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Publication date:
2008

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Jamison, A., & Holgaard, J. E. (2008). *The cultural appropriation of contextual knowledge*. Paper presented at Engineering Education in Sustainable Development 2008. Bridging the Gap, Graz, Austria.

The cultural appropriation of contextual knowledge

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1. Introduction – Changing contexts of science and engineering

Whether we characterize it as a new “mode” of knowledge production (Gibbons et al 1994) or as a new kind of “triple helix” linking the state, universities and private corporations, there can be little question that major changes have taken place in recent decades in what might be termed the societal contexts of science and engineering (Hård and Jamison 2005).

On the one hand, at a macro, or discursive level, societal support for science and engineering has come to be justified in ever more explicitly economic terms, as it is increasingly recognized that economic growth and prosperity have come to be based on the development of products derived from scientific and engineering research. On the other hand, at a micro, or practitioner level, universities, where scientists and engineers are educated, have largely come to be transformed into places for doing business. What were once, at least in part, characterized by academic “freedom” and a spirit of “community” have become dominated by procedures and values taken from the business world, at the same as the links between universities and private companies have become ever more intensified.

This commercialization of science and engineering has obviously had a significant effecton the knowledge that is made, or produced b scientists and engineers, but the effects of commercialization are seldom addressed within science and engineering education and educational research. Our aim in this paper is to discuss some of the difficulties involved in bringing an understanding of these contextual changes into the education of scientists and engineers. We characterize three ideal-typical strategies of cultural appropriation of contextual knowledge that are based on our experience at Aalborg University in Denmark, where we have been part of a group charged with teaching contextual knowledge for all first-year students in science and engineering. Each strategy, we suggest, has different implications for education for sustainability, but it has proved far from easy to strike a meaningful balance between them.

2. PBL and contextual knowledge at Aalborg University

For more than 30 years, Aalborg University in Denmark has educated scientists and engineers by using a problem and project oriented approach, based on project work in teams, which has been characterized as a kind of interactive learning, and, with reference to Klafki (1985), exemplarity. Exemplarity means that the students by means of experiences working with a situated case are able to reflect upon conceptual and methodological frameworks and at the same time are able to work with a more comprehensive approach to understanding their field of study which also takes account of ethical dimensions.

The students work in groups for some 50 percent of their time preparing a problem-based project, as the philosophy is to align the education as much as possible to their future professional practice. It is recognised in the curriculum that engineering competence embraces both technical and contextual knowledge; however for most engineering programs the teaching in what we have termed contextual knowledge only takes place during the first two semesters where there is emphasis on a problem analysis and technological assessment that goes beyond purely technical considerations.

The students work in project groups of some 4-8 students during 3-4 months each semester, and they document their work in a report (approx. 80-100 pages). The students are in most cases presented with a range of project proposals at the beginning of the semester, but the problem formulation and project design is student directed. The problem which calls for a technical solution is contextualised first of all through a problem analysis where the students discuss the different components of a problem, including social aspects, and outline technological alternatives for solving the problem, as well as the societal factors and barriers for achieving the solution. After the solution has been designed, the consequences and potential of the technological solution are assessed.

The learning outcomes at the school of basic studies are thus meant to be threefold, including both technical, processual and contextual knowledge. At the first two semesters the students prepare a 7-15 ECTS project with the help of two supervisors. One supervisor, the so-called main supervisor, has the responsibility for the technical learning outcomes, whereas the so-called co-supervisor has a responsibility for the contextual learning outcomes.

The responsibility for facilitating process competencies is shared. The main supervisor is a natural scientist or an engineer. This might also be the case for the co-supervisor although a humanist or social science background is more common, although the orientation of the co-supervisors is quite varied. Furthermore, the students also have different educational backgrounds when entering university life. Some of the students are educated at the general gymnasium where analytical skills are emphasised within a broad field of subjects, whereas the technical gymnasium emphasise process and methodological skills related to technological innovation.

The 7-15 ECTS projects are supported by courses related to the three distinct areas of learning outcomes, which are evaluated at an individual oral exam with their point of departure in group based project documentation. By integrating course curriculum into the problem based project the students show their ability to use the course material, transfer it into a new contextual frame, argue for its relevance and combine knowledge from different courses into more comprehensive analytical frameworks. Besides this project examination however, they have single course exams in selected courses that are considered fundamental to their engineering education as for example mathematics and computer programming.

The 2 ECTS course Technology, Humanity and Society (THS) is provided to support the integration of contextual knowledge into the project work. The objective of the course is to provide engineering students with an understanding of the interplay between their technical field and the context in which their particular technical “solution” is to be implemented. The goals of the course content are threefold. First of all, the students are introduced to different contextual approaches to engineering. Secondly, different methods to analyse problems and assess the consequences of potential technological solutions are provided. And finally, the students are made familiar with some of the specific contextual factors related to technological development. Among those contextual factors are the rather comprehensive matters of resource exploitation, social responsibility, political processes and cultural adaptation. Figure 1 outlines the THS course in more detail.

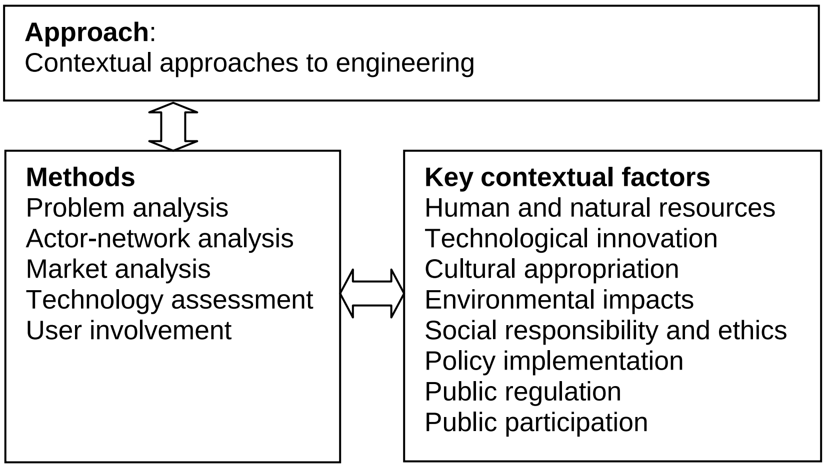

Figure 1: Outline of the course in Technology, Humanity and Society.

In specific relation to engineering education for sustainable development the TMS course provides a framework for contextualising a specific technical solution in the project oriented setting, by allowing the students to experience the need to address such issues as environmental regulation, eco-design, environmental impact assessment and social responsibility in relation to a specific technology. The philosophy is that they thereby become more likely to consider the social and environmental aspects as an integrated part of their professional identity and thereby consider the learning meaningful. In this way the curriculum tries to explore what Gough & Scott (2007) characterize as “the possibility for higher education to produce educated, innovative, independent, self-determining, critical individuals while at the same time achieving wider political goals”.

3. Strategies for contextualising science and technology

What we have experienced in our teaching and coordination of the teaching activities related to contextual knowledge is that among supervisors as well as students there are different motivations and approaches to contextualise the technical problems and solutions; in other words there is a kind of tension between different strategies for contextualising science and technology. These strategies can at best be viewed as a way of differentiating contextual knowledge in different engineering projects, but the co-existence of the different strategies also causes problems. First of all, there is a risk that the supervisors differ in their views to an extent where the students do not grasp the interconnections between the technical and the contextual parts of their projects, but instead see the different approaches as competing, and where they have to choose, so to speak, which chair to sit on, so as not to fall between two chairs. Another risk is that the supervisors, although they might agree on the necessity of contextual knowledge emphasise their own approach in an exclusive fashion and thus serve to deprive the students of adequate orientation in the range of approaches.

On the basis of our experience at Aalborg University, we have distinguished three strategies for contextualisation that are based on different ways of approaching, or telling stories about the relations between science, technology and society (Jamison and Hård 2003). One strategy of providing education in contextual knowledge could be termed the *market-oriented* strategy, and serves to educate students about commercial contexts and the life-worlds of business and commerce. A second strategy is *academic disciplinary*, and seeks to socialise students into the dominating techno-scientific discourse of the particular engineering or natural science discipline or field. A third strategy, which might be termed *socio-cultural*, educates engineers to pursue their professional practice in a social and environmentally responsible way by supporting historical reflection, critical thinking and ethical awareness. Table 1 outlines the key characteristics of the three strategies in more detail.

Table 1: Three strategies for bringing contextual knowledge into engineering education

Strategy	**Market oriented**	**Academic disciplinary**	**Socio-cultural**
Rationale	contextual knowledge is for cultivating entrepreneurship	contextual knowledge is for habituating students in a field	contextual knowledge is for fostering a hybrid imagination
Story-line	Economic innovation/social construction, techno-logical development	Scientific creativity, professional reflection	Cultural appropriation, narratives of use
Main contents	Innovation and S&T studies, market analysis	Theory of knowledge and philosophy of science, epistemological analysis	History of S&T and cultural studies, cultural assessment

The first *market oriented strategy* aims at contextualizing technical problems and solutions by focusing on processes of technological innovation and the flow of financial and material resources within the so-called product chain. The emphasis is on providing students with tools to understand how to manage and organize these processes and optimize the flow of resources from a business perspective. Students tend to be guided to investigate the actors and networks involved in the process of innovation in relation to their particular technical solution. Market analysis is regarded as a central element in the development of a given product, and much of the contextual project work is based on one or another variety of innovation studies or science and technology studies, by which technological development is seen as kind of social construction (Jamison and Hård 2003). Education for sustainability in this approach is related to cultivating entrepreneurial skills and is thus a kind of preparation for taking part in the world of green business (cf. Jamison, 2001), and the students are introduced to different tools to assess the environmental impacts from products, to be aware of environmental regulations and the market potential for green products. Sustainable innovations are seen as in market terms and the eventual consumers for the particular technical solution are often explicitly investigated in the student projects.

In the second *academic* strategy of contextualization emphasis is on exploring the knowledge base, or cognitive foundation of existing and new technology. The rationale is that basic research is the starting point of technological development, and therefore contextual knowledge is primarily about theory of science and reflections on methods. The focus is on professional reflection and the students are taught to analyze the epistemology, or underlying rationality of their particular field of techno-science. Students tend to be introduced to a conceptual framework which gives them the opportunity to reflect on their professional practice e.g. in relation to the quality criteria that are considered important, together with the validity and reliability of the methods of research. In this strategy, the debate between realists and relativists, and the various schools of philosophy of science and engineering are usually introduced. Education for sustainability plays a marginal role in this strategy, although the ethical responsibilities of the scientist and engineer are sometimes taken up in individual projects.

The third socio-cultural strategy aims at contextualizing the technological debates, institutions and everyday life practices concerning human-technology interactions, and the way new technology is integrated, or appropriated into the broader culture. In their contextual work, the students are taught to assess the socio-cultural meanings of their “solution” and investigate relevant contexts of use, that is, to consider the pros and cons, the consequences and implications of their project. The emphasis is on the users of technology rather than the producers, and the students are introduced to the cultural history of technology and science as the basis for their contextual work, e.g. Hård and Jamison, 2005. In this way, the students are taught to see their technology in direct relation to broader social and cultural theories and concepts and sometimes reading and discussing social and political theory is a part of the project work. Contextualization means in this strategy an active effort to connect the technical solution to real socio-cultural, or environmental, problems. Education for sustainable development is treated in this strategy by seeing environmental problems in a broader perspective, and dealing with the relationship between the technological, environmental and social dimensions in an integrated and holistic manner. Rather than emphasizing green business, the students are encouraged to look at sustainable development in terms of the making of "green knowledge" (Jamison 2001).

4. Dilemmas of cultural appropriation of contextual knowledge

With our point of departure in the described PBL philosophy, we have long argued that the students should be introduced to all of these three rather different strategies for contextualizing technical problems and solutions in the course "Technology, Humanity and Society", with examples drawn from the particular engineering field in question. On that basis, and with help from their supervisors, they could then use their knowledge, and make their appropriate mix of contextual approaches, in the project work depending on the technologies that they are working with. However, this has proved to be much easier said than done, which can be illustrated by the following stories taken from real life situations.

Story 1: A clash of engagements

"A group working with energy supply has called a meeting to discuss their problem analysis with their two supervisors. The co-supervisor is an avid environmentalist and environmental researcher and he is quite pleased with the group's work as it attempts to identify the strengths and weaknesses with the existing Danish system of energy supply. The main-supervisor follows up by saying that he is not at all pleased by their problem analysis as he regards it as pure politics. He argues that the students are not being objective, and that their sources are biased and not valid. The co-supervisor asks for examples and as an example the main supervisor points to reports that have been produced by the Danish Environmental Protection Agency. The co-supervisor cannot disagree more, and the meeting from that point on is a quarrel between the two supervisors and the students find themselves rather frustrated. After that experience the group discusses what to do. They decide to arrange separate meetings with the main-supervisor and the co-supervisor, to avoid similar situations. In the rest of the project the students feels that a lot of energy is used on keeping both supervisors happy – or at least not angry."

What we have here is what Etienne Wenger (1998) would call a clash between different communities of practise. The co-supervisor went into the project with a strong interest in environmental politics and he finds it important that the students reflect on the debate in society concerning energy consumption and the different alternatives for energy supply. The main supervisor simply does not see such matters to be scientific, and will not accept such material as a part of an academic report. This example is an extreme case, but several examples have proven that it is difficult to pursue a socio-cultural strategy with the acceptance of the main advisor.

Story 2: The quest for consensus

"A meeting has been arranged among co-supervisors to discuss the next year's course in technology, humanity and society for electronic engineering students. A new member who joined the group last year says that the course is too focused on tools to consider different contextual matters in product innovation, and he is quite concerned that the students are exclusively guided to consider "how" they can manage contextual factors without considering the "why". One of the most experienced members of the group looked down and took a deep breath. Hmmm, she started. In principle she said, she totally agreed. However, the students

found it very hard to be reflective, as they were so technical. Many of the students were from the technical gymnasium she argued, and they were not that keen to learn about these more abstract issues – and considering the pressure to limit the emphasis on contextual knowledge from the engineering departments, she really did not want the bad publicity from student's critiques to reach the head of basic studies. But it was not that she did not agree. Actually if it was up to her, there would be more focus on sustainable development and not sustainable business. But, she argued, the main supervisors liked the idea of contextualizing by taking the market as a contextual framework. And if they do not buy the ideas from us contextual folks, she argued, the students are also likely to resist. The new member was clearly disappointed, and as a compromise, he was given the task to lecture the students in order to get them to reflect more on the processes of technological innovation. It was not a success seen from the students and the main supervisor's point of view, and the following year, the course curriculum again was exclusively market-oriented."

This example shows how a prior agreement to emphasize the marketing oriented strategy limits contextualization of technical solutions. The main supervisors find it important to keep to this strategy as they consider it to be less abstract and more related to the student's professional life after completing their study. Furthermore, most students entering the field of electrical engineering have a secondary education at the technical gymnasium, which gives them an instrumental view on technology which is difficult to modify. The co-supervisors know that this scope is too limited but at the same time they realize that it is difficult to change strategy since the market oriented strategy has been so dominant for the last 10 years.

Story 3: Context in search for text

"It was the second year of co-supervision and it had mainly been up hill. The engineering students were not at all interested in what he had to contribute with. Although the main-supervisors had been quite supportive, he did not seem to get through to the students. This time however, it was different. A group came along, with an almost insatiable interest in contextualizing their project work. Finally, he felt the joy of teaching and he was confident that this group could go really far. Suddenly one day the main-supervisor called him up on the phone to talk to him about the progression in the group. He was rather concerned that the group would not be able to pass, as they had not even considered the technical learning outcomes. The co-supervisor excused that he had been carried away by the enthusiasm of the group and he had not even thought about the other learning outcomes. The two supervisors arranged a shared meeting with the group, and they managed to convince the group to align their effort to the prescribed learning outcomes. The co-supervisor was relieved, as he realized that he had guided them as if they had been social science students and not future engineers."

The case shows the importance of close collaboration between the main supervisor and the co-supervisor to secure a balance of text and context. A premise though is that the collaboration is built upon mutual respect – at least on the surface. The students are very inexperienced at this point in their education as they are just adjusting to a new learning environment, and as they strive to learn to question the theoretical and methodological frameworks of their fields and cope with the uncertainty of problem oriented projects, it is evident that the questioning of the prescribed learning outcomes are left up to the established study boards. Another issue exemplified in this case is that the influence of personal engagement of supervisors can have a tendency to contort or even neglect the prescribed learning outcomes. The experience is that most co-supervisors have a preference towards one of the three strategies which to a high degree can be related to their personal values.

Story 4: The not invited

"The head of basic study had called a meeting with representatives from co-supervisors and main-supervisors of nano-technology. The co-supervisors in the nano-technology group had complained that the course in Technology, Humanity and Society in the planning process of the new education of nano-technology had been assigned to the physicists and biologists and they

felt no support from the course, which in the process had been renamed: The natural-scientific picture of the world. Furthermore, the co-supervisors argued, the students had mentioned that they had trouble coping with the level of physics in the course, and they were concerned whether the course actually was going to address contextual issues of nano-technological solutions and problems. The main-supervisors instead showed irritation to the idea that the students were being asked to contextualize nano-technology without sufficient understanding of the natural-scientific and academic foundation of the field. The co-supervisors asked whether it was insinuated that they, not being physicists or biologists, were not able to contextualize nano-technology from a humanistic or socio-technological perspective. The main-supervisors answered that they in fact did not consider such contextual knowledge as scientifically valid. One co-supervisor responded that it was very hard working with people living in an obsolete scientific paradigm. The head of study concluded, that the existing course curriculum was not being sufficiently fulfilled, and handed the responsibility to the co-supervisors."

This is an example of encapsulation of a specific engineering discipline. At best an academic disciplinary strategy will be accepted under the condition that the objectivity of the conceptual framework is not questioned. There was an absolute failure to communicate between the representatives of the main supervisors and the co-supervisors. In many of the projects that were subsequently carried out, however, the main supervisors showed themselves to be much more differentiated in their attitudes to contextual knowledge. This example illustrates the importance of the main supervisors to be willing to cooperate with the co-supervisors, but also for the co-supervisors to be willing to challenge the main supervisors, which is not always easy!

5. Conclusion

We have distinguished three strategies for contextualisation of technical problems and solutions: a *market-oriented* strategy, which serves to educate students about commercial contexts and the business life-world; an *academic disciplinary* strategy, which teaches the students to reflect on the philosophies and theories of the particular engineering or natural science discipline; and a *socio-cultural strategy*, striving to educate engineers to pursue their professional practice in a social and environmentally responsible way by supporting historical reflection, critical thinking and ethical awareness.

The stories we have told in this paper show that the cultural appropriation of contextual knowledge into a problem-based educational institution is not something that happens automatically and without conflict. The stories show that it can be quite difficult to pursue a socio-cultural strategy of contextual knowledge without being captured by the dominant discourses within a specific discipline or falling victim to the commercialization pressures and succumbing to the market-oriented strategy. It is important to stress that there are considerable differences between what motivates students, what natural scientists find important, and what the contextual knowledge teachers find important – and as the examples show, the tensions between main supervisors and co-supervisors can often be difficult to resolve. There are different kinds of risks in getting too caught up in one specific strategy – if the two other players do not agree it is a struggle – if they agree fully some aspects might be neglected.

In relation to education for sustainable development, we would contend that it can be useful not to focus too exclusively on any one strategy but to encourage students – as well as teachers – to see contextual knowledge as a hybrid combination of different skills and knowledge and different strategies of cultural appropriation. The limitations within the market-oriented strategy and the academic disciplinary strategy need to be balanced with broader considerations of socio-cultural context. Sustainable business is important – but not sufficient for addressing the complexity of sustainable development. For that purpose, we have to consider the variety, or plurality of cultural appropriation process, by which technology and sustainability is to be appropriated into the very different kinds of life-worlds – business, government and everyday life - that coexist in the contemporary world.

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