Developing Undergraduate IT Students' Generic Competencies Through Problem-Based Learning

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Abstract **– Possession of generic competences is recognized as a very important characteristic of future professionals in the field of information and communication technologies (ICT). There is a high pressure on higher education institutions (HEIs) to provide students with both technical knowledge and generic competencies. This study introduces a learning environment set in line with the principles of problem-based learning (PBL) aimed at raising students' generic competences. Based on responses from 227 students, the results suggest that students perceive the set learning environment contributing to the development of a wide range of generic competences.**

Keywords **– Problem-based learning; students' generic competences; IT service management.**

1. Introduction

The future education and employment of young people appears to be a significant topic in today's society, which is being enhanced by rapid technological development and consequently by economic and societal changes. Special pressure is put on the education and employment of future professionals in the field of information and communication technologies (ICT), since the ICT sector is directly responsible for 5% of Europe's GDP but contributes far more to the productivity of almost all other sectors, furthermore plays significant role in changing citizens life style and well-being of society in general [1]. Its importance is evident from current predictions about future trends in ICT professional jobs and demand in Europe from 2012 to 2020, where three different scenarios indicate that demand potential will exceed predictions about the number of ICT graduates [2]. As with the growing demand for the professionals in the ICT sector, the demand for various skills by ICT graduates has undergone big changes.

Although general consensus on expectations regarding different skill combinations acquired by ICT professionals exists, there is little consensus on which skills these may be, since there is no universally accepted classification of ICT skills nor consensus about the most important skills. This mostly depends on the job position and associated tasks and work assignments by particular job positions. To fulfil the needs of the 21st-century job market, students' generic and transferable skills such as problem-solving, creativity, teamwork, critical thinking etc., are desired. Therefore, ICT studies' curricula should provide students with both technical and non-technical skills.

With the identified need for different sets of competencies expected from graduates' entering the labour market, the pressure is also on educational institutions to provide programs contributing to the development of those competencies. Among others teaching methods, the literature stresses on PBL as the turning point from traditional educational approaches to innovative ones which encourage lifelong, collaborative, student-centred, and self-regulated learning [3] that, as such, contributes to the development of the necessary skills for the future workplace.

The aim of this paper is to provide a description of the implementation of PBL elements into an IT service management undergraduate course in such a way that it contributes to the development and/or evolution of students' generic skills. The specific research goal is to determine which generic competences are, according to the students'

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perception, developed to a larger extent using this approach.

This paper first provides a theoretical background related to PBL and generic competences. Afterwards, it describes the implementation of IT service management course in line with PBL principles and provides analysis of the development of generic competences in this course. Finally, the paper ends with a discussion of research results.

2. Generic competences and problem-based learning (PBL)

Generic competences have been given a lot of attention in the latest decade, both in research and practice. Special attention has been given to generic competences in the European Higher Education Area (EHEA), starting from 2000th important initiatives in higher education, namely the Bologna Process and Lisbon strategy. One comprehensive project, TUNING Educational Structures in Europe, recognizes the importance of fostering the development of both professional and generic competences as an objective of educational programs [4]. It defines competences as *"a dynamic combination of cognitive and metacognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values"* and distinguishes three types of competences: instrumental, interpersonal, and systemic. TUNING proposes a list of 31 generic competences applicable to any educational programme. Young and Chapman [5] provided a historical overview of generic competences and propose a more comprehensive list of 58 generic competences and clustered them as basic, conceptual, personal, people, business, and other skills. Based on this framework, Strijbos [6] conducted a review of generic competences and summarized them in a cluster of people, personal, and conceptual skills. For the purpose of this research, 17 most relevant competencies for students in the ICT study domain were extracted, as listed in Appendix.

PBL can be described as a student-centred instructional approach that focuses on complex real-world problems which are more appropriate for teamwork than for individual work, in order to facilitate the development of students' critical thinking and problem-solving abilities, and on absorbing fundamental concepts for different study domains [7] [8] [9] [10]. In a learning environment organized according to PBL principles, students are faced with several different activities such as planning, communicating their ideas, gathering information, implementing and evaluating projects that have real-world applications, and thus have an opportunity to develop a variety of different generic and transferable skills. From students' point of view, PBL contributes to improvements in terms of learning gains, motivation, enjoyment, involvement, team work quality, and overall satisfaction, but increases the study time and effort compared to traditional learning [10].

3. IT service management course description

A PBL approach was used to organize an IT service management course for educating future ICT professionals, with the aim of contributing to the development of desired generic competences from future employers. Some results of student satisfaction and work performance were presented in the previous work of authors [11], [12]. The course *IT service management* was performed at the University of Zagreb, Faculty of Organization and Informatics, in the third year of undergraduate study. The main goal of course is to introduce students to all aspects of IT service development, where issues like resource management, time management, financial planning, market analysis, design (visual and functional) of new service, communication with potential clients and teamwork are also included. Owing to the requirements of a good PBL problem, the structure of the course was modified to introduce problems that will 1) raise students' interest and motivate them; 2) introduce students to basic principles or information and require them to make decisions; 3) require cooperation from all members of students' team owing to its complexity; 4) include all team members into the discussion, and 5) connect previous knowledge to new concepts and consequently link new gained knowledge and skills to concepts in other (future) courses [7]. The course with included PBL elements was first introduced in the academic year 2013–2014 as a pilot [12], and then improved in the academic year 2014–2015 with a stronger focus on PBL elements. The course was performed over 17 weeks, with 14 laboratory exercises and 14 lectures held (three weeks were reserved for knowledge tests). During the lectures, students were introduced to basic principles and information regarding certain phases of IT service development, as well as various best practices, development methods, and connected concepts. On the other hand, the main idea of organizing course exercises was to put students in a very similar situation to the one experienced in the actual professional world in order to enhance their generic competences in finding appropriate solutions to identified problems. Therefore, at the beginning of the semester, groups of students (four students) were formed, and each group represented a small IT company ('virtual company'). Each 'virtual company' was in the phase of placing a new IT service on the market, where a new service was presented as an original and creative solution of an identified real-world problem, in the form of a web or mobile application.

Course exercises were organized in two phases. In the first phase, virtual companies were preparing the presentation of their ideas in the form of wireframes and blueprints, which they used for demonstrating functionality and planned performance of new IT services to the potential client. At the beginning, virtual companies were obligated to prepare their service catalogue and define the mission, vision, and goals of the company. The next step was to define and describe the target group of the new IT services that the company was introducing to the market. Consequently, it was necessary to conduct market analysis and risk analyses (SWOT). Based on the results of the analysis, companies chose their competitive strategy. At the end of the first phase of the course exercises, a business meeting was held where each virtual company presented its new IT service to the potential client (course lecturers) and tried to secure future cooperation in order to deliver the final service to the client. Potential clients were invited to the business meeting with a formal invitation letter send by a virtual company, which provided information on the purpose, date, and planned duration of the meeting. During the meeting, the client asked questions about the service and/or presented situation(s) where he could use the demonstrated service. Consequently, potential partners negotiated on service requirements and modifications. Based on their critical thinking and group/team consensus, students in virtual companies decided which requirements can be met and fulfilled and which could not.

The second part of the course exercises was based on the results of the negotiation process held during the business meeting. All arrangements agreed between partners were supposed to be delivered at the end of second exercise phase (end of semester) by students' virtual companies in the form of an IT service prototype. After the meeting, all agreed issues were documented in business records, bill of quantities, and Service Level Agreements. Virtual companies were introduced with various tools for prototype development and they were invited to try, evaluate, and choose tools that met their preferences and needs (or type of service, e.g., mobile or web application). Prototype creation encompasses storytelling preparation, application visual standard creation, and prototype testing. Besides the prototype development, the second phase of course exercises introduced issues regarding recruiting a new person in the team. Each virtual company was obligated to prepare an analysis of current resources (personnel) and define the job profile for the new person that they wanted to employ. Based on the received applications and motivation letters from other students in the course, virtual companies performed an evaluation and made decisions about a new team member. At the end of the semester, all students were invited to evaluate their own work (self-assessment) and the work of their colleagues (peer-assessment) for the final prototype presentation. Finally, at the end of the second part of the course exercise, the second business meeting was performed, which included the presentation of final IT products to the business partner.

According to [13], a good PBL problem has the following characteristics: 1) the problem should be unclear, and the information needed to solve it should be incomplete; 2) there should be more than one way to solve the problem; 3) the problem should not have a single right answer. As students were proposing potential problems from the real-world environment on their own, with teacher only as a moderator in that process, all of the proposed problems met the abovementioned characteristics of good PBL problem. At the beginning of the course, neither students nor teachers knew how the final solution for the proposed problem should look like. To successfully complete all the tasks set in front of them, students attended obligatory classes each week where they were presented short guidelines and examples on a certain topic scheduled for that week. Teacher's role during the exercises was as a supervisor and moderator, so he/she discussed with students all their dilemmas but also monitored their work. Each week, newly introduced task presented a continuation of the previous tasks so students were expected to work continuously to be able to fulfil all the course requirements on time.

4. Research method

An exploratory study with students at the University of Zagreb, Faculty of Organization and Informatics who attended the undergraduate course *IT service management* in the academic years 2013–2014 and 2014–2015 was conducted. At the end of the course, students were provided with a list of generic competences that were incorporated into the course (see in Appendix) and they were asked to rate on a 5-point Likert-type scale (1 [strongly disagree] to 5 [strongly agree]) their feelings regarding developing a certain competence after course completion. Participation in the study was not made obligatory for students in order to ensure that the answers are received only from those students that were motivated to participate in the study. In the academic year 2013–2014, 104 responses were obtained from 140 students attending the laboratory exercises, with a response rate of 74.2 %. The core sample consisted of 78 male (75%) and 26 female students (25%). In 2014–2015, altogether 123 students filled the questionnaire at the end of the semester, out of 140 students attending laboratory exercises, indicating a response rate of 87.85%. A total of 107 (87%) of them were male and

16 (13%) were female. For the purpose of analysis, the 2014 and 2015 dataset were observed as one, so that the total number of respondents is 227, out of which 185 (81.5%) are males and 42 (18.5%) females.

For the purpose of this research, a shortened TUNING list of generic competences was used, since they are applicable to different educational programs and are updated according to the relevant trends in EHEA [4]. The list contains 31 generic competences, also called transferable skills that are becoming more and more relevant for preparing students for their future role in society in terms of employability and citizenship. Not all the generic competences from the abovementioned lists were obtained during the course. Therefore, the initial list of competences was revised in accordance with a review of competences important for the education of future ICT professionals and the authors' experience in that field, and in line with the proposed course organization. Appendix provides a list of 17 generic competences included in the analysis.

Table 1. demonstrates the coefficients of Pearson's correlation results. Correlation results among the 17 generic competences show that all competences were positively correlated, but without very strong correlations. All Pearson's correlation coefficients are above 0.293, and the highest are 0.603 (GC13 and GC14) and 0.623 (GC14 and GC15).

Table 1. Correlation matrix of generic competences

	GC 1	GC 2	GC 3	GC 4	GC 5	GC 6	GC 7	GC 8	GC 9	GC 10	GC 11	GC 12	GC 13	GC 14	GC 15	GC 16	GC 17
GC1	1																
GC2	0.45	1															
GC3	0.56	0.39	1														
GC4	0.35	0.41	0.27	1													
GC5	0.41	0.43	0.35	0.55	1												
GC6	0.40	0.44	0.35	0.47	0.57	1											
GC7	0.31	0.41	0.33	0.39	0.39	0.53	1										
GC8	0.47	0.37	0.33	0.38	0.41	0.48	0.45	1									
GC9	0.33	0.33	0.33	0.30	0.38	0.45	0.35	0.51	1								
GC10	0.38	0.37	0.39	0.34	0.44	0.49	0.42	0.51	0.46	1							
GC11	0.37	0.44	0.39	0.35	0.34	0.42	0.40	0.46	0.37	0.37	1						
GC12	0.31	0.42	0.32	0.44	0.44	0.39	0.44	0.39	0.29	0.34	0.54	1					
GC13	0.44	0.39	0.33	0.36	0.34	0.44	0.43	0.44	0.31	0.35	0.46	0.54	1				
GC14	0.45	0.39	0.41	0.37	0.43	0.46	0.33	0.44	0.46	0.44	0.49	0.49	0.60	1			
GC15	0.36	0.32	0.41	0.34	0.47	0.36	0.42	0.43	0.41	0.38	0.43	0.54	0.47	0.62	1		
GC16	0.55	0.46	0.46	0.40	0.46	0.45	0.42	0.51	0.44	0.45	0.42	0.48	0.50	0.56	0.54	1	
GC17	0.44	0.53	0.46	0.34	0.42	0.45	0.48	0.44	0.41	0.40	0.51	0.46	0.54	0.54	0.53	0.56	1

Although in general all the generic competences are found to be developed during the course on a large scale (see Appendix), the authors' intention was to determine if there were different factors underlying a set of generic competence items. Therefore, an exploratory factor analysis was conducted. The ratio of sample size (N=227) to the number of generic competence items (13:1) was above the minimum ratio (10:1) suggested for factor analysis [14]. To check the adequacy of the dataset to conduct a factor analysis, following analyses were performed: 1) Kaiser-Meyer-Olkin's sampling adequacy criteria of 0.935 shows that there are a significant number of factors in the dataset, and an MSA (individual measures of sampling adequacy for each item) of each factor above 0.9 indicates that all items belong to a group and should be included in factor analysis; and 2) Bartlett's test of sphericity showed that P-value was less than 0.001, which also suggest that factor analysis is worth pursuing. The perceived overall development of generic skills expressed as an average of 17 variables was used as a criterion scale for assessing the correlation of items with the criterion. Item-total correlations and correlation with the criterion measures above >0.6 indicates a good validity of scale, while the Cronbach's alpha coefficient of 0.925 indicates a good reliability of this 17-items scale.

To determine the number of factors to be described, which is not a single-solution process, the scree test and eigenvalue rule were used. Examining the scree plots of data or correlation matrix compared to random 'parallel' matrices suggested four factors, while a more strict Kaiser's rule using eigenvalues suggested only two factors. Since there is no ideal solution, the results of factor analysis with different number of factors were compared and the solution with four factors, as suggested by the scree test, seemed to be the most appropriate, using the principal component analysis as the extraction technique and varimax rotation. The solution with four factors was improved in comparison with solutions with fewer factors, while solutions with more factors resulted in factors that are explained with only one or two items.

Table 2. Items loadings on four factors

	Factor1	Factor2	Factor3	Factor4
GC1				0.93
GC2		0.45		
GC3				0.44
GC4		0.61		
GC5		0.59		
GC6		0.58		
GC7		0.48		
GC8			0.49	
GC9			0.63	
GC10			0.52	
GC11	0.51			
GC12	0.64			
GC13	0.61			
GC14	0.64			
GC15	0.64			
GC16	0.49			
GC17	0.56			

The reliability of scales can be determined by using Cronbach's alpha coefficient for internal consistency. Cronbach's alpha coefficient of all four extracted factors, as shown in Table 3., is greater than 0.7 and can be considered as acceptable. Except a good value of Cronbach alpha, the solution with four factors improves the distinction between factors, taking into account the following principles: 1) there are no loadings greater than 0.41 on two or more factors for any of the variables and 2) there are no loadings of less than 0.45 on all scale factors. Table 2. brings the items loadings on four factors, while Table 3. shows a detailed description of the factors. A detailed examination of the content of four extracted factors provides an overview of different groups of competences to be developed during the course, organized according to PBL principles. A Venn diagram in Fig. 1. shows an approximation of the size of each factors, while cross-sections shows their interconnection based on the correlations between factors (Table 4).

Table 3. Description of four factors

	Factor description	**Number of items**	**Proportion var**	**Cumulative var**	**Cronbach's alpha**
Factor1	Interaction skills	7	0.184	0.184	0.878
Factor2	Personal skills	5	0.141	0.326	0.807
Factor3	Problem-solving and creativity skills	3	0.112	0.438	0.736
Factor4	Knowledge skills	2	0.099	0.537	0.713

Table 4. Correlation between factors

	Factor1	Factor2	Factor3	Factor4
Factor1	1			
Factor2	0.707	1		
Factor3	0.690	0.769	1	
Factor4	0.602	0.541	0.54	1

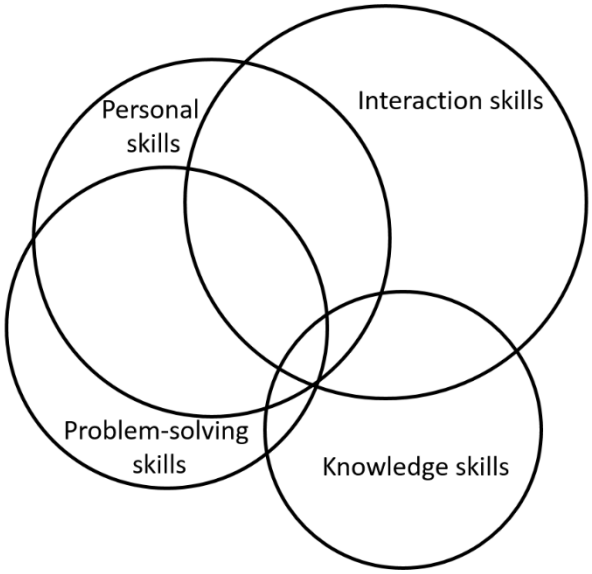

Figure 1. Venn diagram representation of interconnections between generic skills

5. Results and discussion

Factor 1 consists of seven generic skills that are all mostly connected with teamwork and include interaction with other persons (Ability to work in a team; Interpersonal and interaction skills; Ability to motivate people and move toward common goals; Ability to design and manage projects; Spirit of enterprise, the ability to take initiative; Ability to evaluate and maintain the quality of work produced; Determination and perseverance in the tasks given and responsibilities taken). Factor 1 was labelled *Interaction skills.*

Five generic skills grouped in *Factor 2* reflect some personal characteristics and skills (Ability to plan and manage time; Ability to communicate both orally and through the written word in first language; Skills in the use of information and communications technologies; Ability to search for, process and analyse information from a variety of sources; Ability to be critical and self-critical). Factor 2 was labelled *Personal skills.*

The common characteristic of the three generic skills grouped in *Factor 3* is that they reflect high desirable skills for the 21st-century workplace related to new situations such as problem-solving and creativity (Ability to adapt to and act in new situations; Capacity to generate new ideas (creativity); Ability

to identify, pose and resolve problems). Factor 3 was labelled *Problem-solving and creativity skills*.

In *Factor 4*, there are only two factors related to knowledge and its application in practical situations (Ability to apply knowledge in practical situations; Knowledge and understanding of the subject area and understanding of the profession). Factor 4 was labelled *Knowledge skills*.

The results of this initial study indicate the positive impact of PBL on the development of students' generic competences, as perceived by students themselves. It is interesting to notice that the creativity (GC9) and teamwork (GC11) skills are assessed with the highest rates in both generations, while time management (GC2) skills are assessed with lowest rates. These findings support those from Davies et al. [15], suggesting that creativity is closely related to opportunities for working collaboratively in teams.

The results of exploratory factor analysis provide a structure of generic competences within four factors, namely, *Interaction skills*, *Personal skills*, *Problem-solving and creativity skills*, and *Knowledge skills*. Those factors are in line with the core IS knowledge/skills proposed by Lee et al. [16]: IS core knowledge (*Factor 4*), Organization and society interpersonal (*Factor 1*), and Personal traits (*Factor 2* and *Factor 3*). In this classification from 2002, creative and critical thinking were considered as personal factors, while our results were in line with some new trends, putting a special emphasis on skills related to problem-solving, connected with critical thinking and creativity [17], [18], [19]. In a review study of generic competences [6], creativity, problem solving and thinking skills were extracted as conceptual skills, together with clusters of people skills and personal skills, which are in line with *Factor 1* and *Factor 2*.

Contribution to the development of students' capacity to generate new ideas, connected with creative and innovative thinking, is very valuable since those skills are stressed as highly important, not only for the future employment of graduates [20], but also for the development of society as a whole in the future, when a lot of challenges, especially related to the technological development, may be faced. Therefore, it is reasonable to extract those skills from a set of other individual skills.

Findings from Lee et al. [16] suggest a change within IS educational programs so they contribute more to the development of students' generic skills. The results of this study indicate that organizing a course according to PBL principles is one possible way to reduce the recognized gap between IS academics and IS professionals. The importance of this finding lies in motivating other teachers to organize their classes, including PBL principles, in the education of future ICT professionals. Speaking from a wider perspective, some studies show the positive association of some generic skills in IT team members with the performance of organizational structures in companies responsible for managing and developing complex information systems [21]. Recently, most of the educational research and professional literature emphasize the need for new teaching methods which would enhance the development of both, professional and generic competences of students. Therefore, the PBL learning environment can be considered as a good preparation for the future success in a working environment.

6. Conclusion and future work

From the presented results and discussion it can be concluded that this study contributes to both the existing PBL research and practical need for generic competences among future IS professionals. Although numerous studies on PBL can be found in the literature, there is no evident focus on its contribution to the development of generic skills. On the other hand, in the literature on education and career development of future IT professionals, many researchers stress the need for development of students' generic skills within higher education courses, but rarely with explorations on how to implement it in practice. The results of this preliminary factor analysis of the development of generic skills within courses organized according to PBL principles indicated four different groups of generic skills that were developed*: Interaction skills, Personal skills, Problem-solving and creativity skills* and *Knowledge skills*. Therefore, the results contribute to the actual topic of enhancing graduates employability through the assessment of generic skills within higher education. As a practical implication of this research, description of how the development of certain generic skill was encouraged within the course implementation provides a good framework for practitioners willing to enhance their student generic skills development through the implementation of PBL activities in their courses.

Appendix

List of generic skills included in the analysis

Generic skill	2014 Mean	2014 Stdev	2015 Mean	2015 Stdev
GC1 [Ability to apply knowledge in practical situations]	3.538	0.812	3.593	0.904
GC2 [Ability to plan and manage time]	3.365	0.925	3.146	0.972
GC3 [Knowledge and understanding of the subject area and understanding of the profession]	3.423	0.720	3.415	0.905
GC4 [Ability to communicate both orally and through the written word in first language]	3.500	1.033	3.447	1.095
GC5 [Skills in the use of information and communications technologies]	3.433	0.922	3.488	1.074
GC6 [Ability to search for, process and analyze information from a variety of sources]	3.558	0.933	3.577	1.079
GC7 [Ability to be critical and self-critical]	3.404	0.971	3.577	1.064
GC8 [Ability to adapt to and act in new situations]	3.740	0.914	3.732	0.915
GC9 [Capacity to generate new ideas (creativity)	3.952	0.885	3.959	0.936
GC10 [Ability to identify, pose and resolve problems]	3.587	0.705	3.667	0.816
GC11 [Ability to work in a team]	4.154	0.932	3.919	1.121
GC12 [Interpersonal and interaction skills]	3.798	0.781	3.642	0.841
GC13 [Ability to motivate people and move toward common goals]	3.538	0.955	3.325	1.098
GC14 [Ability to design and manage projects]	3.625	0.850	3.626	1.051
GC15 [Spirit of enterprise, ability to take initiative]	3.615	0.978	3.561	1.065
GC16 [Ability to evaluate and maintain the quality of work produced]	3.510	0.881	3.504	0.881
GC17 [Determination and perseverance in the tasks given and responsibilities taken]	3.606	0.781	3.577	1.000

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