RUBRICS TEMPLATES FOR PERSONAL COMPETENCES' SELF-ASSESSMENT OF MASTER OF SCIENCE IN SOFTWARE ENGINEERING PROGRAMME GRADUATES

Juan M. Carrillo de Gea[1], Begoña Moros[1], Joaquín Nicolás[1], José L. Fernández-Alemán[1], José A. García-Berná[1], José A. Sánchez[2], Ambrosio Toval[1]

[1] Department of Informatics and Systems, University of Murcia, Murcia
{jmcdg1, bmoros, jnr, aleman, josealberto.garcia1, atoval}@um.es
[2] Department of Informatics, University of Oviedo, Gijón
sanchezsjose@uniovi.es
Spain

Abstract: There is an increasing interest in the evaluation of academic, and especially, professional competences related to software engineering and technology. In particular, providing graduates that are willing to pursue postgraduate studies with a mechanism for self-assessment would be useful. In this work, rubric templates were used for this purpose and implemented in a web portal. This system was developed in order to provide the competence assessment functionality through the Internet. The proposal was validated in the context of an Erasmus+ project run by six European universities.

Key words: e-Competence Framework (e-CF), rubrics, software engineering education.

1. INTRODUCTION

Collaboration among universities allows students to participate in international learning projects such as the European Erasmus+ programme. This is a great chance for them not only to extend their academic knowledge, but also to integrate in a different culture and to obtain experience moving abroad. These opportunities arise thanks for the agreements reached between the European Commission and the participating Universities.

The establishment of bilateral agreements among the universities are the basis for the recognition of the study subject competences achievement when students return to their home university. In this sense, evaluation methods must be as much accurate as possible in the destination university, so that students can justify the

same knowledge gained as if they were at their home university. In a more general scenario, an adequate procedure should be available for the students to justify the competences that they have already acquired. For this purpose, rubrics used as scoring guides for specific expectations, or critical attributes to be assessed in the study subjects, are appropriated methods to rely on. In contrast rubrics are not frequently used in Computer Science education despite that are relative well understood for competence assessment [1]. Consequently, the generalization of the use of this evaluation instrument might lead to expose rubrics before the assessment, so that students reach an idea of what professors consider more important in their subjects [2].

Several methods have been proposed so far to measure competences acquired by the learners based on rubrics. Cable [3] undertook an assessment related to the detection of the major trait expected in students' work in an object-oriented programming course. For the assessment, primary traits with a scoring rubric guide for each trait is included. Another example is Estell [4], who proposed a web-based interactive programming portfolio methodology to access both an evaluation form and detailed rubrics for the evaluation of the portfolio. Moskal, Miller and King [5] used a scoring rubric to grade and track students' knowledge development as they progress through the course. Trivedi, Kar and Patterson-McNeill [6] showed a web-based system to manage peer evaluation guided with rubrics for programming appraisal.

The *Implementation of Software Engineering Competence Remote Evaluation for Master Program Graduates* (iSECRET) project is an Erasmus+ programme run by six partner universities in Europe [7]. It offered a framework for researching the problem of academic and professional software engineering/software technology knowledge representation for master programme graduate's competence testing purposes. One of the major tasks performed in the context of the iSECRET project was the definition of rubric templates for personal competences' self-assessment of graduates that are interested in enrolling in a postgraduate study programme. In this paper, the iSECRET approach for defining, using and populating these rubrics is presented.

In this study the competences were divided into academic and professional for subjects' assessment process. Based on the European e-Competence Framework (e-CF) [8], professional competences were classified depending on the first dimension proposed in this framework. In relation with the business process, the competences are categorised in 5 areas, which are *plan*, labelled with letter A; *build*, labelled with B; *run*, labelled with C; *enable*, labelled with D and *manage*, labelled with E. Another division was done following the 40 e-competences identified in the second dimension.

The rest of this paper is organised as follows: Section 2 introduces our proposal for rubrics templates for personal competences' self-assessment. Section 3

presents the application of this approach in the context of a European research project. Finally, Section 4 shows our conclusions and further work.

2. PERSONAL COMPETENCES' SELF-ASSESSMENT

A rubric is an easily applicable form of authentic assessment. Developed rubric templates give clear guidelines on how to evaluate or grade *knowledge*, *skills* and *attitudes/proficiency levels*. Each rubric template contains the following items:

1. One or more dimensions that serve as the basis for judging the student response.
2. Definitions and examples to clarify the meaning of each dimension.
3. A scale of values on which to rate each dimension.
4. Standards of excellence for specified performance levels accompanied by models or examples of each level.

The rubrics proposed in this paper were created as follows: (i) firstly, the structure of a rubrics template for personal competences' self-assessment was proposed based on previous research [9], and accepted by the iSECRET project partners; (ii) secondly, starting from this template structure, the project partners developed rubric templates for their subjects; and (iii) finally, after that, those templates were populated with descriptions of expected learning outcomes, specifically adapted to knowledge, skills and attitudes/proficiency levels.

An example of a rubric table is provided in Table 1, which includes the most important elements for competence evaluation, adopted as our base template.

Table 1. Example of rubric table

Level / Score	**Beginning 1**	**Developing 2**	**Accomplished 3**	**Exemplary 4**	**Score Evaluation**	**Weight**
Knowledge 1	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		
Knowledge 2	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		

…						
Skill 1	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		
Skill 2	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		
…						
Attitude / Proficiency 1	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		
Attitude / Proficiency 2	[Description reflecting beginning level of performance]	[Description reflecting movement toward mastery level of performance]	[Description reflecting achievement of mastery level of performance]	[Description reflecting highest level of performance]		
…						
				TOTAL SCORE:		**1**

The process for developing the rubric templates used in the iSECRET project is made of the following activities:

1. For each competence (academic or professional, e-CF) a separated competence scoring rubric is created. Each competence rubric must be assigned a unique competence identifier.
2. In each competence rubric there are three parts: knowledge, skills and attitude/proficiency level, containing several items (see Fig. 1).
3. Each competence element may be scored from 1 to 4 (i.e. beginning - 1, developing - 2, accomplishing - 3, exemplary - 4). Fig. 2 shows more information on this regard.
4. Total competence score calculation is performed using weights from 0 to 1 (e.g. for academic competence: part knowledge - 0.5, part skills - 0.3 and part attitude/proficiency level - 0.2; or for professional, e-CF competence: part knowledge - 0.3, part skills - 0.4 and part attitude/proficiency level - 0.3).

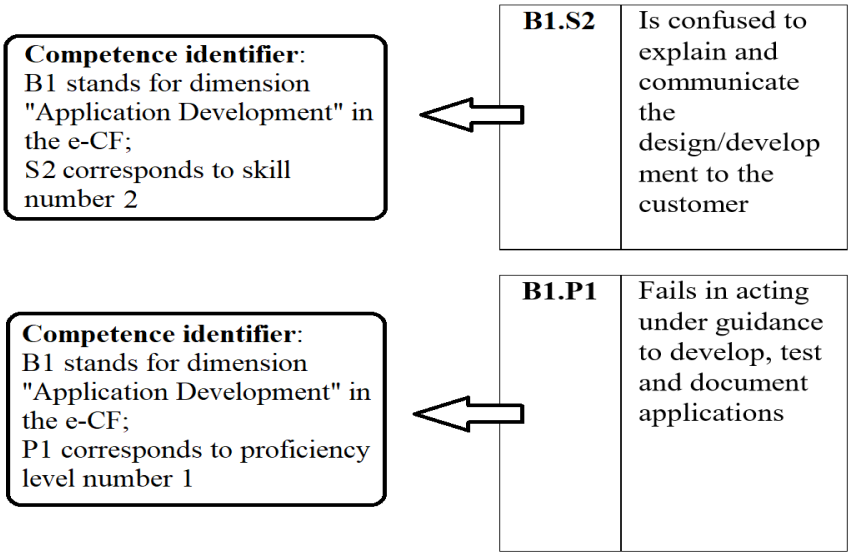

Fig. 1. The rows in the rubric represent the competence's knowledge, skills and attitude/proficiency levels, and they are assigned unique codes to identify them

The instructor should highlight key phrases in the rubric that describe the student's performance, and then they should write a final score in the score evaluation column. Highlights might appear in more than one column. The teacher may also choose to "decimalise" scores; for example, giving a 2.5 in one row to indicate that the student is progressing toward a 3.

The computation of the score evaluation is done as follows:

$$Total\ score = \sum_{k=1}^{K} e(k) \times w(k) + \sum_{s=1}^{S} e(s) \times w(s) + \sum_{a=1}^{A} e(a) \times w(a) \quad (1)$$

As shown in (1), the total competence score is obtained multiplying the score evaluation obtained in each knowledge, skill and attitude/proficiency level by each weight defined in the rubric.

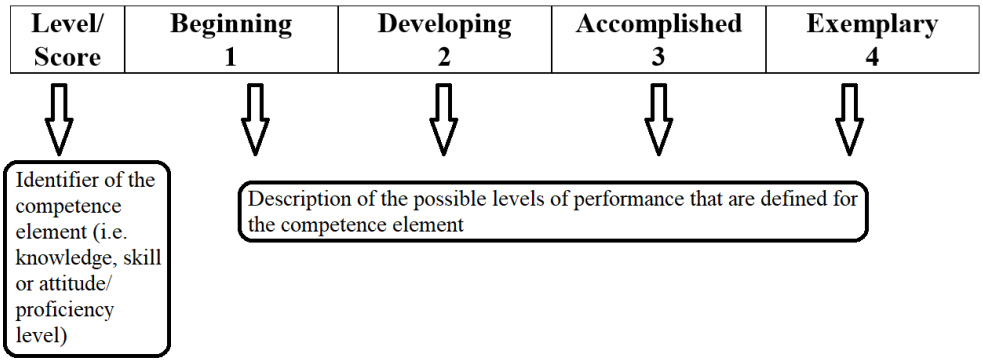

Fig. 2. Proposed scale for knowledge, skills and attitude/proficiency levels scoring

Table 2 shows the rubric that corresponds with the professional competence B.1 from the e-CF, which is included in the subject Sp03 "Requirements Engineering".

Table 2. Subject "Sp03. Requirements Engineering". Competence Scoring Rubric for the competence "B.1. Application Development"

Level/ Score	Beginning 1	Developing 2	Accomplished 3	Exemplary 4	Score Eval.	Weight
Knowledge						
B1.K3	Student cannot answer questions about functional and technical designing	Student is uncomfortable with functional and technical designing, and is able to answer only rudimentary questions	Student is at ease with functional and technical designing, but fails to elaborate	Student demonstrates full knowledge on functional and technical designing with explanations and elaboration	***3***	0.1

B1. K12	Student cannot answer questions about modelling technology and languages	Student is uncomfortable with modelling technology and languages, and is able to answer only rudimentary questions	Student is at ease with modelling technology and languages, but fails to elaborate	Student demonstrates full knowledge on modelling technology and languages with explanations and elaboration	***2***	0.1
Skills						
B1.S1	Is confused to explain and communicate the design/development to the customer	Uses personal opinion to explain and communicate the design/development to the customer	Uses a limited range of criteria to explain and communicate the design/development to the customer	Uses multiple criteria to explain and communicate the design/development to the customer	***4***	0.1
B1.S2	Is confused to perform and evaluate test results against product specifications	Uses personal opinion to perform and evaluate test results against product specifications	Uses a limited range of criteria to perform and evaluate test results against product specifications	Uses multiple criteria to perform and evaluate test results against product specifications	***3***	0.1
B1.S5	Is confused to manage and guarantee high levels of cohesion and quality	Uses personal opinion to manage and guarantee high levels of cohesion and quality	Uses a limited range of criteria to manage and guarantee high levels of cohesion and quality	Uses multiple criteria to manage and guarantee high levels of cohesion and quality	***2***	0.1
B1.S6	Is confused to use data models	Uses personal opinion to use data models	Uses a limited range of criteria to use data models	Uses multiple criteria to use data models	***3***	0.1
B1.S8	Is confused to cooperate with development team and with application designers	Uses personal opinion to cooperate with development team and with application designers	Uses a limited range of criteria to cooperate with development team and with application designers	Uses multiple criteria to cooperate with development team and with application designers	***2***	0.1

Attitudes (Proficiency level)						
B1.P1	Fails in acting under guidance to develop, test and document applications	Relates with limited proficiency how to act under guidance to develop, test and document applications	Accurately relates how to act under guidance to develop, test and document applications	Provides a complete and accurate leadership for acting under guidance to develop, test and document applications	***4***	0.1
B1.P2	Fails in systematically developing and validating applications	Relates with limited proficiency how to systematically develop and validate applications	Accurately relates how to systematically develop and validate applications	Provides a complete and accurate leadership for systematically developing and validating applications	***3***	0.1
B1.P3	Fails in acting creatively to develop applications and to select appropriate technical options. Accounts for others development activities. Optimizes application development, maintenance and performance by employing design patterns and by reusing proved solutions	Relates with limited proficiency how to act creatively to develop applications and to select appropriate technical options. Accounts for others development activities. Optimizes application development, maintenance and performance by employing design patterns and by reusing proved solutions	Accurately relates how to act creatively to develop applications and to select appropriate technical options. Accounts for others development activities. Optimizes application development, maintenance and performance by employing design patterns and by reusing proved solutions	Provides a complete and accurate leadership for acting creatively to develop applications and to select appropriate technical options. Accounts for others development activities. Optimizes application development, maintenance and performance by employing design patterns and by reusing proved solutions	***3***	0.1

In the previous table, the competence scoring rubric indicates that each knowledge, skill and attitude/proficiency level has a weight of 0.1. It is important to note that the weights are chosen by the instructor according to their own criteria. Also, the score evaluation in this example is shown in column "Score evaluation". It represents the specific level reached by the student.

$$\begin{aligned} Total\ score = {} & 3\times 0.1+2\times 0.1+4\times 0.1+3\times 0.1+2\times 0.1+ \\ & 3\times 0.1+2\times 0.1+4\times 0.1+3\times 0.1+3\times 0.1=2.9 \end{aligned} \quad (2)$$

As presented in (2), the total competence evaluation is 2.9, which is a value between Developing - 2 and Accomplished - 3.

3. VALIDATION OF THE PROPOSAL

In the context of the iSECRET project, a one-year (60 ECTS) joint master programme in modern software engineering and technology was proposed, and their subjects were designed. This includes the syllabi of these subjects and in particular, the detailed description of rubrics for the self-assessment of personal, academic and professional (i.e. based on the e-CF) competences of Master of Science in software engineering programme graduates. This definition was done in accordance with the details provided in Section 2. Therefore, the different partners of the iSECRET project defined in an independent but coordinated fashion their subjects as part of the master programme.

As a validation activity, partner universities prepared the rubrics of two major subjects and two specialisation subjects. For each of these subjects, partner universities developed the rubrics of, at least, one academic and one professional competence. As a result, the project partners created a total of 44 rubrics. Moreover, the developed rubrics were implemented in the Software Engineering Competence Evaluation Internet Portal (SECEIP). This system, which has been developed in the context of the iSECRET project, helps self-evaluate master programmes' graduates and master students by performing on-line testing assignments.

5. CONCLUSION

This paper includes a proposal for the definition and use of rubrics for remote testing of software/technology-related competences in the context of an Erasmus+ programme project. According to our experience in the iSECRET project, rubric templates were in general an appropriate strategy to assess competences. As pros and cons, the use of rubrics helps in the evaluation of the students' knowledge,

skills and attitudes/proficiency levels. They are easy to use, flexible and powerful instruments. On the other hand, they imply a higher workload for the teacher in order to formalise the correspondence between competence levels and outcome from the students.

As further work, automatic evaluation by means of quizzes inserted in SECEIP should be implemented. Currently, this assessment is done manually, since the quizzes and the rubrics are not linked in the system.

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Information about the authors:

Juan M. Carrillo de Gea – He is a Research Associate and Adjunct Professor at the University of Murcia, Spain. His current research interests include requirements engineering, requirements reuse, global software development and empirical software engineering. He is also involved in other research lines, principally e-health and e-learning.

Begoña Moros – She is a Lecturer at the Department of Computer Science, University of Murcia (Spain). She has a background in model driven engineering, requirements models and requirements traceability. Her current research interests include green computing, in particular how to foster sustainable software development by means of green requirements specifications and processes.

Joaquín Nicolás – Dr. Joaquín Nicolás Ros is an Associate Professor in the Department of Computer Science and Systems at the University of Murcia, Spain. He received B.Sc. and Ph.D. degrees in Computer Science. Currently, his main research interest is in requirements engineering, concerning reuse-based requirements engineering, global software development, education, usability and sustainable processes. Contact him at jnr@um.es.

José L. Fernández-Alemán – He is an associate professor at the University of Murcia, where he is a member of the Software Engineering Research Group. He received his BSc (Hons) degree in 1994 and his PhD degree in 2002, both in Computer Science from the University of Murcia.

José Alberto García Berna – He is a PhD student at the Department of Computer Science and Systems of the University of Murcia. His research interests are Requirements Engineering and Project Management, specifically Green Software Engineering and Sustainability in Information and Communication Technologies.

José A. Sánchez – He is a Computer Science Engineer and MSc on New Technologies in Computer Science from the University of Murcia (Spain). Currently he is a PhD student at the University of Oviedo (Spain) developing his PhD thesis in Vehicular Networks in Smart Cities. His main research areas of interest are related to Vehicular Networks, Intelligent Transportation Systems and Telematics Environments.

Ambrosio Toval – He is a full professor at the University of Murcia, in Spain. He holds a BS in Mathematics from the University Complutense of Madrid, and received a Ph.D. in

Computer Science (cum laude) from the Technical University of Valencia (both in Spain). He is involved in a variety of applied research and development projects with industry and conducts research and technology transfer in the areas of requirements engineering processes and tools, privacy and security requirements and applications in the e-health, e-learning and mobile development domains. He has published in the same topics in international journals, such as IEEE Software, IST, REJ, Computer Standards & Interfaces, IET, IJIS, etc. Dr. Toval is currently the Head of the Software Engineering Research Group, at the University of Murcia. He can be contacted at the Faculty of Computer Science, Campus de Espinardo 30071, University of Murcia, Murcia, Spain; atoval@um.es.

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