A MODEL FOR BUILDING SKILLS AND KNOWLEDGE NEEDED IN THE JOB MARKET

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Abstract

Finnish IT companies are facing a shortage of software engineers in several fields of software development. The field evolves quickly as new technologies emerge, as processing power of computers grows and as data available for processing becomes abundant. How can a university of applied sciences keep its teaching relevant from the point of view of companies that need personnel with new skills and knowledge? How do the teachers keep their own professional knowledge and skills up to date to be able to pass the knowledge and skills on to their students? How do the educational institutions know what kind of skills and knowledge the employers need in the first place? This paper presents a model for tackling the above-mentioned challenges in the context of university level education of future and current IT-professionals. The model has been tested in the teaching of artificial intelligence to undergraduate students of business information technology. Experiences from the implementations of the model have been gathered and analysed. The results show that the model clearly is a success among all stakeholders. The main novelty of the model is that it allows the dynamic and timely adjustment of curricula when new skill and knowledge requirements arise from the industry.

Keywords: Professional knowledge and skills, business information technology curriculum, life-long learning for teachers, higher education, company cooperation.

1 INTRODUCTION

Similarly, as many counterparts around the world, ICT companies in Finland are facing shortages of software engineering professionals. The ICT field evolves quickly as new technologies emerge, as processing power of computers grows, and as masses of data to process grow. When facing skills shortages, ICT companies understandably turn to universities and universities of applied sciences for recruiting fresh young graduates with the latest skills. Some opt to recruit students whose studies are still incomplete and give these new recruits precision training on the skills to master and hone in the future. Ideally, of course, students would learn the relevant robust skills while they study, and then learn more as they enter the world of work. While some companies do set up their own in-house academies and train their existing staff on the necessary new skills, teaching is not their core business – nor do they want (or even need) to focus on all the academic flavours one's university-level education entails. Smaller companies do not have this luxury at all, and hence, they rely on recruiting people with the necessary skills. It is, hence, obvious that having an up-to-date learning offering and skilled teaching professionals is vital for any higher education institution for providing skilled future software engineering professionals for the world of work. This basic requirement proposes the following questions:

1. How can a university of applied sciences keep its learning offering and teaching relevant for companies in need of personnel with the latest skills and knowledge?
2. How do teachers keep their own professional knowledge and skills up to date, and what are the ways to pass the knowledge and skills on to their students in this ever-progressing field?
3. How do higher education institutions know what kind of skills and knowledge the employers need in the first place?

This paper presents a model for tackling the above-mentioned challenges in the context of university level education of future and current ICT professionals. We tested the model in the teaching of artificial intelligence (AI) to undergraduate students of business information technology. The novelty of the model lies in the fact that it enables the flexible and timely modification of the curriculum and the effective implementation of novel topics demanded by the employers.

2 RELATED WORK

Given the fast pace of change in the world of work, higher education institutions are at a risk of lagging behind. There are few areas where this risk is more apparent than in software engineering. While research is exploring unknown territories and sometimes makes even ground-breaking endeavours, undergraduate education typically offers the basic, robust skills that are enduring and, in many ways, model the existing practices in the industry. Research oriented universities are themselves shaping the future [1] and therefore their curricula have a lower risk of lagging behind. In addition, the course topics of research universities are more theoretical and thus may stand the test of time better than the more practically oriented course topics of the universities of applied sciences. This article focuses on how to design and implement practically oriented and timely courses into the curricula.

Software engineering, along with computer science, has evolved rapidly [2] and is a fairly recent addition among the disciplines of the academia. Collaboration between the industry and the academia has been intensive all throughout the existence of the discipline, but the modes of interaction have remained largely the same. Skevoulis [3] lists four models of collaboration, which we summarize as follows:

1) Learning acquired from the university to a specific problem,
2) Local industry collaboration with students working on a problem posed by a company,
3) Commercial activity within a university, or
4) Collaborating through cooperative education.

In our university we have routinely in place all four of the above mentioned types of collaboration with the software industry. We would call the last one work placement, and the requirement for a Finnish UAS undergraduate is six months. In some universities it may be longer, e.g. one academic year in the software engineering program of the Rochester Institute of Technology [3].

Despite the active collaboration, research has indicated gaps between skill requirements of the job market and the skills taught in institutions of higher education (see e.g. Boronina et al.[5]). There is no shortage of studies on how to overcome this gap. Higher education institutions have also developed many strategies for creating curricula that stand the test of time, and allow for renewing when need be. Typical strategies include e.g. having advisory boards for degree programmes or fields of study. Others may involve extensive studies and research that look into the wider implications of developing digital technologies [6]. Some solutions include the development of an entire curriculum in close cooperation between professionals working in the field and academics [7]. For example, the master's program in Safety Engineering developed at the Katholieke Universiteit Leuven has both academics and professionals from the companies involved as lecturers and teachers [7].

Knowing the industry skills needs and demand is paramount for any higher education institution, and staying abreast with the changes occurring in the workplaces is necessary to be able to provide the right skills at the right time. As discussed above, the approach has been rather traditional up until very recently, when a number of Finnish universities of applied sciences turned to using cognitive artificial intelligence in investigating the competences needed and guiding their curricula updating [8]. The data used for this analysis is public job adverts that are then compared to the curricula and course descriptions of the participating higher education institutions. An ongoing project [9] is using cognitive AI to identify skills related to software engineering (coding skills, specifically) needed based on job market data and compare them with the offerings of the universities of applied sciences. The information obtained is also used to develop new courses and study modules that meet the demands of the job market.

3 METHODOLOGY AND CASE DESCRIPTION

The methodology used in the study is action research [10] [12], meaning that the authors themselves were involved in the case under study: as a teacher and as a manager. We had acknowledged the need to develop both the learning offering and the teaching staff skills, when we entered into discussions of providing education in AI with a specific purpose: providing companies with graduates skilled in AI methods and tools. Facing this apparent and imminent need of providing this specific education, and yet, at the same time, realizing our own staff is in need of updating and widening their own professional sphere, we saw the opportunity in designing a novel course type. This type would allow for both AI skills for students and possible future skilled professionals for companies, but it would also allow for

professional growth and development for the teaching staff. A course design involving multiple stakeholders and an uncharted territory meant that action research was the only viable option.

Course offering that involves project work for companies or visiting practitioners is by now a staple MO for introducing real-life cases in universities of applied sciences. The same goes for hackathons and other intensive events that gather both companies and students to tackle given challenges over a short time period. The students of business information technology at Haaga-Helia University of Applied Sciences already have well-established opportunities to learn current topics in a company-driven way. These include the software development project courses commissioned by partner companies [13] and technology-specific courses where the content is completely provided by companies. There is also a model for implementing student-driven courses on topics in demand.

A course type that involves multiple companies, new challenges, possibly offers thesis topics for students, and builds learning around skills and tools not very familiar to anybody (lecturers included) is a definite novelty – especially as it is carried out within a regular course cycle, in this case a period lasting eight weeks. Building this meant that lecturers "took leave" of their usual preparations (as there was very little time), gave their own professional development a chance (in entering a world previously little known to them), and plunged into the experience with an open mind. The case required collaboration, constant reflection and tuning, and learning as one moved forward.

The case under study is the development of an entry-level course on artificial intelligence (AI) for 3rd year business IT students. The demand for the course came from local companies who were experiencing specific skills shortages: people familiar with methods and tools involving AI. Collaborating with these companies and a software provider, we (academics including lecturers and management) jointly designed a model that required the following: the flexible modification of the curriculum and the implementation of courses on topics that are novel to the lecturers. The practical implementation also involved all three parties: the academia (students, lecturers, and management), the companies needing specific skills, and a software provider. We implemented the model twice in the context of a course on AI. We collected feedback from participating students, companies and academics after both implementations.

4 RESULTS

The results of the study consist of both a model created for the flexible implementation of courses that answer the demands of the software industry and of experimental results gathered from the various stakeholders while implementing the model.

4.1 The model for flexible implementation of industry driven courses

The researchers created a model for flexible creation of courses that would deliver skills and knowledge demanded by the IT industry. This model is depicted in Figure 1. As the figure shows, the model has three main stakeholders: companies needing skilled workforce, companies providing technological solutions and learning materials, and the academia, consisting of teachers, students, and management.

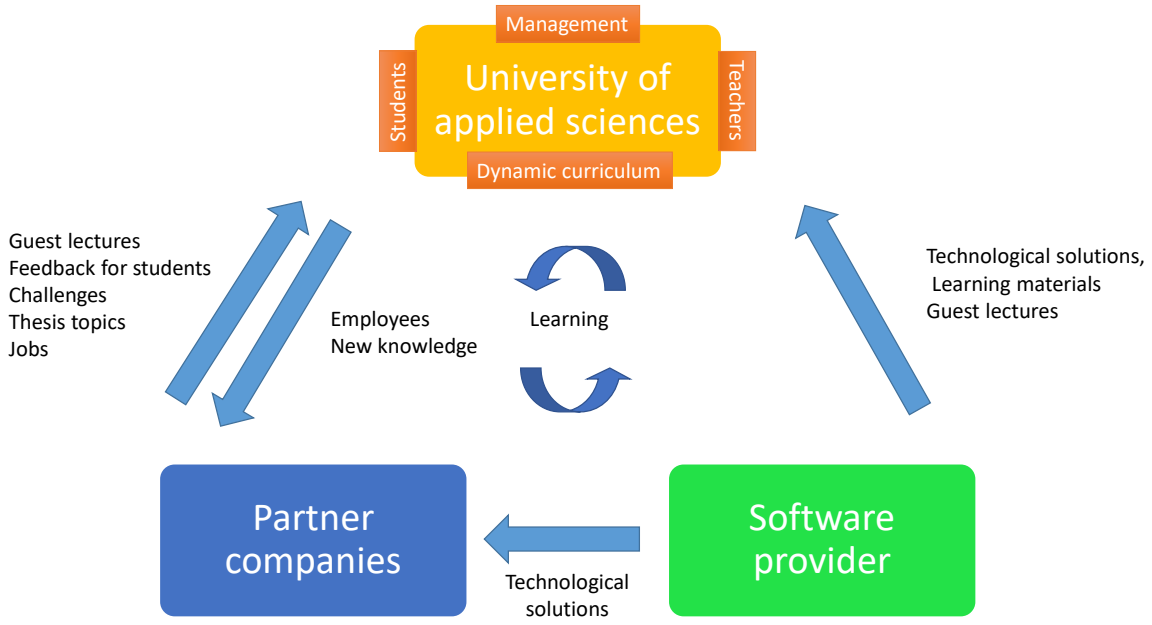

Figure 1. The model, its stakeholders and the value provided by each stakeholder are illustrated above. Learning is in the center as it is the shared and common objective of all stakeholders.

The initiative to develop the skills and knowledge of both teachers and students comes from the companies, which have an active role all the way through. The software provider company actively promotes its technological solutions to both its customer companies and the academia. These companies typically provide learning materials that instruct in using its software. Examples of such companies include IBM, Microsoft, Google and Amazon. The other type of companies involved in the model are the customer companies of the software provider. These companies typically need skilled workforce and they turn to the academia for this reason.

In our model, there is only one software provider company, but several – typically around eight – partner companies. These companies may already be customers of the software provider or they may be looking into the technologies provided by it. As the arrows of Figure 1 illustrate, the partner companies and the academia have a close and reciprocal co-operation. The partner companies provide the academia with guest lectures, challenges and thesis topics for students as well as feedback related to these. They provide jobs for the students and feedback on the curriculum for the teachers and management. The academia, in exchange, provides the partner companies with skilled employees and new knowledge. The role of the software provider company is less interactive. It consists in selling or giving the technological solution to the academia and the partner companies and of providing guest lectures and learning materials to the academia.

4.2 Evaluation of the model: stakeholder experiences

The created model was evaluated by gathering qualitative data from the stakeholders involved in the implementation of the model. The model has been implemented two times in the form of a course on AI. Table 1 illustrates the number of informants involved in evaluating each of the rounds of the implementation of the model.

Table 1. The number of informants per stakeholder category involved in evaluating each of the implementations of the model.

	First implementation	Second implementation
Students	29	39
Companies	8	7
Software providers	1	1
Lecturers	2	2
Management	3	3
Total	**43**	**52**

Table 1 shows that in the first round 29 students and in the second round 39 students were involved in evaluating the model. This is the total number of students that passed the course. In the first round, the feedback was gathered in the form of oral qualitative discussions held at different phases of the course with the entire class. In addition, one student was thoroughly interviewed after the first implementation. In addition to common feedback discussions, also anonymous feedback was collected in the form of an online questionnaire after the second implementation.

The students were asked to reflect on their own learning in the course. They were also asked to specify both good practices and challenging issues in the implementation of the course. The students were specifically asked if they were interested in writing a thesis or working in one or several of the partner companies and if they found the challenge given by one of the partner companies motivating.

In the answers the students say that they appreciated very much the concrete case examples given by the guest lecturers from the partner companies. This served both as a good introduction to the course topic and as a good source of motivation for learning the course contents. Some students were interested in contacting the partner companies for a thesis topic or a job, but a considerable number of students regarded the skills required by the companies as too demanding. The tools for building AI applications provided by the software company received some negative feedback as some students would have preferred to study the tools of some other software provider. However, most students had no previous experience on building AI applications and were happy to learn the tools of one of the market leaders. Almost all students appreciated the challenge given by one of the partner companies. This challenge was implemented as the course project. According to the students, a company-defined challenge was a much better alternative than having to invent the project work topic by themselves. The students also very much appreciated the feedback given on the finished projects by the company.

The companies were asked if they had recruited or were considering to recruit any of the students and if they were interested in continuing the cooperation in the form of giving guest lectures and/or project and thesis work topics. From the first implementation one student was directly recruited to a partner company, but in general partner companies seem to appreciate a more long-term cooperation with the academia and students. Companies are interested in improving their image as employers in the field of AI in general and in giving students concrete challenges that will provide them with new ideas and enable them to learn about AI. All companies were willing to continue the cooperation. So far, the course has more partner companies than it can take in. This is quite natural because the initiative of the course came originally from the companies.

The teachers were asked about the amount and meaningfulness of work that the new model entails. The lecturers do regard the courses that have been implemented using the model as very interesting professionally as they offer a way to keep their knowledge and skills up to date. However, even though many course materials and several lectures are provided by the software company and the partner companies, the teachers regard this type of course as quite demanding. The teacher should have a very good theoretical background on the topic because the materials and guest lectures given by the software provider and partner companies are practically oriented and often cover a very narrow subfield of the

domain. The teacher should have the expertise for putting the concepts into their right context, to show the relations between the technologies presented and to draw an overall picture of the domain.

The management was asked if the model facilitates – in terms of flexibility of the curriculum, employee satisfaction and budget - the flexible creation of courses with topics new to the lecturers but important for the companies. The management regards the model both as a means of ensuring lifelong learning for the teachers and of keeping the curriculum up to date in a flexible and cost-effective manner. However, they regard that the high level of commitment of the companies might be hard to maintain. In addition, they see that also students of the master's and life-long learning courses for IT professionals might be able to contribute to the subject matter of the courses implemented using the model. This is because these students often already work in the partner companies or companies very similar to them.

5 DISCUSSION

The model is clearly a success among all stakeholders: students, companies, managers in higher education and teachers. Some former students have been employed in the field of artificial intelligence or are writing their thesis on the topic. The course implementations also have been so popular that only approximately half of the students willing to take the course have been able to do so due to limited resources. The partner companies involved are willing to provide more guest lectures, projects and thesis work topics as well as mentoring than what can be taken into the courses. The software provider company is willing to continue and broaden the cooperation. In the following, we will discuss in more detail the implications of the model from the point of view of the managers and the teachers.

One of the comments of the management is that it might be hard to maintain the high level of commitment of the companies. In the current case, the initiative of the entire course came from the companies themselves – both from the software provider and the partner companies that are using or considering to use the software offered by the provider. This ensured that the companies were very committed to providing contents for the course.

Over time, given this particular area and the specific skills it entails, it may well be that companies find it easier to recruit skilled personnel and the need is no longer so dire. This inevitably leads to less commitment in the course. It is very probable that teachers will also have learned the topic and there is no longer that much need for company involvement as the specific area may have become a regular part of curricula. However, as the model has proven to be highly suitable for attaining skills in new emerging areas or technologies, it probably works for other topics, too. This, of course, entails that the right elements are in place: companies in need of new learning and skilled personnel, emerging new technologies and related tools, and the academia that can flexibly accommodate new learning in its curricula.

Where curricula nowadays are typically rather fixed, this model requires curricula that allow for flexibility and new additions dynamically. As higher education institutions need to provide solid academic education to their undergraduate students, some parts of the curricula obviously remain relatively stable. These parts relate especially to enduring skills and transferable skills whereas transient skills need to be rethought and remodeled much more often. As mentioned earlier, real-life project work, hackathons and other events are regularly brought in as part of learning in higher education institutions. These do not necessarily entail any changes in curricula. Full-blown course offering, however, does require rethinking of curriculum – in this case at a speed not conceived possible earlier. Applying the model, we were able to provide the learning timely also from the point of view of companies.

Working with companies in both teaching and RDI (research, development and innovation) is a standard way of operating in universities of applied sciences. Project work, whether smaller challenges solved during learning or bigger RDI projects, alone entails active interaction and collaboration. Currently, Haaga-Helia University of Applied Sciences has more than 100 active partner companies. To sustain a model like the one described in this paper, we clearly see a need to develop the partnerships even further. This may involve not only guest lectures but also whole courses taught by company representatives in collaboration with academic lecturers.

Given that some of the course contents, especially the tools used, was relatively new to the lecturers, they learned it during the course implementation. For them, it was also an opportunity to develop their own professional skills without attending a traditional training. Time to prepare for the course was minimal, but having thought of the proper learning materials before-hand they were able to orient

themselves to the course and its learning objectives. As a university of applied sciences, we had acknowledged the need to reskill and upskill our own staff in AI, but had we sent the lecturers to a traditional training course, we would have been late vis-à-vis the needs of companies.

One of the key findings in the study is that the role of the teacher is very different from the traditional role when he is implementing a course according to the new model. Therefore, we suggest that our teachers should be made aware that we can offer at least two different types of teacher roles:

1) The traditional role of a teacher where the teacher is in charge of everything in the course. He is also the ultimate authority in the course – with regard the subject matter, the organizational issues and pedagogy. This type of orientation is needed when teaching fundamental knowledge and skills to the students: be it a programming language, requirements analysis or research methods. In this role, the teacher should possess a deep understanding of the subject matter and he must keep himself up to date with the latest developments. In addition, he should have excellent pedagogical skills.

2) The second and new role offered by our model to the teacher is that of a co-learner and team leader with regard to the students and that of a consultant with regard the partner companies. In this role, the teacher should possess a solid theoretical background on the subject matter as well as an overview of practical software tools that may be used. However, the teacher does not typically master the details of the specific software that is learned in the course and he does not know about all the possible use cases presented by the partner companies. In this role, the teacher is the authority when it comes to pedagogical issues and an overall view on the subject matter and the software products related to it. However, the software provider is the ultimate authority when it comes to the usage of its products. The partner companies are the ultimate authority when it comes to the use cases related to the technology and to the skills and knowledge needed from their personnel. The role of the teacher as a consultant with regard to the partner company requires very good communication skills as well as an overview of the domain in question. The teacher is able to form this kind of overview based on the formal education he has received as well as based on all information he has collected whilst collaborating with several partner and software provider companies in the field.

We propose that the above mentioned two different types of roles should be made transparent to the teachers. Both roles are needed. Some teachers may opt for teaching only courses requiring one type of role and some teachers may opt for courses requiring different teacher roles. However, it is important to acknowledge that the roles are very different. As explained in the description of the case university in the methodology section, Haaga-Helia University of Applied Sciences also has other well-established models for bringing in company-driven and current topics into its courses. Of these models, only the software project involves an intensive commitment from the teacher. The role of the teacher in the software project type of course is somewhat similar to the role 2) presented in conjunction with our model. The difference is that as the topics of the software projects typically vary very much, and as there is only one partner company involved, it is difficult for the teacher to gain a deeper perspective on any specific topic or domain and thus the role of the company consultant is not obvious. Therefore, we can say, that the role 2) is a new role to the teacher even though elements of it are present in our previous and well-established models for company collaboration.

6 CONCLUSIONS

The universities of applied sciences should be able to dynamically adjust their curricula to the needs of the future employers of their students. This is typically achieved through various forms of cooperation between academia and industry as well as through research done on the future or current needs of companies.

In this paper, we presented a novel model that enables the introduction of courses on new skills and knowledge into the curricula of higher education institutions in a much more dynamic manner than before. The model also shows (and allows for that) how students may start learning even before their teachers. Finally, also the participating companies end up gaining new knowledge and skills. The model was implemented two times in the form of an undergraduate course on AI. We presented its evaluation by gathering and analyzing the experiences of all stakeholders from the two consecutive course implementations.

The main novelty of the model is that it allows for a dynamic modification of the curriculum in a timely way. The teachers that possess the relevant theoretical background on the subject matter may start teaching in cooperation with the company partners even before they have learned the practical details of the tools and company cases. This saves both time and resources as the teachers don't need to go

to a traditional training before they can deliver the course. The partner companies benefit in the form of new ideas and a broader perspective on the subject matter. They may also benefit by recruiting skilled workforce. The greatest winners of the model are the students who get an up-to date and practically oriented course and who learn skills and knowledge with high demand on the job market.

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