IT SPIRAL: A Case Study in Scalable Software Engineering Education

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Abstract

IT SPIRAL is a collaborative project by nine universities and four industries to develop a common curriculum for teaching software engineering. It combines existing foundation educational practices at the individual universities, a shared DVD library on advanced software engineering topics, and common intensive sessions led by industry participants. It aims to develop advanced IT skills in top-level students, shared educational skills and materials among the universities, and practical cooperation with industry to focus and advance masters level software engineering education. IT SPIRAL combines fundamentals, advanced topics, and a practical focus in a scalable approach to developing world-class software engineers.

1. Introduction

Scalable software engineering education can use methods developed in the testbed of the IT Specialist Program Initiative for Reality-based Advanced Learning (IT SPIRAL). The use of a library of DVD-based lectures and presentations for basic and advanced software engineering topics allows rapid and efficient increase in the number of students. The intensive practical sessions leverage the participation of industry partners to allow effective work with the students in a way that also can be rapidly increased in scale.

2. What is IT SPIRAL?

IT Specialist Program Initiative for Reality-based Advanced Learning (IT SPIRAL) is a collaboration of nine universities and four industries in the Kansai area in Japan that provides a common foundation for teaching software engineering using the strengths of the universities and industries in collaboration. It is a new approach to teaching software engineering for Japan, using the combined expertise and knowledge of universities and industry in a combination of video lectures provided by the universities, team exercises, and instruction and practice under the direction of industry participants. The goals of the project include developing advanced IT skills among selected students, cooperation among universities in providing software engineering educational materials, and cooperation with industry in providing a practical focus to master's level software engineering education.

IT SPIRAL grew out of two observations. First, industry and the modern world increasingly depend on software intensive systems. Problems with such systems are often more social issues than purely technical difficulties. We have already seen such incidents in banking systems, stock exchanges, traffic control systems and other areas. Second, there is an insufficient supply of skillful software engineers. The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) called for projects under the name of the "Leading IT Specialist Program" to expand practical software

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engineering education in graduate universities in Japan to help reduce the gap between increasing demands and insufficient numbers and quality [1]. The requirement for collaboration between universities and industry was a fundamental part of the projects. MEXT selected and funded six projects for four years out of 26 proposals from various universities.

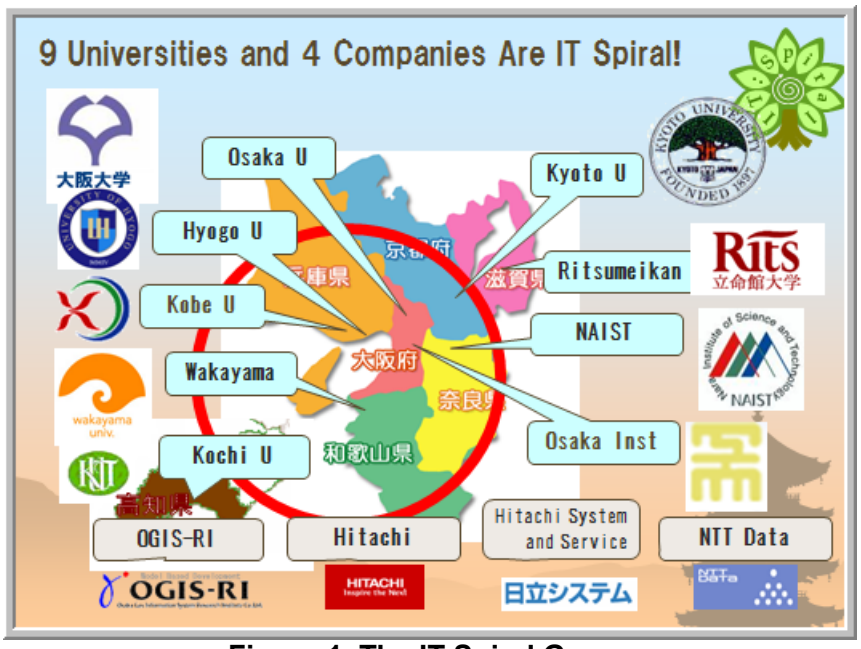

Figure 1. The IT Spiral Group

In the Kansai area, MEXT selected IT Spiral, headed by Osaka University, for its unique collaboration with many university software engineering professionals and researchers. This project includes nine universities in Kansai area listed in Table 1 and four industries as shown in Figure 1. Although others were interested, the initial project was limited to that group.

Table 1. IT Spiral Universities

Member Universities	
大阪大学	Osaka University
大阪工業大学	Osaka Institute of Technology
京都大学	Kyoto University
高知工科大学	Kochi University of Technology
神戸大学	Kobe University
奈良先端科学技術大学院大学	Nara Institute of Science and Technology (NAIST)
兵庫県立大学	Hyogo University
立命館大学	Ritsumeikan University
和歌山大学	Wakayama University

3. What is special about IT Spiral?

IT SPIRAL intends to develop top-level software engineers with technical background for the long term. It deliberately focuses on selecting talented students and encouraging world-class software development activity. It provides systematic software engineering education. One of the key realizations in developing the collaborative

curriculum has been that it is not enough for students to know that they can use a particular method to develop something or that they use some tool in a particular way. Instead, IT SPIRAL encourages students to ask why this method works, and are there any other ways to do things. This shift from knowledge, comprehension, and application -- Bloom's lower levels -- to analysis, evaluation, synthesis and even further into creativity and transfer into new domains of thought [2] has not been easy, but it is considered a necessary part of the new curriculum, as shown in Figure 2. Appendix D of the Guide to the Software Engineering Body of Knowledge (SWEBOK) described Bloom's Taxonomy [3].

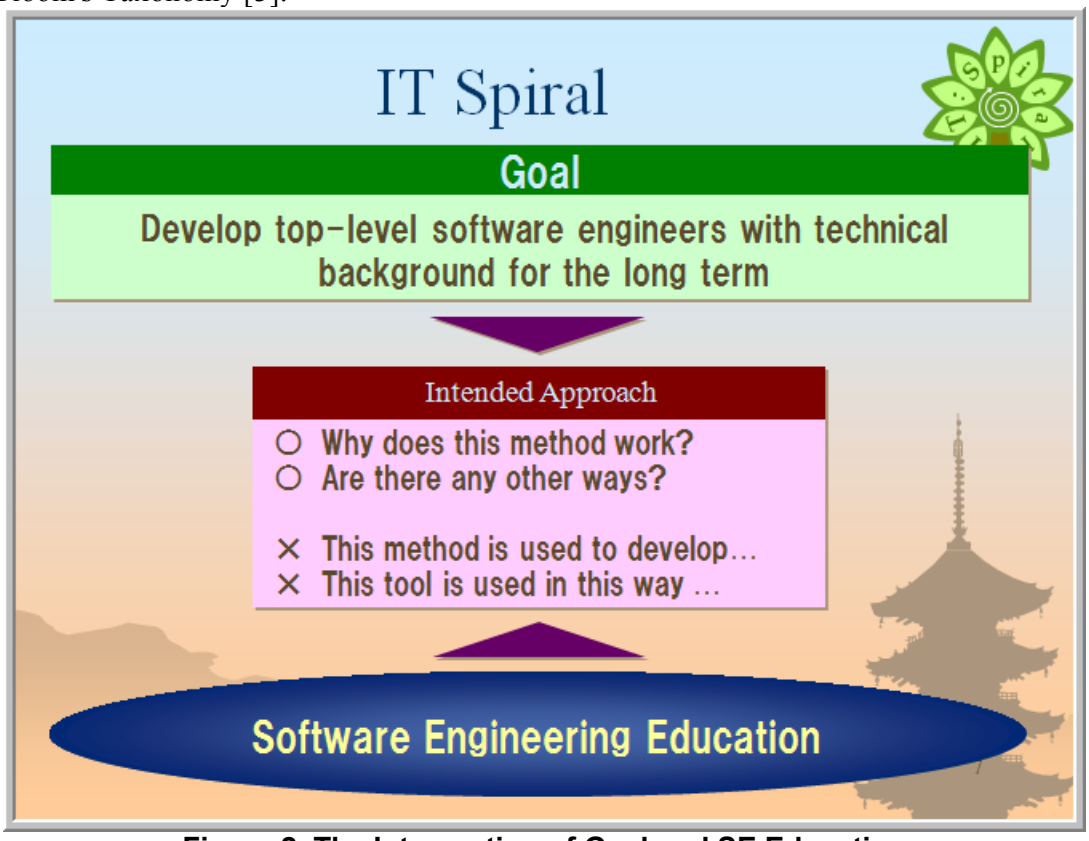

Figure 2. The Intersection of Goal and SE Education

Three elements help to develop the desired talent. First, the project involves top educators, researchers, and industry leaders in the Kansai area. Second, the project is selective, with 40 top-quality students each year. Third, the curriculum and materials were developed for this purpose drawing on resources of all nine universities and four industries.

The curriculum builds on three core concepts. It begins by systematically teaching fundamental subjects related to software development, the basic skills of software engineering. It also teaches new trends, techniques, and research with the theories behind them, to encourage the capability of continuous learning and adaptation. Finally, the curriculum provides practical development opportunities, encouraging practical skills.

The classes also reflect this threefold division. Each graduate school assigns and teaches fundamental software engineering subjects to students at their university. Faculty from all of the universities have developed a shared library of DVD lectures

and associated exercises or materials on advanced software engineering subjects, which each university can use in their own way to enhance the software engineering education for their students. During the first year, this produced 60 one-hour lectures organized into 12 volumes focusing on various advanced topics such as:

Code Clones	MCU Architectures	Agile Methods	Software Patterns
UML design	Data Mining	Real-Time Software	Web-based software
Meta-modeling	Software repositories	Components	Frameworks

Finally, industry lecturers with university teaching assistants teach the practical software engineering subjects. These sessions are especially important because they bring the real world of software engineering into the academic programs and challenge the students [4]. The students from all nine universities go to Nakanoshima Center, a common meeting point, for six hours of intensive work on alternative Fridays. Figure 3 shows the students at work during the common intensive session. The DVD library and intensive sessions reflect the reversal of the lecture/homework paradigm, since the DVDs can be watched whenever convenient, allowing the intensive sessions to focus on questions, exercises, and problem-based learning [5].

Figure 3. The IT SPIRAL Intensive

IT SPIRAL used the Computing Curricula 2005 (CC 2005) [6] and SWEBOK [3] materials extensively during design of the curriculum. One of the areas of discussion during the curriculum design process looked at the existing expertise in the 10 SWEBOK areas. Figure 4 shows the mapping of expertise by the various universities against those areas. This helped identify, for example, the two schools that could provide materials and expertise in software requirements. The university names have been removed from the column headings in this chart to protect confidentiality.

While there are known concerns about the SWEBOK and CC 2005 recommendations [1], these were available while IT SPIRAL was developing. IT SPIRAL intends to participate in the new Graduate Software Engineering Reference Curriculum project (GSwERC) [7].

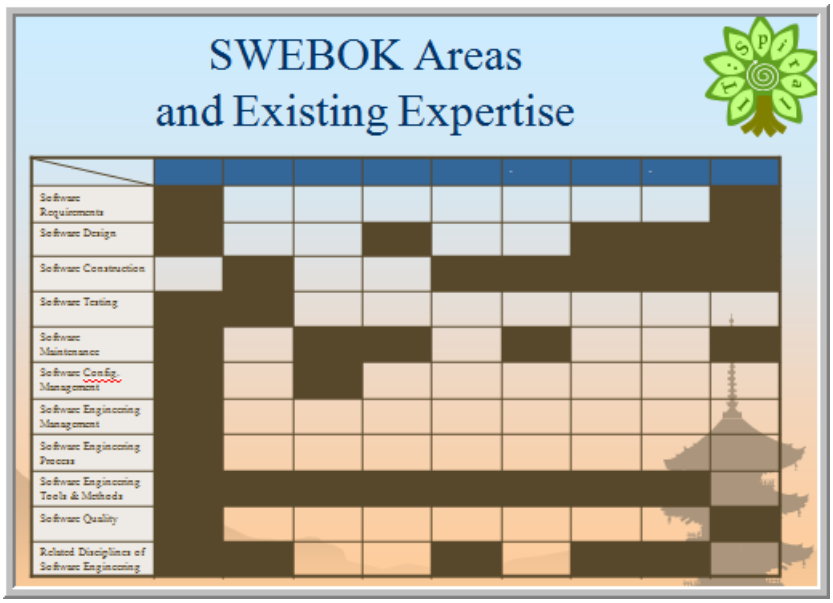

Figure 4. Mapping SWEBOK Expertise

IT SPIRAL can also be considered in terms of pedagogical frameworks such as that of the National Survey of Student Engagement [8]. Although the measures are informal, IT SPIRAL has set high expectations for student achievement (level of academic challenge). The three branches of the IT SPIRAL curriculum encourage student involvement with the educational process, and application of knowledge in various situations (Active and collaborative learning). Industry experts, teaching assistants, and faculty interact with the students as role models and mentors (Student-faculty interaction). The varied learning opportunities clearly enhance the educational environment of IT SPIRAL (Enriching educational experience). Finally, the universities involved promote involvement in the program (supportive campus environment).

4. What has IT SPIRAL done?

One of the key questions for a project such as this is how to measure the effectiveness, as suggested in Figure 5. For the IT SPIRAL project, the most important measure is fostering top-level software engineers who can demonstrate that they have mastered practical software engineering techniques. A related important result is the promotion of cooperation between the universities and industries in developing top-level software engineers.

First, it has developed a common one-year curriculum for software engineering masters students in the Kansai area that includes emphasis on basic skills, advanced topics, and practical capabilities. Second, it provides a model for university and industry collaboration in such education, combining local classes, a shared DVD library of lectures, and bi-weekly common intensive practical sessions. Third, it has raised a number of questions about the best way to share materials, projects, assignments, tests, and similar parts of the educational experience.

Our experience with the shared DVD library indicates that teaching assistants can easily show the DVDs to a class, freeing the faculty from repetitive lectures. Copying the DVDs and sending them to other universities allows a single expert to reach many more students. Our experience also shows that simply showing the DVDs is not very effective. However, having the teaching assistants stop the DVDs at natural pauses and

ask the students to discuss the main points or any questions increases the interest and involvement of the students with the material significantly. Structured interaction lets the students teach each other and develop deeper knowledge of the material being taught [7].

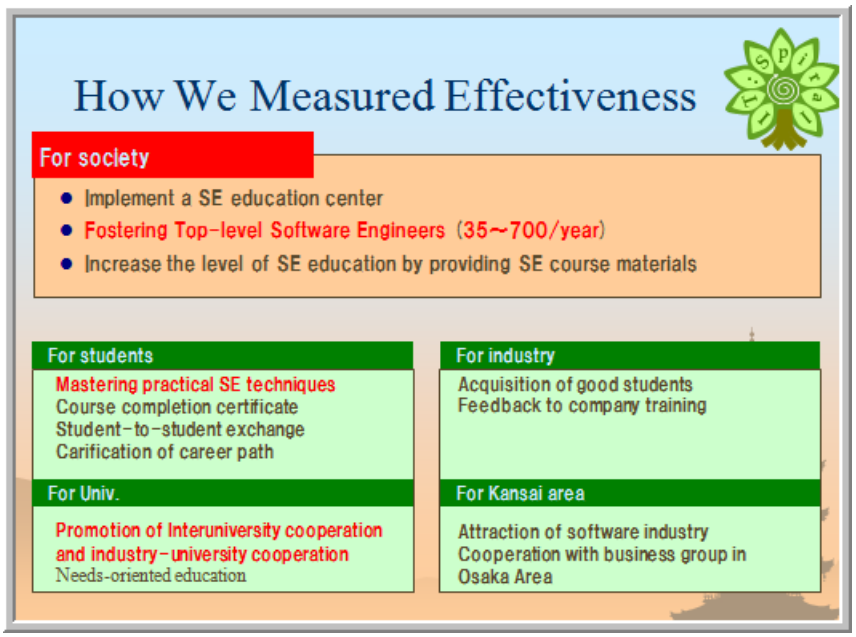

Figure 5. Measuring Effectiveness

One measure of the influence of IT SPIRAL is the distribution beyond the core students. For example, one report indicates that while 42 students are involved in the core lectures, 253 students from the nine universities have used the DVD library, and 1293 students have taken part in the fundamental courses. Additionally, the DVD library and other teaching materials are already being requested and loaned to other institutions of higher education such as the Osaka City University and Keio University graduate schools, and industry. Also, there are plans for an international symposium in January 2009.

Table 2 shows selected results from a recent survey of faculty and industry leaders involved in the project about some key parts of the IT SPIRAL project:

Table 2. Selected Survey Results

PURPOSE	• The main purpose is practical software development training. • Enterprises benefit from developing and obtaining IT talent to support Japanese information technology. • Students obtain basic skills for IT talent, including communications technology and management understanding. • Universities improve their educational approach through cooperation and experimentation with new educational methods.
DIFFERENCES	• Students can meet people from other universities and industry. • Corporate lecturers bring experience with actual development process • Software development is covered from early requirements to

	testing, • Highlights the importance of estimation and project management. • The use of video materials with team exercises
RESULTS	• Improved communications skills and the practical software development attitude among students. • A library of video materials, practical lectures, and courseware for real projects. • High student satisfaction ratings, industry obtains high quality graduates, and the growth of intercollegiate cooperation.

6. What are the recommendations and lessons learned?

One of the areas for future discussion and collaboration concerns the shared libraries and other products of IT SPIRAL. While the focus in the first years has been on lecture materials, the project has also developed exercises and practice materials. The IT SPIRAL project also intends to document the curriculum and pedagogical framework and make it available for other universities to build on. The project is also working on shared tests and assessments and we expect that developing consistent methods for assessment of the IT SPIRAL students can provide another useful shared body of materials. At this point, all of the IT SPIRAL materials are shared among the project members, however as the project continues we will also examine possibilities such as placing the IT SPIRAL classes in OpenCourseware or Creative Commons licensing, subject to MEXT approval.

One of the areas for future development concerns undergraduate preparation leading to the Master's Level IT SPIRAL studies. For example, it might be helpful to recommend an undergraduate curriculum that would lead naturally to the IT SPIRAL courses. Also, we will consider ways to reuse the IT SPIRAL materials in other Master's level programs. For example, various other courses at the nine universities have already used the DVD lectures. A final consideration for future planning of the IT SPIRAL program concerns the continuing education all of the students, both academic and lifelong learning or industrial. After students graduate from the program, should IT SPIRAL provide continuing access for them? For example, as the project develops new DVD lectures on new topics, should the graduates receive a newsletter and be able to visit the university library if they are interested in watching one of the new topics? In essence, the IT SPIRAL project needs to be integrated with undergraduate, other graduate programs, and continuing education programs at all nine universities and in the industrial partners.

IT SPIRAL has shown that cooperation between universities and industry can provide a wider range of educational materials and more depth. It has also shown that involving industry directly in the educational experience benefits the universities, the students, and industry. Finally, it has shown that video materials, team projects, and practical experience provide students with necessary academic background and good practical experience with applying that knowledge.

Can the methods used by IT SPIRAL provide scalable, effective software engineering education? The DVD library certainly provides a solution to scalable shared materials, and frees faculty from repetitive lecturing. The use of team exercises and industry partners in practical intensives provides a powerful learning experience, but would require additional participation by more industry partners to grow. It isn't a panacea, but it is a start.

Acknowledgement

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