing them an external view on their performance. 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 analyzing the overall progress within a learning unit. This activity provides the insights on the dynamics on the overall learning process. It enables educators tracking the appropriateness of the pace of learning and helps identifying learners who need support. While in classroom settings the monitoring activity is often implicitly performed by a teacher, online and distance learning environments need to provide educators with specific means for observing the different social and process dynamics in a course. This is required to enable practitioners to select suitable moderating and support strategies.

The additional competence specification during the design phase allows adapting the monitoring and moderating 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.

2.2 The Adaptive Evaluation Engine Architecture

For the present software suite, the first two phases of the online course life cycle (see Section 2.1) were modeled. The software suite presented here is the last version in the implementation of the *adaptive evaluation engine architecture* (AEEA) presented in [15]. With the introduction of the EQF in the architecture, it has been reduced from six stages to four stages. Final sequence of stages is presented in this paper. This architecture is a technical design that characterizes a methodology for competence driven lifelong learning. The architecture describes the online course lifecycle supported in data models. The course is carrying out by teachers and students through software applications. Fig. 3 shows the AEEA design that is structured into two packages, the *design package* and the *runtime package*. The design package is in charge of educational activities of *learning design phase*. The runtime package is in charge of educational activities of *implementation phase*.

The *competence authoring application* is used for defining learning prerequisites and learning outcomes. Based on a competence model that is structured by knowledge areas as well as the EQF as qualification model, teachers select the knowledge areas and competences for their course. An initial level for each competence defines the prerequisites and the final competence level defines the expected learning outcomes. *The learning design (LD) authoring application* supports teachers to define learning activities

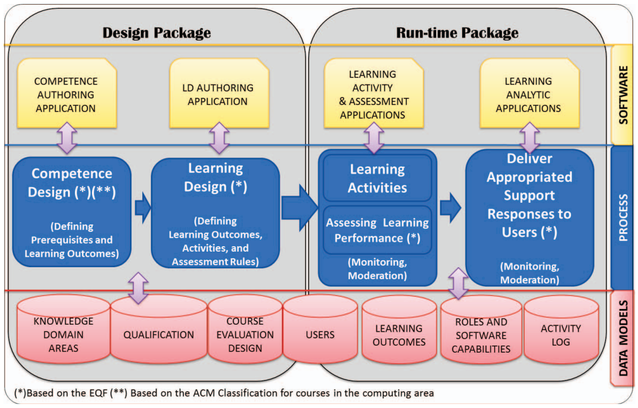

Fig. 3. The adaptive evaluation engine architecture.

elements (see Section 2.1). The course learning design model is defined by the collection of learning activities elements. This model defines the strategies for bridging gap between the prerequisites and the learning outcomes as a set of rules. These rules define the competence development process in terms of expected levels of qualification in activities. Therefore, the script for moderating and guiding the learning process can be visualized as a matrix between learning activities and competences reporting expected qualifications. Each entry in this matrix represents an expected competence level for an activity. A row of this matrix defines the steps of qualification of a competence from the initial qualification level (prerequisite) to the final expected qualification level (learning outcome) thought one or more assessment activities. The first version of the competence and qualification model for the *design package* was presented in [16]; this data model was later modified to adopt the EQF. The first version of the AEEA data model was based on IMS-LD and IMS-QTI. Findings of the ICOPER project suggested simplifying the competence qualification models; and thus taking an alternative path from the IMS-QTI and IMS-RDCO specifications that aimed to connect test items (questions of summative assessment tests) with competences [17], [18]. The present paper shows the last version of AEEA, in which the data model is based on the EQF.

Concerning the *runtime package* development to provide support guided by feedback, the AEEA claims for applications that support a 360-degree feedback to user such as [19]. In a 360-degree evaluation, a person receives feedback by everyone in its circle. For an educational lifecycle, the students' circle includes the teacher, the classmates or peers, and themselves. Therefore, to obtain a 360-degree feedback in evaluation the assessment applications must provide teacher-assessment as well as peer-assessment and self-assessment. Initial versions of the 360-degree assessment applications were presented in [20]. The current assessment application (see Section 4.3) was completely rebuild for reducing LMS platform dependences and for better support for EQF by the data Moodle. The assessments applications allow align the previously defined moderation script using a 360-degree feedback. The learning analytics applications allow monitor the learning progress and meaningful feedback. The design of these applications is detailed in the next section.

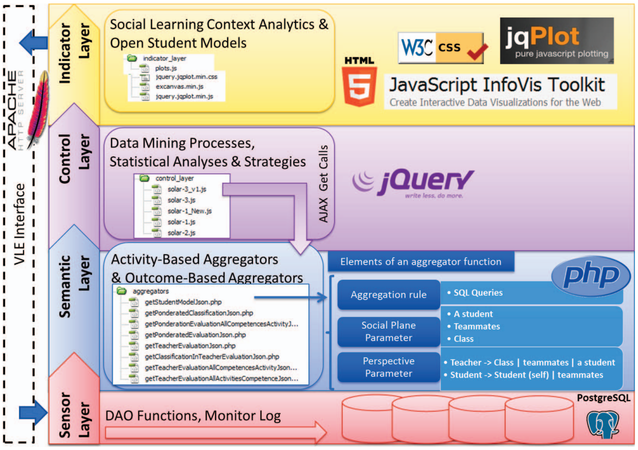

Fig. 4. The activity-based learner models technical framework. Initial version reported in [27].

2.3 The Activity-Based Learner-Models

It was necessary to make a deeper analysis to know how to build a learning analytic application for monitoring and moderation of competence-based courses. Thus, the present section enlarges the last stage of the previous technological architecture to clarify the elements and procedures from data capture to analytics report.

On the one hand, the increasing availability of educational data and the recent emerging learning analytics research field [21], [22], [23], [24] we see potentials to support the monitoring and moderation of courses based on the EQF by aggregating learner activities in a web-based learning environments. On the other hand, recent work on open student models [25], [26] seems to be also supportive for the above mentioned issues. Open student models can express the rather complex dependences between study behavior, EQF competences and the underlying learner model. Hsiao, Bakalov, and Brusilovsky use open student models to present the student progress in self-assessment tasks with parallel and introspective views.

In [27], we define a technical framework to build *activity-based learner models* to monitor learners activities and produce learning analytics solutions. Fig. 4 shows the current version of this architecture to give appropriate support response to users in competence driven lifelong learning. Currently, the monitoring of this framework can be either activity centred or outcome centred. The prototypes of indicators implemented in [27] were an example for activity centred monitoring. In this paper, the learning analytics provided are generated from outcome centred monitoring. In the previous paper, the type of visualizations for competence developments has been defined as *social learning context analytics* and *open student models*. *Social learning context analytics* are analytic tools that expose, make use of, or seek to understand social context(s) where the learner is involved [28].

Two main theoretical concepts provide the underpinning for the *activity-based learner models*. These concepts are described by Florian-Gaviria et al. [27] in detail. The two main concepts are: 1) The actuator-indicator model, and 2) Engeström's activity theory.

1. The *actuator-indicator model* [34] describes four technological layers to proceed from monitoring and assessment to suitable response to users. The four layers are:

   a. The *sensor layer* is in charge of saving log data and learning outcome data. It also manages data access objects for applications.
   b. The *semantic layer* is in charge of set up aggregators of data activities, learning outcome data and logs. Software roles and capabilities establish the social perspective of the current user (e.g., teacher, nonediting teacher, student, site administrator). Besides the particular parameters of each function, the aggregators have always an additional parameter, the context (self, peers, class). This parameter represents the social plane in which the user is interested to show the results of the aggregator. A social plane is the angle of vision or scope in which the function collects data (collect data of one student, a group or of the whole class). Therefore, the answer of an aggregator changes depending of this parameter.
   c. The *control layer* is in charge of arranging data collected by one or more aggregators. The control layer process and format aggregated information using rules, data mining techniques or statistical analysis. Additionally the control layer also holds functions that implement strategies for coordinate the result delivery to display functions in the next layer.
   d. The *indicator layer* is in charge of rendering the formatted data into widgets. It uses a particular function to display different types of learning analytics such as: plots or widgets as smart indicators, recommendation widgets, and visualization of competence analytics among others.

2. The *Engeström's activity theory* [29] is our pedagogical base. The 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 outcomes can trigger new activities. This allows the systematic description of complex processes. This model has been used to analyze the effectiveness and the efficiency of business processes for identifying potential improvements of work settings. This theory has been used in educational-technology [30] and instructional design [31], [32] where the concept of *social planes* (individual, peers, or class plane) have been applied. For instance Glahn et al. [33] found evidence for triggering awareness and reflection through visualization of information from different *social planes*. For implementing this theory, Florian-Gaviria et al. [27] clarified strategies for building activity-based aggregators as functions in a semantic layer of a VLE. The functions have three main elements: an aggregation rule, a social plane (single student, teammates, and class) and a role

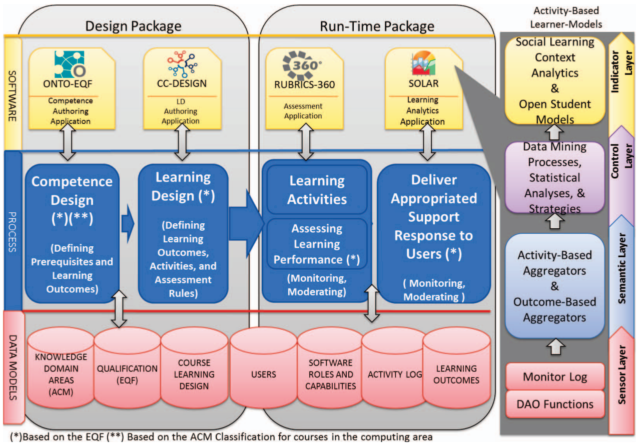

Fig. 5. The AEEA software suite.

perspective (teacher, peers, and student). In this paper, the same approach is used to build outcome-based aggregators. These new aggregators use input data collected specifically from assessment activities.

The main research question of this study addresses the need for structuring a suitable methodology for teachers to carry out their courses in competence driven lifelong learning. Teachers need software applications to support their work in a process from learning design to complex data analysis and feedback to students according to the EQF. Therefore, the question is:

"How can teachers make effective use of the EQF for designing, monitoring, and moderating their lessons?"

Integrating the EQF and activity-based learner-models has approached this question. The AEEA applied these concepts for defining a competence driven learning process. These features structure learning analytics techniques for providing activity-based feedback as well as outcome-based feedback.

This integration is an attempt of structuring a suite of software applications to support a methodology that can be used by teachers and instructional designers in TEL. Fig. 5 shows the integration of background models to produce the AEEA software suite. The software suite objectives for teachers and the software applications are explained in Sections 3 and 4, respectively.

3 Suite Objectives in Course Lifecycle

Section 2 outlined the two technological architectures of the prior research. We see potential in the integration of such models to allow construction of a suitable software suite for lifelong competence development in higher education based on the EQF. The results of software implementation and practical evaluation of these applications in HE courses are presented for the first time in this paper.

At this moment, the AEEA software suite is a set of four fully implemented Web applications 1) ONTO-EQF, 2) CC-DESIGN, 3) RUBRICS-360, and 4) SOLAR) that are independent from a learning environment. ONTO-EQF, CC-DESIGN, and SOLAR have not been presented before. As was mentioned earlier, RUBRICS-360 was completely reconstructed due to a change in the data model (see Fig. 2), as well as university policy restrictions on using the Moodle platform.

The AEEA suite supports teachers in using the EQF throughout the lifecycle of courses to achieve the following objectives:

1. ONTO-EQF application enables teachers to define a core of competences for their courses based on the EQF. The competences are ordered by knowledge domain areas. Teachers define prerequisites and learning outcomes by selecting the initial level and the final level of qualification for each competence. This way, teachers can map the objectives of their course to the EQF. This application is inspired in the administrative competence mapping that was implemented for the MACE project.[1] The novel aspect is not the graphical interface but to evaluate this kind of social competence authoring tool in a personalized formal education environment for teachers with the aim of sharing competences definitions and also entire course competence designs based on the EQF.
2. The teachers' objective with using the CC-DESIGN application is to focus their course design of learning activities and assessment 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.
3. The teachers' purpose with the RUBRICS-360 application is to perform EQF-competence assessment 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 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 assessment tasks.
4. The teachers' goal with SOLAR is to monitor the progress of a course and of individual learners on the course relevant social dimensions (a student, teammates, and classmates). Another objective is to create awareness and reflection for teachers of how learners are developing or not the competences related with the course. The SOLAR application provides visual overviews of the progress of learners against the plan of teacher. It provides parallel views of individual student performance against anonymous summary of the performance of peer students (teammates and classmates). Another objective for teachers is to find patterns of failure and successful in students, and potential problems in the course design.

1. http://www.mace-project.eu/index.php.

4 TEACHERS CASE STUDY

This case study explores the social perspective of teachers. It was performed in the fall semester of 2011 using three courses in programming.[2] In total, 20 teaching persons participated: 12 computer science teachers (four of them were coordinator teachers) and eight computer science teaching assistants. Six of these teaching persons were females and the other 14 were males. The range of age was between 24 and 48 years old. Eleven of the teachers in the study had no previous experience in this type of design. Nine of the 20 teachers had some experience designing a course with competences but none of them had used before levels of qualification for competences describe by the EQF. There were 100 students enrolled in the first course, and there were 20 students enrolled in both the second and third course.

Despite the fact that the social perspective of learners it is important, it is not explored in this study to focus on the teacher's perspective. Other two case studies exploring the social perspective of students were conducted in parallel with this study.

Teachers were asked to use the AEEA Suite to evaluate whether its applications could assist them in understand student models and development of competences. The usefulness of the AEEA applications to include the perspectives of the EQF in course design was also evaluated.

We designed a survey. The survey was divided in seven sections, one section to collect demographic data, four sections to inquire about each application of the AEEA suite, a section related to the AEEA suite and, finally a section to give the opportunity for open comments. Questions were mainly designed to measure the satisfaction, usefulness, and opinion of teachers during the test period. The questions were formulated in a variety of types, including open questions, five-point Likert scales with single choice questions, and matrix tables with single choice questions. In the case of five-point Likert scales, 1 always means the worse option and 5 always means the best option. The question items of the survey and results are presented in Section 6.

In the remainder of this section, the test process and applications used for teachers are described.

4.1 Design Phase Applications

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. As described before, the ONTO-EQF graphical interface and user interaction is inspired in the administrative competence application of MACE project. For this case study in the area of programming the knowledge domain areas were extracted from the ACM Computing Classification System [35] while MACE project application use a Classification System for Architecture Domain. The selected/created competence can be added to the course using the button "Add to course" added to ONTO-EQF application. 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. The most of the teacher needed a previous capacitating to learn how define competences (skills, knowledge, and personal competences) following the EQF framework.

The second web application that teachers used was the CC-DESIGN; this is a complementary course design application to edit prerequisites, learning outcomes, and qualification rules of EQF competences. CC-DESIGN is used to design a plan of activities and the expected level of qualification for each one of the competences involved in these activities. Fig. 6 shows the CC-DESIGN interface.

In CC-DESIGN interface the upper table (see Fig. 6a) shows the competences already added to the course ordered by knowledge domains areas. Using a slider widget, teachers can edit the minimum (prerequisite) and maximum (learning outcome) level they expect to develop each competence in their courses, from the eight levels of qualification of the EQF. The second row of tables (see Figs. 6b and 6c) shows the evaluation activities of the course. For assessment of competences, the percentages of self-assessment, peer-assessment, and teacher-assessment are defined in a table (see Fig. 6b); and, in the context of traditional course evaluation, the percentages of its evaluation are defined in a table (see Fig. 6c).

In the table (see Fig. 6d), 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. An evaluation activity is qualified with a series of expected learning outcomes (EQF level of competences). If a competence is not evaluated in a particular activity, the slide bar is replaced by an icon, which expresses "not available." Two rounds of design were needed to end design tasks properly.

In Fig. 6, 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 Level 1* and the final learning outcome expected is the *EQF Level 3* (see Fig. 6a). This competence is assessed with three evaluation activities: 1) *algorithmic problems and exercises at Level 1*, 2) *practice of algorithmic at Level 2*, and 3) exam at Level 2 (see Fig. 6d). Twenty percent of the *algorithmic problems and exercises evaluation* is a student self-evaluation, the remaining 80 percent is the teacher evaluation (see Fig. 6b).

4.2 RUBRICS-360: Assessment Application

After the previous two stages of design, the courses began and the teachers' evaluations of competences were made. The RUBRICS-360 application of the AEEA Suite was used. This application provides a 360-degree formative assessment of competences (self-assessment, peer-assessment, and teacher-formative-assessment) for courses. Fig. 7 shows a part of the RUBRICS-360 interface. Tests are scoring rubrics (rating scales).

From the script of qualifications defined with CC-DESIGN, RUBRICS-360 builds automatic tests for assessing activities using scoring rubrics. RUBRICS-360 extracts the

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

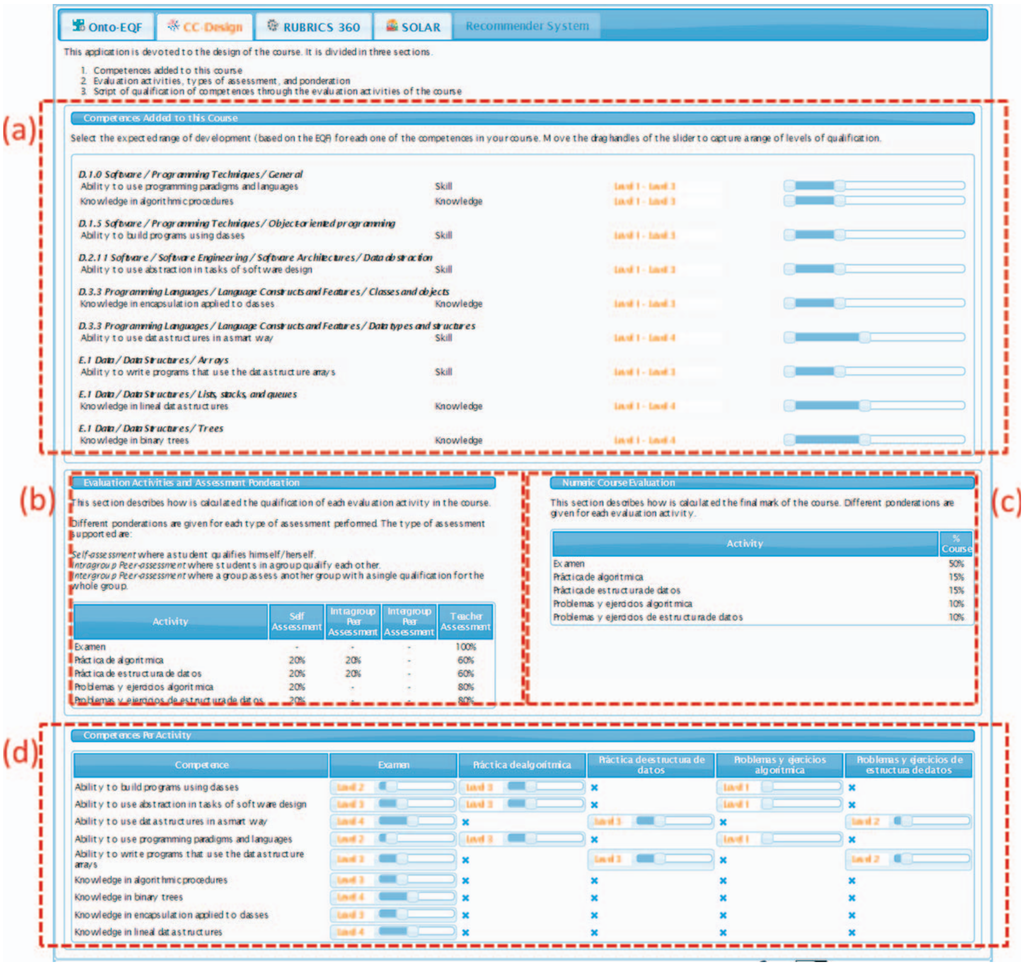

Fig. 6. Teacher interface of the CC-DESIGN application.

associated competences for each activity and sorts them by type of learning outcome (knowledge, skill, personal competence). For instance, in Fig. 7, the evaluation activity is the exam. The exam assesses nine competences; four of them are classified as knowledge and the other five are classified as skills. The scoring rubrics have eight categories that correspond with the eight levels of qualification for each type of learning outcome in EQF (see Fig. 7a—EQF levels of knowledge—and Fig. 7b—EQF levels of skill). In addition, the level expected for each competence in the evaluation activity is highlighted (yellow). For instance, the level expected in the exam for the first competence knowledge in algorithmic procedures is Level 3 (see Fig. 7c). The descriptor in this case is the EQF descriptor for Level 3 of knowledge (see Fig. 7d). The teacher qualifies the level achieved by the student for each competence

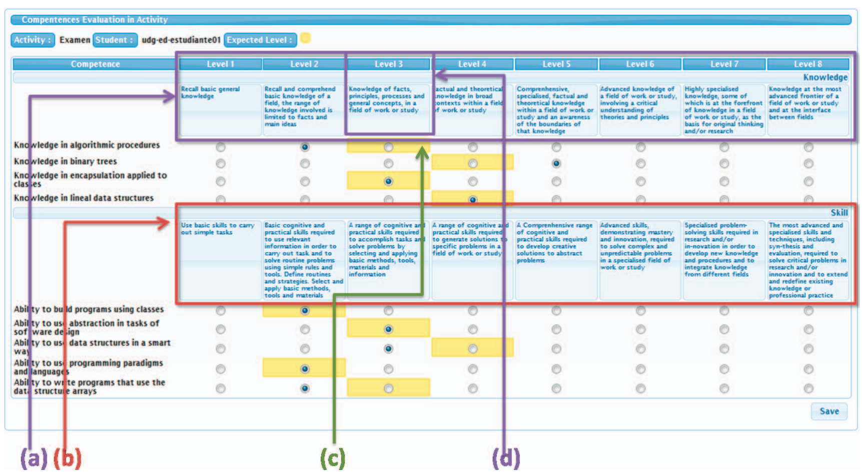

Fig. 7. Part of teacher interface of the RUBRICS-360 application.

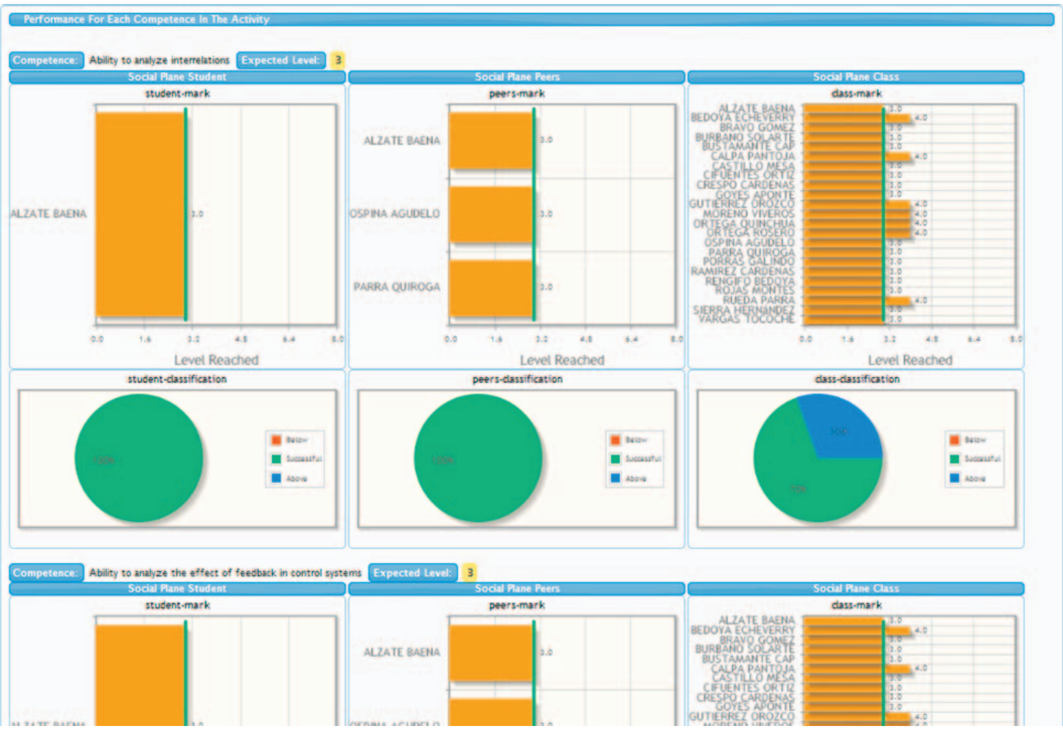

Fig. 8. Part of dashboard with visualizations related to qualification of competences in an activity.

using radio buttons. The same kind of interface is used to perform self-assessment and peer-assessment for activities where the teacher qualification plan demands to do so from students.

4.3 SOLAR: Social Learning Analytic Research

Finally, after the assessment data are saved, the SOLAR application starts to produce visualizations of competence analytics. SOLAR is the fourth Web application of AEEA Suite. This provides social learning context analytics of performance and the development of competences in courses.

The visualizations are showed with parallel social planes; the social planes are: student, teammates, and classmates. The social plane student shows data of a single student, the social plane teammates means a group of students working collaboratively, and finally the social plane class shows data of the whole class. The visualizations are adaptable depending on the user role (teacher, student). Teachers can see the student names in visualizations whereas students only are allowed to see their own data, teammate data, and anonymous summary of the performance of classmates. Fig. 8 shows part of the dashboard with results of a single evaluation activity and a particular student selected. The learning analytics are computed and the corresponding visualizations change according to the selected student.

In Fig. 8, the evaluation activity shown is *practical evaluation*, it associates at least two competences, for each competence six plots are generated, two plots for each social plane. The left column shows plots for the social plane student, the middle column shows plots for the social plane teammates and the rightmost column shows plots for the social plane classmates. The bar charts show the level achieved for each student, the pie charts show the percentage of students which achieved the expected level (green slide), the percentage of students below (orange slide), and above of the expected level (blue slide).

In the second dashboard, the same kind of plots can be generated searching not for activity but for competence and student. In this case, the dashboard shows six plots for each activity in which the competence selected was evaluated.

Additionally, both dashboards show a summary view for each social plane. For instance, Fig. 9 shows a summary view of the second dashboard for the competence *ability to analyze interrelations*. For the social plane *student*, a bar chart reports the activities that evaluated the competence and the achieved levels. A label above each bar indicated if the student was below the expected level (orange label), achieved the expected level (green label) or was above the expected level (blue label). The plots for social plane *teammates* and *classmates* are stacked bar charts of number of activities (axis Y) versus student (axis X) reporting the number of activities below (orange color), successful (blue color), or above of the expected level (green color).

5 Results

Once teachers completed the courses, they filled in the designed survey to evaluate the usefulness and satisfaction of the AEEA suite for them. In this survey, teachers answered open questions about how well they understood the applications and tasks, if they used some strategies to complete the process, how they achieved the proposed objectives (especially after questions with * in Table 1), if they had some advice to improve the suite, if they had suggestions for new learning analytics, if they needed extra information or new abilities to perform the proposed tasks.

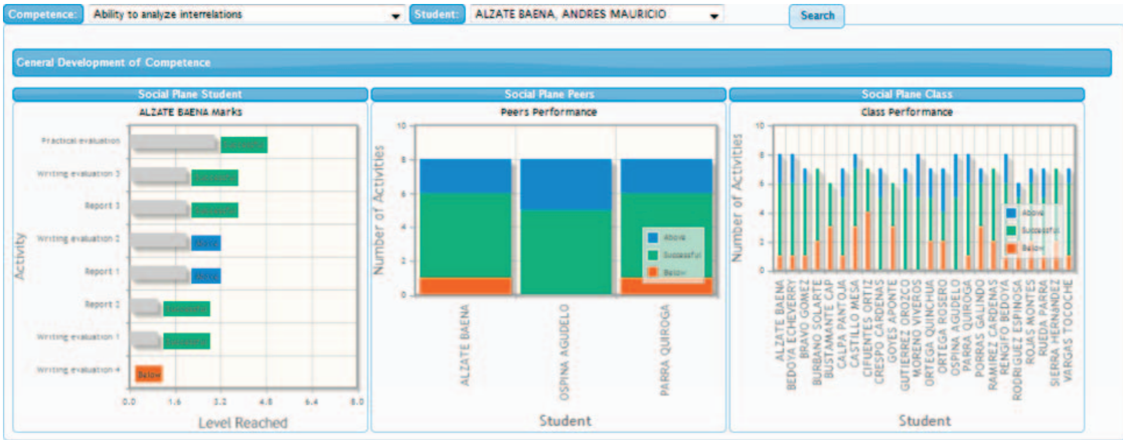

Fig. 9. Visualizations related to general development of a competence.

In addition, to know how many teachers were satisfied, they answered a series of questions (see Table 1) where they had to choose the most appropriate response of a five-point Likert scale from 1 (very dissatisfied) to 5 (very satisfied). Finally, at the end of the survey a space was left to additional comments. Our report on the results is organized along the lines of five segments. The first segment is related to the general process and the overall AEEA Suite. Further segments are correlated with a one particular application. Table 1 summarizes the satisfaction percentages, amount of responses, mean and standard deviation for each question. Fig. 10 shows the subjective teachers' evaluation for each itemized survey question.

5.1 General Process and the AEEA Suite Results

These results show the more difficult tasks for teacher were those related to design. Only 60 percent of teachers considered the design tasks to be easy (see Q2.1). In the open questions and the additional comments teachers report a cognitive overload because they need to understand the EQF before they could use the design applications. Despite the fact the new design methods were not easier than the ones teachers used to use (see Q2.2), the new methods were considered useful (80) (see Q2.3). The outcome-based support satisfied 95 percent of teachers (see Q2.6). In general, teachers found the suite useful (80 percent) (see Q2.10). Eighty percent of teachers would recommend the suite to their colleges (see Q2.11). The teachers highly recommend this kind of integrated process (85 percent) (see Q2.12). In the open questions and the additional comments, they recommend develop this kind of applications as a university policy. Moreover, they expressed that they were pleased to carry out design tasks and found out that these were useful to generate automatic assessment and learning analytics later.

5.2 ONTO-EQF Results

Results show that the task of design of competences (see Q3.1) was not so easy for teachers (65 percent). On the other hand, teachers found the EQF (see Q3.3) and the ACM classification (see Q3.2) as good bases for the purposes of ONTO-EQF, the both questions with a satisfaction of 90 percent. Eighty-five percent of teachers thought ONTO-EQF supports them to map the objectives of their courses to the EQF (see Q3.5). The open answers about how teachers felt they did this mapping (Q3.6), all agreed to mention they did it by transforming course objectives into competence development ranges.

5.3 CC-DESIGN Results

Results about CC-DESIGN show that the instructional design task was the most difficult task for teachers with a satisfaction of 60 percent (see Q4.1). Nevertheless, they were pleased to carry out this task based on the EQF with a satisfaction of 80 percent (see Q4.2). Furthermore, they perceived the application as well implemented with a satisfaction of 80 percent (see Q4.3). The open answers to Q4.5 that inquired about how teachers felt they aligned the course elements to the EQF shows that teachers did it through the definition of the matrix competences versus activities.

5.4 RUBRICS-360 Results

The results about RUBRICS-360 show great percentages of satisfaction for teachers. The assessment tasks were easily performed by the teachers (see Q5.1) with a high satisfaction 85 percent. The proposal best received was to provide an application for 360-degree feedback in assessment (see Q5.2). When teachers were asked about the EQF descriptors as scoring rubric descriptors they rated a good satisfaction 75 percent (see Q5.3). Teachers seem to be delighted with the automatic generation of evaluations (see Q5.4) with a satisfaction of 85 percent. Ninety percent of teachers were pleased with the application to trigger reflection and awareness (see Q5.6). Moreover, in the open answers to question Q5.7 teachers said that they could reach reflection and awareness when they performed the assessment tasks and thought carefully the qualification levels for each student.

5.5 SOLAR Results

With regard to SOLAR, understand the meaning of visualizations (see Q6.1) was moderately rated 70 percent. The appearance of SOLAR was suitable for teachers (see Q6.2), the satisfaction percentage was 85 percent. The support for monitoring and moderation with SOLAR was perceived with high satisfaction 90 percent (see Q6.3). Eighty percent of teachers could identify patterns of failure

TABLE 1
Results of the Survey Filled in by Teachers

Evaluation questions about the AEEA Suite	μ	σ	Satisfaction
Q2.1 Was it easy for you to complete design tasks for your course?	3.35	0.875	60% (n=12)
Q2.2 Was it easier to complete design tasks than the way you used to do it?	3.40	0.821	60% (n=12)
Q2.3 Was it useful to desing including the perspectives of the competences in activities?	4.10	0.718	80% (n=16)
Q2.4 Was it easy for you to complete the course tasks in run-time?	4.20	0.696	85% (n=17)
Q2.5 Was it easier to complete tasks in run-time than the way you used to do it?	4.10	0.641	85% (n=17)
Q2.6 Was it useful the outcome-based monitoring and moderation for your course?	4.65	0.587	95% (n=19)
Q2.7 Is it suitable for you the EQF as framework for design tasks and run/time tasks?	4.20	0.696	85% (n=17)
Q2.8 Were the instructions to perform design tasks run-time tasks clear?	3.70	0.571	75% (n=15)
Q2.9 How satisfied are you performing educational activities using Web 2.0 applications?	3.60	0.681	70% (n=14)
Q2.10 In general, was the AEEA Suite useful?	3.90	0.553	80% (n=16)
Q2.11 Would you recommend this suite to other people or peers?	3.80	0.768	80% (n=16)
Q2.12 Do you think integrated applications, for modeling, monitoring and moderating courses, based on the EQF are needed by teachers?	4.25	0.716	85% (n=17)
Evaluation questions about ONTO-EQF	**μ**	**σ**	**Satisfaction**
Q3.1 Was it easy for you to complete the task of competence design for your course?	3.45	0.826	65% (n=13)
Q3.2 Do you think the ACM classification is appropriated to select computing knowledge areas?	4.50	0.688	90% (n=18)
Q3.3 Do you think the EQF is a suitable framework to design competences?	4.50	0.688	90% (n=18)
Q3.4 How satisfied are you with the wiki of competences to desing competences for your course?	4.25	0.716	85% (n=17)
Q3.5 * Do you think ONTO-EQF supports teachers to map the objectives of their courses to the EQF?	3.80	0.523	85% (n=17)
Q3.7 Would you like a recommender system that suggests competences based on selections of teachers with similar courses?	4.00	0.918	80% (n=16)
Q3.8 Do you prefer a graphical visualization of the competence classification like a treemap?	4.00	0.649	80% (n=16)
Evaluation questions about CC-DESIGN	**μ**	**σ**	**Satisfaction**
Q4.1 Was it easy for you to complete the tasks of instructional design for your course?	3.35	0.875	60% (n=12)
Q4.2 Is it suitable for you to carry out the learning design tasks based on the EQF?	3.90	0.553	80% (n=16)
Q4.3 How satisfied are you with the CC-DESIGN application to design your course based on the EQF?	3.80	0.410	80% (n=16)
Q4.4 * How satisfied are you with the CC-DESIGN application to align the course elements to the EQF: 1) Activities 2) Assessment 3) Activities Outcomes?	3.95 4.25 4.00	0.510 0.786 0.649	1) 85% (n=17) 2) 80% (n=16) 3) 80% (n=16)
Q4.6 Would you like a recommender system that suggests possible activities for your course based on the added competences?	4.25	0.716	85% (n=17)
Evaluation questions about RUBRICS-360	**μ**	**σ**	**Satisfaction**
Q5.1 Was it easy for you to complete the competence assessment tasks for your course?	4.25	0.716	85% (n=17)
Q5.2 Is it valuable for you the 360-degree feedback in assessment tools for your course?	4.55	0.686	90% (n=18)
Q5.3 Is it a good idea to use EQF descriptors as rubric score descriptors?	3.75	0.550	75% (n=15)
Q5.4 Was it worth the effort of design in order to produce automatic evaluation templates?	4.25	0.716	85% (n=17)
Q5.5 Is it a good idea to qualify levels achieved by students for each activity and each competences?	3.75	0.444	75% (n=15)
Q5.6 * How satisfied are you with the RUBRICS-360 application to trigger reflection and awareness?	4.50	0.688	90% (n=18)
Evaluation questions about SOLAR	**μ**	**σ**	**Satisfaction**
Q6.1 Was it easy for you to understand the meaning of visualizations?	3.50	0.827	70% (n=14)
Q6.2 Was the overall appearance of SOLAR elements (colors, plots, etc.) suitable for you?	4.25	0.851	85% (n=17)
Q6.3 How satisfied are you with the SOLAR application for monitoring and moderation?	4.45	0.686	90% (n=18)
Q6.4 * Was it possible for you to detect patterns of failure and successful of students using SOLAR?	4.00	0.649	80% (n=16)
Q6.6 Was it easier to understand these patterns with SOLAR than without it?	4.45	0.686	90% (n=18)
Q6.7 * Was it possible for you to detect possible problems in course design using SOLAR?	4.00	0.649	80% (n=16)
Q6.9 Was it useful for your teaching-work the learning analytics presented?	3.75	0.444	75% (n=15)
Q6.10 * Do you think that SOLAR can assist teachers in raising awareness and reflection about performance of students?	4.00	0.795	80% (n=14)
Q6.12 Do you think that this kind of dashboards can assist teacher in understanding performace of students in social planes?	4.25	0.716	85% (n=17)

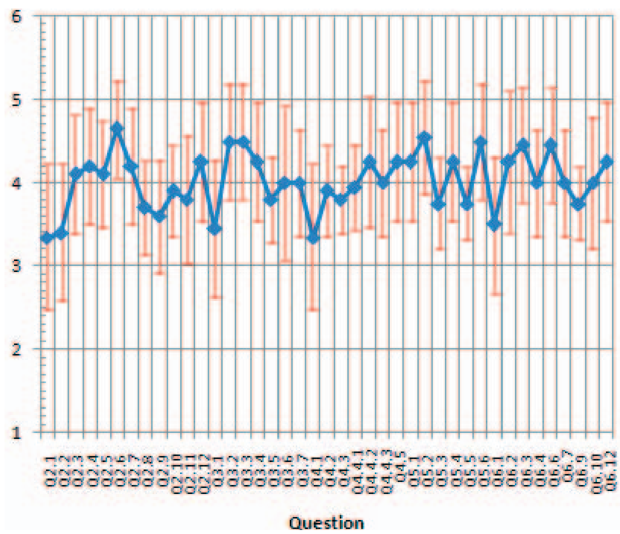

Fig. 10. Summary of the subjective teachers' evaluation for each itemized survey question.

and successful using SOLAR (see Q6.4). In the open answers of question Q6.5, teachers said that they could identify failures and success for each student understanding the set of visualizations of competence performance. They suggested implementing complementary visualizations; one that shows a summary of the performance student model and another that shows the summary of the class performance. They also said that with SOLAR they could identify these patterns in competence development that before they were unable to monitor. Teachers could identify (80 percent) possible problems in the course design using SOLAR (see Q6.7). In the open answers of Q6.8, they said these problems were revealed when they noticed in the visualizations a high percentage of the students with performance below the expected level. The learning analytics presented were useful (75 percent) for the teaching work (see Q6.9). In the opinion of teachers, 80 percent of them think that the SOLAR application triggers reflection and awareness (see Q6.10). The summary of open answers to Q6.11 reveals that the awareness and reflection were raised in teachers when they appraised in understanding the set of visualizations for each student. Parallel views of social planes (see Q6.12) seem to be well received by teachers to understand social student's behavior (85 percent). The open answers to Q6.13 show that teachers could understand the performance of a particular student against other social planes when they analyzed the parallel visualizations.

6 Discussion

This research was conducted with the aim of fill the gaps between the EQF objectives in learning and the practical way of carry out them in online courses. Therefore, we were interested in validate not only each software application of the AEEA Suite but also the whole learning process proposed for a course based on the EQF. We are pleased to find out high satisfaction between teachers with the process and the united software applications. Moreover, teachers suggest building this kind of software suites as institutional applications in universities. We are also satisfied because the objectives planned for teachers in each application were achieved by them. Additionally, according with the results the software suite seems to be well implemented and with a suitable theoretical background. Therefore, the AEEA software suite supports a methodology for designing, monitoring, and moderate lessons using the EQF.

Although design tasks were reported as difficult, at the end of the process teachers felt rewarded with the automatic generation of test for assessment and the learning analytics displayed in dashboards. We think they found design tasks difficult because this case study was the first experience, for many of them, with a course based on the EQF. We need 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 instructional design tasks, especially instructional design based on the EQF. 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 competence levels using the CC-DESIGN application.

With regard to RUBRICS-360, its philosophy (assessment of competences in terms of EQF qualification levels in activities) and tasks of assessment, they were well received by teachers. A small percentage (5 percent) of teachers asked if they could personalize descriptors in the scoring rubrics of test. The other 95 percent felt that is a good idea to use the descriptors of the EQF as descriptors of scoring rubrics because they save time and have normalized descriptors for all courses and evaluations. The results confirmed reflection and awareness process in teachers using RUBRICS-360.

We also find a cognitive overload in teachers in task of analysis of visualizations (understand the meaning). Teachers report an acceptable satisfaction in the easiness of this task. They were pleased with the visualizations but they spend more time than they expected in this task. Maybe it is because this case study was their first experience with learning analytics of competence development; for most teachers, this was their first experience with any kind of learning analytics. With the suggestions of teachers collected from the open questions and the final comments section of survey, we are implementing a series of improvements and new functionalities in dashboards to allow personalization to teachers. Our proposal of parallel views of perspectives in social planes can be extended with the concept of introspective views of [25], [26], that is, to include a navigation scheme to offer an overview of all items present in the model, allows for zooming into different parts of it and filtering according to different criteria, and provides details on demand. Another way to extend our dashboards is to include visualizations of progress in number of tasks performed through the time [16], [17], [26]; our concept of visualization of progress in development of competences could provide a better idea of learning progress in time.

In SOLAR application, teachers could identify, with an acceptable satisfaction, patterns of failure and successful in students. We think that a complementary option of visualizations for this purpose should be a net-visualization of students according to their performance (class performance model) and a radial representation of student performance (the entire student performance model). The open comments related to the SOLAR application show that teachers were able to monitor student progress and also to be aware and reflect about performance of students.

Maybe, it is a good idea for future versions of the AEEA Suite to develop recommender systems to assist teacher in tasks of design. We ask about two kinds of recommenders and the teachers mark as high these possible recommenders 80 percent and 84 percent (see Q3.7 and Q4.5).

7 Conclusions

We have presented the AEEA suite. The suite allows teachers an integrated process of modeling, monitoring, and managing lessons driven by the EQF. A case study with teachers was presented.

The suite is based on solid pillars such as the EQF as model of qualification of competences, a learning process based on the EQF, the actuator-indicator model and the activity-based learner models as software architecture frameworks. The activity-based learner models include social perspectives in social planes for monitoring of activities and production of different kinds of learning analytics.

To carry out the learning process proposed it is necessary some steps of instructional design. This process demands time for preparing the course. Then, teachers appreciate this time of design as an investment to have monitoring and analysis about learning progress of students in activities and competences.

The results show cognitive overcharge for teachers in tasks of design and interpretation of learning analytics. Some strategies such as new visualization (net graphics, progress of learning in time); updates of existing visualizations (with introspective views) and possible recommender systems have been planned to decrease this problem.

Our proposal for assessment of competences is a 360-degree feedback evaluation, based on scoring rubrics whose descriptors are taken from the EQF. This proposal was well received by teachers.

In particular, the SOLAR application is innovative because present learning analytics about competence development for different social perspectives (student, teacher) with parallel social planes (single student, teammates, classmates). Considering the results the SOLAR application can assist teachers in creating awareness, kindling reflection, understanding students' behavior in social planes, and understanding patterns of success and failure in competences development.

This case study seems to show that in practice teacher are not so familiarized with the EQF. It will be a good idea to explore more on this topic.

The major contribution in relation to the entire AEEA suite is that teachers are pleased to have integrated applications to design, monitor, and moderate competence development in their practice.

As future research, we plan to have a second case study with students and teacher to test the entire possibilities of the AEEA Suite. Some comments and suggestion of the first case study will take into account to produce a further version of the AEEA Suite, especially learning analytics solutions. We are evaluating the possibility of combine visualizations of progress in tasks and introspective views along with the current visualizations of development of competences. We are also exploring possibilities to add recommender systems to the suite, the results suggests a high need of them for design tasks. As mentioned before, a possible recommender is a recommender of competences for a course, another possible recommender is a recommender system that suggest activities according to the EQF levels selected for developing a competence; the EQF descriptors can bring light to the kind of evidences and activities to achieve a particular level. Also, it is possible to classify students according to their performance in competences development and find out what kind of recommendations we can generated for them.

We are aware of some possible biases because of methodology issues of this case study using only surveys and final personal interviews. Definitely, new experiments will include other empirical approaches such as statistical analysis with data collected before and after the experiments, eye tracking or thinking aloud studies. Moreover, there is a clear plan to use data from learning analytics and open student models produced by SOLAR application to demonstrate the learning effects of the proposed software suite. For instance, the collected data can indicate if the students are learning faster or if they are obtaining better qualifications than those students in courses without using the suite.

Last but not the least, from personal interviews to teachers at the end of surveys some findings arose. It was notorious that social applications required more efforts to personalize levels of navigation, even in a virtual higher education environment. A key finding was that teachers need a mechanism to link EQF competence qualifications with marks (or grades) of appraised activities. Necessities of 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.*

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REFERENCES

[1] European Commission, "European Credit Transfer and Accumulation System (ECTS): Key Features," http://ec.europa.eu/education/lifelong-learning-policy/doc/ects/key_en.pdf, 2004.
[2] NAFSA: Association of International Educators, "The Bologna Process," *2007 International Educator Supplement,* 2007.
[3] J. Mencinger, "Can University Survive the Bologna Process?" *Proc. Symp. Socio-Economic Perspectives in the Life Sciences Conf.,* pp. 1-5, 2004.
[4] European Parliament Council, "Recommendation of the European Parliament and of the Council of 23 April 2008 on the Establishment of the European Qualifications Framework for Lifelong Learning," *Official J. European Union,* vol. 51, no. 2008/C 111/01, 2008.
[5] L. Zahilas, "The European Qualifications Framework (EQF): 'A Tool to Describe and Compare Qualifications," http://www.nqf.gov.gr/Portals/0/EQF_ADAPT.pdf, 2012.
[6] S. Broek, B.-J. Buiskool, M. van Oploo, and S. de Visser, "State of Play of the European Qualifications Framework Implementation," http://www.europarl.europa.eu/committees/fr/studiesdownload.html?languageDocument=EN&file=73578, pp. 1-120, 2012.
[7] D. Verpoorten, C. Glahn, M. Kravcik, S. Ternier, and M. Specht, "Personalisation of Learning in Virtual Learning Environments," *Learning in the Synergy of Multiple Disciplines,* U. Cress, V. Dimitrova, and M. Specht, eds., vol. 5794, pp. 52-66, Springer, 2009.
[8] *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory,* vol. 2, C.M. Reigeluth, ed., Routledge, 1999.
[9] D. Hernández-Leo, J.I. Asensio-Pérez, and Y. Dimitriadis, "Computational Representation of Collaborative Learning Flow Patterns Using IMS Learning Design," *Educational Technology and Soc.,* vol. 8, no. 4, pp. 75-89, 2005.
[10] A. Masson, A. Macneill, C. Murphy, and V. Ross, "The Hybrid Learning Model—A Framework for Teaching and Learning Practice," *Int'l J. Emerging Technologies in Learning,* vol. 3, pp. 12-17, 2008.
[11] D. Verpoorten, M. Poumay, and D. Leclercq, "The Eight Learning Events Model: A Pedagogic Conceptual Tool Supporting Diversification of Learning Methods," *Interactive Learning Environments,* vol. 15, no. 2, pp. 151-160, Aug. 2007.
[12] European Commission, *The European Qualifications Framework for Lifelong Learning (EQF).* Office for Official Publications of the European Communities, pp. 1-20, 2008.
[13] R. Koper and M. Specht, "Ten-Competence: Lifelong Competence Development and Learning," Idea Group Inc, pp. 230-247, 2007.
[14] E.A. Davis and N. Miyake, "Explorations of Scaffolding in Complex Classroom Systems," *J. Learning Sciences,* vol. 13, no. 3, pp. 265-272, 2004.
[15] B. Florian-Gaviria, S.M. Baldiris, and R. Fabregat, "Adaptive Evaluation Based on Competencies," *Proc. Workshop Modeling and Evaluation of Accessible Intelligent Learning Systems (AIED '09),* vol. 495, pp. 54-63, 2009.
[16] B. Florian-Gaviria, S.M. Baldiris, and R. Fabregat, "A New Competency-Based E-Assessment Data Model," *Proc. IEEE Education Eng. Conf. (EDUCON '10),* pp. 473-480, 2010.
[17] B. Simon and P. Mirja, "ICOPER Reference Model Specification Draft," http://www.icoper.org/results/deliverables/D7-3a, 2010.
[18] I. Gutiérrez Rojas, R.M. Crespo, M. Totschnig, D. Leony, and C.D. Kloos, "Managing Assessment Resources in the Open ICOPER Content Space," *Collaborative Learning 2.0: Open Educational Resources,* A. Okada, T. Connolly, and P.J. Scott, eds., IGI Global, 2012.
[19] M. Petrov and A. Aleksieva-Petrova, "Developing a Software Tools for Nontraditional Methods of Assessment," *Proc. Int'l Scientific Conf. (CS '08),* pp. 490-495, 2008.
[20] B. Florian-Gaviria, S.M. Baldiris, R. Fabregat, and A. De la Hoz-Manotas, "A Set of Software Tools to Build an Author Assessment Package on Moodle: Implementing the AEEA Proposal," *Proc. IEEE 10th Int'l Conf. Advanced Learning Technologies,* 2010.
[21] C. Glahn, M. Specht, and R. Koper, "Smart Indicators on Learning Interactions," *Creating New Learning Experiences on a Global Scale,* E. Duval, R. Klamma, and M. Wolpers, eds., pp. 56-70, Springer, 2007.
[22] S. Govaerts, K. Verbert, and E. Duval, "Evaluating the Student Activity Meter: Two Case Studies," *Proc. Advances in Web-Based Learning Conf. (ICWL '11),* pp. 188-197, 2011.
[23] H. Drachsler and W. Greller, "Confidence in Learning Analytics," *Proc. Second Int'l Conf. Learning Analytics and Knowledge (LAK '12),* May 2012.
[24] R. Ferguson, "The State of Learning Analytics in 2012: A Review and Future Challenges a Review and Future Challenges," Technical Report KMI-12-01, Knowledge Media Institute, The Open Univ., 2012.

[25] F. Bakalov, B. König-Ries, T. Hennig, and G. Schade, "Usability Study of a Semantic User Model Visualization for Social Networks," *Proc. Workshop Visual Interfaces to the Social and Semantic Web (VISSW '11),* 2011.
[26] I. Hsiao, F. Bakalov, P. Brusilovsky, and B. König-ries, "Open Social Student Modeling: Visualizing Student Models with Parallel Introspective Views," *User Modeling, Adaptation and Personalization,* vol. 6787, pp. 171-182, 2011.
[27] B. Florian-Gaviria, C. Glahn, H. Drachsler, M. Specht, and R. Fabregat, "Activity-Based Learner-Models for Learner Monitoring and Recommendations in Moodle," *Towards Ubiquitous Learning,* C. Kloos, D. Gillet, R. Crespo García, F. Wild, and M. Wolpers, eds., pp. 111-124, Springer, 2011.
[28] S.B. Shum and R. Ferguson, "Social Learning Analytics," Technical Report KMI-11-01, The Open University, 2011.
[29] Y. Engeström, "Expansive Visibilization of Work: An Activity-Theoretical Perspective," *Computer Supported Cooperative Work,* vol. 8, no. 1, pp. 63-93, 1999.
[30] P. Dillenbourg and P. Tchounikinew, "Flexibility in Macro-Scripts for Computer-Supported Collaborative Learning," *J. Computer Assisted Learning,* vol. 23, pp. 1-13, 2007.
[31] C.M. Reigeluth, "Instructional Design: What Is It and Why Is It?" *Instructional-Design Theories and Models: An Overview of Their Current Status,* vol. 1, pp. 3-36, Reigeluth, 1983.
[32] P. Dillenbourg, "Integrating Technologies into Educational Ecosystems," *Distance Education,* vol. 29, no. 2, pp. 127-140, 2008.
[33] C. Glahn, M. Specht, and R. Koper, "Visualisation of Interaction Footprints for Engagement in Online Communities," *Educational Technology and Soc.,* vol. 12, no. 3, pp. 44-57, 2009.
[34] A. Zimmermann, M. Specht, and A. Lorenz, "Personalization and Context Management," *User Modeling and User-Adapted Interaction,* vol. 15, nos. 3-4, pp. 275-302, Aug. 2005.
[35] ACM, "What Is ACM?" http://www.acm.org/about/class/1998, 1998.

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