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6. Role playing and its effects on a first semester computer programming course

Abstract: This paper reports on our experience of introducing a group project combined with role-playing in a first semester university course, i.e., the Computer Programming Methodology course, offered in a non-computer engineering curriculum, where first year students used to have low participation in the final exams. Students selected their role among a) Coordinator, b) Analyst, c) Programmer, and d) Tester. The goal of our experiment was to increase engagement in the course among first year students. The main results showed the positive relationship between role playing and final exam participation. The analysis of the quality of the attributes of the pilot application gave us important information about what the students consider as desired or attractive quality characteristics, as a kind of valuable feedback for instructor, with an additional and quite unexpected attractive attribute regarding the enhancement of academic writing skills.

Keywords: *Role Playing, Project-Based Learning, Engineering Education, Programming courses*

1. Introduction

Computing courses are characterised by complexity and difficulty for many reasons (Byrne and Lyons, 2001). Many of the latter are attributed to the complexity of modern software complemented with the transition from individual programming to team-based software development. Moreover, the students' required effort to understand the theoretical concepts and their relations to user-requirements or the software applications that they use on a day-to-day basis (Stoilescu and Egodawatte, 2010), related to an academic course time-frame of 13 weeks being insufficient (Jenkins, 2002).

For all these reasons, a variety of educational techniques and methods are used in computer science courses, among them role-playing which is well-known for the active engagement of students during the teaching process. Role playing motivates and engages students in real world scenarios and enhances learning. As such, some researchers like Buldu (2022) have incorporated role playing as an extension of dramatic play in a teachers education programme. Also, Vatalis (2017) uses simulations in groups of students for teaching a sustainability course, whereas students change their roles in a cyclical way. The team of academics consisted of Moreno-Guerrero, Rodríguez-Jiménez, Gómez-García and Navas-Parejo (2020) who used role playing along with educational videos to the "Organisation and Management of Educational Centres", a master's degree level course for future teachers of compulsory education. Most importantly, role play as an active learning strategy can be used, not just in face-to-face classes, but also in blended or distance learning (Erturk, 2015).

The work of Díaz Redondo, Vilas Arias and Solla (2012) presents a relevant experience of the educators at the School of Telecommunications Engineering at the University of Vigo (Spain). The academics formulated groups and each student is assigned a typical role in a software development project, i.e. as a project manager or designer or requirement analyst, with promising results. Erturk (2015) presents a role playing strategy that has been applied from 2013 through 2015 at the Eastern Institute of Technology (EIT) in New Zealand, in the "Systems analysis and Design" course. This initiative has involved students in the computing and information technology bachelor's degree programme.

At the same time, several surveys and studies show the low proportion of women in computer science education programs as well as, more generally, in STEM (Software, Technology, Engineering and Mathematics) (e.g. Adam, 2005; Farmer, 2008; Margolis and Fisher, 2003; Directorate-General for Research and Innovation, 2021; Tomassini, 2021). Although most countries have more women than men enrolled in tertiary education, the number of women who choose STEM at university level is around 15% (Chavatzia, 2017). As a consequence of this *gender gap*, the employment of women in the technology sector is also low.

Our initial empirical observations during our teaching experience at an Engineering School, and specifically in the "Computer Programming Methodology" course (1st semester) motivated this study as it showed that the classic formula of two-hour lectures supplemented by two-hour laboratory sessions per week, may not meet expected results. Another observation was the fact that first-year students, especially female students, refrained from participating in the final exam of the course. This realisation prompted us in the academic year 2018-19 to design and offer a pilot group projects initiative, complementary to the lectures and labs. As such, we applied role playing along with group projects (Diaz Redondo, Vilas, Arias and Solla, 2012) as a learning strategy, in which the students assumed distinct roles with the obligation to present at the end of the semester an integrated project that required a combination of theoretical and laboratory knowledge, but at the same time it simulated the development of an integrated software application which, in addition to knowledge, also required an extra set of skills (i.e. cooperation of team members, preparation of a written report, and, public oral presentation of the project results).

This initiative of the tutors is a step towards integrated and active learning, which suits adults, such as our students, according to Rogers (2010). The methodological approach that we followed is similar to the out-of-class role-playing that other tutors have implemented in IT courses, as illustrated above, however, it contains original elements as it captures the situation before the experiment and then it attempts to interpret qualitative elements of the role-playing process and contribute to the tutor's feedback in relation to the classification of the pilot application characteristics, thereby adding value to current research in the field.

The methodological approach is presented in the second section. The results of the role-playing analysis and the classification of the features of the pilot application are presented in the third section along with conclusions in the final section.

2. Methodological approach

Bearing in mind that the role playing technique had not been applied previously in our course and given our empirical observation of low participation in the final exams, the known difficulty of IT courses, our experience in adult education and our intention to strengthen active participation in our teaching practice, we proposed to the first year students in the 2018-19 academic year to take part, voluntarily, in a group project combined with undertaking distinct roles. The strategy that we followed is broken down into three phases, as shown in Figure 1.

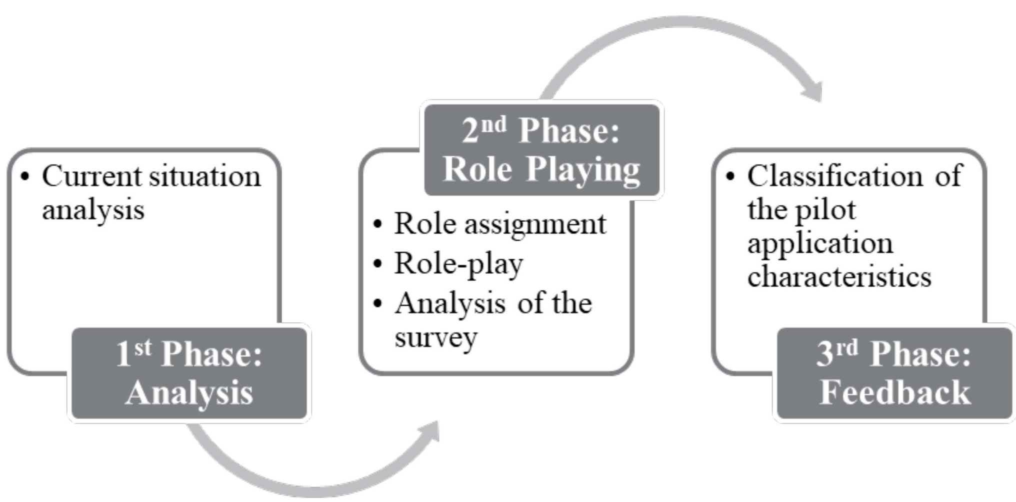

Figure 1. *The methodological approach*

In the first phase, the current situation in relation to the participation in the final exams was analyzed, since there was a suspicion that the first-year students avoided participation by leaving this obligation for the following year(s). Students have this possibility based on the current legal framework, i.e. to be examined in a course in the year that they choose. Subsequently, in the second phase of our strategy, we assigned group projects in combination with roles. The analysis of the roles assumed by the participants was based on the responses to a questionnaire designed and distributed to the participants (see the appendix). Finally, in the third phase, feedback, the characteristics of the pilot application were analyzed based on the Quality Model of Kano (1984) and the answers to the specially designed second part of the questionnaire.

The pilot implementation of this learning method in the second phase bore several challenges. Firstly, group projects are a well-known educational technique applied in engineering schools of later semesters (Palmer and Hall, 2011). This method was new for the first year students, and it was challenging as they did not know each other very well and were not confident in role selection and team formation. Another challenge was that students did not have enough practice in team working in secondary education level. Furthermore, the assignment of roles nullified the possible intentions of some to not actively participate in the development of the project and therefore to reap the effort of fellow students - members of their group. Finally, the integrated development of a software application created the conditions for strengthening a series of skills that might not have been cultivated to a sufficient degree in secondary education, such as producing a written academic report, which constituted an additional challenge for the participants.

The topics of the projects had as a common theme the creation of a Customer Relationship Management (CRM) system and required the use of a word processor for documenting requirements, a diagram editor for producing Data Flow Diagrams and flowcharts and the Code::Blocks Integrated Development Environment (IDE). The students were trained in the latter during their laboratory sessions. The students were asked to form groups of 4 to 5 people, with the following distinct roles: Coordinator, Analyst, Programmer A, Programmer B and Tester. We assigned two programmer roles on one hand to follow the pair programming technique (see, e.g. Plonka, Sharp, Van der Linden and Dittrich, 2015) and on the other hand to help students be less intimidated of the requirements of this role as they would not be alone in this task. This practice also reflects our experience in real-world application development (see e.g., Spanoudakis and Moraitis, 2022).

To facilitate the work of the groups, at the beginning of the semester, clear instructions on the roles per case were distributed along with a template of the written report where each role had a section to complete. The students knew that at the end of the semester they would have to publicly present their team's project, both to their fellow students and to a group of tutors, deliver the written report and the software they developed. In the end, they would be asked to participate to an anonymous research survey by completing a questionnaire.

For the needs of the survey, we designed a questionnaire, which is listed in the Appendix. The questionnaire is divided into two sections: the first section includes demographic and other information related to the role of each student (questions numbered 1 to 10).

The value of feedback from the tutor to the students and, vice versa, from the students to the tutor has been commented on by many researchers (e.g. Knowles, Holton and Swanson, 2015). In the third phase, in order for the students (who presented the group projects) to provide feedback to the tutor, a group of specially designed questions on the attributes of this pilot application was included in the second section of the questionnaire. The analysis of the characteristics was based on the well-known model of Kano (Kano, 1984; Kano, Seraku, Takahashi and Tsuji, 1996). Kano proposes three levels of quality, as follows:

1. *Attributes of expected quality or must-be characteristics*. The must-be characteristics are considered as basic. If these requirements are not fulfilled, the customer (or student in our case) is completely dissatisfied, while, on the contrary, if they are fulfilled they do not affect satisfaction. For example, when a customer buys a pen, it is implied that it can write. These requirements are obvious, not-expressed and implied. Thus, as these attributes constitute basic expectations, they do not make customers happy; their absence, however, makes customers unhappy or dissatisfied.
2. *One-dimensional attributes of desired quality.* When the one-dimensional attributes are fulfilled, they affect satisfaction in a way that the higher the level of fulfilment, the higher the satisfaction level and vice versa. These attributes are explicitly demanded and constitute what is called "desired quality".
3. *Attractive attributes*. The attractive attributes have the greatest influence on satisfaction. Fulfilling these requirements leads to increased satisfaction, as in the case of an unexpected fast service in a bank queue. On the contrary, if these requirements are not met, they do not imply dissatisfaction. These characteristics represent the "attractive quality".

According to the classic Kano model, the classification process takes place through the application of three steps:

a. All participants in the survey are asked how they would feel if performance on a particular attribute is high and how they would feel if it is low.
b. The answers to these (double) questions are collected through a qualitative scale (Likert scale) and a cross-table is created with the frequencies of the answers.
c. The cell of the cross-table with higher frequency is identified and the attribute is classified according to Table 1.

Table 1. *Kano model attributes classification template.*

		Low performance of attribute				
		VS	SS	NN	SD	VD
High performance of attribute	VS			A	A	D
	SS	S	S	I	D	E
	NN	R	R/I	I	I	E
	SD	R	R/I	R/I	S	
	VD	R	R	R	S	

Legend: *VS: Very Satisfied, SS: Somewhat Satisfied, NN: Neither Satisfied Nor Dissatisfied, SD: Somewhat Dissatisfied, VD: Very Dissatisfied, A: Attractive, D: Desired (one-dimensional attribute), I: Indifferent quality, R: Reverse quality, E: Expected or must-be quality, S: Skeptical (re-examine the quality).*

Thus, section two of the questionnaire examines the quality characteristics of the pilot application. According to the Kano model, participants are asked to answer two questions for each attribute: how they would feel if the performance is high and how they would feel if the performance is low (functional and dysfunctional nature of question). In this sense, and using a 5-point Likert scale, question 11 of the questionnaire is specially designed and includes 11 attributes in three sections, as follows:

(11.1) Teaching: 4 attributes (PC operation, C language, flowcharts and Data Flow Diagrams),
(11.2) Tools Usage: 3 attributes (Code::Blocks IDE, Word processor and PowerPoint), and
(11.3) Soft Skills: 4 attributes (collaboration, written documentation, time management, problem solving).

3. Results of the Pilot Implementation

Existing situation analysis

The detailed data of first year students for three consecutive years as well as the year of the pilot application are presented in Table 2. In the first row we present the totals followed by the values for females and males. Moreover, we present graphically the students' participation in the final exams for all three years in Figure 2, again the total, followed by females and males.

Table 2. *Quantitative data for academic years 2015-16 to 2018-19.*

	2015-16		**2016-17**		**2017-18**		**2018-19**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Students	161	100%	155	100%	167	100%	169	100%
Female students	37	23%	36	23%	36	22%	28	17%
Male students	124	77%	119	77%	131	78%	141	83%
Total students participation to final exams	91	57%	63	41%	42	25%	64	53%
Female students participation to final exams	16	43%	8	22%	8	22%	13	46%
Male students participation to final exams	75	60%	55	46%	34	26%	51	36%

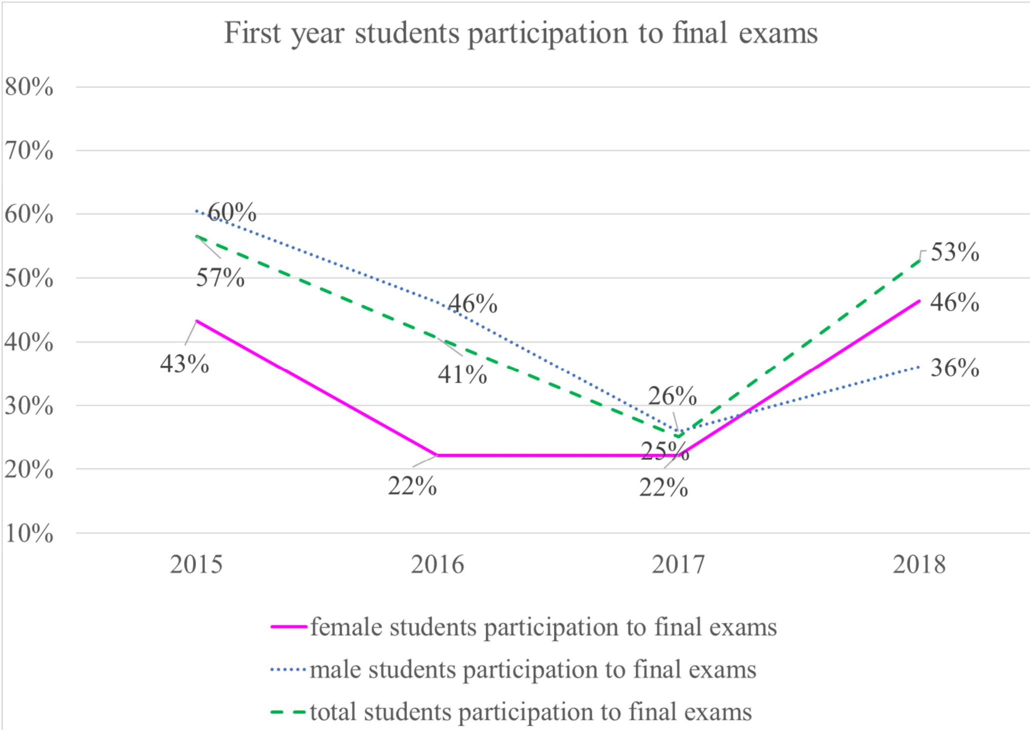

Figure 2. *First year students' participation in the final exams for academic years 2015-16 to 2018-19.*

An initial finding is that the low percentage of first year female students in the specific engineering school (23%, 23%, 22% and 17%, in the four years) follows the general international trend, i.e. that females are persistently underrepresented in STEM studies (Adam, 2005; Farmer, 2008; Margolis and Fisher, 2003; Directorate-General for Research and Innovation, 2021; Tomassini, 2021).

Regarding the participation of first-year students in the final exams (Table 2, Figure 2), in 2015-16 a total of 57% of the 161 admitted (first year) students participated, while only 43% of the 37 admitted females participated. Accordingly, in year 2016-17, a total of 41% participated, and only 22% of the females. Similarly, in the year 2017-18, a total of 29% participates, and 24% of females. Based on these figures, we observe that the participation of first-year students in the final exams is overall low. Accordingly, females participate less in exams than males except in the pilot implementation year 2018-19, where females participated at a higher rate (46%) than males (36%). Therefore, a first observation is that in the year of the pilot application females have reversed the previous picture of lower participation in exams compared to males.

In particular, for the year 2018-19, the number of students who participated or did not participate in the role playing was checked in relation to the participation or non-participation in the final exams. The results are shown in Table 3 and the Pearson Chi square test showed the following: X^2 (1, N=169) = 18.155, p = .000 which results that role playing in combination with group projects and participation in final exams are not independent of each other. There is a statistically significant relationship between role playing and final exams participation, i.e. role playing enhanced participation. Despite this, there are still a number of students who participated in the pilot application, who did not attend the final exam (40 people). However, we can claim that role playing was a kind of "motivation for participation". This is confirmed by a number of scholars who focus on the benefits of active learning for improving the learning outcomes and abilities of students/ graduates (e.g., Dimitropoulos, 2023).

Table 3. *Cross table.*

		Participation in role playing group project		
		Yes	No	Total
Participation in final exams	Yes	46	18	64
	No	40	65	105
	Total	86	83	169

Demographics and student roles in the research survey

In the year 2018-19, 169 students were admitted and from them 18 groups with a total number of 86 students participants were formed. Twenty girls participated in groups out of the 28 admitted to the School, which in principle indicates that most girls chose the specific innovation of the course without apparent hesitation. After the projects were completed, 66 people, or 75% of the participants in the groups, took part in the survey.

Table 4 presents the collected data. The age of all participants was 18 years old and all were studying in the 1st semester. Rows three to seven of Table 4 show the distribution of the roles of the sample, with an interesting observation regarding the most valuable role, that students of the sample have chosen the role of Programmer with a high percentage at 47% and the role of Coordinator with 33.3%.

The significance of the role of Programmers is associated with the development of the project and its final delivery and, thus, constitutes a basic-core role. The high percent for the value of the coordinator role indicates *less obvious* skills of students who have just entered a degree programme, without having any prior experience on how to coordinate their own life away from home, knowing peers, struggling to make new friends, find their feet on the new university environment, managing their own life, etc., the so-called social skills. The schools' insistence on teaching these types of courses during a period of transition of students can only increase the difficulty, as Jenkins (2002) mentions.

Subsequently in Table 4, the answers to the question n. 10, i.e. how confident are the students in their ability to repeat the project without any support from the instructor, show that most students (51.5%) replied on the medium point of the 5 level scale, which corresponds to medium confidence. This result confirms the literature (Jenkins, 2002) for the difficulty and complexity of Programming courses.

Table 4. *Demographics and students' roles.*

		f	%
Gender	Male	56	84.8
	Female	10	15.2
Role	Coordinator	14	21.2
	Analyst	13	19.7
	Programmer A'	13	19.7
	Programmer B'	13	19.7
	Tester	13	19.7
Most Valuable Role	Coordinator	22	33.3
	Analyst	7	10.6
	Programmers (A' and B')	31	47
	Tester	6	9
Confidence for future involvement of students on similar programming projects without support or guidance from the instructor	Not at all confident	1	1.5
	Low confidence	8	12.1
	Medium confidence	34	51.5
	Very confident	15	15
	Absolutely confident	8	12.1
Total		66 students	

An important finding lies in the separate analysis of roles by gender, which showed that no female took the role of Programmer, so this role was taken by the brave (males). This result (see Table 5) is in line with the international reality of the low participation of women in computer science or computer engineering or related specialties.

Table 5. *Role selection by gender.*

		Man	Woman	Total
Team Role	Coordinator	10	4	14
	Analyst	10	3	13
	Programmer A	13	0	13
	Programmer B	13	0	13
	Tester	10	3	13
	Total	56	10	66

Pilot application attributes and their classification

For qualitatively studying the 11 attributes of the pilot application, the Kano model was applied. For every attribute a cross table was delivered, like the one presented in Table 6. In the table, the cell with the highest frequency is checked. For example, for the first characteristic (teaching about computers Yes-No) the cross table indicates that most replies (25 replies) exist in the cross tabulation cell of “very dissatisfied” in the absence of the characteristic and “very satisfied” in its presence. Thus, the Kano model for such cases indicates that it is a Desired quality characteristic. In the same way all the characteristics were classified:

a. *Desired quality characteristics* (one-dimensional characteristics):
    i. Teaching about Computers
    ii. Teaching of C Programming Language
    iii. Teaching of Flowcharts
    iv. Use of the platform Code::Blocks IDE
    v. Use of the Word for text processing
    vi. Use of the PowerPoint for preparing presentations
    vii. Enhancing Team Working skill
    viii. Enhancing Time Management skill
    ix. Enhancing Problem Solving skill
b. *Indifferent quality characteristics* (neither satisfaction, nor dissatisfaction)
    i. Teaching the Data Flow Diagrams
c. *Attractive quality characteristics*
    i. Enhancing academic writing skill (preparing an academic report for the application)

Table 6. *The teaching for computers cross table*

		Low performance of attribute				
		VS	SS	NN	SD	VD
High performance of attribute	VS	1	0	1	8	**25**
	SS	1	1	7	14	6
	NN	0	0	0	1	1
	SD	n.r.	n.r.	n.r.	n.r.	n.r
	VD	n.r.	n.r	n.r.	n.r.	n.r.

Legend: VS: Very Satisfied, SS: Somewhat Satisfied, NN: Neither Satisfied Nor Dissatisfied, SD: Somewhat Dissatisfied, VD: Very Dissatisfied (n.r.: no replies)

Therefore, most of the attributes are considered as of desired quality. These affect satisfaction of students in an analogous way. The higher the level of fulfilment, the higher the satisfaction level and vice versa. Thus, if the course offers these characteristics, these attributes add additional satisfaction to the students. This result is interesting, among others, because it extends on issues beyond teaching. As such, our students express their requirements on issues of “usage” of various software tools which are not included in the classical offered course, like the usage of the word processor or the PowerPoint tool.

Even though no attempt was made to learn both specific tools, nevertheless the tutor had foreseen from the beginning of the semester and distributed relevant supplementary material with instructions for the preparation of the text of the report and the specifications of the presentation. A basic assumption was that first semester students already possessed these basic IT skills. The "enhancement" of these specific skills, along with soft-skills such as team-working, time management and problem solving are considered as attributes of desired quality of the whole effort.

At the same time, we identified a specific characteristic of attractive quality, which corresponds to the ability of students to write an academic report. As the enhancement of this competence was not expected, it caused delight to our students, and it represents the characteristic of "attractive quality". [For a systematic effort to improve generic skills through the teaching of university courses see Krassadaki and Matsatsinis, (2012); or through seminars, see Krassadaki, Lakiotaki and Matsatsinis, (2014)].

Finally, the feature of teaching Data Flow Diagrams was included in the category of indifferent quality. This means that teaching this unit of course content contributes neither to student satisfaction, nor to student dissatisfaction, regardless of performance. This information was used in the following years and the Data Flow Diagrams were excluded from the course content.

4. Conclusion

In conclusion, role playing in combination with group projects had positive results. Firstly, low final exams participation was documented and subsequently the positive contribution of the pilot application. The research that we conducted at the end of the experiment had a dual objective, on the one hand to investigate the roles of the students and on the other hand to analyze the quality characteristics of the overall pilot design.

The roles of Programmer and Coordinator emerged as the most valuable roles. Females notably assumed the roles of Coordinator, Analyst and Tester, avoiding the role of Programmer. In addition, a classification was made in terms of quality of the attributes of the pilot application. The later showed that the students consider most attributes as of desirable quality, i.e. those related to teaching, using the software and enhancing skills. One skill-enhancing attribute was classified as of attractive quality (composing written academic texts) and one teaching attribute as of indifferent quality (Data Flow Diagrams). No attributes were classified as of expected (must-be) quality. This type of feedback to the tutor was an unexpected and valuable contribution of this pilot application.

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