Practical IT Education. Deepening of Technology, Expansion of Work, and Development into Headwaters: A Systematic Effort to Achieve Higher Levels

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Abstract

A practical IT education is a combination of lectures and exercises, as well as learning and putting into practice the theory of a fundamental system technology. The following is presumed. It is important to execute such education by directing the accumulation of knowledge and the expansion of knowledge through the spiral model, making it more educationally effective.

The present treatise considers the efficacy of education when supplemented with working examples of graduate research that direct the accumulation and expansion of knowledge through a spiral model, and lectures accompanied by graduate research. Further examples are shown of the development into headwaters and systematic effort through a spiral model as a plan for increasing the efficacy of the education. This effort relates to "practical IT education", for which new directionality is suggested.

Keywords: Education, Spiral model, Skill, Measurement, Graduate research, Headwaters

Introduction

In the thesis (Fujio, 2000) the author provided the necessary knowledge needed to analyze, design, and build information systems. Since the combination of lectures and exercises is important (Felder & Silverman, 1988), the author provided specific examples of sales management design. In thesis (Fujio, 2002), the author provided the technological development format of the basic system of a 3-tier e-business. Further, in thesis (Fujio, 2003), the author performed a study on the theme of "activating the local community using IT", giving 4 specific examples, as well as measuring the efficacy of education.

Regarding graduate research carried out on the basis of the thinking in theses (Fujio, 2000, 2002, 2003), the present treaties shows the measurement results of an analysis of student questionnaires over the past 3 years, and suggests directionality for "practical IT education" through supplemental fieldwork for areas in which the efficacy of education is low.

Deepening of Technology and Expansion of Work

Science and technology have advanced from the past to present with the accumulation and expansion of technology. In education, is it also possible to accumulate and expand knowledge? Specific examples of graduate research are examined hereafter and the possibilities are investigated. Considering Kolb's spiral model (Kolb, 1984), a lifecycle in Barry Boehm's spiral model (Barry, 1988) using Object-Oriented Analysis/Design, is applied in the present treatise. The accumulation of knowledge, the vertical axis of the spiral model (Figure 1), is defined as the deepening of technology. The expansion of knowledge, the horizontal axis, is replaced by the expansion of work. The effect of education in graduate research was also measured according to the level of the students.

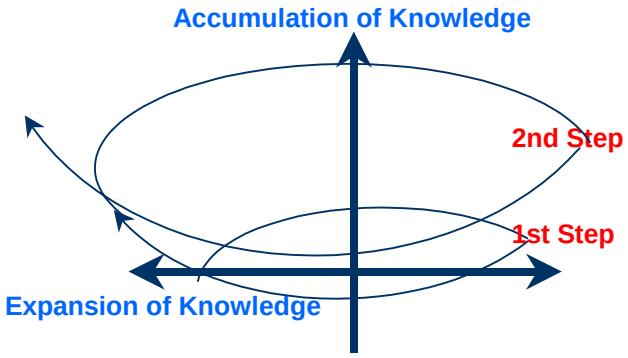

Figure1: Spiral Model

Deepening of Technology

Application was made of the accumulation of knowledge, or in other words, the deepening of technology, to the design and manufacturing phase of the lifecycle of an information system construct. The research lifecycle of 1-year is divided into four phases, "Planning", " Environment Development", "Construction", "Evaluation and Paper/Design Specification". The next year research is succeeded by the late research. The technology is deepening step-by-step. The vertical axis of Figure 1 represents the accumulation of knowledge. In order to understand the trial manufacturing system of the previous year, students first acquired basic knowledge about servers, Java, databases, etc., and solved problems from texts and reference books to gain understanding. Next, an understanding was obtained of the architecture used in the trial manufacturing system of existent graduate research, which was developed by its application to the future systems designed in graduate research. Table 1 shows 4 years of examples.

"Year-No." in Table 1 refers to the students, wherein "01-1" refers to the first student graduating in 2001, and "01-2" refers to the second student graduating in 2001. The author extracted the research of two students from each year. It can be seen that student "01-1" in Table 1 designed a client-centered system, using Windows as the OS and Access as the database, and programmed it using Java.

Generally, the student designed trial manufacturing system started as a client centered system and later as a server centered system. The OS on the server was mainly Windows, but Linux was also used. The Java language started with Java and was expanded to JSP and Servlet, and Access was used mainly for the database, but MySQL and PostgreSQL were also used. For the client computers, use was made of mainly Windows PCs, but i-mode cellular phones were also used. As can be seen, as the years passed, the technology deepened and knowledge was accumulated.

Table1: Deepening of Technology

Year-No.	Client centered system		
	Client side		
	OS	**Java Language**	**Database**
	Windows	**JAVA**	
01-1	○	○	○

Year-No.	Server centered system									
	Server side								Client side	
	OS		**Java Language**			**Database**			**PCs**	**Cellular Phone**
	Windows (Tomcat)	**Linux (Apache-Tomcat)**	**JAVA**	**JSP**	**Servlet, JavaBeans**	**Access**	**MySQL**	**Post-gre SQL**	**Windows**	**i-mode**
01-2	○		○							○
02-1	○		○			○				○
02-2	○		○	○		○			○	
03-1	○		○				○		○	
03-2	○		○	○	○	○			○	○
04-1	○		○	○		○			○	
04-2		○	○	○				○	○	

The Expansion of Work

The system domain of design and a trial manufacturing in application was applied to the work processed by the information system. Even work for the trial manufacturing system was expanded with the spiral model, which has a 1-year cycle. The horizontal axis in Figure 1 represents the expansion of knowledge. Students with ability and volition understand the basic work, and can expand it to the entire system. It is important that social science students have an understanding of information, money, and the distribution of goods in order to build a complete system (Dhamija, Heller, & Hoffman, 1999). Examples of work expansion are shown in Table 2.

"Year-No." in Table 1 is made to correspond to the students. Specially mentioned items in Table 2 describe the characteristics of the applications. For instance, student "01-1" has a client centered design, in which the work of the client is customer management. Student "01-2" has customer management on the server, student "02-1" has added sales management, student "03-2" has added product management, and student "04-1" has added accounting, expanding the work. Even the i-mode function is expanded from the schedule referred to in "01-2" to the stock browsing referred to in "02-2"'. As each year passes, the work expands, and knowledge increases.

Measurement of the Efficacy of Education

Graduate research was preceded as follows. Third year students spend one day a week in class (90 minutes), 30 times in all, learning the "IT basics" and "System design basics using database/Java". Fourth year students individually decide on a theme for graduate research for which they accomplish "research and design a trial manufacturing system". Main themes are how to solve the local communities' problems using information systems. Once a week (90 minutes) they report on their study progress, receiving the guidance of the instructor.

Table2: Expansion of Work

Year No.	Client centered system	
	Client side (Work)	Notes
	Customer management	
01-1	○	**1)**

Year - No.	Server centered system										
	Server side (Work)								Client side(Work)		Notes
	i-mode server function		**Customer management**	**Sale management**		**Product management**		**Accounting**	**PCs**	**Cellular Phone**	
	Schedule table	**Stock browsing**	**Customer list**	**Order**	**Stock**	**Buy**	**Stock**	**Profit**	**Online terminal**		
01-2	○		○							○	**2)**
02-1			○	○					○		**3)**
02-2		○		○						○	**4)**
03-1			○	○	○				○		**5)**
03-2		○				○	○		○	○	**6)**
04-1			○	○	○	○	○	○	○		**7)**
04-2			○	○	○				○		**8)**

1)Customer's record, discount by record points 2) i-mode design 3) Basic sales management
4) i-mode & database 5) Expansion of sales management 6) i-mode & PCs
7) Expand to sales, product management & accounting 8) Complicated Regional e-commerce

Figure 2 shows the skills of 22 students graduating from 2001 to 2004, after the completion of their graduate research, and was compiled based on questionnaires. The Appendix shows a sample skill level questionnaire. It investigates skill level (A) that students have only acquired in lectures and laboratories. About the same skill level items, using the same format questionnaire, are used to investigate skill level (B) after graduate research. To measure the graduate research effect, the research structures are classified and shown with explanatory remarks. "High level" indicates students who willfully researched reference materials and created an advanced trial manufacturing system. 9 applicable students are distilled. 8 students in Table 1/2 are included in this high level. "Mid level" indicates those students who researched reference materials and created an average trial manufacturing system. 9 applicable students are distilled. "Research level" refers to the other 4 students who mainly researched reference materials, but did not make a trial manufacturing system.

The vertical axis indicates skill levels (Lethbridge, 2000) that were acquired, wherein "0" represents students who have no knowledge, "1" means he is familiar with the material, "2" means he has acquired a basic knowledge, "3" means he can apply his knowledge, "4" means he has learned a lot, and "5" means he has learned deeply and is an expert.

The horizontal axis shows items learned relating to administration/management (administration and information, management and information), research methods (how to proceed with research, how to write a thesis), system building techniques (Lethbridge, 2000) (acquisition of requirements, analysis/design techniques, database design, network design, software design, algorithm

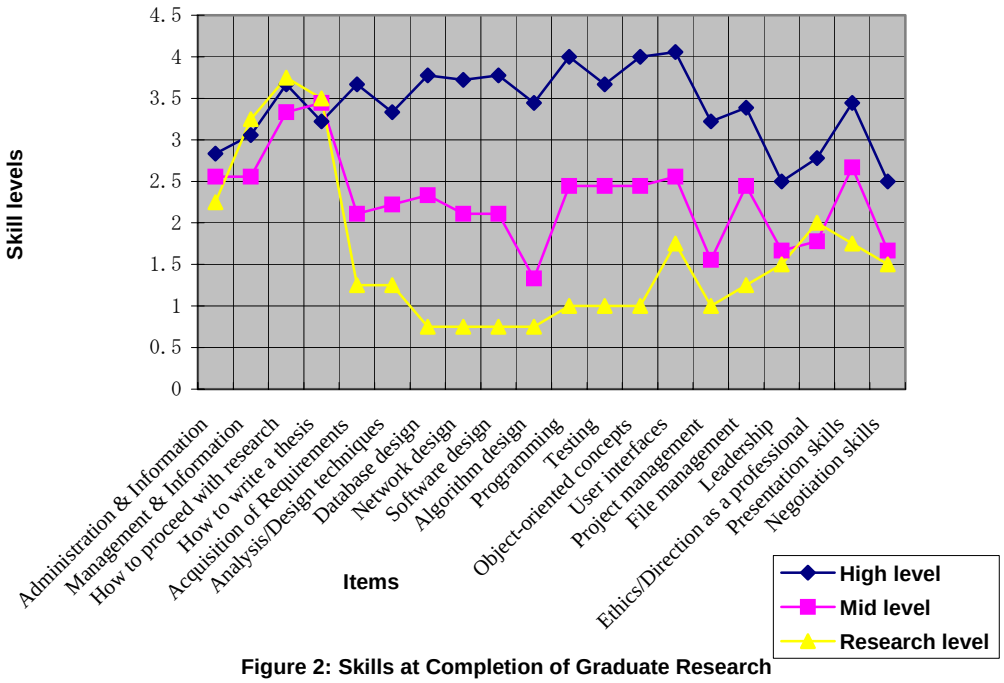

Figure 2: Skills at Completion of Graduate Research

design, programming, testing), system architecture (object-oriented concepts, user interfaces), development management (project management, file management), SE skills/morals (leadership, ethics/direction as a professional, presentation skills, negotiation skills).

Skills at completion of graduate research

Items relating to administration/management in Figure 2 are studied to learn how to solve problems of administration and management in information systems. Basic knowledge can be applied regarding “Administration and Information,” wherein “high level” skill is 2.8, “mid level” skill is 2.5, and “research level” skill is 2.2, and for “Management and Information,” “high level” skill is 3, “mid level” skill is 2.5, and “research level” skill is 3.2.

“High level” skill for “how to proceed with research” as a method of doing research is 3.7, “mid level” skill is 3.3, and “research level” skill is 3.7, with 3.3-3.5 for all skill levels being appropriate for applying knowledge on “how to write a thesis.”

Students of social science have attained the basic skills for all skill levels “high,” “mid,” and “research” for skills relating to administration/management as well as for how to proceed with research.

The skills for the 8 items of system building techniques and the 2 items of system architecture are for a “high level” of 3.4-4, and high for students who willfully made a trial manufacturing system. “Mid level” skills are 2—2.5 and the “research level” is 0.7-1.2. Students who only did research with reference materials are low. However, 1.4 is low for “mid level” in “Algorithm Design,” and 1.8 is high for “research level” in “User Interface.” A great difference in skills can be seen between the “high level,” “mid level,” and “research level” for these items.

A “high level” skill for “project management” in development management is 3.2, “mid level” is 1.5 and “research level” is 1.0, which is low in comparison to other items, since it relates to individual research. The SE skills/morals and presentation skills are higher due to the holding of presentations for graduate research with a “high level” skill being 3.5, “mid level” being 2.6 and “research level” being 1.7.

Comparison of graduate research and lecture skills

Figure 3 is a comparison of skills after the completion of lectures, with the skills existent up to the point when the graduate research is completed. “High level” and “mid level” skills were investigated.

“Management and Information” skills relating to administration/management increased from 2.7 to 3 for the “high level,” and from 1.9 to 2.5 for the “mid level.” In addition, skills in research methods on “how to proceed with research” and “how to write a thesis” increased in both the “high level” and “low level” from 2.4 to 3.4, showing a great effect from graduate research.

In system building techniques, the following items showed a great increase in skill. “Database design” increased from 2.8 to 3.8 for the “high level” and from 1.9 to 2.4 for the “mid level.” “Network design” increased from 2.6 to 3.8 for the “high level” and from 1.5 to 2.2 for the “mid level.” “Programming” increased from 3.8 to 4.0 for the “high level” and from 2.1 to 2.4 for the “mid level,” and “testing” increased from 3.3 to 3.7 for the “high level” and from 2 to 2.4 for the “mid level.” As can be seen from above, the breadth of improvement in the “high level” is greater in comparison to that of the “mid level.”

“Object-oriented concepts” in system architecture skills showed greatly improved breadth from 3.2 to 4 for the “high level” and from 2.1 to 2.4 for the “mid level,” and “User Interface” increased from 3.8 to 4.1 for the “high level” and from 2.2 to 2.6 for the “mid level” because the

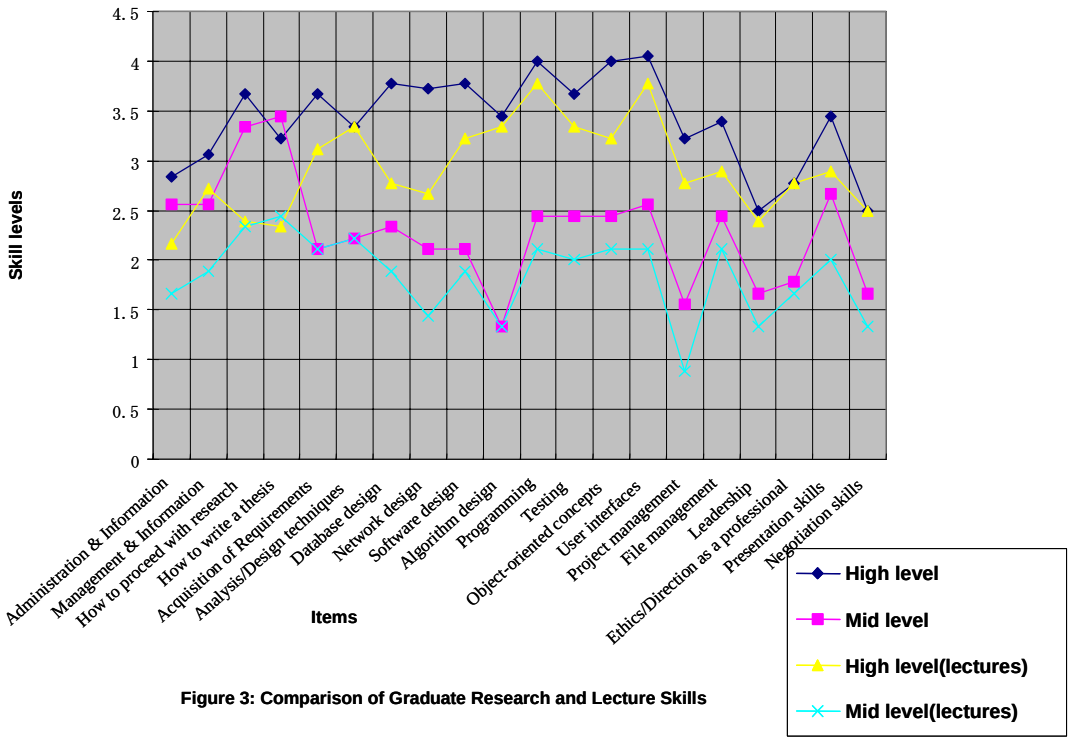

Figure 3: Comparison of Graduate Research and Lecture Skills

students had hands-on experience in an actual system.

An increase can be seen in “project management” in development management skills from 2.8 to 3.2 for the “high level” and from 0.9 to 1.5 for the “mid level.” “Presentation ability” in SE skills/morals increased from 2.8 to 3.5 for the “high level” and from 2 to 2.7 for the “mid level.”

The supplemental effect of graduate research can be seen overall. The efficacy of education, where graduate research supplements lectures, is understood to be especially great in “high level” students.

Development into Headwaters and the Systematic Effort

The vertical axis of the Spiral Model in Figure 1 represents the accumulation of knowledge toward development into headwaters and the horizontal axis represents the expansion of knowledge as a systematic initiative. In industry, information strategies are proposed with a current survey or analytical phase, in order to plan the desired information system images. In the University, desired system images are drawn, designed and created by students primarily based on bibliographic research, primarily because of the time or cost required to execute field surveys and to examine the current situation.

So far the philosophy, importance of experience, has been mentioned on Cone of Experience (Dale, 1946), but was not embodied in the universities. As an embodiment for higher-level development, examples are cited of field studies for building sightseeing information systems relating to current surveys or analytical phases constructing the upper level information systems. Next, as an example of an organizational initiative, an introduction is made of fieldwork, which has been started by the university.

Sightseeing Information System

This is an extracurricular activity in which research examination of regions is accomplished by planning independent fieldwork in which the students can freely participate. The students propose a plan to be executed, and if there is agreement, the expenses are provided by a support group. In addition to achieving an understanding of the current situation, problem points are educed, and resolution measures are proposed and created using an information system. Examining the current situation comprising the source point of IT education, consideration is given as to whether or not the problem areas can be resolved.

The first test is to undertake the following types of survey, to educe the problem points, and to propose measures for their resolution.

Survey (fieldwork)

1) The ASO region was made the subject region in which survey items were established in relation to the sightseeing characteristics of the region.

(1) Hot springs; (2) Points of nature; (3) Lodging establishments; (4) Product development; (5) Shopping sites

2) The survey method comprises the accumulation of information through the Internet, the use of fieldwork (on site surveys), and survey questionnaires.

Diverse surveys were undertaken in multiple locations, giving rise to the overall characteristics.

(1) Fieldwork

- On site, surveys of lodging and sightseeing facilities were conducted.

- Collection of many still pictures and moving pictures

(2) Questionnaire Survey

- Responses: survey items were created for each object facility.

- Lodging facilities: information was collected relating to location, client information characteristics and peripheral sports. Pictures were taken of the external environment and the inside of rooms and baths. Collected materials included lodging guides and peripheral maps and the like.

Presentation

Survey materials were compiled to be visually self-explanatory.

e-Map System

Surveyed and analyzed hot springs or lodging facilities were displayed by hand on electronic maps.

Owing to temporal limitations, and the lack of experience in the use of scientific survey methods, the survey was restricted to a limited region, and the anticipated results could not be obtained. However, the upper-level field survey obtained was an information system otherwise unavailable through the construct of only the University, and the fact that the current state of the region could be ascertained on the basis of individual experiences is a significant achievement.

"Moyaisuto" Education Program

"Moyai" is a slogan used when rebuilding the relationship between man, nature, and regional society. Beginning with this year, the objective of this program will build upon individual experiences by constructing a career from among the large number of experienced successes and failures, and from among many human relationships with nature, touching upon the actual regional problems and creating proposals for their resolution. The initiative will involve all students, including graduate students.

The anticipated results will build upon (the strength of cooperation between the regions and the universities and the like), and include publications extended to the regions (relating to discovered regional problems and resolutions), educational effects (individual re-discoveries and edification, relating to an understanding of the regional economies and administrations, and their cultures and traditions and succession, etc.), and education/research.

Hereafter, we would like to establish the position of "Education in IT Survey Research Region" within the education program of this type of organizational "fieldwork".

Conclusion

The author has given actual proof applying the accumulation and expansion of knowledge through the spiral model to the education of information system building.

The deepening of technology and the expansion of work (Table 1 and Table 2) is regarded as having been successful, as shown by the actual results of 4 years of students. In addition, measurements of the effectiveness of education (Figure 3) provide actual proof of the effectiveness of education supplemented by a combination of lectures and graduate research. However, the increase in the amount of skill for such things as the “acquisition of requirements” and “analysis/design techniques” in system building techniques, and “leadership, ethics/direction as a professional,” and “negotiation skills” in SE skills/morals has been limited. In order to strengthen this area, consideration is given to the development of upper classes for the fieldwork referred to in item 3, which has become the primary body. Furthermore, through the organizational accom-

plishment of the fieldwork, a single layer educational effect can be anticipated. This is a place in which students can experience for one selves a method for independent discovery and resolution of problems points, and correction of the regional views.

Hereafter, studies will be accelerated for methods of initiative and guidance for building an information system for increasing the efficacy of education.

References

Barry, W. B. (1988). A spiral model of software development and enhancement. *IEEE Computer, May*, 61-72.

Dale, E. (1946). *Audio visual methods in teaching*.

Dhamija, R., Heller, R., & Hoffman, L. (1999). Teaching e-commerce. *Communications of the ACM, 42*(9), 50-55.

Fedler, R. M. & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Fujio, Y. (2000). Information system design of undergraduate education. *Proceedings of SITE 2000, Society for Information Technology & Teacher Education International Conference*, 359-364.

Fujio, Y. (2002). Education of overall IT system design. *2002 Proceedings Informing Science + IT Education Conference*, 507-511. Available at http://proceedings.informingscience.org/IS2002Proceedings/papers/Fujio047Educa.pdf

Fujio, Y. (2003). Building a regional community with IT. *2003 Proceedings Informing Science + IT Education Conference*, 7-16. Available at http://proceedings.informingscience.org/IS2003Proceedings/docs/010Fujio.pdf

Kolb, D. A. (1984). *Experiential learning.* Englewood Cliffs. NJ: Prentice Hall.

Lethbridge, T. C. (2000). What knowledge is important to a software professional? *Computer, 33*(5), 44-50. *IEEE Computer Society*.

Biography

Yoshinori Fujio is a professor at Prefectural University of Kumamoto, where he teaches Information Administration, Software Design, Information System Development and Web related courses. He has authored papers on Education in Information Technology & Computer Science, CASE and 4 books on the subject of Information Processing Engineering.

From 1966 to 1994, he belonged to NEC, Nippon Electric Company, where he engaged in design of magnetic tape controls on NEC's computer and managed the Technical Support Center for SE. In the meantime, he had contributed to the national Σ project for increasing software productivity in Japan.

Appendix

Skill evaluation questionnaire for information science & technology

Research Day XX Day, XX Month, XX Year

School register Name Faculty

*About skill level that only you have acquired in lectures/laboratories**; before graduate research***

Please write sign ○ on your attained skill level in Table.

"0": **you have no knowledge** "1": **you are familiar with the material** "2": **you have acquired the fundamental knowledge** "3": **you can apply your knowledge** "4": **you have learned a lot** "5": **you have learned deeply and are an expert**

Items	0 1 2 3 4 5	Notes
#Relating to administration/management		
1.administration and information		
2.management and information		
#Research methods **3.how to proceed with research**		
4.how to write a thesis		
#System building techniques **5.acquisition of requirements**		
6.analysis/design techniques		
7.database design		
8.network design		
9.software design		
10.algorithm design		
11.programming		
12.testing		
#System architecture **13.object-oriented concepts**		
14.user interface		
#Development management		
15.project management		
16.file management		
#SE skill/morals **17.leadership**		
18.ethics/direction as a professional		
19.presentation skills		
20.negotiation skills		