Learning Tacit Knowledge in Life Science Graduate Programs in Taiwan

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ABSTRACT

In this paper we describe preliminary results of a three-year project that examines the enculturation of doctoral students in life science programs in Taiwan, Japan, and Singapore. The purpose of the study is to examine how doctoral students in life science enrolled at universities in these three countries learn to become scientists and how information and communication technologies affect such processes. The project is in its first year, and we completed data collection in Taiwan during the summer of 2009. Data was collected using quantitative surveys, qualitative interviews, and time-diaries from advisors and doctoral students in life science programs in three Taiwanese universities. Preliminary results show that current students tend to have problems related to too great a reliance on computers, kits, and the Internet, and as a result, they fail to assimilate tacit knowledge that is invaluable in becoming the next generation of scientists.

Keywords

Knowledge production, scholarly communication, life science, information & communication technologies

INTRODUCTION AND BACKGROUND

Studies of graduate science education are important to gaining a better understanding of knowledge production processes, so that universities are able to successfully support the next generation of scientists.

In this paper, we describe preliminary results of a three-year project that examines the enculturation of doctoral students in life science programs in Taiwan, Japan, and Singapore.

These countries have steadily exhibited high rates of creativity, innovation, and productivity in recent years. As such, they are promising cases to study (Lemonick, 2006; Stiglitz, 2007). The project is in its first year, and the preliminary findings are drawn from some of the qualitative data collected in Taiwan during the summer of 2009.

The importance of learning and sharing tacit knowledge is widely recognized (e.g., Nonaka, 1994), especially in the knowledge production processes in science (e.g., Collins, 1974; Kennefick, 2000). As Duguid (2005) points out, however, many articles that deal with knowledge transmission focus on converting tacit knowledge into codified knowledge. This leads to an emphasis on "knowing that" rather than "knowing how" (Ryle, 1949). On the other hand, "knowing how" provides useful contextual background that helps us understand how "knowing that" is utilized. "In learning situations, . . . it is not simply what a mentor or teacher can say, but also what he or she implicitly displays about the particular art, craft, or discipline" (Duguid, 2005, p. 112). Thus, Duguid stresses the importance of learning how, which tends to be transmitted in a tacit form.

One of the reasons that scholars have paid more attention to the codification of tacit knowledge is partially due to the attention that Information and Communication Technologies (ICTs) receive in knowledge management literature. However, studies (e.g., Johannessen, Olaisen, & Olsen, 2001; Hara, 2007) have shown that ICTs are not particularly appropriate for sharing tacit knowledge. It is not just the limitation of tools' affordances, but also how people use them (Huysman & Wulf, 2005); which is to say, ICTs have the potential to be useful when connecting to others who are knowledgeable (e.g., Wasko & Faraj, 2005), despite their limitations in facilitating the transmission of tacit knowledge discussed above.

The original purpose of the study was to examine how graduate students gain tacit knowledge via their advisors in East Asian countries. As we interviewed advisors, they reported that they picked up tacit knowledge while they

were in graduate school for training. However, students today rely more on technology—some might say they over-rely—for knowledge gathering. Often, this is a solitary exercise conducted outside of a framework that includes face-to-face exchange of tacit knowledge; it's just not always the most meaningful exchange. As one advisor put it:

> Even . . . by looking at totally unrelated projects, you learn. . . . I just walk by some other labs and see some different apparatus. And then, you're curious about the function. And next time when you have a problem, maybe you're just looking for more ideas, more of what kinds of equipment or what kind of methodology or methods you can use (M09, personal communication, May 18, 2009).

Just like the literature of apprenticeship (e.g., Rogoff, 1990, 2008) and communities of practice (Lave & Wenger, 1991; Hara, 2009) suggest, current faculty members learn to become scientists by observing and spending time with other scientists and students. However, "They [students] don't do that . . . . They just hurry back to their computer or are surfing on the web" (M09, personal communication, May 18, 2009). Although Barjak (2006) confirmed that there is a positive relationship between being productive and the frequent use of the Internet for scientists, previous studies have not examined how ICT use affects students' learning in science programs.

STUDY CONTEXT
During the Japanese occupation (1894-1945), only one university existed in Taiwan. Since then, the number of universities in Taiwan has steadily increased. Since 1986, the demand for higher education in Taiwan has rapidly increased, and the number of higher education institutions has grown "from 28 in 1986 to 127 in 2000" (Wang, 2003, p. 265). The percentage of students who are between 18-21 years of age and who attend a higher education institution is 35.4%, which is approximately the same percentage as in the U.S. (34.6%). With these numbers, Wang (2003) concluded that Taiwan's higher education system has reached a level similar to the one in the U.S. and Japan.

The hierarchy of Taiwanese higher education emulates that of U.S. higher education institutions (Wang, 2003). Faculty members have three ranks (Assistant, Associate, and Full professors), and assistant professors are usually pre-tenure. After the reform of higher education initiated by the Taiwanese government in 1987, higher education in Taiwan was encouraged to internationalize, i.e., develop ties with universities overseas (Mok, 2003). In addition, the government instituted a systematic method for distributing funding (Mok, 2003). In fact, many participants reported that "publications in SCI [Science Citation Index]" are used primarily as productivity measurement when asked—though a few faculty members were skeptical about this particular measurement. A full professor who received his Ph.D. in the U.S. commented: "you know SCI? I don't like

that at all, because it's kind of crazy" (M30, personal communication, May 27, 2009). Another faculty member who spent ten years in the U.S. confirmed the idea that SCI is not a particularly useful measurement for gauging productivity by stating that "That's totally stupid if you ask me. . . . ten years I spent time in the States, nobody mentioned SCI to me" (M09, personal communication, May 18, 2009). The idea that productivity can be measured through SCI publications influences students' attitudes. "[T]he students will actually say, 'You say we're going to submit this manuscript to this particular journal. But this journal is only five points, impact factor is only five. Five actually is pretty good. Well, the other journal is like eight. Why don't we try that one instead of this one?'" (M09, personal communication, May 18, 2009). Another relevant factor for educating the next generation of scientists in Taiwan is that the number of students willing to go abroad (mainly to the U.S.) to earn a doctorate is declining in science. "My classmates, more than their seventy or eighty percent they go abroad for Ph.D. But now, maybe in our department, less than ten percent" (M30, personal communication, May 27, 2010). In this context, we examined how doctoral students learn to become scientists.

RESEARCH METHODS
We employed mixed methods (Schutt, 2006) to collect both qualitative and quantitative data in three higher education institutions (two national universities and one private university) in Taiwan. We conducted face-to-face quantitative surveys with 30 faculty members and 70 doctoral students in life science disciplines. Of these 100 participants, we recruited a sub-sample of 11 faculty members and 15 doctoral students for further face-to-face qualitative interviews.

Data Collection
The quantitative surveys covered questions regarding demographics, research area, research productivity, collaboration, support networks, ICT use, mentoring practices, and interaction with students (or advisors). The interviews lasted from 45 to 75 minutes. The participants were recruited by the country coordinator for the project, and we used a snow-ball sampling method (Schutt, 2006). All the qualitative interviews with faculty were conducted in English, with one exception. This faculty member was granted a Ph.D. in a Japanese university, and the interviewer was a native speaker of Japanese. Thus, the interview was conducted in Japanese, and the data was coded in Japanese. The quotes from this interview, however, have been translated into English. Only five qualitative interviews with students were conducted in English while the other ten interviews with students were conducted in Chinese, and are currently being translated into English for analysis. In this paper, we only report the analyses of the interviews with advisors.

Study Participants

All the advisor participants were Taiwanese. The majority of the advisors were granted Ph.D. degrees in U.S. institutions (eight out of eleven). Only two received their Ph.D. degrees in Taiwan, while another received a Ph.D. from a Japanese institution. Six participants were male, and five were female. The average number of years they spent outside of the country was 4.7 (ranging from one year to nine years). Only one faculty member did not have training overseas. The participants' research areas were limited to life science, although individual disciplines ranged from chemistry to molecular biology and neuroscience. Out of eleven, seven participants were full professors, three associate professors, and one assistant professor.

Data Analysis

The quantitative data was recorded by interviewers on paper and stored in SPSS, and all the qualitative interview data was tape-recorded and later transcribed.

The coding scheme was developed from the ground-up; no a priori coding scheme existed. Once all the interviews were coded, the codes were entered into NVivo 8.

PRELIMINARY FINDINGS AND DISCUSSIONS

In this section, we report preliminary findings—primarily focusing on the effect of ICTs, especially when it comes to supporting the acquisition of tacit knowledge by doctoral students.

As other studies have found (e.g., Tapscott, 2009), younger generations are more comfortable with technologies. However, overreliance on technologies can cause some problems. For example:

> The young students are not like what we were before or the older students—they can put more time in at their lab—and the new students have a lot of new computers and are free to explore. So, they are more interested in the Internet world, instead of a conventional lab or techniques (M01, personal communication, May 13, 2009).

Another faculty member pointed out that:

> … if I ask them [students] to look for an answer, they tend to just go to their computer, and go on the Internet. Even if there is an expert next door. They probably won't do that face-to-face. It just does not occur to them at the very first moment they can walk down the hall and ask an expert for the help (M09, personal communication, May 18, 2009).

This is problematic because these students miss the opportunities to learn from senior students or faculty members through face-to-face interactions, which could not only offer the particular knowledge they need, but also provide "cultural knowledge" about how to become a scientist. In addition, both M09 and M01 mentioned the problem of too many resources:

> . . . another problem is that there are too many answers from the resources they can find on the Internet. It is hard for them to judge which one is the best answer for them. And if they're not careful enough or just grab a quick answer, they will, most of the time or a lot of time, use answers that are not the optimal solution for their [problems]. (M09, personal communication, May 18, 2009).

As Duiguid (2005) points out, "[A]s teachers induct students into their discipline, they spend a great deal of time showing students how to read, for this is not simply a matter of learning to decode a text in the abstract, but of learning to decode from the perspective of that discipline" (p.113). By mostly interacting with computers and the Internet, students fail to take advantage of such learning opportunities. A prominent researcher in Taiwan describes the difference between the education he received in the U.S. in the seventies and the education he observes for current students in Taiwan:

> . . . students now just study from the computers. They pick up all the publications so quickly. But, I read so much at that time in the library [when I was a student]. And that helped me so much so now I can write very well. . . . But most students don't do all this. They just come and go very quickly so they don't learn how to write as well as I do. . . . and the skills are not so down to earth. They just used the kits, all these formulations. They just know this kind of extract protein; they don't know how the protein comes out (M26, personal communication, May 23, 2009).

He continued to say that [students] "don't know the real scientific basis for the important procedures in their scientific activities . . . . They just pick up this and that. They're just like a big chef—they take all the recipes" and make meals without contemplating how things work together.

Another professor in a different university echoed this concern:

> I think now that everything is using kits, kits, so basically you just add the following instructions: Add A1 and B1 and 2 and 3. Now it's like they don't even try to understand the concept or why the kit works . . . Like ten years back, . . . for each step, you have to add this chemical and that chemical. And they probably would in that case ask "Why am I doing this step? Why am I doing the second step?" And now if you ask them "How this particular kit works? Why do you have to perform this step?" Most of them wouldn't know." (M09, personal communication, May 18, 2009).

This issue of kit-based experimentation has, perhaps, created some of the problems. A faculty member who was educated in the U.S. commented:

> When I was young in the United States, when the instrument was done, you had to try to figure out what is the problem, where it is, and then try to fix it. Otherwise, you were delayed in your work, especially when you wanted to ask some maintenance engineering [staff] to come to fix it. It cost a lot of money at the time, waiting, so usually we would just tear off the instrument and try to fix them ourselves. But now the student just sits there and don't touch the instrument. Big change (M01, personal communication, May 13, 2009).

This issue is also related to students' attitudes. When asked about the traits of star students, three faculty members, out of eleven interviewed, emphasized "being independent" as one of the characteristics of successful students in science.

In fact, when asked about science training in Taiwan, one of the prominent researchers said:

> . . . the students in this country, probably, are not so independent in solving the problems encountered in their research. Not like what I was trained. I usually went to the library. I went to different labs to ask for advice. To get the professors' opinions all by myself. My advisor really didn't have the time to take care of all the students. He had like twenty students. But here, because the number of students is much smaller . . . we can really talk with students more frequently (M26, personal communication, May 23, 2009).

This small advisor/student ratio appears to provide an advantage for students in Taiwan, but this is not necessarily the case for fostering independent researchers. This may also be cultural and partly due to the structure of the graduate training. Another established full-professor commented:

> R[5]: In U.S. . . . my graduate professor gave me full freedom. She gave me a paper, this is the copy; that means, are you interested in that? Oh, I am interested. Go ahead, start it! After that, nothing . . . . So, I think this is very good because you have whole freedom, but here maybe a student cannot do that.
>
> I: Too dependent?
>
> R: Yeah, yeah . . . . I like to train them like this way, but for example, at the beginning they need to struggle because they don't know which way to go (M30, personal communication, May 27, 2009).

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[5] R refers to "respondent" and I refers to "interviewer."

Perhaps the nature of being dependent creates the situation in which students are overly reliant on technologies. If they go to computers and the Internet for answers, they get immediate answers. They do not have to *figure it out*.

Of course, using ICTs does not always produce negative effects; there are positive effects. For example, it makes it easier to find collaborators overseas and to communicate with them: "It's changed paper research, information search, and e-mail [by increasing] communication with the colleagues abroad or outside university" (M01, personal communication, May 13, 2009).

Another senior faculty member described a collaboration with a Taiwanese faculty member at the University of California, San Francisco:

> He gave me a clone of an enzyme made from Alzheimer cancer patients. He and I collaborate on this project using e-mail and websites . . . I'm glad to have this opportunity. My research will become high quality through such collaborative projects (M13, personal communication, May 19, 2009).

Moreover, another advantage of using ICTs for research and networking is to help overcome some of the language barriers with foreign researchers:

> . . . after I left USA for sixteen years, my English went downhill so much; however, my writing skills [are] okay. So, e-mail really helps because in e-mail I can change if I write [something] wrong. I can correct them and then send it out (M04, personal communication, May 14, 2009).

Although findings indicate both pros and cons of using ICTs in research and learning in this context, it is imperative to consider possible downsides of ICT use in tacit knowledge acquisition in graduate science programs.

CONCLUSION

This paper presents preliminary findings of the ways in which doctoral students in life science programs learn to become scientists. We found that the faculty perceived that current students tend to rely too much on computers, kits, and the Internet. This may create a tendency to have fewer face-to-face interactions with colleagues and faculty members, which diminishes opportunities for faculty and other colleagues to impart tacit knowledge, such as "knowing how" and "cultural knowledge." This lack of face-to-face interaction may make or break our next generation of scientists.

We are currently in the process of translating all the remaining interviews conducted in Chinese into English. These interviews are with doctoral students in Taiwan and will reveal students' perspectives. Moreover, once we complete data collection in Japan and Singapore, we will have a compelling data set for comparison.

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