Analysis of Expectations of Students and Their Initial Concepts on Software Quality

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***Abstract*— Quality is everywhere in every discipline. Software quality has been included in all regular education programs both at undergraduate level and in postgraduate programs with more or less intensity and wideness. However, several authors have questioned the real effectiveness of software quality education related to the real understanding of the concept. This paper analyses the expectations of students with and without working experience in software development regarding software quality education and the preferences and the ideas expressed before the training courses.**

Keywords-software quality; education; curriculum; quality culture.

I. INTRODUCTION

Quality is one of the three typical dimensions for managing every project in the well-known iron triangle first presented in [1] no matter if it is an industrial or a software one. Although later than other engineering sectors, software development also embraced the challenge of quality as part of its regular responsibilities, facing the challenge of adapting methods to the peculiar nature of software [2]. Independently from its value as a market trend or real management goal, software quality management is one of the topics included in educational programs at undergraduate level and in postgraduate programs. However, some contributions (e.g. [3]) have identified intrinsic problems in understanding the concepts related to software quality, then looking for new perspectives for a correct understanding of software quality. This conflict was also described in [4] when they wrote "If you are a software developer, manager, or maintainer, quality is often on your mind. But what do you really mean by software quality? Is your definition adequate? Is the software you produce better or worse than you would like it to be?" Even the authors conducted a small survey to 27 readers to know more on several aspects of this conflict. This is consistent with some results already presented many years ago [5] related to perception of students (postgraduate with some experience) regarding software quality and some of its associated concepts, observing some improvement in the perception of software quality as well as some changes in preferred topics after completing the specific course in the area.

Obviously, when dealing with software quality in software engineering education there are several references which doubt of the capability of regular programs to embed the idea of quality in students' mind. For example, [6] think that quality is central and critical in software development but that it is usual computer science faculty do not devote enough attention to teaching their students how to develop high-quality software (at least looking at the curriculum design and implementation). Of course, the recommendations for really effective curricula in software engineering are also frequent and are always including the topic of software quality and associated methods and techniques (see e.g. [7]). Of course, the most general models for software engineering education are always considering software quality has a pillar of the curricula in software engineering: e.g., the well-known Software Engineering Body of Knowledge (SWEBOK) [8] devotes one of its 10 Knowledge Areas to Software Quality Analysis.

As a summary, we can say that software quality is always clearly present in practically 100% of educational programs in software engineering but it seems to be a topic which frequently raises questions on the real impact on students. However, the consequences of the unsatisfactory results of the education on software quality go beyond the limits of possible deficiencies in the qualification of (future) software professionals. As software engineering is mainly a human activity, not just a technical matter of technology, perceptions of software engineers deeply impact the results in term of productivity and quality. The work with Human and Organizational Factors (HOF) and nontechnical issues highlight that the people involved in the software development process are as important as the processes and the project.

Different studies have shown how these factors lead to improvements in products, increases in productivity, or decreases in production costs. As an example, [9] provides the outcomes of a study carried out in a professional environment. It shows that certain organizational factors, that might not affect project success, negatively affect software quality: among the factor of influence there is a wrong quality culture or a lack of sense of quality achievement. Additional discussion and information could be found in [10]. Although there are different aspects which confirm the practical impact of misconceptions on software productivity

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and quality, poor understandings of quality principles has been identified as relevant in effectiveness of software projects. Moreover, these barriers may hinder the achievement of good results in educational programs. The main goal of this study is the analysis of the expectations of students to know how working experience and learned concepts may influence their attitude towards software quality.

The paper is organized as follows. Section II describes the educational experience where the data on students' opinions and expectations were collected. The analysis of results is provided in Section III, while Section IV outlines some conclusions and suggests some future lines of action.

II. EDUCATIONAL EXPERIENCE ON SOFTWARE QUALITY

Authors frequently teach courses on quality managements systems and software quality in different undergraduate and postgraduate computing programs. Our experience tend to show that theoretical or rather abstract or high level concepts imply a more difficult understanding than those more connected to low level practical work. Given that software quality management works at a higher corporate/organizational level, especially those students without working experience tend to be less connected to the corresponding ideas.

Together with our concerns on the real effects of courses, we wanted to check several aspects on the expectations of students when they are exposed to software quality education. Thanks to the collaboration of students, we collected information from several courses where we got a reasonable variety of profiles and education levels which provides some representativeness to results. The selected courses and groups of students were the following ones:

G1: Undergraduate in 2nd and 3rd year of Informatics Engineering program at University of Alcalá with two different courses "Software Engineering" and "Advanced Software Engineering" where there are 20 hours devoted to software quality: 39 respondents (Madrid).

G2: Undergraduate in 2nd and 3rd year of Information Systems program at University of Alcalá with two different courses "Software Engineering" and "Advanced Software Engineering" where there are 20 hours devoted to software quality: 14 respondents.

G3: Undergraduate in 4th year of Information Systems and Informatics Engineering programs at University of Alcalá with a specialized course on "Software quality, testing and maintenance" with 60 hours: 11 respondents (Madrid).

M1: Students enrolled in the Master program on IT Project Management at University of Alcalá with specific courses on "quality management and software quality" with a total of 100 hours: 9 respondents.

Although the topics in all courses are very similar, the approach in each of them is obviously different depending on the specific educational goals, previous courses, students' background and profile as well as duration. In fact, biggest differences are evident when comparing teaching to undergraduate and to postgraduate students. It is important to remark that all the students have attended previous courses on other aspects connected to software quality such as software testing and configuration management. However, there was a general scheme of points taught in each course:

- Concept of quality and differences between software and other products. Other concepts related to quality and management by processes.
- Corporate perspective: quality management systems and continuous improvement. Standards and frameworks for software process improvement (ISO, CMMi, etc.)
- Project quality management: software quality assurance, activities and techniques
- Software quality evaluation: models and metrics

INITIAL QUESTIONNAIRE

1. Write a definition of quality: _____
2. So, which of the following phrases is most adjusted to your idea of quality?
Highest possible level, no matter who is the customer
Something associated to expensive and luxurious products
Product has some guarantee in case of problems
Balance between price and value
Concept to be customized to specific needs of the customer
3. Have you ever heard about software quality?
☐ Informal chat with colleagues
☐ Commercial presentations
☐ Articles or conference papers
☐ Books (whole or chapters) related to this topic
☐ You know quality standards and have worked with them
☐ You do not have any references about this but you guess its importance

4. So, your idea about software quality is:
(1) Unfavourable impression: it is useless or impractical
(2) Rather unfavourable impression: it represents a great effort to get poor results
(3) Neutral impression: we need to improve and we can do it but it is essential to know how to do it
(4) Favourable impression: we are able to achieve good results by applying certain techniques
(5) Very favourable impression: it is incredible that we are not still applying these techniques.

5. In your opinion, who or what should encourage the adoption of quality techniques in the practice? (you can mark several options)
☐ Quality department
☐ Management
☐ Software professionals and technicians
☐ The need of satisfying legal dispositions or standards
☐ Customers, contracts or market pressure
☐ Others (please indicate) _____

6. Which of the following topics do you consider as the most important for this course? Put them in order of preference from 1 to 5 (have you ever heard about them?)

☐ ISO 9001 (ISO 9000-3)	*Heard ☐*
☐ Quality management systems	*Heard ☐*
☐ Testing, reviews, audits	*Heard ☐*
☐ Software process improvement	*Heard ☐*
☐ Quality control and evaluation (metrics)	*Heard ☐*

Have you ever worked in professional software development (undergraduate students)? ☐ Yes ☐ No

Figure 1. Initial questionnaire

Questionnaire in Fig. 1 was used for information collection from students, the same for all the groups. This form is replicating the one already used in a previous study [5] where it is described the design considerations as well as the methodological considerations. The idea was being able to compare some results in the future. Each form had 4 closed multiple choice questions as well as to open questions apart from a question on real working experience in software projects. Only undergraduate students were asked about their working experience since all master students were experienced. It was clearly commented to students that there were not correct answers to the questionnaires, that it was aimed at capturing their ideas freely expressed. Only graduate students and experienced undergraduate students were asked about which techniques they would intend to use in their job after the course. Of course, questionnaires were anonymous.

Only after collecting all the information, the teacher was allowed to exploit the activity to organize a free debate on their perceptions and the reflections associated to them.

III. ANALYSIS OF RESULTS

Given the small samples, the main goal of the analysis is getting descriptive information of the ideas expressed through the questions. Specific goals are the following:

G1. Which is the initial concept of quality for those attending the course? (question 1)

G2. Is the concept of quality different between experienced and unexperienced? (questions 1 and 6)

G3. Which is the opinion on quality of those attending the course? (question 2).

G4. Is the opinion on quality different between between experienced and unexperienced ? (questions 3 and 4)

G5. Knowing if opinion on quality is the same between students with working experience and those without it? (question 4)

G6. Which is the opinion on who should be the promoter/sponsor of quality? (question 5).

G7. Knowing if the idea that people tend to make responsible only to the quality department of the whole results of the organization? (question 5)

G8. Which is the opinion on orientation to customer? (question 6)

We present the results extracted from questionnaires in Table 1, separating results for unexperienced and experienced students to enable an easier analysis of data.

1) As seen on the Table 1, most part of respondents knew or has heard about software quality (only 3% remain ignorant before the course). This is not exclusive of those inexperienced students (2.2%) although one experienced did not have previous references. It is remarkable that 28.4% of experienced and 16.4% of inexperienced have worked with standard or have been working in practical application to projects.
2) Many respondents have acquired knowledge through theoretical or practical courses (approx. 40% of experienced and 53 % of inexperienced. Although there is a slight difference (13.8% of experienced vs 12.3% of inexperienced), there is not much impact of commercial information (while teachers thought before this experience it was the opposite).

TABLE I. RESULTS FOR WITH AND WITHOUT EXPERIENCE

	Experience (31,81%)	No experience (68.18%)
# students	35	75
Concept of quality		
Requirements and need	37.1 %	34.66 %
Customer satisfaction	14.3 %	12 %
Guarantee	0	24 %
Tools and maintenance	2.86 %	2.66 %
Correct function	20 %	10.66 %
No losing time	2.86 %	1.33 %
Product value	14.3 %	5.33 %
Process	8.57 %	4 %
Void answer	0 %	5.33 %
Ideas on quality		
Highest possible level	25.71 %	13.33 %
Luxury/expensive	0 %	1.33 %
Guarantee	5.71 %	8 %
Value-price balance	22.85 %	28 %
Customization	45.71 %	49.33 %
Previous references		
Speech/debates	7.32 %	8.64 %
Commercial presentations	6.5 %	3.64 %
Theory in courses	23.6 %	30.5 %
Practical work in course	16.3 %	23.2 %
Articles and conferences	9.75 %	10 %
Books	7.32 %	8.64 %
Working with standards	13.8 %	7.73 %
Practice in projects	14.6 %	5.45 %
No references	0.81 %	2.22 %
Quality idea	4.08	3.85
Motivator/sponsor		
Quality department	28.8 %	20.2 %
Top management	5.08 %	5.64 %
Professionals/technicians	20.3 %	24.02 %
Every employee	39 %	33.9 %
Customers/market	6.78 %	15.3 %
Other	0	0.81 %
Customer orientation:		
Information for use	2.86 %	25.33 %
Satisfy customer specification	0	2.66 %
Satisfy customer needs	51.4 %	37.33 %
Features and requisites	8.57 %	2.66 %
Post-sales service	0 %	0 %
Developing services and systems oriented to customers	2.86 %	0 %
Product reliability and maintainability	0 %	0 %
Information for choosing product	14.3 %	16 %
Do not know	2.86 %	0 %

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Void	8.57 %	9.33 %

3) Initial idea on software quality is rather high as our informal observation was suggesting: average for experienced is 4.08 while unexperienced scored 3.85, both numbers really high. When we compare undergraduate (4.02) and graduate students (4.22) differences are also small. Only 4 people (0.02%) started with level 2 (Rather unfavourable).
4) Frequent misconception in old fashion quality organizational cultures detected by Crossby [11] where majority of people believes that quality is a only responsibility of the quality department seem s to be still alive in a good number of undergraduate students (25.1 %) while is really reduced in master students (7.14%). It is worth to remark the high proportion of undergraduate and postgraduate who think that the main responsibility for quality is on the shoulders of the own software professionals. It is important to note that the largest percentage of people is correctly thinking that quality is a responsibility of all workers in the organization, more clearly for experienced students (57.14%) than for unexperienced (34.2%). Finally, market/customers is the main driver and motivator for quality for 15.2 of postgraduate students versus 7.14% of the undergraduate ones. In general there is a good consistency with the current philosophy of quality in the organizations.
5) From the definitions of quality written by students we can see that the most mentioned concept is the one referred to requirements and needs, similar for experienced (37.1%) and unexperienced students (34.6%). The second most mentioned option is customer satisfaction with 14.3% and 12% respectively. The most relevant difference between both groups of students appear in the option of focusing quality as a guarantee procedure (maybe allowing refund if customer is unsatisfied): 24% of undergraduate mentioned that while none of postgraduate did.
6) When expressing their idea of product/service quality the idea that quality concept has to be adapted to the needs of each customer is accepted by the majority (45.71% experienced and 49.33% unexperienced). Both groups reject the idea of associating quality with expensive/luxurious products while both groups consider relevant the existence of a proper balance between price and value.
7) When dealing with the concept of customer orientation, we want to highlight that information for using the product is the main aspect for 25.33% of unexperienced students while satisfying customers' needs was chosen by 37.33% while 51.4% of experienced students chose customer satisfaction letting the information for using the product as the last option.
8) There is a wide variety in the initiatives which inspire more interest in students for putting them into practice. It is interesting to note that there were no other options apart from the ones shown in the questionnaire. Adoption of techniques, tools and quality standards keep a good medium level (between 30% and 50%) while certification activities score low, maybe because they are considered as options out of the decision power of the respondents.

We decided not to analyze differences among the different courses as the sample numbers were small and the goal was focused on general expectations of students only distinguishing the impact or working experience. Analyzing the effects of the different courses was not meaningful since they are a non-representative subset of the official syllabus available for software quality education: i.e., results could not be applicable to other designs of software quality courses. Regarding the analysis of post-course results, we collected data confirming that our courses finally helped fix the misconceptions on software quality work (e.g., thinking that not everybody has a direct responsibility in quality), but we are not discussing here in order to avoid mixing the analysis of expectations with the analysis of educational effectiveness of our courses.

IV. CONCLUSIONS

First valuable result for us has been a better knowledge on the expectations and the initial idea that our students have in mind before starting the courses. This has already served us to adjust the pedagogical methods and the details of topics to better fit our teaching activity to the students profile and background. It has also enabled a more solid discussion of stereotypes on quality, creating new materials and activities to better debate on the implications of the different views of software quality (see e.g., [3]). It was really useful to find out that still a relevant number of students think that the main responsibility of quality relies on the quality department instead of accepting that every worker is essential to assure quality results, thus trying to convince them with the basic ideas from [11]. Also knowing the main interests in the field of software quality has helped us in reconsidering the way of explaining and teaching each topic in the course.

The contribution of our work is clearly focused on knowing which are the attitudes and the conceptions regarding software quality of students and professionals. It is well-known that an effective quality management strategy has to rely on the contribution of everybody to achieve the quality goals. As an example, discovering that a relevant percentage of professionals are still thinking that the quality department is the main responsible of quality is very important to the practical implementation of software quality management: organizations simply cannot assume that professionals are coming with clear ideas so teams can directly start to work with processes and method for software quality. This is also an important lesson for other educators in software quality: techniques and methods are essential but they are useless if the attitudinal and conceptual part is not worked.

We expect to cumulate more data during the present academic year to enlarge samples so more sophisticated

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analysis using multivariate analysis. We are also already using an after-course questionnaire to evaluate the evolution of the quality concepts from the initial idea brought by students to the outgoing one which will guide their professional activity. We expect that students (as happened in [5]) will raise the value given to quality while they also tend to improve the perception and correct understanding of the concept of quality.

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