

Developments in the fields of Software Engineering

Professionalism, standards and best practice

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Abstract: Software Engineering needs to be seen as a professional discipline and for this to occur there needs to be both educational and professional infrastructures which reflect a true “engineering” ethos. A summary of recent movements in the fields of Software Engineering education and professionalism is given, followed by a more in-depth analysis of four particularly significant projects/activities: the project concerned with the Software Engineering Code of Ethics and Professional Practice, the Guide to the Software Engineering Body of Knowledge (SWEBOK) project, the Production of the Software Engineering volume as part of the CC2001 effort, and the work associated with the International Federation for Information Processing's proposals regarding the Harmonization of Professional Standards in information technology and how this relates to Software Engineering. Finally, conclusions are presented along with details of further work that needs to be undertaken.

Key words: curriculum, Higher Education, professionalism, Software Engineering, standards

THE KEY ROLE OF SOFTWARE ENGINEERING

In a world that is more and more dependent on Information Society Technologies there will be an expanding key role for Software Engineers. As stated in the documentation relating to priority thematic areas for research within the European Framework 6 initiative (FP6 ud): “Information society technologies (IST) are transforming the economy and society. Not only are they creating new ways of working and new types of business, but provide solutions to major societal challenges such as healthcare, environment, safety, mobility and have far reaching implications on our everyday life. The IST sector is now one of the most important of the economy, with an annual turnover of EUR 2000 billion, providing employment for more than 12 million people in Europe.”

Within the documentation the following needs are also highlighted:

- Technologies for trust and security;
- Addressing societal challenges;
- The development of a trusted knowledge based society;
- New computational models;
- The development of new technologies for software and systems that address composability, scalability, reliability and robustness.

All this indicates that there is a clear recognition that our future will depend on IST and that IST will have a major effect on citizens, business, and organisations. However, this recognition needs to be taken a stage further – there needs to be a realisation that such a future will depend on those who develop and deliver the systems based on IST and key amongst these will be Software Engineers. It must also be recognised that there continues to be major problems associated with many software projects. Too many projects are late, over budget and unpredictable. Often entire projects fail before ever delivering an application or, if completed, fail to deliver the required functionality. Also, in many instances when a product is delivered, the quality falls well below what should be expected from leading edge technologies. What is very clear from case study literature is that, whether one is concerned with product or process, a third vital ingredient is people. It is thus people rather than product or process that should be regarded as fundamental to the production of quality software. Other engineering disciplines, which may be considered analogous to that which supports software, have one prime feature with regard to staffing - that at the appropriate levels they have professional staff who are formally licensed or accredited as competent within their discipline. This is simply not the case within the software industry.

It is clear that Software Engineers will play a vital role in a world more and more dependent on IST. However, it is also clear that Software Engineering needs to be seen as a professional discipline - in line with other traditional branches of engineering. For this to occur there needs to be both educational and professional infrastructures and standards which reflect a true “engineering” ethos.

INTERNATIONAL MOVEMENTS TOWARDS SOFTWARE ENGINEERING PROFESSIONALISM

To support Software Engineering as a professional discipline there needs to be both educational and professional infrastructures along with appropriate standards that reflect a true “engineering” ethos. During recent years there has been some progress and clear indications that these areas are receiving higher priority. For instance:

- In 1999 and early 2000 a significant number of academic papers promoting areas related to Software Engineering professionalism started to appear in major computing journals. For example, much of the November/December 1999 issue of IEEE-CS Software and the May 2000 issue of IEEE-CS Computer were devoted to this.
- The IEEE Computer Society and the Association for Computer Machinery in 1998 created the IEEE-CS/ACM Software Engineering Coordinating Committee (SWECC) which was made responsible for co-ordinating, sponsoring and fostering all the various activities regarding Software Engineering within the IEEE-CS and ACM’s sphere of operation. This committee then progressed various projects to advance Software Engineering in areas such as standards of practice and ethics, body of knowledge, curriculum guidelines, and exam guidelines. However, in summer of 2000 this formal co-operation came to an end.
- The Texas Board of Professional Engineers in June 1998 enacted rules that recognised Software Engineering as a distinct engineering discipline plus legislation that enabled Professional Engineering licenses to be issued to software engineers in Texas. However, subsequent progress has been slow. The number of licences issued has been low and each has depended on examination wavers. Also, such a system of licensing has not yet been adopted by any other USA state.
- A joint task force on Software Engineering Ethics and Professional Practice (SEEPP), established by SWECC, has developed a Software Engineering Code of Ethics and Professional Practice. The code has been

- accepted by both the IEEE-CS and the ACM. In addition, many other national professional bodies for computing have reacted positively to it.
- The Guide to the Software Engineering Body of Knowledge (SWEBOK) project, which was also initiated by SWECC, has aimed at achieving a consensus view by the Software Engineering community on a core body of knowledge (BoK) for professionals within the Software Engineering discipline. The trial version of the guide that has resulted from the project has been actively promoted for public use and comment since early 2001.
 - In autumn 1998, the Association for Computing Machinery (ACM) and the Institute for Electrical and Electronic Engineers Computer Society (IEEE-CS) established a joint task force to undertake a project devoted to producing a new version of their curriculum guidelines for undergraduate programs in computing. The project was named Computing Curricula 2001 (CC2001) and the task force were directed to:
 - “To review the Joint ACM and IEEE/CS Computing Curricula 1991 and develop a revised and enhanced version for the year 2001 that will match the latest developments of computing technologies in the past decade and endure through the next decade.”
 - The early work within the curriculum project resulted in the task force deciding to divide the new Computing Curriculum 2001 (C2001) report into several volumes, each of which would focus on a particular computing discipline. One of these volumes will specifically address Software Engineering and it is expected after public review and feedback that this volume will be finalised early in 2004.
 - During the 1990s the International Federation for Information Processing (IFIP) were progressing a project on the Harmonisation and Acceptance of International Standards for IT Professionals, as it was believed that there was a need for rationalisation in this area. Also, the World Trade Organisation was promoting the view that, in an era of international treaties which promoted free trade and the free movement of workers from one country to another, the establishment of standards for the qualifications of professionals. In 1998 a draft standard entitled “Harmonisation of Professional Standards” was produced. This document set out the standards of tertiary education, experience or practice, ethics, and continuing education that a customer might expect from a practitioner offering services to the public. It was hoped that eventually the document could be developed to become a Standard in the sense of ISO. During the last three years a significant number of international activities have been undertaken to promote and evaluate IFIP’s harmonisation document with regards Software Engineering.
 - IEEE-CS has introduced a scheme to enable it to offer a Certified Software Development Professional designation to successful applicants.

The scheme has clearly been designed to support the society's efforts to establish Software Engineering profession. The professional certification being offered by IEEE-CS has three components: exam based testing demonstrating mastery of a Body of Knowledge, extensive experience base in the performance of the work or profession being certified, and continuing professional education. Details of the scheme are available on the web and also on a CD (CSDP, ud). The latter also contains reprints of related academic articles plus copies of Software Engineering Code of Ethics and Professional Practice and the SWEBOK Guide (Trial Version).

For an international community the most significant of the above probably are:

1. The project concerned with the Software Engineering Code of Ethics and Professional Practice,
2. Guide to the Software Engineering Body of Knowledge (SWEBOK) project,
3. The Production of the Software Engineering Volume as part of the CC2001 effort,
4. IFIP's proposals within its harmonisation document and their relevance to the Software Engineering profession.

Each of these will now be considered in turn.

SOFTWARE ENGINEERING CODE OF ETHICS AND PROFESSIONAL PRACTICE

The IEEE-CS/ACM Co-ordinating Committee (SWECC) has been responsible for the creation of a joint task force on Software Engineering Ethics and Professional Practice (SEEPP). This task force, under the chairmanship of Donald Gotterbarn of East Tennessee State University, has developed the Software Engineering Code of Ethics and Professional Practice. The code is available (SEEPP ud) in two forms: a short version which summarises aspirations at a high level of abstraction and a full version which includes additional clauses. The latter provide examples and details of how the aspirations of the code should change the way persons behave as Software Engineering professionals. Table 1. details the eight principles laid out in the short code.

The code has been accepted by both the IEEE-CS and the ACM, and other national professional bodies for computing have reacted positively to it. It has received publicity both at conferences and in international journals. Also there is currently more recognition that ethical issues are becoming

more and more important within computing. Nevertheless there have been some problems. The whole area of professionalism tends to be neglected by major parts of the software industry, which appears to be mesmerised with technological aspects to the detriment of human related areas and issues. There are also problems on how ethics education should be incorporated into the curricula and how it should be taught. Many believe that it needs to be fully integrated into all subjects and that positive guidance to ethical behaviour need to be in place in current software engineering courses starting in the early stages and running through the entire program.

Table 1. Principles in Software Engineering Code of Ethics and Professional Practice (SEEPP ud)

Area	Principles
1. PUBLIC	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 judgement.
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 GUIDE TO THE SOFTWARE ENGINEERING BODY OF KNOWLEDGE PROJECT

The SWEBOK project, which resulted from the co-operation between the IEEE-CS and ACM on Software Engineering, is aimed at achieving a consensus view by the Software Engineering community on a core body of knowledge (BoK) for professionals in the Software Engineering discipline. The project is being run from the University of Quebec in Montreal and it is taking a three-phased approach similar to that adopted for the development of the Ada programming language, consisting of Straw Man, Stone Man, and Iron Man phases. Full details of the project and its development can be found on the project's web site (SWEBOK ud). The results of the Straw Man phase were published in September 1998 and defined the project's strategy and rationale. During April 2000 a more or less finalised edition of the Stone Man Version of the Guide (version 0.7) was released on the project's web site. This was then further refined and renamed as the Trial Version (version 0.9) which was then promoted for public use (the name was amended so that users would not incorrectly assume that the contents have been "set in stone"). In April 2001 the Industrial Advisory Board for the project approved field trials for the Guide for a two-year period. During this time the members of the project team have been very active in promoting the Guide which has been made available both as a hard copy international publication and a free download from the project site. A request for formal reviews on the use and content of the Trail Version of the guide was announced in May 2003. Once these have been analysed the results will then feed into the third stage of the project.

The SWEBOK project represents a very systematic piece of work that has attempted a broad and international approach in its reviewing process. Although the production timescales are rather long it should finally produce an authoritative and accepted BoK for the discipline. Of particular note is that the whole of the reviewing process has been visible and is available on the project's web site. Although the BoK is not yet in its final form the work accomplished so far can be used to support the teaching within the discipline. The Guide certainly is a very useful resource for both staff and students at undergraduate and graduate levels. Also, the reviews themselves can be used to demonstrate to students the disparate views that exist across the community. However, these very positive features also have a downside. Clear difficulties with SWEBOK arise because of it being an extremely large and complex project with a rather long timetable. It is also likely that it suffered from insufficient publicity on an international level during the earlier stages, though that does appear to have improved over the last four

years, where there has been a clear effort to publicise it at relevant international conferences and in journals. In addition, a close inspection of the contents of the trial version of the guide shows what could be regarded as a USA, or at least a North American continental, bias within parts of it.

SOFTWARE ENGINEERING VOLUME OF CC2001

To progress the work on the Software Engineering volume for undergraduate curricula (known as CC2001 Software Engineering or simply CCSE) there is a joint ACM and IEEE-CS initiative supported by the four groups of volunteers detailed in table 2. Also, a CCSE web site (CCSE, ud) has been established to support the project and document progress. The CCSE documents have been posted there as and when the various working groups have produced them.

Table 2. Volunteer groups supporting CCSE

Group	Responsibilities
1. Steering Committee	The organisation and co-ordination of the development of CCSE.
2. Advisory Board	Advice and links with external bodies.
3. Education Knowledge Area Group	Defining and documenting a Software Engineering body of knowledge which is known as the Software Engineering Education Knowledge (SEEK). This body of knowledge is seen as being specific to the development of undergraduate Software Engineering curricula.
4. Pedagogy Focus Group	Using the SEEK in the development of undergraduate Software Engineering curricula and the definition of undergraduate Software Engineering courses/programmes. It will also consider and advise on appropriate Software Engineering pedagogy.

In the development of the volume, extensive use has been made of external reviewing by both the general Software Engineering community and by international experts in the field. Also, a number of open events have been held at international conferences to assist in the development of the volume. Notable of these have been:

1. A workshop which was held on 25th February 2002 at the Fifteenth Conference on Software Engineering Education and Training (CSEE&T 2002), in Covington, Kentucky. (Thompson and Edwards, 2002).

2. An International Summit on Software Engineering Education (SSEE) which was held on Tuesday 21st May 2002 and was co-located with the 24th IEEE-CS/ACM International Conference on Software Engineering (ICSE2002), in Orlando, Florida. (Thompson et al, 2004).
3. A second International Summit on Software Engineering Education (SSEE II) which was held on Monday 5th May 2003 and was co-located with the 25th IEEE-CS/ACM International Conference on Software Engineering (ICSE2003), in Portland, Oregon (Thompson and Edwards, 2003).

The project is naturally large, complex, and has an expected life of 10 years or more. Progress at times has been slow at times. However, a first public draft of the Software Engineering Volume was released for public review this August via the public web site. Since then the steering committee have been actively soliciting reviews and it is hoped that the Volume should be finalised by the end of the year for publication early in 2004. In the current draft the main chapters cover:

- Guiding principles;
- The Software Engineering Discipline;
- Overview of Software Engineering Education Knowledge (SEEK);
- Guidelines for Software Engineering Curriculum Design and Delivery;
- Courses and Course Sequences.

A clear reason why the development of CCSE has been somewhat slow is that across North American Universities there are still relatively few Software Engineering programmes in comparison to the surfeit of Computer Science programs. This is simply not the case in other countries. For example, in the UK in 2002 there were at least 50 higher education institutions offering Software Engineering as a single subject degree (Edwards et al. 2003). The lack of a wide base of existing programs in North America has tended to make the developers of parts of the volume somewhat cautious in their proposals and there has a clear wish to do much from “first principles” rather than take a more “engineering” approach of “improving what already exists”. In the development of the volume there have also been issues regarding what actually constitutes undergraduate education. One major issue that became very clear during the SSEE summit in Orlando was that there were two very differing viewpoints with regard to this level of education. One viewpoint was that such education is primarily about knowledge and the other was that understanding and ability should be regarded more highly.

With an expected lifetime for the volume of some 10 years there will need to be mechanisms in place that will ensure, as far as is possible, that any developed curricula remain reasonably current. Also there will be

ongoing issues about addressing different modes of learning and delivery as in many parts of the world, within the next 10 years, traditional classroom delivery may no longer be the norm.

IFIP PROFESSIONAL STANDARDS INITIATIVE

In 1998 a working party within Technical Committee 3 (TC3) of IFIP produced a draft document concerned with the “Harmonisation of Professional Standards” (a copy of which can be found with the record of meetings on IFIP’s site and within the publications listed later in this section). The draft standard was presented in August 1999 at the overall TC3 committee meeting in Irvine, USA and at the TC3 WG3.4 seminar held in Baltimore, USA. In the draft, introductory sections explain the overall purpose of the work, why professional standards are needed, to whom the standard will apply and clarifications concerning the terminology used. The main part of the standard then addresses the following areas, all of which are obviously relevant to Software Engineering:

- Ethics of professional practice,
- Established body of knowledge,
- Education and training,
- Professional experience,
- Best practice and proven methodologies and
- Maintenance of competence.

The IFIP harmonisation document does represent a very high level view of what is needed, nevertheless, it is very sensitive to the many complex issues that exist in the area of professionalism. It thus can provide a useful framework for further work regarding Software Engineering professionalism also it has positive attributes in that it was developed with international use as a major goal. Over the last three years conference presentations, panel sessions, participative workshops and summit meetings have been used to promote the harmonisation document within the Software Engineering arena. Of note are:

- A workshop which was held at the 2001 Conference on Software Engineering Education and Training (CSEE&T) in Charlotte, North Carolina in February 2001. (Thompson and Edwards, 2001).
- A full day workshop which was held during the 2001 International Conference on Software Engineering (ICSE) in Toronto in May 2001. (Thompson, 2001).

- A full day summit which was co-located with the 2002 International Conference on Software Engineering (ICSE) in Orlando in May 2002. (Thompson and Edwards, 2004).

The major conclusions from these activities have been:

- That there is a need for structures to support Software Engineering professionalism and that there is a need for harmonisation.
- That the IFIP document draft is a positive step and that it can be used as a framework or meta-model for Software Engineering professionalism. However, more work needs to be done on it at a detailed level.
- That the Software Engineering Code of Ethics and Professional Practice and the Guide to the Software Engineering Body of Knowledge (SWEBOK) can be seen to satisfy the first two areas highlighted in the IFIP document.
- That public safety is a fundamental driver towards professionalism. The view was expressed that one day something really major will go wrong and it will be the subsequent legislation produced by countries/states/provinces that will provide the impetus for professionalism.

CONCLUSIONS

Much of the work that has been done under the auspices of IEEE-CS and ACM high standard and it should be carried on at an international level. Software Engineering is a discipline that must operate at a global level. Other engineering disciplines such as Mechanical Engineering (which shaped the 19th century) or Electrical Engineering (which shaped the 20th century) to a great extent developed and operated within domains defined by nation states or, at least, continental boundaries. Software Engineering is different to these older disciplines in that it must be viewed in a wider context. Already we have situations where, for example, software can be specified in the USA, developed in India, and then used globally on the Internet. It is thus of paramount importance that the discipline is viewed at a global level rather than at just at the continental or national level. However, there often appears to be a lack of will or even interest in professionalism within a significant element of the community itself and in addition incompatibilities in academic and professional standards tend to act against any global harmonisation of the discipline.

Nevertheless, the IFIP report on the Harmonisation of Professional Standards should encourage international co-operation within all computing disciplines including Software Engineering. Also the very nature of the IFIP

committees ensures that it has, and will be, considered at an international level and hence can not be judged to represent the view of only one sector or country. The harmonisation document essentially defines a framework, which should truly assist advancing Professional Standards if it is used in a sensitive and appropriate manner. If we consider the six areas addressed in the IFIP document and the ACM/IEEE-CS supported projects discussed in this paper we can see that there has been some real progress in the fields of Software Engineering education and professionalism. In particular:

- The ethics of professional practice is supported by the Software Engineering Code of Ethics and Professional Practice.
- An established body of knowledge is provided by the Guide to the Software Engineering Body of Knowledge (SWEBOK) and also by the Software Engineering Education Knowledge (SEEK) defined in the CCSE Volume.
- Education and training needs are supported by the CCSE Volume though this is primarily directed at education.

Yet, there is much that still needs to be done with regard to:

- Professional experience and training
- Best practice and proven methodologies
- Maintenance of competence

Therefore it is planned that to address issues in these areas a further workshop/summit will be held at the IFIP 2004 World Computer Congress in Toulouse during August 2004. It is hoped that such an event will enable opinions to be formed on:

- What are the key steps in a career in Software Engineering and other branches of computing?
- What education and training are really needed?
- How should professional behaviour be regulated?
- How is competence maintained and certified?

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BIOGRAPHY

J. Barrie Thompson is currently professor in Applied Software Engineering, School of Computing and Technology of the University of Sunderland, United Kingdom. He is interested in educational, professional and ethical aspects associated with area of Software Engineering. He promotes development of innovative teaching approaches which are relevant to the needs of industry and promote technology transfer. He is a member of the Steering Committee which is overseeing a joint task force of the IEEE Computer Society and the ACM who are currently engaged in producing the Software Engineering Volume of an International Curricula for Computing. He also is vice-chair of IFIP Working Group 3.4 (Professional and Vocational Education and Training). The International Federation for Information Processing (IFIP) is a body which aims to co-ordinate the various facets of computing/information processing across the world. IFIP has an infrastructure of Technical Committees (TCs), each of which has a number of Working Groups (WGs). TC-3 is concerned with computers in education. Within this, W.G. 3.4 is a Working Group whose brief is education and training for IT professionals and advanced end-users.

REFERENCES AND SOURCES OF FURTHER INFORMATION

CCSE, *Computing Curricula Software Engineering: the Software Engineering volume of CC2001*, information is available from the project's web site: <http://sites.computer.org/ccse/>

CSDP, IEEE Computer Society Certified Software Development Professional, Web Site: <http://computer.org/certification> . Support CD: *Developing Software Engineering as a Profession*, Published by Institute of Electrical and Electronic Engineers, Inc, ISBN 0-7695-1899-0.

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IFIP International Federation for Information Processing information available from web site: <http://www.ifip.or.at>

SEEPP Project concerned with the Software Engineering Code of Ethics and Professional Practice. Details of this are available at the following Web Sites: <http://computer.org/tab/seprof/code.htm> , and <http://computer.org/tab/sweec/SWCEPP>

SWEBOK, Software Engineering Body of Knowledge Project , Web Site is at: <http://www.swebok.org>

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