Integration in Curriculum Development

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Abstract

Integration is a specific goal in several universities currently. The School of Chemical Technology in the Aalto University (formerly known as the Faculty of Chemistry and Material Sciences, Aalto University) saw the need to develop a new Degree Program of Bioproduct Technology (BPT). The new Program accepted its first students autumn term 2010. The development work has been conducted in an extensive cooperation within the School and the University for over two years and the development work still continues.

In the early stage of the development process it was realized that certain principles provide scaffolding to all work in this Program. One of these principles is integration. It was understood that all sorts and levels of integration is needed to create a Degree Program that is able to meet the requirements the working life sets for our graduates. Integrating natural sciences into professional subjects, integrating English into other courses, integrating working life skills within all the courses, as well as providing teaching of what can be called tools-of-the-trade, for example mathematics, within the Degree Program themes has been the guiding principle in the development work. Our Workshop on Integration includes four points of view on integration within BPT.

The first case is about integrating working life tools, such as using mathematical programs, learning co-operation skills, how to prepare presentations etc., into courses. The second case discusses the attempt to integrate English with a Natural Fiber Material Science course and how students view this possibility. Case number three is a new course at BPT Degree Program that builds bridges between different kinds of materials. The students’ knowledge on basics of material science in general, as well as broader knowledge in the field of synthetic polymers, increases their competence as future engineers in FBI. The fourth example of integration is the aspects of sustainability during an optional course Insights for Sustainable Development in Technology, Economy and Art. This course offered views to the sustainability from the technological, ecological, economic, social and cultural perspectives, which were further processed in students’ reflective journals.

With these we will build a starting point to our workshop. The objective of our Workshop on Integration is to share experiences gained during the development work and, in cooperation with the workshop participants, to further establish tools to other curriculum developers for easier integration.

1. Introduction

The need to develop a new Degree Program in the Department of Forest Products Technology at the Aalto University School of Chemical Technology offered an excellent opportunity to integrate several important perspectives in the curriculum. In the beginning of the millennium the driver for the curriculum development in the Department of Forest Products Technology was
internationalization. Already then several supporting aspects, such as English language, were integrated in the majors of Forest Products Technology.

The driving force for the recent development work was the structural change that Forest Based Industries (FBI) has been undergoing lately which also reflected in the universities both in reoriented research and lowered amount of applicants. A broader view was needed and this meant moving to a broader conception of biomaterials instead of traditional forest products and their raw materials.

The new Master's Program of Bioproduct Technology (BPT) accepted its first students in the autumn term 2010. The development of this Program was conducted in an extensive cooperation within the School and the University for over two years and the work still continues. One of the guiding principles of the development work has been integration. The project group stated in the early stage of the process that all sorts and levels of integration is needed in order to create a Degree Program that is able to meet the requirements the working life sets for our graduates.

Recent research in the field of engineering education also supported the perspective of integration. Based on the social constructive learning theory, learning is seen as an interactive building process of knowledge, skills and attitudes [1]. In order to implement the learned concepts, the context in which they are learned is crucial.

For example skills studied and practiced in an unnatural environment are not so easily transferred into the real working life situations [2]. It is also known that studies are clearly more motivating for students if the issues to be studied are connected with real practical working life situations or their simulations. Problem or project based learning are examples of how to integrate the study content with various skills and abilities [3]. Based on those observations, it is a very important issue in engineering education to embed different general skills with the engineering content. In the current information society it is also noticed that basic information is outdated so soon that it is much more important to teach the process of acquiring new information than to merely study a particular content [4].

There are several ways to implement integration in curriculum development. The most systematic and well-know is the CDIO-approach,[5] However, following the CDIO is not possible for all universities for a number of reasons and other methods are also needed. In this paper we introduce four cases that show how integration has been implemented at our School. First we will describe how the integration has been included in the curriculum development work, then we discuss integration of English into all of the Master's Program courses and finally we introduce two course examples where integration has played an essential role. The first course is an obligatory course for all the BPT students and the second is an optional course that has attracted a significant amount of BPT students.

Our cases will build a starting point to our workshop. The objective of the Workshop on Integration is to share experiences gained during the development work. The key questions are: What can be integrated? What the participants of the workshop have integrated? What was needed to succeed in the integration? What have been the most challenging aspects in the integration? Our aim is, in cooperation with the workshop participants, to further establish tools to other curriculum developers for easier integration.

2. Case 1: Integrating working life skills and tools

2.1 Internationalization

This case explains how working life skills and tools, such as using mathematical programs, learning co-operation skills, presenting technical data etc., have been integrated into BPT
courses.

The Department of Forest Products Technology began to consider integration of working life skills into its curriculum in more detail in the beginning of the millennium. Graduates from the Department entered working life and started to work in the companies that operated not only in Finland, but in Europe and outside Europe. One could work in a very small Finnish city far away from the capital area and still use English daily while at work. The ability to communicate in the international working environment was defined as one of the skills students should learn when they were studying in the Department. Being able to communicate does not require mastering a language, but it consists of a desire and competence to relay a message to others on various issues.

Discussions between the Head of the Department and the companies of the Forest Products Cluster lead to an intensive, five-year development project after which all the courses at the M.Sc. level were taught in English. Language was not the only aim of the project, but also the scope, the goals, the contents and the outcome, as well as the teaching methods of the courses were reviewed. The reason for the extensive development effort was the Department’s desire to educate competent engineers who are capable of working in dynamic positions both in Finland and abroad.

The representatives of the companies involved in the development project had regular meetings with the planning group of the Department. There were students in the group along with the professors, study administrators and project engineers. The group discussed what needed to be done, but also why the tasks were necessary.

The Head of the Department encouraged the teachers in the Department to develop their teaching skills already in the late 1990’s. The development of teaching skills became more systematic along with the teaching in English, because the Department wanted to support students’ learning also through improved teaching methods. Approximately 10 teachers accomplished University Pedagogics (YOOP), 30 ECTs of voluntary pedagogical training offered by Helsinki University of Technology during the internationalization project and approximately another 15 teachers after that. Shared experiences of the modern teaching methods encouraged teachers to try new approaches in their courses. This meant motivating students to work in groups, using Problem Based Learning (PBL) method, including reflective journals in the courses, giving more feedback to students on their tasks (e.g. reports, presentation, group work). Wider projects were also introduced in the courses.

Sometimes motivating meant forcing, because students tend to persist using their familiar working habits. However most feedback from the students was positive and this together with improved results encouraged the development process to persevere.

2.2 Broader perspective

The vast development work implemented in the beginning of the 2000’s in mind, it was fairly easy to start planning a new Program, the Bioproduct Technology Degree Program in 2008. In the new Program the integration of working life skills, such as mathematics, communication and group working skills are systematically planned when it has been possible.

Mathematics, chemistry and physics are all compulsory studies in the BPD Program. Traditionally in the Finnish engineering studies these topics are considered important when the Programs are planned but the students do not find the connection between natural sciences and their own study field and therefore do not find the natural sciences motivating. It is also a tradition that most of the mathematics, chemistry and physics courses are taught during the first study year and most of these courses offer slight, if any, connection to the topics which actually interest the students.
In BPT the mathematics studies are planned to be synchronized with other studies to ensure that the mathematical tools needed for some other courses are available to the students when they need them. The mathematics teacher uses examples from the Bioproduct industry and the teacher is also able to visit other courses when the mathematics tools are used for the first time. All these actions are thought to help the students to apply their mathematical skills as required. Earlier this connection has not been good and teachers of other subjects have been forced to teach mathematics in their courses. All this development work is implemented in close cooperation with the Institute of Mathematics and could not be completed without it. As only the first year of BPT studies is completed, the results cannot yet be verified. However, already it is known that more students have completed their mathematics studies according to the schedule than before.

Prior to this development work, a vision paper was created by interviewing 30 FBI experts and by analysing several relevant publications and policies, such as the EU 202020-paper [6]. The vision 2020 paper clearly showed that the communication skills are one of the most important skills for practising engineering in FBI in the future. Therefore the communication skills are practised within several courses. Already from the very beginning the students have several presentations per semester, first in groups and later individually. The students have already said that this beneficial to them.

Group work is another of the skills that is practiced throughout the Program. It also starts with low-risk group work and develops into well-structured project organization where everyone has their own roles, such as a manager or a coordinator.

Since most of the BPT courses are new and many of the teachers have had pedagogical training, the need for integration was accepted and the courses were developed considering this. The very fruitful co-operation between the disciplines has also been essential in order to develop mathematics or other courses, such as the polymer and material course that is later explained in more detail. This level of integration requires coordination that is approved and facilitated by the Head of the Program. Another requirement is that the students take their courses in the order planned in the Program. This is a significant change in the Finnish university system, which has allowed more freedom for the students on scheduling their courses.

3. Case 2: Integrating English

The Department of Forest Products Technology was one of the first departments at Helsinki University of Technology which adapted English Medium Instruction (EMI) and it still is the only one which offers teaching only in English, with no parallel courses in Finnish. This was seen as both a benefit and a threat at the beginning, but through the years we have seen many successes as a result. Currently seven of the Department’s professorships are held by international (i.e. not Finnish) professors which gives the students no other choice than to communicate with their professors in English. Graduating students spontaneously comment on how much their English skills have improved when they have been “forced” to use English on a regular basis in their activities.

As we know, FBI have always been international with both import and export foci, while the recent developments have made this even more so with mills and other facilities being built mostly in other parts of the world and not in Finland. Since the business partners come from various parts of the world, English is usually the lingua franca used in communications between them. When the latest developments in processes and other research are reported in English, the scientific and academic audience is much wider than when the reporting is completed in Finnish. These reasons clearly guide the choice of the language and thus even the new, Bioproduct Technology Degree Program is an EMI program.

Since all the courses in this Master’s Program are held in English, students are exposed to English, at least passively, on a daily basis. This is similar to situations in CLIL [7]. CLIL
teaching has shown beneficial results on especially content learning. It is not absolutely clear why some studies indicate that the content learning in CLIL teaching is superior when compared to regular teaching, but researchers suggest that as students have to concentrate more because of the foreign language, they also concentrate better on the content itself. CLIL teaching is, however, quite a controversial issue which is continuously discussed and even criticized. In this case, however, the content and English will be taught by different teachers and the cooperation between these teachers will not be as intense as in CLIL.

Despite the original controversy on EMI, the new BPT Program operates in English. Students are also required to complete three credits of international language studies at an advanced level [8]. This language for most students is English. As the new Program and its possibilities were discussed, an option of integrating the required English studies with another course emerged. The integrated English course was discussed with the Language Center as well as the School Academic Affairs. As a result of these discussions, the new, integrated English course is in its planning process and will be implemented for the first time in the autumn semester 2012.

Students were also asked for their opinions on having English as an integrated part of their other course or courses. Unfortunately the response rate on the paper-based student questionnaires was very low as we received only 16 responses. Most of the respondents (12/16) showed great interest in this, as they could concentrate on the subject matter more while developing their English skills. Interestingly enough, some students (4/16) preferred to have a separate English course rather than an integrated English course. A course where students need to complete reports as well as present the results to the rest of the group seemed ideal for the purpose of the integrated course. Since the language requirement is only three credits, this can be integrated into the subject course which runs over two periods and thus allows for student development already during the course.

Most language courses are run during one six-week period which only allows a superficial approach on most issues discussed during those courses. Students can be made aware of certain issues but actual changes and transfer effect usually occurs only after the course. One of the goals with the integrated English course is to develop the topics further with the longer time frame and to gain the transfer effect from the discussed language issues immediately when working on the course assignments.

We, naturally, expect the results on this course to be perceived as beneficial and we intend to ask students’ feedback specifically on how they view the integrated English and its influence. The earliest we are able to report on these results is 2013, but we look forward to favorable views on our carefully planned work.

4. Case 3: Integrating material science

Case number three is a new course at BPT Degree Program that builds bridges between different kinds of materials. The students' knowledge on the basics of material science in general, as well as their broader knowledge in the field of synthetic polymers increases their competence as future engineers in the FBI.

This integration takes place in two courses, one of which is theoretical and the other is practical. The theoretical course starts with an introduction of the field of materials science in general, the variety of different kinds of materials and the most important parameters characterizing their nature. After these general issues the focus of the course shifts into synthetic polymers. The basis of the course development is five years of experience in teaching the basics of polymers to students in Degree Programs of Chemical Technology, Materials Science and Bioinformation Technology.

Students from different Degree Programs naturally have their own kind of focus in their studies of materials science and technology. This has been seen in a concept study [9]. This study
demonstrated the idea of the meaning of the Degree Program on students’ identity already in the very beginning of their studies. It is important for the teacher to be aware of students’ underlying thoughts about the taught subject matter to be able to enlighten the studied area from reasonable points of views. The situation in which teachers of polymer technology from the Department of Biotechnology and Chemical Technology go to the Department of Forest Products Technology and start to teach their topic without taking into account students’ attitudes towards, for example, the usefulness of the subject area possibly leads to an unfavorable situation related to learning. It is important that teachers are able to integrate themselves in the entity of the individual course.

Students’ thoughts of the learned subjects are to be integrated into larger entities than just the studied courses. Many students, especially in their first study years, seem to take the courses as blocks which do not necessarily have anything to do with each other. The teachers must recognize this and work on the idea of integrating courses into larger wholes in the Degree Programs and also integrate the learned material in the surrounding society. Materials Science is a good example of a subject that touches everyone daily: each item we use is made of some material and there is a specific reason for each material selected for their purposes. Sustainability being a growing idea today, we all have to make decisions regarding this. Therefore, the focus is not merely on students’ professional development but also on them becoming responsible customers.

Learning is activated by weekly assignments which replace the conventional exam. Discussions and plenty of sample material are also used in the course.

The practical course supports the issues presented in the theory course. It pertains to measuring of properties from error analysis to standards, and the development of results from measurement data. The aim of this short course is to introduce the basic phenomena and show the differences in the behavior of different kinds of materials from wood to metals and from paper to thermoplastic polymers.

5. Case 4: Integrating multidisciplinary approach of sustainability

Sustainability is one of the core subjects in engineering education and it is included in many courses within the curriculum. However, quite often in the engineering education, sustainability is seen only from the technical point of view although that is only one side of sustainability, as it also includes social, cultural and economic views. In order to obtain a full picture of sustainability multidisciplinary studies integrated in all levels of engineering education are required. Furthermore, the wide range of knowledge related to sustainability demands both system and critical thinking, supported by creativity together with communication, interaction and group working skills, integrated in major studies.

Case four, the course Sustainable Development of Technology, Business, Art and Design, represents one example of multidisciplinary integration of sustainability into Bachelor Majors in engineering, business, art and design [10]. The course was created in co-operation between three different Schools of Aalto University, the School of Science, the School of Economics and the School of Art and Design and it was offered as an optional course to all first year students. However, due to the very heavy work load of the first study year, less than 10 % of students attended this optional course. One exception was the Degree Program of BPT, where 20 % of students participated in this course. This might be partly because of the topic, which is strongly related to the learning goals of BPT and partly also because of the second and third year students who changed their study program from old Forest Products Technology to the new BPT and they probably had more time in their schedules.

The goal of the course, Sustainable Development of Technology, Business, Art and Design, was to enforce and guarantee long term orientation and motivation for sustainability with social, economical, technical and cultural views. Another goal was also to integrate teaching of the first
year topics to significant research topics and build the elements of an academic community among students, university staff and faculty.

The course was offered in a form of lecture series and those lectures were given by professors from different disciplines, such as national economy, international trade, new media, graphical design, nanotechnology, brain research, energy, ICT, water management and recycling technology. Students’ thinking was supported by reflective journals, written weekly after each lecture, and commented by teaching assistants. Students were encouraged to discuss the topic of the weekly lecture also outside the lecture hall with each other.

The analysis of the students’ reflective journals shows the importance of linking the content both to their studies and also to their everyday lives, based on the constructive learning theory of knowledge building. The everyday life aspect seemed especially important for the first year students: they very often reflected on their previous experiences with the content presented during the lectures. This personalization is important also to their motivation: students need to understand the importance of the content for them to be highly motivated. Students usually have a career in mind already in the beginning of their studies. This goal for studies can change, but it guides them and provides perspective in order to reflect new information from their courses. Linking new issues, even remotely, to their personal goals is a source of motivation, for example engineering students started to be interested in economy after the lecture when they realized that economical aspects are also part of working life skills and sustainable development.

Another important issue regarding students’ motivation was the novelty value of the contents presented during the lectures. Students were immediately more interested in the topic if it was novel enough, even if they did not find clear link to the topic in their own studies or personal life. Furthermore, in addition to content novelty, students also appreciated the expertise of the lecturers. The professors with long experience in their research fields were able to present different perspectives with personal opinions supported by well-explained facts. Those different perspectives and comparison between them, together with real life examples, made comprehension of specific topics easier than mere theories. Students also managed to link the content to their own interests easier.

This lecture series, given by professors from very different disciplines, was an attempt to utilize the multidisciplinary scenario of new Aalto University – a combination of science, technology, economics, art and design. During the first year linking the study content was more challenging than when the course was offered the second time. This was probably because most of the lectures were the same both times and on the second time they knew more about their colleagues’ presentations and were able to present sustainability as a linking factor. The coordinators of the course were also more familiar with the course entity and they were able to offer ideas to help in linking the content between lectures and find different aspects of sustainability when they were commenting the students’ reflective journals. This type of personal guiding can play a very important role in making integration of different contents easier to students although it requires teacher resources. However, sometimes small issues, such as an introduction of lectures with a few sentences already created a certain bridge between different topics. Questions given to students may also help them to find linking, for example, between designing of commercials and sustainability, which was not so self-evident, although those are related by consumption habits and people behavior.

6. Conclusions

As our cases show, integration is possible within one course and between courses. Program-wide integration is, naturally, more effective. As stated in our first case, the need for integration must be identified and accepted widely, since the change between “the old way” and the
integrated way is large. If the Head of the Program does not understand the need for rethinking old structures, the required work seems too complex.

The change requires the teachers involved in planning to have pedagogical skills. In our case the need for pedagogical training was realized already in the beginning of the millennium and, therefore, we had sufficient amount of knowledge to implement the BPT program.

Integrating language with content is nothing new. Despite this, it is less common at Aalto University School of Chemical Technology than you would expect. Working differently from others and changing the way things have been done in the past requires more work, but should also benefit not only the students but also the staff.

As stated in cases 3 and 4 integration requires co-operation and knowledge sharing between teachers and disciplines. This, nevertheless, cannot occur without time and thorough discussions. The start is slow, but the results, more motivated students and usually better learning, quite often speak for themselves.

We aim to also learn as we implement the integration in these different cases. The goal is to be a learning organization which can modify those aspects of courses or Program that seem not to work while developing those aspects even further that provide favorable results. Being open and active while asking for feedback and comments should help us reach our desired goal for students and thus also for our benefit. Integration moves the idea of teaching towards systems thinking. High quality teaching cannot be separate actions of individual teachers inside their own vicinities e.g. research groups, majorities or even Degree Programs. High quality teaching is systematically planned, well resourced and carried out in wide co-operation.

7. Acknowledgements
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References
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