Adding 'Professional Awareness' to the Software Engineering Curriculum

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Abstract - **This paper presents a proposal to integrate the learning skills and professional awareness in an engineering education course for the Professional School of Software Engineering at the National University of San Augustine, Arequipa - Peru. The known problems of writing and oral communication in technical careers from other engineering programs are outlined. Engineering student's improvements reached by other engineering programs is explained and discussed as the jumping board for the development of the new course. The goals for initial professional awareness in student's communication artifacts were related to specific Accreditation Board for Engineering and Technology (ABET) criteria. A new course called Writing Articles and Research Reports (RAII) taught within the student's major department was created emphasizing effective communication and the need for continuous learning with the understanding of ethics and professional responsibility. The constructivist approach was used to design the course and an exposition of the mapping between the design of the course and the skills that are intended to achieve is outlined in the paper. The investigation includes the student's initial opinions regarding the impact of the new focus in the development of their professional skills and abilities.**

Keywords - Active Learning, ABET, Skills Professional, Skills of awareness, education,

I. INTRODUCTION

The Arequipa region of Peru has three universities with professional degrees in Information Systems and Computer Sciences. A national and international analysis of current trends in the computing industry, the computing employment market, and the academic arena yield the need for professionals in the field of Software Engineering. Over the past few years our San Agustin University chose to change the scope of the educational degree to Software Engineering. The change to Software Engineering has seen growth in student numbers, interest in our alumni taking additional SWE courses, and employment opportunity for our region and our country. The elaboration of the curricular grid took into account the Software Engineering Book of Knowledge (SWEBOK 2013).

When you considered from a global perspective the development of the software industry, and the growth of our Software Engineering program at our university, it becomes obvious that our future graduates need to work in a global environment in multidisciplinary teams, that can resolve problems that change constantly. In addition, much of what the students have learned (technologies, software, methodologies, programming languages, etc.) will have to continue to evolve and change after graduation [1]. Under this context students are expected to graduate with certain skills in addition to the technical skills that are part of all Engineering curriculum [2].

ABET (Accreditation Board for Engineering and Technology) stresses the importance of the skill "professionals" and the skills of "conscience" in addition to the development of technical skills to achieve excellence in the training of engineers [2]. In response to these needs there are many experiences related to the teaching of these skills. One of the most comprehensive studies is located in the Shuman work [3]. Williams presents a systematic review of the literature on the experiences of the teaching of these skills [1]. Other more specific work related to the ability to communicate and effectively developed in [4] , [5] , [6] , [7] , [8] , [9] and [10].

In this article we will show the experience of the Professional School of Software Engineering [11], at the National University of San Augustine [12], Arequipa - Peru, in the course of writing articles and research reports (RAII). Our work shows the mapping between the existing design of the course and the skills that are intended to accomplish: (g) the ability to communicate effectively, (i) the recognition of the need for continuous learning and (f) the understanding of the ethics and professional responsibility. As part of our work, we have considered the views of students. We analyze the students' appreciation of the skills that we aimed to develop within RAII. This past year, we issued the course for a second time, in this new semester we included several changes with regard to the first time that it was rendered. These changes are shared in the form of lessons learned.

The rest of the article is organized as follows. In section II we present the design of the RAII course, we emphasize the teaching approach, and the monthly work and content. In section III we explain the mapping between the design of the course and the skills that are intended to achieve by the student. We also introduce the perception of the students with regard to their learning. Section IV highlights the lessons learned, and finally our conclusions.

II. THE DESIGN

RAII was added to the curriculum of the Professional School of Software Engineering at the National University of San Augustine, Arequipa - Peru in 2013 and will be referred as RAII. The course is a typical Peru 17 week duration semester course. It is offered in the students 3rd semester for 2 credits and meets for 2 hours per week in a lecture setting. The additional ABET skills that RAII seeks to develop in the students are:

(g) The ability to communicate effectively,
(i) The recognition of the need for continuous learning, and
(f) The understanding of the ethics and professional responsibility.

A. The approach

The learning strategies we employed in the course are based on a constructivist model that will foster an active learning approach [13] [14]. The constructivist approach embraces the idea that knowledge cannot be acquired in a passive way [15]. RAII was designed for students to develop these ABET skills (g), (i) and (f) in the constructivist approach.

B. The Work

To achieve active learning throughout the semester each student writes a feature article publishable, taking into account the IEEE format, based on a theme of research given by the professor. The article only has 6 pages, with a minimum of 20 references. There are 5 revisions throughout the semester. Deliveries are incremental. The patterns of how to perform a schema, in where to look for information, how to determine what is relevant, and the drafting standards are taught between the first and third week of classes. From that moment onwards, the professor's role is an internal review. During the semester, the students present their work to the faculty/class twice. In the first exhibit is a progress report where the student describes the basic concepts that will be discussed in their research. This allows for feedback to the student and assures that the student is headed in the correct direction and prepares the student for the final report. In the second exhibit the complete work is presented including an analysis of the ethical issues related to their topic and what is the social impact of this engineering application.

C. The Articles Topics

The first day of classes, each student receives the topic of their article. Each item was formulated by the teachers of the course to with the following learning objectives: (a) help the student increase the understanding of the scope of his/her career (b) teach the students the impact their software engineering solutions have in a global context, including environmental and social (c) help develop critical thinking and (d) improve the motivation and involvement the students will have with activities related to their future profession.

Some examples of the themes developed this semester were:

- Comparative analysis of the use of augmented reality for the teaching of mathematics in primary education: USA and Europe.
- Comparative analysis of the use of augmented reality in projects of Architecture and Urbanism: Japan and Europe.
- Comparative analysis of the use of ubiquitous computing in Medicine: USA and Latin America
- Comparative analysis of the use of augmented reality in the teaching of physics and chemistry in Secondary Education: USA and Japan.
- Explanation of Math and physics behind AngryBirds: as used in secondary education.
- Comparative analysis of the technology used in Augmented Reality: Software and Hardware.
- Comparative analysis of the use of Alice and Java as a First Programming Language.

D. The Content of the Course

RAII's has sufficient theoretical content to enable the course content to be presented in the beginning with the drafting of the paper and formal oral presentations. During the 17 weeks of class, only 4 are dedicated to the development of the paper topics as listed in Table 1. During the first two weeks of the semester, Units 1, 2 and a portion of the Unit 3 (up to references and quotations ACM/IEEE) are discussed in the classroom. After the progress report in Week 7, the remaining topics for Unit 3 are discussed in the classroom. Two weeks later as the students

complete their research the material Unit 4 is discussed. By developing the paper requirements throughout the semester, the students obtain the information they need in a "just in time" approach. This way the students are more willing to pay attention to the presentations, since the material presented is required for the next step in their paper process.

TABLE 1
COURSE CONTENT WRITING ARTICLES AND RESEARCH REPORTS

Unit 1: Introduction
• Why do I need to know write? • Why do I need communicate?
Unit 2: Plan Drafting, search of information and Critical Reading
• Drafting Plan: The Diagram • Search for information: what where to search, how do I know that it is relevant? Citetex, Databases DatosIndexadas: SCOPUS, Science Direct, EBSCO, IEEEXplore, publications of IEEE/ACM • Critical Reading: that is relevant when Leo, what information i is useful.
Unit 3: Drafting
• Parts of the Article • Drafting Rules: paragraphs, sentences, punctuation, musicality. • Use of graphics, tables and figures. • References and citations: IEEE and ACM Style • Abstract, Introduction, Related Jobs and Conclusions
Unit 4. Oral Expression
• Mental Schema • Management of auditorium: visual contact, displacement, • Knowing how to listen **Preparation of exhibition material** • Slides • Content • What to put in and not to put?

III. MAPPING

The RAII course was designed to promote and develop the ABET skills (g) the ability to communicate effectively, (i) the recognition of the need for continuous learning, and (f) the understanding of the ethics and professional responsibility. In this section we present the *initial* analysis of these *ABET* skills.

A. RAII and Ability (g): Ability to communicate effectively

Following the studies by Pimmel [16], the best way to acquire the "professionals" skills are to: (a) provide opportunities to practice the skill, (b) give frequent feedback and (c) have structured discussion activities.

The design of RAII allows students to formally immerse themselves into the research process for four months. Each student receives up to five instances of feedback. Each feedback instance includes the review of the form and the content based on the guidelines given at the start of the assignment. Along with the formal feedback sessions, each student is asked the basis for their chosen article references in informal meetings with the faculty. This practice expects the student to explain the how and why the article contributes to their work.

During the semester, the student has two presentations on their article. In the first exhibit the article's progress is articulated. The second exhibition is the actual article presentation including an analysis of the ethics and the social impact. Each exhibition has a 5 minutes time limit without any kind of visual aid. This forces the student to work a mental schema and to practice oral communication skills. During the presentations the students are also evaluated on the guidelines received in Unit 4.

B. RA II and Ability (i): The recognition of the need for continuous learning

According to the proposal of Candy [17], there are two areas that the student must develop in order to achieve the continuous learning: (a) will be able to do (motivation): curious, disciplined, analytical, reflective, responsible, creative, independent and (b) can be done (ability): has developed skills of search and retrieval of information, has knowledge about the learning process, develops and uses its evaluation criterion (critical thinking).

Extending the list of skills of "can do" submitted by Candy [17], the Faculty at the School of Engineering of the University of Pittsburgh [2] expanded this to also consider:

- Demonstrate writing skills, listening and talking
- Follow a plan of learning
- Identify, retrieve and organize information
- Understand and remember new information
- Demonstrate critical thinking skills and
- Reflect on the self-understanding.

RAII is a Software Engineering course, thus the assignments were selected to increase the students' motivation to embrace the software field. Thus, the proposed topics were aimed at Augmented Reality, Video Games Programming Languages and Programming competitions. In some cases students requested a change of their topic, according to their own interests. As long as their proposed topic was in line with the Software Engineering community the faculty typically approved the change in topic.

Having the entire semester to complete the article, allows the students to expand the skills of: developing a work plan, searching for information on specialized databases, identifying what is relevant to their topic, and writing formal technical papers. During the feedback session the student is consulted on the content of the references used (understand and retrieve information).

An indicator for us has been the quality of the first evidence of assessment. This is the Schema accompanied by five articles related to the theme. All articles delivered by students have references from specialized sources such as proceedings, journals and transactions. As part of the assessment protocol, each student was asked the schematic contribution of the referenced articles.

C. RA II and Ability (f): An understanding of the ethics and professional responsibility

Herker[18] states the teaching of ethics should not be a course. Ethics needs to be integrated to many of the curriculum courses. Herker proposes ethical aspects in engineering should achieve the following results: (a) increase the sensitivity of ethics (b) increase in the knowledge of relevant standards or behaviors (c) ethical judgment improved and (d) improves the will power ethics.

The course of RAII gives the students a space to develop these aspects. During the writing process, the student had to find finished work of others, then respect the work of others and just copy it and present it as their own. This is an exercise in ethics. Meticulous work is done in the revision of the articles, the validation of the references, and during the first exhibit they must demonstrate that their work is based on the references but not just a copy of the references. The students are aware of the importance of ethical conduct. Likewise, it is important to emphasize that the final section of each article is the student's opinion on the social and ethical considerations of the assigned topic. This practice seeks to increase the sensitivity of the critical and ethical student.

D. Perception of the students in regard to their learning

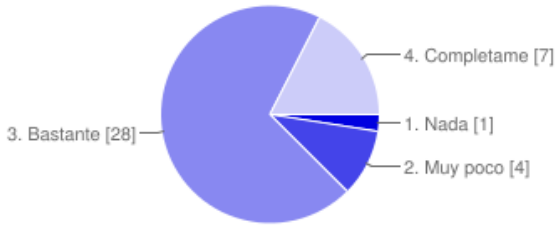
We consider it important that the student develops an appreciation and respect to their learning. For this purpose a questionnaire was designed with five questions that measured the impact the assignment had on their learning. The questions are shown in Table 2. The first three questions measured the skills raised for RAII. We also included two additional questions related to the ABET skills (h) to understand the impact of the solutions of software engineering in a global context, environmental and social and (j) have knowledge of topical issues. The results of the survey helped the faculty measure the impact of the curriculum and since we adjusted the content between the first and second offering of the course, it helped us measure the possible impact of the changes and gave us insight into how to expand the course of RAII to develop the skills (h) and (j) in a future version of the course. The Survey was offered to the entire course and was completed by 40 pupils or approximately 35% of the students that took the course.

Table 2: Survey skills developed in RAII according to criteria of ABET

A. RAII i allows you to develop the ability to communicate effectively (formal written communication and oral communication formal) 1. Nothing 2. Very little 3. Quite 4. Completely
B. RAII allows me to understand my responsibility and professional ethics 1. Nothing 2. Very little 3. Quite 4. Completely
C. RAII enables me to recognize the need for a continuous learning in my professional life 1. Nothing 2. Very little 3. Quite 4. Completely
D. RAII lets me understand the impact of the solutions of software engineering in a global context, environmental and social 1. Nothing 2. Very little 3. Quite 4. Completely
E. RAII allows me to have knowledge of current issues 1. Nothing 2. Very little 3. Quite 4. Completely

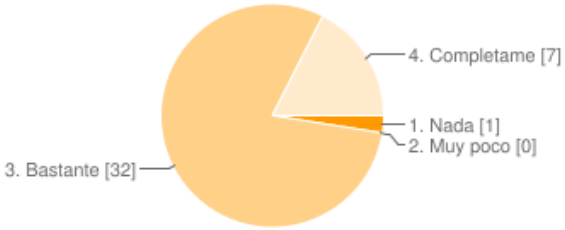
In Figure 1 thirty-five of the forty students expressed agreement that the RAII course allows them to develop communication skills. Four students expressed an opinion of "very little" and one student expressed the course developed "nothing". In summary, 87.5 % of the students have a favorable opinion with regard to the ABET ability (g).

Figure 1: Result question 1



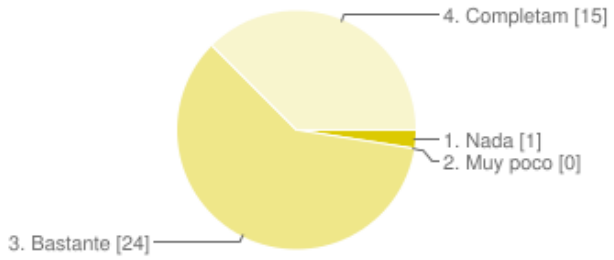
In Figure 2, it is noted that of the 40 students 39 students consider that RAII enabled them to recognize their ethical responsibilities. Thus, 97.5 % of the students expressed a favorable opinion with regard to the ABET ability (i).

Figure 2: Results question 2



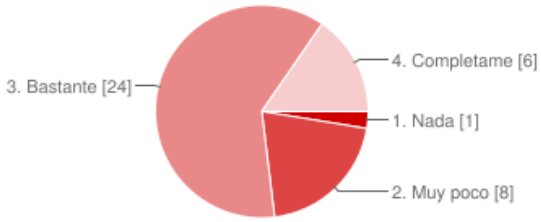
In Figure 3, it is noted that of the 40 students 39 students consider that RAII enabled them to recognize the need for continuous learning. Thus, 97.5 % expressed a favorable opinion with regard to the ABET ability (f). It is important to note that in this question the amount of students' who answered *completely,* is almost double the number who responded well in questions 1 and 2.

Figure 3 : Results question 3



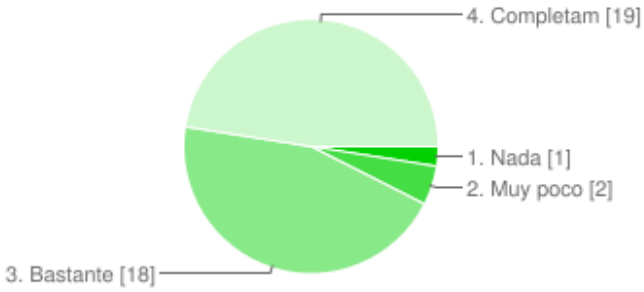
In Figure 4, we found that only 30 students (76.9 %) consider that RAII enabled them to understand the impact of the solutions of software engineering in a global context, environmental and social.

Figure 4: Results question 4



In Figure 5, it is observed that 37 students (92.5 %) believed that the RAII course allowed them to expand their knowledge of current topics; which leads us to conclude that the writing assignment increased the students' interest to address these issues. Here it is also noted that the number of students who answered *completely* is quite high.

Figure 5 : Results question 5



Based on the results of the evaluations we can conclude that the appreciation of the students with regard to what brings RAII to the development of the skills proposals is quite favorable. While the first three questions relate to the skills raised in the course. The last two questions allow us to see that RAII has the potential to develop the skills (h) and (j) of the ABET requirements.

It is important to note that while the skill (i) is the most related to the topic of the course, this won less approval with respect to the skills related to understanding ethics and continuous learning.

IV. LESSONS LEARNED

RAII was issued for the first time the Semester 2014 - I. The course of 120 students was divided into three groups, each group was led by a different professor. Currently the course of RAII has 120 students that is divided into four groups. Listed below are the lessons learned from the experience of the first and put into practice this semester for the second offering.

A. Restrictions of Form

There are some restrictions to ensure the drafting of the paper, and the product the students get in this experience meets the expectations of the faculty. Some of them are:

a) Do not allow the use of tables within the main text, only as annex.
b) Do not allow the use of figures within the main text, only as annex.
c) Do not allow textual quotations.
d) Do not allow the use of listed.

The reason for the restrictions are due to that in previous experiences the students attempted to reduce the amount of text through the excessive use of tables, figures and quotes. The restriction (d), force the student to a greater narrative in the drafting and to work the content of a list into individual paragraphs. Another direction we may consider is to use a word count instead of a page count for the paper. This is a discussion that continues to be debated.

B. Forms of Revision

During the semester 2014-I the revisions took two styles of assessment:

- not face-to-face - articles were reviewed outside of the classroom and delivered to the students in class
- face-to-face - each student explained the annotations that appeared in their articles and then giving feedback on how they should include in article.

The face-to-face style was found to more effective. The next revised article had fewer errors. The logistics for this style of review is challenging since it requires an average of 15 minutes with each student. Considering the 2 hours class time per week and the enrollment of 40 students per class, the opportunity for this style of review was very limited.

C. Number of students

Supported in the previous paragraph, this semester reduced the number of students per group, by increasing the number of class sections. This reduced student/faculty ratio gave more time for feedback sessions and include spaces for discussion with regard to the articles of the references.

D. Issues of Article

To be students of 3rd semester and not have much experience in issues of race, the define issues interesting and motivating is critical to ensure that the student is involved in the activities of the course. Similarly, the themes are intended to give students an overview of the scope of the software engineering and its social impact, ethical and environmental.

E. Drafting Plan

The first deliverable of the semester corresponds to the Plan of drafting (diagram). In the previous semester it was detected how much the difficulty the students had in regards to realizing the scope of the topic and the level of granularity at the schema level. The first semester of the course also made it clear, that there was a need to discuss with students how to approach the concept of researching their topic. The correct definition of the schema is a critical element to teach the student. A proper schema will guide the work of the student throughout the semester.

Thus, during the second offering of the course, students' was advised and a discussion was offered in the proper approach to the development of their schematic. We also requested each student to bring copies of their printed articles related to their topics to class. This helped serve as the basis for the elaboration of the scheme. By adding annotations and underlining the sections that were considered relevant the student was forced to not just list a reference, but evaluate the usefulness of the reference. This practice greatly facilitated the development of the schematic and served as the basis for initial discussion on the relevance of each point.

F. Work Related

At the end of the previous semester it was detected that the article did not have a section for related work. We felt it was necessary for the students to add this section because it would strengthen the critical reading component. This new section is important because it requires that the student identify the difference in their work to other existing jobs and improves the state of the art of investigative work. The second semester offering of the course included this section.

V. CONCLUSIONS

In this article we have shared our experience on the course design drafting articles and research reports, that under a constructivist approach, is trying to foster the development of the ABET skills: (g) to communicate effectively (i) the recognition of the need for continuous learning and (f) the understanding of the ethics and professional responsibility. Our work presents the mapping between the body design of the course and the planned skill.

We have presented the student activities, which revolve around the monthly work: writing a publishable article. The wording of an article allows students to develop a work plan, familiarize themself with the specialized databases for searching for information, develop their critical thinking, their ethical sensitivity and develop the skill of drafting a formal technical report. At the same time, the course design has allowed us to provide the student opportunities to practice

oral communication skills through feedback sessions and frequent structured discussions, in addition to the two exhibitions.

From the surveys taken by the students, we have seen that the perception of the course with respect to the development of the skills raised is favorable, one of the aspects that it has come to our attention is that this writing assignment has the ability to highlight to the students the importance of the ethical aspect, and the skill of communication, a central theme of Software Engineering.

Finally the last two questions in the survey, we have noted that the course could also help to develop the skills (h) and (j).

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