ETHICS AND RESPONSIBILITIES IN A CDIO BASED SOFTWARE ENGINEERING PROCESS

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ABSTRACT

The great impact that Software Engineering has had on society during the latest decades has put demands on that discipline to become a mature, as well as a trustworthy engineering discipline. Here, the so called, software engineering Code of Ethics has been introduced to encourage such development.

The Code of Ethics has a prime focus on the Public, and a secondary focus on co-operation and development. While the Code of Ethics in first place concerns Software Engineers in professional work, it is interesting to see how this concept influences maturity and trustworthiness also to students in educational project based work.

This contribution will cover on-going experiments in project based courses where students reflect on the Code of Ethics. Such reflections should have impact on team work, as well as on views on Software Engineering for the common public. The main question concerns how student's project work may be improved through such reflections, to meet previously observed cases of low self-responsibility and effort. The contribution covers case studies of CDIO based projects, as well as the concept of the Code of Ethics of Software Engineering in itself.

According CDIO, using the Code of Ethics in education should have relevance to several points of the CDIO syllabus, such as, 2.4 Attitudes, Thought and Learning, and 2.5 Ethics, Equity and Other responsibilities. The case studies as such, furthermore relate to aspects such as team work and communication, besides the core of the CDIO intension of driving student projects.

KEYWORDS

Project based learning, Education concepts, Software Engineering, Ethical aspects, Process improvement.

INTRODUCTION

During a couple of years, the author of this contribution has provided project based courses based on principles from Software Engineering (SE), as well as from the CDIO initiative ([12]). In the context of SE several working process models have been suggested and used, both professionally and in education. This was also covered in [2] where the author on one hand pointed out clear correspondences between such process models with concepts of CDIO. On the other hand the author covered a project based case study course, where this was used in education. To improve students' grade of self-reflection and self-responsibility, the lecturer (as well as the author) introduced still another concept from SE, that is, the so called Capability Maturity Model (CMM) in the course. This work is covered in [3] and seemed to lead to significant improvements.

Still, even though improvements in self-responsibilities could be seen, there were groups of students that still seemed to be quite passive and peripheral to the core activities. This led to frustrations and irritations between those students and those that were more active. To improve the situation even more, the lecturer decided to work more on improving the core attitudes of students. Sources of inspiration for such improvements have again been principles from SE, as well as from CDIO.

CDIO has clearly pointed out ethical issues and self-responsibilities as learning outcomes of the CDIO Syllabus ([13]). For instance, point 2.4 of [13], on Attitudes, Thought and Learning include, ”the general character traits of initiative and perseverance”. Moreover, 2.5, on Ethics, Equity and Other responsibilities include “professional ethics, integrity and social responsibility, professional behavior... and trust and loyalty”.

According [5], SE has only relatively recently reached the status of a legitimate engineering discipline and a recognized profession. As pointed out by [8] “a mature profession must have several key infrastructure components”. In [8] several such infrastructure components are covered, including:

- *Recognized body of knowledge*. The software engineering body of knowledge is an all-inclusive term that describes the sum of knowledge within the profession of software engineering ([8]).
- *Professional societies*. Many professional SE societies exist, still, the two probably most significant are Association for Computing Machinery (ACM) and IEEE Computer Society (IEEE CS).
- *Code of ethics*. “The Code describes the ethical and professional obligations against which peers, the public, and legal bodies can measure a software developer’s behavior” ([5]).
- *Initial professional education system*. This point relates to degree programs provided by Computer Science, and SE departments.

What is interesting here is that it is not considered enough with core components such as a defined body of knowledge and appropriate education for a discipline to be regarded as mature. More peripheral components, such as professional societies and ethical codes are also considered important. Especially, well established and trustworthy societies should be of fundamental matter since those will have impact on primary infrastructure components, such as body of knowledge, as well as on secondary components, such as ethical codes.

To put those discussions in contexts of education, the lecturer has approached CDIO attributes such as ethical behaviour, loyalty, and self-responsibility, to meet problems with low activities amongst groups of students. The SE Code of Ethics has here been used to implement such attributes. This contribution will start with an overview of the course where the Code of Ethics has been introduced in education, and a clarification of the problem addressed in this contribution. Concepts of the Code of Ethics will then be presented, followed by how this was used in the courses, and observed course results. Thereafter reflections on some related work, as well as a summary will be provided.

ON THE CURRENT PROJECT BASED CASE STUDY COURSE

In autumn 2010 and 2011, the author of this contribution has provided a course for third year bachelor students, in contexts of interactive house, or smart house. The course has also resulted in several degree projects where concepts on interactive house have been elaborated upon. One example on such a degree project concerns a support system for young students

(age about 16-20 years) at a school, Riksgymnasiet ([9]), for students at secondary level with functional disabilities. That work has furthermore resulted in a course on a master level for further smart house investigations and implementations. We will leave out more details on the master level course here, while the bachelor course will be further explained below, where after the core problems addressed in this contribution will be provided.

A Bachelor level project based course

The project of a bachelor level course concerns a so called interactive house, here a small scaled physical model of a house. Several devices, physical or simulated, such lamps, fans, and radiators, music media players, a microwave oven, or a coffee machine, should be controlled from computers or Smart Phones. Figure 1 outlines this. The structure of this system was presented in [2] and [3], and will only be briefly covered here to put this contribution in an appropriate context.

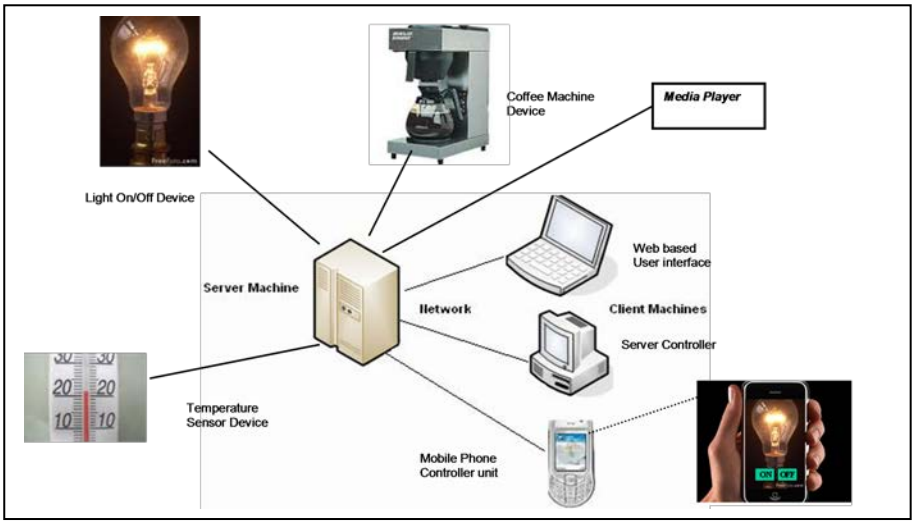

Figure 1. Illumination of system of the Case Study.

A project group of size approximately 15 to 20 students should be divided up into subgroups with respect to functionality. Figure 2 illuminate on this project group structure. Here *devices* relates to equipments of the house, while *units*, relate to user driven equipments (Smart Phones, lap tops).

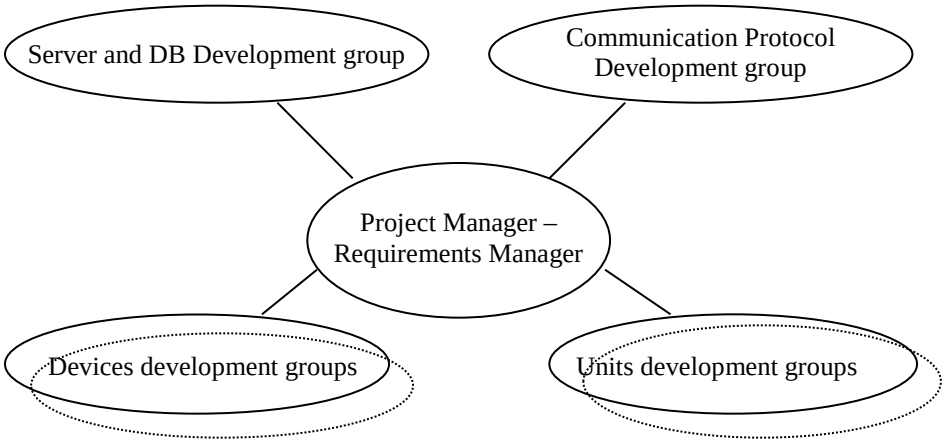

Figure 2. Project group structure.

A project manager, and a requirements manager, has main responsibilities for controlling the group and communicating different aspects of the group's work. The project group has a meeting each twice week with teachers for discussions and feedback. To those meetings there should be uploaded a number of documents representing their work so far. Please see [2] or [3] for more information on the course. The application context for this kind of system should in first place be support system for people with disabilities.

The course is divided up into two major parts. One of those concerns the working process, and is assessed on the basis of the project meetings, and the documents that should be delivered until those meetings. Here the working process is typically performed in a Conceive-Design-Implement-Operate style. The other part concerns the product of the project, that is, the implementation of features of the smart house. This contribution mainly regards the working process, and will mostly leave out the more technical parts.

Core problems observed

The core problems that were observed when the course was provided 2011 seemed to be found in behavior of some subgroups. A project group as a whole includes several subgroups. In some subgroups the involved students seemed to have bad impact on each other, leading to bad results both when it came to produced artifacts, and technical solutions. For one of the project groups especially, there were three subgroups that made the rest of project group suffer from their low effort, low loyalty to the rest of the project group, and to the project manager of the group. There were also several occasions of great irritations between the project manager and those subgroups at the project meetings with the lecturer. The students of those subgroups also had to make complementary work after the other students passed the course.

Even though attempts were made by the lecturer to increase the sense of self-responsibility and loyalty amongst the students, it was clear that the situation necessitated other approaches. Such approaches had to include further self-reflective activities. Preferably that should be done from a perspective of professional SE approaches, for reasons of professional motivations. Typically, the Code of Ethics could play that role, which also leads to the approach covered in this contribution. That is, at the course 2012, the Code of Ethics was introduced as an experiment in the purpose of meeting the observed problems of the 2011 course.

ON THE CODE OF ETHICS

Illuminating on professional ethical manners are not a new thing, neither is it unique for SE. There are several examples on ethics for different fields, such as, Medical ethics, Legal ethics, ethics for Psychologists, Engineering ethics, etc. As presented in [8], ethical codes are of importance for a profession to be considered mature.

The SE Code of Ethics is a result from cooperation between the ACM and IEEE CS ([10]). The purpose of developing a Software Engineering Code of Ethics is to document the ethical and professional responsibilities and obligations of software engineers ([6]). As is the case for the CDIO syllabus ([13]), the Code of Ethics comes in different versions with respect to levels of abstraction. The short- or high abstraction level version is provided below, while the long version may be found in, for instance, [1] and [6]. Please see e.g., [10] for more in depth discussions on the Code of Ethics.

1. **PUBLIC** - Software engineers shall act consistently with the public interest.
2. **CLIENT AND EMPLOYER** - Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.

3. **PRODUCT** - Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.
4. **JUDGMENT** - Software engineers shall maintain integrity and independence in their professional judgment.
5. **MANAGEMENT** - Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.
6. **PROFESSION** - Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.
7. **COLLEAGUES** - Software engineers shall be fair to and supportive of their colleagues.
8. **SELF** - Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

The Code instructs practitioners about the standards that society expects them to meet ([6]). But then, what is it here for education? Illuminating on this may prepare awareness concerning appropriate ways to behave professionally. Still, is the Code useful also for educational purposes, where the above covered points may have impact on behavior in courses as a student? Can an awakened awareness during study time have impact on, e.g., point 7 for improving team work? Can for instance point 8 be used to encourage higher grade of self-responsibility to find out what is required from oneself to fulfill the dedicated part of a project? If those questions and similar can be answered positively then the ethical issues would be practiced on and have concrete meaning during education, and not be seen as only preparing issues for a future profession.

APPROACHING THE CODE OF ETHICS IN A PROJECT BASED COURSE

Approaching the SE Code of Ethics at the previously mentioned course has been done in several steps, including signing a contract where students acknowledge the Code of Ethics. The form of the contract is presented further below. More precisely, the following steps have been followed:

1. The short form of Code of Ethics is introduced at one of the introductory lectures of the course
2. About the second week in the course the concept is covered one more time. Still, this time a contract should be signed by students, and handed in to the lecturer.
3. A couple of more weeks later the teacher introduces the longer form of the Code of Ethics. With this introduction follows a new contract sign. The main purpose behind this was to push the students further in ethical thinking, with more possible positive impact on their project work.
4. At the end of the course students take part of a course evaluation, covering the approach of introducing the Code of Ethics in the course.

Besides from this the Code has been discussed at the project meetings, and at the project presentations performed by the students. Below the steps presented above will be further discussed.

Introduction to the Code of Ethics

At the early lecture for introducing the Code of Ethics, it was also made clear that there were to be an experiment on this. This experiment, as well as previous experiments done in previous courses (see for instance [3]), were performed in the purpose of improving the working process. It should be voluntarily, and then not graded. The contract should be very easy and

uncomplicated in its nature, just following the points of the Code of Ethics, as presented in the section above, expressing one's own standpoint towards each of those points.

Furthermore, also the teacher should have an ethical perspective on this, not to force students to behave in ways they have agreed upon through a contract (forcing was not considered as an intension). Furthermore, the teacher should be careful in reproducing statements expressed by students. Because of that reason, and negotiation (which is interesting in itself) with the students, expressions following below are not exactly copied from their original statements, but should still be close enough to follow their original meaning.

First contract

The contract includes the points presented in Section 'The Code of Ethics', with space left for the students' comments on each of those. The comments should concern a student's standpoint towards those. Signing the contract then means that you are willing to meet what you have commented and behave according to that. The main intension behind this is to approach awareness on appropriate behavior in project work. Below examples on comments are provided.

Examples on comments,

1. **Public**: *-I believe a software engineer shall act in the public interest because product of software that she/he is making is used by the public. -Civilian security must be considered. –As more and more people are dealing with software it is extremely important to provide them with safety.*

2. **Client and Employer**: *-We should do our best to satisfy our client's requirement. -I believe in this modern age we are creating the dreams come true, so software engineers have to share everything with their clients and employers to make the future bright. –I think a software engineer should be true to his/her employer/client so that they together can fix a problem*

3. **Product**: *-Since software engineers are making software it is in his responsibility to have professional standards. -We will test our software while developing, to ensure that it meets the highest professional standards*. *–Ensuring the highest standard possible is important to sustain in the long run and compete with other software products.*

4. **Judgment**: *-A software engineering shall always maintain self-integrity and should be honest to his work. -If we did not maintain this we cannot make any creative and professional things. –Yes, software engineers shall maintain integrity and independence since it can provide better working environment*

5. **Management**: *-The manager has and should take greater responsibilities in promoting and maintaining an ethical approach in the process. - Yes, theoretically. –In managing it is equally important to be ethical as it is to be part of the process.*

6. **Profession**: *-Yes, if software engineers are not in line with the public interest they cannot keep interest of public. -Software engineers always have to have good reputation. –Yes, with good spirit of course*

7. **Colleagues**: *-Yes, in order to achieve big goals we need other people's help and their support to be successful. -It is a must otherwise a good project is not possible. –Yes, so the outcome can be highest*

8. **Self**: *-There is no end of learning, so I think it is obvious for them to participate in learning regarding the practice of their profession. -Software engineers really should keep learning and improving themselves. –Yes, learning ethics is practiced in every phase also.*

Especially interesting is here to see the that the comments of 7 and 8 meet up well with questions stated in section “ON THE CODE OF ETHICS”.

Second contract

The second contract was preceded by a presentation of the longer version of the Code of Ethics (see e.g., [1]). The reaction was generally that it seemed to be a too exhaustive approach, with a loose of interest to participate, as a result. From the lecturer’s point of view, however, it is still of interest, since the core of the experiment actually rather deals with quality of their project work. We will leave out students’ comment here, because of the space limitations.

Evaluation

As is common for courses, a course evaluation is performed in at the end of the course for reasons of course improvements. The course evaluation part concerning the Code of Ethics covered questions that should be vague and open enough, such as: *What are your opinions on the Code of Ethics? Is it necessary to have that to professional software engineers? Is it necessary to introduce that in education? How do you think that the introduction of the Code of Ethics has affected you?*

From a course of approximately 50 students there were 35 answering students. The answers show an overall very positive attitude towards the Code of Ethics. It didn’t seem to be any reason for any opposite approach. This concerns both the Code of Ethics as a professional standpoint and as an educational as well. Almost all answers show that clearly, such as:

-I feel that it is one of the main parts in SE, it is really important to know about this already in education. -You get to know how you work in real life by introducing this in education. -It has made me understand that you should respect each other’s opinion. -It is good to understand it as early as possible in education. -This has taught me that it is not only about code, it is so much more. -I think it should be introduced to programmers as soon as their work affects other people. - This made me realize how important our work is. -It is necessary for professional engineers to have a code of ethics, especially with today’s society being built on computers and technology. - It is important to introduce it during the education so we have time to reflect on it. -The code of ethics focus on social issues of organization, it influences team work and communication. It reduces fights inside the group. –I think the code of ethics is important and everyone should have them. But I don’t think one can educate by learning any particular topic but students can be motivated to be ethical, and I think this course helped us in some way. Etc.

When it comes to the more general comments on the course also they were overall positive. In some cases the course seemed to be confusing to start with, and they requested more explicit information. Still, a confusing start may from the lecturer’s point of view actually be motivated on the basis of need of practicing complex and unfamiliar systems. Comment on course, include:

-The course was good, looking forward to future courses with this quality. –It’s a good course for preparing students for real life work. –I love this course and learned a lot in this last project, and I think it will be useful in the future. –Overall I think it has been a great experience for me. –I really enjoyed the course, and feel I have learned a lot about myself. It was confusing to start but it improved.

OBSERVED RESULTS

At previous cases of the course it has been clearly pointed out by the lecturer that the students should support each other in their work. Even though attempts have been done to do that, and even though approaches have been introduced by the lecturer ([3]) to improve self-responsibility for the project, there have been some serious conflicts within the groups. Through the explicit introduction of the Code of Ethics, and especially point 7 of those, this attitude has been even more motivated, because of its professional correspondences to SE. What could be seen also from the lecturer (that is the author of this contribution) is that the atmosphere of the groups has been calmer and smoother than previous year. There still have been conflicts, but not even close to what was experienced before.

At the project meetings the Code of Ethics was discussed. It was most often brought up by the students themselves, and as a part of the documents handed in by students to those project meetings. In those documents, that acted as steering documents for the whole group, it was clearly stated that the Code of Ethics were supposed to be followed, and especially that they were to be supportive to each other (point 7). Also point 5 was emphasized, that is, there should be a supportive approach towards the project manager, since this is not an easy position to have.

At the final presentation day, all groups of the course managed to fulfill their tasks, which was not the case last year ([3]). When presenting their work, the Code of Ethics was again brought up as something important to follow, and then especially point 7.

To put things in more concrete terms:

- At the 2011 course, there were about 57 active students. At the final date of the course, 48 of those passed the part of the course concerning the working process and documentation. 9 of those had to make complementary work.
- At the 2012, there were about 48 active students. At the final day of the course every one of those fulfilled the part of the course concerning the working process and documentation.

Even more, one of the groups of the 2012 course seemed to be more careful about The Code of Ethics, putting that more clearly in the steering documents, and discussing more about that, then the other groups. That group also seemed to manage communication and cooperation better than the other groups. Moreover, the result when it comes to the product of the project was more stable, with more features, than the products of the other groups. The members of that project group also got the overall highest grade.

From the point of the course lecturer, the use of the Code of Ethics has had positive impact on the project work of the students. Questions pointed out have been answered positively. Moreover, covering the code from a SE professional point of view has furthermore motivated reflections on ethical behavior. A conclusion from the lecturer is therefore that the approach of using the Code of Ethics in this course, or other courses, should proceed also in the future.

RELATED WORK

The Swedish National Agency for Higher Education (HSV, [11]) has had as one of its main responsibilities to investigate and guarantee the quality of education of Swedish universities (that organization has however recently been split up into two parts; it is however outside the scope of this contribution to discuss that matter further). In 2012 and 2013 special focus has been on engineering programs, including Computer Science and SE. Among other things the

investigation illuminates on a set of learning outcomes. It is here especially interesting to see that amongst those learning outcomes *societal and ethical aspects* are especially pointed out. A conclusion from this should be that the study of ethical aspects and a higher grade of maturity as an effect of that is something that should be seen as important to engineering programs, which probably is in opposition to how it generally is commonly implemented in engineering education. Approaching the Code of Ethics in SE programs exist even though explicit examples seem to be rare. One example of this though can be seen in [4], where the concept is introduced already in an introductory SE course, as a way of emphasizing generic skills that industry expects from students. From those perspectives the efforts behind this contribution and its continuing work is seen as especially encouraging.

SUMMARY

Ethical points of views have been shown to be of interest from educational perspectives, such as from the Swedish National Agency of Higher Education, and from CDIO. Code of Ethics forms a standard for professional behavior; this is also the case for the Software Engineering Code of Ethics, where this code furthermore serves a purpose of maturing the field of Software Engineering in itself. The conclusion should therefore be that the Code of Ethics should be introduced within SE education for reasons of preparing students for a responsible and mature professional life.

Moreover, using the Code of Ethics within education, and then especially in project based courses, may have the impact that students improve skills concerning communication, supportive manners, and responsibilities concerning team work and product, and so on. An implication should then be improvements on results both when it comes to working process and product.

This contribution has discussed the introduction of the Code of Ethics in Software Engineering project courses. Students have reflected over this and contributed with their own approaches towards this. The experiment on that introduction has been performed at the third year of a bachelor level computer science program. While it certainly may be hard to draw clear conclusions according correlations between that experiment and result of course, observations show improvements on team work, and also on product.

Furthermore, students have shown to be positive towards the Code of Ethics, and the introduction at the courses. This concerns both for reasons of preparing them for their future careers, and for the benefits of project work. A final conclusion from the author of this contribution should therefore be that it is definitely worth the effort to continue with this approach also in future courses. Currently students' comments on the Code of Ethics have been handed in only for the lecturer to take part of. Yet another future approach would be to expose those (anonymously) to the student groups for those to even further reflect on the Code of Ethics.

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BIOGRAPHICAL INFORMATION

Daniel Einarson, has a PhD in Computer Science and has several years of experience in teaching Computer Science and Software Engineering. Furthermore, the author has been experimenting with several different forms of software process models as models for educational forms. Moreover, with inspiration from the CDIO initiative the author will strive after developing the educational forms for Software Engineering even further.

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