Entraining students in Professional Issues: challenging their structures of knowledge

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The Problem

Teaching within Computer Science (CS) has traditionally been accomplished by the delivery of a large quantity of knowledge-based lectures supplemented with practical laboratory sessions, reinforced with individual and (some) group-based practical work. This pedagogic pattern is not confined to CS, but is common across cognate disciplines [Hativa]: mastery of facts, presented in incremental stages, from simple to complex, each stage building on the last, is the common paradigm for teaching.

Whilst this lecture-based pattern guarantees the efficient presentation of material, it frequently does not address other learning issues; for example, learner autonomy and synthesis of knowledge [van Heuvelen]. This is a particularly potent question for CS where the vast majority of our graduates will take employment in the discipline after graduation. This means that we must aim not only to equip them with a coherent corpus of material, but also to have them acquire particular practitioner-skills throughout their undergraduate career

Professional software engineers are exposed during their careers to many more problems than the strictly technical. These will occasionally be large-scale, such as taking an ethical stand on the use of systems they develop, but more often they will be small-scale and personal, connected with their responsibilities to other groups and stakeholders in the systems they develop. Many of the problems that they will have to face will be personal, some will be connected with (e.g.) the legal and regulatory framework within which they operate. It is the clear responsibility of educators to prepare their students to deal with such problems, not only in terms of an understanding of society's (formal and informal) expectations, but also by giving them the intellectual and learning capabilities to examine issues and formulate responses. This area of the syllabus has become known as "computer ethics", "social issues" or "professional issues", often depending on the perspective from which it has been taught and might be expected to cover. Typically, it will include (as well as technical standards and competence in their application):

?? Adherence to standards of integrity and impartiality, and to codes of conduct and practice.
?? Ethical considerations and the public good.
?? General and specific law (business law, personal and professional liability and technical statutes).
?? Duties to clients, employers, employees and the public.
?? The roles of the relevant professional bodies.

Although some of our students have direct experience of such issues, mainly due to prior commercial experience (and are thus of immense value in grounding discussions), the majority lack both the domain knowledge and the understanding of the constraints of professional practice which would allow them to recognise the relevance of these issues. In practice, they perceive the major problem of systems development (in Ralph Johnson's coinage) as the fight against the compiler, rather than a professional or ethical activity. This perception has an impact on the ways in which professional issues can usefully be taught.

Common Problems and Common Solutions

Three methods for teaching professional issues have been identified [Gotterbarn]:

?? Introductory (survey based) dedicated courses

?? Integrating the discussion of relevant issues into all courses, as and where appropriate

?? An in-depth course given late in the programme

Independent of these methods, three distinct "levels" (approaches to the material) have been identified [Bynum]:

?? "pop"—where teaching is based around popular conceptions and reports of the issue, with little attempt to set them in a more formal context

?? "para"—similar sources are utilised, but parallels are drawn between them, and themes and attitudes are drawn out

?? "theoretical"—where the tools, techniques and theories of ethical philosophy are used to address the particular relevant issues

Using these characterisations as a framework, we can examine common approaches, together with the problems they address and create.

Student inexperience

Students, in general, lack the domain knowledge and professional experience to relate ethical material to their perception of what it means to practice software development. This causes them difficulty in relating "stand alone" material, at whatever level, to what they are being asked to do in the rest of their courses.

Students' perspective of the discipline

Especially at the outset of their programme, students have a narrow (yet firmly held) idea of what constitutes "computer science". This leads them to reject material which they perceive to be peripheral to their concerns, and makes the teaching of "theoretical" ethics courses problematic, doubly so if they are taught by staff from outside the discipline. This may especially be a problem in the UK, where degree courses are specialised from the outset, rather than having the more general freshman year typical of degrees in other countries.

Institutions' perspective of the topic

A number of institutions teach professional issues as a separate component, either within early parts of the degree, or as part of a "senior level" group software engineering project (Gotterbarn, *op cit.*). Although we can see the benefits of Gotterbarn's "capstone" approach, we agree with Bynum (*op cit.*) that leaving professional issues until so late in the programme can encourage students to view it as a peripheral, or as educational after-thoughts.

Conversely, teaching professional issues through a separate course, and using traditional lecture-based delivery (especially in the "para" and "theoretical" models), can lead students to believe that such issues are purely of academic interest, a view which is permitted by the lack of experience of many students in "real world" situations, a problem only partially addressed by even group-based undergraduate software engineering projects.

Evidence of comprehensiveness and comprehension

In the UK, as elsewhere, the relevant professional bodies (the British Computer Society and the Institution of Electrical Engineers) require that professional issues are addressed in courses which they accredit, and successful completion of such a course is (*inter alia*) a pre-requisite for the granting of professional status (as a Chartered Engineer), although this is not yet the passport to practice which it is in other engineering disciplines. Not only do they require that it is covered, but also (in common with CSAC/CSAB in the USA) they require that it be mandatory (rather than elective), visible in the published syllabus, and comprehensively assessed [BCS].

Integration of professional issues treatment across the curriculum can be an effective method of grounding students' understanding, but is unlikely to satisfy the accrediting bodies as to completeness of coverage or of assessment. Without substantial co-ordination [GotterbarnB], it can also degenerate into a purely negative "pop" approach, with insufficient depth of understanding imparted, and with students not being required to reflect on the material presented. As Bynum (*op cit.*) observes, such material is rarely perceived by staff to be central to the course in which it is being presented, which makes it a first casualty of time pressure

Overloading in project-work

The use of project work (for instance Gotterbarn's "capstone" approach) to introduce ethical issues can lead to overloading of the curriculum. Projects are high-cost (not least in terms of student effort), and are typically used to introduce students to problems of software scale, management and lifecycle techniques and so on. Adding ethical and professional dilemmas to such projects can cause panic.

An obvious extension of this technique is to use industrial placements to address professional issues. These are, after all, where the real problems occur. Asking students returning from such placements to reflect on any ethical or professional issues they encountered is clearly effective, but assessment of their responses is difficult without (potentially inaccessible) knowledge of the circumstances pertaining within their placement organisation, and it is not practical (or even ethical) to require such organisations to provide opportunities to test a student's resolve!

Case studies

Much use has been made of Case Studies in the teaching of professional issues, mainly in the form made popular by "RISKS" pieces, or of "scare stories" from professional sources and the popular press (for example the Ariane 5 booster failure and the London Ambulance Service's routing system). The negative nature of many reported incidents, and the lack of detail released due to commercial or legal pressures, makes many such case studies simplistic, and allows students to reach trivial conclusions ("they should have done more testing", "they should have used a more experienced contractor"), which would be much less obvious without the benefit of hindsight and media trivialisation.

In order to address these problems, many fictional (or factional) case studies have been generated, allowing details to be filled in and cut-and-dried issues to be clouded over in the interests of provoking debates and multiple interpretations. While these can be highly successful, they require an enormous amount of preparation (relative to delivery) if they are to be non-trivial.

Regardless of the source of the case study, there is a tendency for them to contain over-dramatic content, leading students to perceive them either as fantasy, or as something that couldn't possibly happen to them. This unusual form of presentation of material (rarely encountered elsewhere in the curriculum), marks it out as separate from the rest of students' studies, and can discourage them from integrating the substantive issues within the context of the rest of their programme of study.

Local Conditions

Accepting that the "integrated" approach to teaching these professional and ethical issues was unlikely to give (identifiably) comprehensive coverage, we took the decision to place the material within the core second-level Software Engineering course, taken by all students on Computer Science and related degree programmes. The overall aims of this course are to build upon first-level Information Systems and Software Design and Implementation courses, introducing issues of scale and group working which are crucial in the development of professional software engineering practitioners.

This course has two major strands: the use of Formal Methods in the specification and design of software, and techniques for producing large-scale software systems (project lifecycles and their costs and management, quality assurance, risk analysis and so on). The strands were already supported by an extensive piece of group-based practical work (a process-centred design and implementation exercise) which would be the students' first exposure to "large" scale development work within their degree programme. It was clear that a suitably wide-ranging case study could be used to provide a framework for professional and ethical issues teaching, to introduce group working and to ground the software engineering issues being discussed in a more "realistic" setting. Our specific aims for the teaching of professional and ethical issues in this setting was to require students to address in a controllable fashion the problems occurring at the intersection of the Professional, Political and Personal worlds (PPP). Whilst some of this would happen without our intervention, as a result of the group software development exercise, we had to consider how to design the remaining structure and content of the course to realise these learning aims.

Theoretical Basis & Implementation

Given the particular (and, perhaps, in some senses, peculiar) learning objectives we had for this course, it was quite clear that these could not be achieved with a lecture-based format. As we considered the problem more deeply, it became clear that it was not only the format of the presentation that would have to change, but also the conceptual framework of the knowledge base. Many authors have noticed and detailed the different approaches and styles which "scientific" and "humanities" students bring to their studies; some suggest that students choose subjects because of this pre-disposing cast of mind [Hudson, Pirsig]. However, we were particularly struck by the characterisation of Bruner [Bruner] who extends this concept to embrace the constructivist view that such differences are not only localised in individuals, but are also reflected in the fundamental way in which knowledge is structured. For our purposes, the constructivist viewpoint seemed particularly valid.

The examples he uses (because they are extreme) are Physics and Literature and he characterises the views they represent as "logico-paradigmatic" and "narrative". Logico-paradigmatic subjects can always (at some stage must always) be tested against some reality or real world event; they can always be verified in some way. This is a world-view that is familiar and comfortable for CS students. At a basic level a program works or doesn't and feedback is immediate and absolute. They get satisfaction from building something that works (later on from building something *elegant* that works *well*) and get frustrated with failure. If it doesn't work, it's wrong; and (equally depressing) if it does work, it's right.

Narrative subjects, on the other hand, can not be falsified. They have a different quality of truth. A story is never wrong. No combinations of events, however unusual or unlikely to exist "in the world" are forbidden. Right and wrong become concepts of a different order and can be interpreted differently by those with different life experiences. This was the world we wished our students to learn in. Consequently, we had to construct a suitable environment. Bruner identifies several constituents of a "narrative" approach: plot, tension and character being the most important. Because these are everyday terms it can be difficult to comprehend that they have technical meaning. However, Bruner's ideas have been operationalised, in the teaching of children (in a range of ages from pre-school to 15) in what has become known as the "Storyline Method" [Cresswell], and we looked to see if these could be adapted in a different teaching context.

In Storyline, teachers construct a setting and, collaboratively, students and teachers create and populate the story, covering all curricular areas. They certainly write pieces of the story, but they may also make pictures or sculptures of the characters, build scale models of the buildings and villages they live in, devise audio or video tapes of activities, and so on. The key features of the success of this approach are that the story (plot) is the backbone, which builds and develops over a long period of time (from 6 weeks to 6 months) and, as the children collaborate in its development, their collective ownership increases interest and sustains motivation.

Plot We wanted to make this approach acceptable for tertiary-level students. We did not feel capable of co-creating a narrative with them (or, indeed, painting murals of the characters), but in this we were fortunate in that there were already case-study materials available. We chose the most fictional and most narrative of these: The Case of the Killer Robot [Epstein]. This contained enough material for us to release one "instalment" per week for 10 weeks, and so build the story over an entire term; this provided us with the essential element of plot. Having presented them with a narrative, however, we could not require them to respond in a logico-paradigmatic form - a quiz or an examination of the principles against philosophical ethical stances. Consequently, we required them to submit a 300-word piece each week that would build to their own narrative response over time.

Character However, we did not want them to respond as themselves. In our aim to get them to internalise the issues, if they responded to a story as 2nd year Computer Scientists they could cognitively distance themselves and deny the truth as it was developing for them. If we required them to participate more closely in the story, they would (we believed) apprehend the issues more acutely. (And, after all, many of them spend nights as Nintendo Warriors, so taking on a persona was not new to them.) Consequently, to engage them in the narrative tension, we required a narrative voice from each group, by allocating them a "viewpoint" from which to write their pieces. The viewpoints we allocated were: Programmers; Managers of the programmers; Corporate Silicon Techtronics (the company who wrote the errant software for the robot); Robotics Inc. (the company who bought the robot); Lawyers; Insurers; ACM; the Public; Newspapers; the community of peers of the programmers (i.e. programmers not working for Silicon Techtronics, but who might be expected to be aware of, and interested in, the incident and its' context.)

These viewpoints provided the basis for their written work, but we could not expect them to be self-motivated enough to persevere with only written interaction over 10 weeks. Following from Bruner's characterisation of the classroom as a forum for the collaborative construction of knowledge and his concentration on the language of education "Language necessarily imposes a perspective in which things are viewed and a stance toward what we view. It is not just, in the shop-worn phrase, that the medium is the message. The message itself may create the reality that the message embodies and predispose those who hear it to think about it in a particular mode" (Bruner, p.121) we realised that we could not avoid the issue of teacher interaction.

Consequently, we held a moot (in a lecture-slot and therefore a lecture theatre) every other week. This was an open forum for discussion of the issues of the case and was facilitated by one of the authors. Anyone could contribute (and anyone might be called on to contribute) but all had to hold to the viewpoint that was allocated to them.

Tension Finally, we had to consider assessment. We decided to admit a single assessment criterion "The development of thought over time". In this way, although written feedback was given on each weekly submission, no mark was awarded until the completion of the entire term's work, requiring them to continually engage with the "plot" until the very end. They could not judge whether they were "right" or "wrong", just if they were approaching the material in an appropriate manner. By using this method we required them to consider and create tension.

Outcomes, Successes & Failures

Outcomes

It is difficult to know if we achieved what we set out to do. We do not know how to measure internalisation of PPP; the "tests" will be in their lives and professional careers. However, it is clear that we have created a learning experience quite outside of that which they usually experience in University. Many of them dislike this intensely. This dislike manifests itself in two main ways.

Firstly there is the proportion (initially large) who simply say: "We don't know what to do" "Tell us what to do" "What do you want" and "What is your marking scheme" In a more targeted form, these criticisms are often about "We don't know who we are", reflecting their lack of knowledge of their viewpoint. These complaints are routinely deflected with repetitions of the criterion and detailed verbal (as well as written) feedback on their pieces. They *are* told what to do, but never told *how* to do it. This is unusual and difficult for them.

Secondly, there is a (small) proportion that reject the entire approach with phrases like "You can't mark CS courses with a humanities marking scheme" and "You're a humanities lecturer" (meant pejoratively:). Unfortunately, in rejecting the approach, and in expending energy rejecting it, they omit or reject the content of the course, too. Those who cannot come to terms with the course in this way, but do not perceive it as a disciplinary difference often over-identify the approach with an individual and compartmentalise it as a matter of style. Of course, there is truth in this.

Successes

As with the children in Storyline, motivation is very high, and often manifested in ways similar to those encouraged in the younger children. Some groups of students spent money on T-shirts for their group, many spent hours producing a "house style" for their submissions. Equally, their engagement with character was often surprising: one group created Alex Kidd, a long-time subscriber to `alt.conspiracy` who devised his own (extensive) series of web pages, which contained (artfully acquired) pictures of members of staff who he wove into the narrative. However, and perhaps most gratifying, their engagement with issues was excellent. This was helped in the first year of the life of the course by one group "whistle-blowing" on other groups who had found the complete archive of material on the web and were downloading it to "read ahead". Consequently, one of the early moots was devoted to an issue that had immediate PPP impact on them. So successful was this in engaging the students on several levels that, subsequently without evidence, the accusation of cheating has been repeated year-on-year.

Other less comfortable successes have been students' involvement with the staff on a personal basis. In the moots, the challenge has never been one-way, and often the facilitator has been asked to take a stance, or relate their own PPP incidents, in a way unusual in the higher education lecture.

Failures

One of the most serious problems has been the "vertical" transmission of knowledge. Because second year students talk about it often and freely, knowledge of the content and approach filters down to the first year. They therefore come armed and prepared against the unusual, committed to amused tolerance rather than active engagement. This attitude does not prevail for many weeks, but has forced us to think about adopting/creating a second scenario, to use in alternate years. In some cases this problem is more extreme, as with a group allocated a particular viewpoint going and asking the previous year what approach to take.

The method has not worked for all. Some groups never worked together effectively and this became a barrier to engagement. In some cases this was a cultural problem - because the groups were self-selected they often split along national or racial lines and this compounded their traditional expectations of the educative experience.

It may be that our failures denote unavoidable hazards of the constructivist classroom. Despite them, we think that the risk is worth taking.

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