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Aspects of Inquiry Applied in Japan and Australia

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Abstract

The author reflects on his experience as a participant in the Professional Development Program (PDP) in 2005 and 2006 and how he has implemented elements of inquiry learning in his curriculum. He taught courses in Japan and Australia and touches on his perception of how the students in his units learned, and what the effects of (learning) culture are on inquiry learning. Through his experiences, the author found that in the first stages of a learning process, inquiry learning can help to engage and motivate students. In the end stage of learning, inquiry learning can help students to demonstrate their ability to think and work independently. One should carefully consider the learning background of students before implementing aspects of inquiry learning, as it can be affected by the culture in which they grew up.

Keywords: course design, culture, engagement, inquiry

1. Introduction

I completed my undergraduate education in Applied Physics in the Netherlands (1991–1995). After working in industry for six years, I moved to academia and completed my PhD degree in Biophysical Engineering (2005). I did my postdoctoral training at the School of Optometry of Indiana University where I worked on an adaptive optics optical coherence tomography system to image the human retina.

I participated in the PDP in 2005 and 2006. When I participated in these workshops, I did not have any experience as an educator. During two academic appointments that followed (Utsunomiya University, Japan and the University of Western Australia, Australia), I had the opportunity to implement my experience with inquiry learning in my teaching. Moreover, my time in Japan helped me to become more familiar with how students from a different culture learn, and how my students benefitted from inquiry learning. Here, I will report on this experience, starting with my experience as a learner in the PDP course itself.

2. My experience with the PDP (2005, 2006)

A disclaimer: since I participated in the PDP, the course has made changes and it is my understanding that some of these changes were implemented to address the shortcomings that I am about to address here.

My perspective on inquiry learning is that it can have some challenges that are important to address in order to implement an effective activity. In particular, **it is important to be self-confident to do well, in particular when you are confronted with a new concept**. For example, during my PDP experience, participants engaged in an optics inquiry activity, which involved apertures. Being thrown into the deep end, I was overwhelmed and fell depressed. Even though the experiment was straightforward, I had a very poor understanding of the physics and did not have the faintest idea of how to get a better understanding.

During the inquiry, we were often asked to reflect, or to give a summary of what our group had learned. In the Dutch education system, we were never put on the spot like this. I had never presented work to others without thorough preparation, and the preparation had often taken hours. Now, I was asked to stand up and provide a summary without spending any time to thoroughly think things through. What if my findings were not shared with the others in my group? Was my conclusion correct? Being asked to give a summary without preparation was common at the course, and since many of my American colleagues stood up and seemingly effortlessly summarized what they had learned, they seemed to have had experience with this concept already. Many delivered with flair and apparently without a trace of doubt.

On the positive side, I enjoyed a hands-on activity that involved making bubbles. In this group activity, we quickly figured out how to make big bubbles and small bubbles. The fact that I still remember this experience and the concepts behind making bubbles, more than fifteen years later, shows how well knowledge can be preserved when you gain understanding of a concept in a practical experiment.

3. Implementing elements of inquiry learning in Japan

At Utsunomiya University, I was involved in three units: an English conversation unit for the MSc students in Optics, a 4th year engineering course for all engineering students, and a course for MSc/PhD students of the Optics program in opto-mechanical design.

3.1 English conversation classes

My Japanese students learned to read, write, and speak English in middle school and high school, but they had few opportunities to practice. My students seemed mostly interested in Japanese culture, manga, music, food, and TV. I myself enjoyed the Japanese entertainment as well, but while we Dutch people are exposed to lots of American and British entertainment, which helps when you want to study English, my Japanese students did not have the same experience.

Looking through the university's windows where my colleagues were teaching, teaching at the university seemed to be mostly "conventional," with teachers standing in front of the class, and students listening. This inspired me to introduce active participation, one of the pillars of inquiry learning, which I had learned through the PDP.

Much of the curriculum for the conversation classes was sourced from my own experience growing up in the Netherlands and not being able to express myself in English. During a college internship at a Dutch company, I answered the phone and was totally flummoxed when the person on the other side of the line spoke English and wanted to talk to a colleague. This had never happened before! The first lesson in the conversation class was therefore about receiving phone calls. How do you answer the phone, and how do you communicate effectively in English? We slowly built on this experience, roll-playing other telephone conversations, with our students asking companies for quotations and complaining about the quality of products.

They would call their classmates, who were acting as foreign professors and they would inquire about internships. An important difference between this unit and a traditional unit was that the students were participating, instead of listening, which seemed to be a major reason why the students enjoyed the course.

The take-away lesson for me was that it is important to engage students to find a subject that they can identify with and to give them the opportunity to practice, to make mistakes and to enjoy what they do. When they become confident, they learn faster. This was the only time that I was teaching a unit with a grin on my face, and the students themselves had a great time as well. Perhaps it had to do with the fact that they were actively participating instead of listening.

3.2 4th year introduction course and opto-mechanical design unit

Many of my students outwardly showed little interest in the course material. Having taught just half a slide after the beginning of a lesson, half of the students had fallen asleep, with their heads on the tables. My Japanese colleagues told me that this was because they were not used to being taught in English. I then had a friend teach one of my classes in Japanese, but this made no difference whatsoever, suggesting that language may not have been the issue.

An important lesson for me was to avoid slides. A presentation with slides made the students too comfortable. They would sit, listen, and fall asleep. In the second year, I used the blackboard instead and told them there was going to be a test at the end. All students participated and nobody fell asleep.

In one of the exercises, I asked them to calculate the coherence length (l_c) of a broadband light source $l_c = (2\ln 2 * \lambda_c^2)/(\Delta\lambda * n)$. They were shown an example calculation for a source with a center wavelength, λ_c, of 840 nm and a bandwidth, $\Delta\lambda$, of 50 nm, giving a coherence length, l_c, of 6 µm in air (index of refraction $n = 1$). All the numbers were written on the blackboard. Even though I showed them how to get to the correct number, half of the students in this 4th year unit did not know how to calculate the 2ln2 part of the equation. Some had not understood that "ln" stood for natural logarithm and others did not know what to do with the first factor 2. Were they supposed to multiply or add? I only found out about this after their exam. Here I learned that I could not rely on my own Dutch experience as a student, being used to asking questions during class. I had to put myself in their shoes. Would I be comfortable asking a question in Japanese in front of all of my classmates, particularly if I made a mistake? This was different from my conversation class, where students had volunteered to join, and where all students were making mistakes.

In the "Advanced computer-aided opto-mechanical design" for the MSc/PhD students, students used SolidWorks (a computer aided design software package) and Zemax (an optical ray-tracing package) to design and build an optical setup. Here, I noticed how lost students felt without a good understanding of the material, and how important it was to guide them carefully through the material. Having students not ask questions in class if they did not understand a concept has made my teaching in Japan more challenging. I also struggled with how to incorporate inquiry learning in the classroom since my experience suggested that inquiry activities rely on students asking questions. One could suggest that inquiry learning could be a helpful tool to get students engaged, instead of letting them sit back or sleep through a class. This point of view would be fair, but in my opinion overestimates the ability of students to overcome their fears and to communicate with facilitators. Recall how much I myself feared having to give a summary in front of the PDP group, not having had this experience as a student myself.

Still, this experience forced me to redesign my course material. First, I explained which problem we were going to tackle, such as the design of a high-speed spectrometer, which could determine tens of thousands of spectra per second. Together, we then did some calculations. I first gave an example, discussing and calculating every aspect of the system, and then we started to play with the numbers. Playing with the numbers seemed to be a key element of this exercise, as it allowed students to develop a better understanding of what each part of the equation really meant. What changes need to be implemented to accommodate a larger optical bandwidth? What do we need to do to improve the spectral resolution? I made sure that the students did not feel lost and carefully guided them through the problem.

We then moved the design to the ray-tracing program (Zemax) and the computer-aided design program (SolidWorks), and again I explained every step, including how to get the information in the computer. The goal was to have two single-mode fibers with two collimators and flat mirrors to send as much light as possible between the two fibers. Here, I used the students' love for Schadenfreude (German: pleasure derived by someone from another person's misfortune) and implemented this in the course. In various assignments, I had students do some of the work on the computer with the beamer showing the other students how the student progressed. The students seemed to enjoy and relate to seeing their friends struggle in front of the class. They were very much engaged and wanted to make sure that they did not make the same mistakes. Perhaps the most important and powerful component in the PDP concept is that students like to listen to their friends and take ownership over the exercise, while they do not necessarily enjoy listening to or being spoon-fed information from the teachers. Instead of pretending to listen to me, they would intensely follow their friends in front of the class, who may or may not have done a good job with their presentations.

After more practice, I would let them struggle by themselves, so that they could become more comfortable making mistakes, getting a thorough understanding of the ins and outs of a problem. The class ended in the lab, where the students had to build and align the setup that they had designed on paper in Zemax and in SolidWorks. This design involved collimating the beam with a Shack-Hartmann sensor, and measuring the power with an optical power meter at the end of the second fiber.

Students need to be engaged. It is very hard for students to be engaged if they feel lost or overwhelmed. They are not engaged when they sit back and listen. They are engaged when they see their friends shine in front of the class, or when they have an opportunity to shine themselves. They are engaged when they feel that they have control and that they can start to explore a problem.

4. Implementing elements of inquiry learning in Australia

The University of Western Australia is the number one university in Western Australia. It is known for its research, its two Nobel Prize winners, and one Fields Medal winners. I was assigned to two units as a unit co-coordinator, which were designed by other faculty.

4.1 2nd year unit

In the 2nd year unit, called "Motion," the students had to build a car which could find its way following a track, and the car carried an air-pressurized Coke-bottle rocket. Students followed instructions from the course reader. They would take classes in which they learned basic theory in electrical engineering and mechanical engineering. Every week, they had a two-hour practical class in which they would put their knowledge into practice. Students would build an electronic circuit on a breadboard, which would then be tested in the robotic car. In a next stage, they would optimize the drag coefficient of a Coke-bottle rocket, which was tested in a wind tunnel. Finally, the assembly would be tested with rockets being launched at the University's cricket oval.

In general, students were motivated to get this system to work. Since they wanted to succeed, there was no need to get them more engaged. They were also inquisitive and wanted to understand how the electronic circuit worked or how they could improve the flight time of the rocket. Initially, there did not seem to be any need for inquiry learning elements to engage them or to increase their interest in the subject.

The electronic circuit however proved to be a challenge for most of the students. They had to do their electronic assembly without having any practical experience with the electronic components or how to test an electronic circuit. They could only determine whether the components were connected properly after the electronic breadboard was installed in the robot car. When the car failed to run properly, they still did not know which part of the electronic circuit had malfunctioned.

This activity was mostly a "cookbook"-like experiment, with the advantage that students did not need a thorough understanding of each aspect of the experiment. If I were to coordinate this unit again, however, I would provide the students with the tools and knowledge to test the components. The AND and NAND logical components proved to be sensitive to incorrect wiring and would often fail after they had been connected incorrectly. The students could not test whether these components were still working and kept struggling.

This experience showed again how important it is to make students feel comfortable when they start something new, before they are thrown into the deep end of the pool. If they are exposed to new material and are thrown into the deep end before they know how to swim, there is a high likelihood that they may drown without proper guidance and support.

4.2 5th year unit

The 5th year unit called "Design 2" consisted of capstone projects where our students worked in 6-person groups on projects that were provided by engineers from industry and by academics of various departments, the so-called project partners. These were design and build projects, meaning that the students had to design a solution, convince the project partner of the design, and then build and test the design. To be clear, this unit was not designed as an inquiry learning unit; some aspects in the unit could benefit from inquiry learning, which will be discussed later.

As an example of a design and build project, I had submitted a brief for a project in which students were asked to build a bilirubin sensor to measure the level of a pigment called bilirubin in the skin. The pigment is a byproduct from the recycling of red blood cells. The concentration of bilirubin is low in healthy people, but can be very high when the pigment is not broken down in the liver. Preterm infants can face this problem, and it is often mitigated by the use of blue light phototherapy, which breaks the bilirubin down into a form that the body can dispose of. The students studied the problem and designed and built a sensor based on light emitting diodes of different wavelengths and a photodiode to measure the scattering of different wavelengths in the skin.

The project partner would give the students a brief for the project, explaining its purpose and what was needed. It is important to make sure that the students and project partner are on the same page. Students would therefore engage with the project partner in several meetings to discuss the project.

The students preferred to lean back and let the project partner do the work in these meetings. They often did not have the language skills to have discussions with the project partner, as English was their second language. They also were not assertive or knowledgeable enough to ask the right questions. This often led to project results that fitted the brief, but that did not fit the expectations of the project partner. In the corporate world, this could get one fired. Here, inquiry was too difficult to handle for most students. They were not in charge, felt lost, and did not feel capable to ask the right questions.

If I were to run the unit again, I would make sure that students would first role play the interactions with the project partner, to be comfortable to know that they were asking the "right" questions. The foreign students could benefit from a unit like the English conversation unit I taught in Japan.

5. Discussion

While it does have its strengths, inquiry learning, as it was taught at the two PDP courses I attended fifteen years ago, can be challenging in that it requires students to be actively engaged with the course material. While it is not bad to have students perform an experiment that is designed to engage them with the material, students can find it challenging to answer tough questions about a brand new topic without the proper support. Based on my experiences in Japan and Australia, I found it beneficial for the instructor to provide some initial guidance to students and to even model an approach before engaging in an inquiry exercise. When students feel more comfortable, they can work on the problem more independently, using inquiry learning components.

We should consider the cultural background of our students before we expose them to elements of inquiry learning. My experience as an instructor with students whose primary language was not English was that many students were uncomfortable asking questions, and had possibly been trained in settings in which they passively received information rather than having interacted directly with a teacher or facilitator. Exposing them to inquiry learning without being sensitive to their learning background could be counterproductive. They are more likely to interact with a teacher or facilitator when they feel comfortable speaking a foreign language, and when they are confident that they can handle the course material. They were less likely to communicate if they were not confident in communicating in English and they did not like to admit that they were lost. To engage them, it proved to be helpful to see their peers in front of the class instead of the teacher.

When learning Japanese, the Michel Thomas and Pimsleur methods were effective. In these methods, the teacher helps you with mnemonics to remember words. The teacher does the heavy lifting. In the Feynman Lectures of Physics, Richard Feynman explains concepts from the ground up, without the learner having to do any of the heavy lifting, which makes these Lectures easier to digest.

Teachers who do too much of the heavy lifting risk that students feel too comfortable. I have worked with students who were extremely confident. Some 4th year students were talking to me as if they had a PhD with 25 years of experience. These students talked smoothly but did not possess fundamental or foundational ideas. Consequently, some failed their capstone projects despite projecting confidence.

I believe in a careful mix of student guidance, in which the teacher does the heavy lifting, followed by a process of inquiry and sink or swim, where the student is slowly moving towards deeper waters to demonstrate that they have fully mastered the material (Figure 1). Aspects of inquiry learning can be implemented in the beginning of a course to engage students. They can be implemented in the later stages when students have had access to the right tools and knowledge.

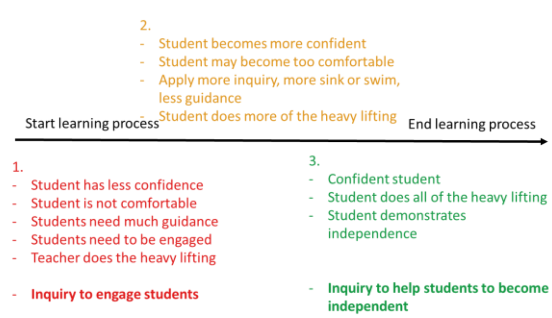

Figure 1: Effective learning process, in which the style of teaching changes with how much experience the student has had with the teaching material.

6. Conclusion

Our societies need well-trained engineers and current teaching methods are often failing, because students are not engaged or feel lost. When confronted with new course material, students need to feel comfortable, without ever being too comfortable, because this could easily lead to over-confidence and a sense of understanding that is actually not complete. Aspects of inquiry learning can be implemented in both the early stages (engagement) and later stages (help students to swim by themselves) of the teaching process. One should carefully consider the learning background of students before implementing aspects of inquiry learning, as it can be affected by the culture in which they grew up.

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