A PRELIMINARY ASSESSMENT OF AN ENGINEERING PROFESSOR'S TEACHING DIFFICULTIES – AN ACTION RESEARCH APPROACH[1]

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Abstract *¾ Undergraduate students in science and engineering schools encounter difficulties in keeping up with the professors much more often than those in other schools. Many science and engineering professors intend to improve the students' comprehension of class materials, but have little success. We decided to approach this problem by action research on the classroom performance of a professor in his course on "Electric Circuits and Electronics with Labs" in the Mechanical Engineering Department. However, he was generally irresponsive or inactive to the suggestions, regarding his teaching skills and classroom management, even his own proposed solutions. We discovered that it is the professor's deep-rooted values that caused the mismatch between the students' learning track and the professor's priority in applying teaching strategies. Since university professors were given full autonomy on what to teach and how to teach. It is important to reveal the unconscious blind spot to the professors before they could effect a sincere transformation for the better.*

Index Terms ¾ action research, educational research, professor – student mismatch, teaching university engineering course

PREFACE

Both of us, the action researchers, have experience in teaching for about ten years. I, the first author, serving as the observer and critical friend in this action research, teach in the Center of Teacher Education of a national university. The second author, a.k.a. Prof. Aliang, teaches in the College of Engineering of the same university. Prof. Aliang has always been concerned about his students' incomprehension of class materials [1][2]. Even though it is not uncommon for an engineering student to fail many courses, owing to the heavy workload of engineering schools, Aliang still feels responsible for the students' failure and attempts to help the students to overcome their learning difficulties. Sympathizing with his concerns, I began the collaborative action research [3][4] with classroom observations and made suggestions of improvements as what was expected of a defacto expert in education.

I. BACKGROUND

Prof. Aliang teaches Electric Circuits and Electronics, a required course for the sophomores of the Mechanical Engineering (ME) Department in the College of Engineering. There are about sixty students in the class. Classes go from 10 am to 1 pm with an additional lab session in the evening. This is the first course in the field of electronics and there is few other course in electronics to follow in the ME Department. So the students are unfamiliar with the subject and generally have difficulty in learning. The percentage of failure in this course is 1/3~1/2 every year.

II. IDENTIFICATION OF PROBLEMS

Knowing the frustrations of his students, Aliang has been trying all kinds of teaching methods but seen little improvement. He asks himself, "Why do the students never do well in class," wondering what else he can still do to facilitate them. As a matter of fact, he is less a perfectionist than simply curious about why students cannot overcome their learning problems, provided with such an academic environment and resources he has worked very hard to offer. Understanding the situations, the researcher found necessary to raise the following questions:

1. What have been the changes in the characteristics of university students in the past few years?
2. How do the professor's perception of teaching and teaching goals effect the quality of teaching?
3. How do the professor and the students, respectively, look upon learning?

III. METHODS OF COLLECTING INFORMATION

Based on the questions raised above, the researchers developed the following methods of collecting information:

1. Classroom observations and the observer's journal entries witten by me,
2. Interactive communications among the researchers, the teacher, and the students through the Web,
3. The reflective discussions among us, the researchers, and also other closely acquainted colleagues,
4. Questionnaires filled out by the students after the mid-term and final, and also
5. Information derived from the triangulation of the collected materials.

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IV. ORGANIZATION OF THE PAPER

In order to better present the mood of the interations between the teachers and the students we decided to present this paper following the provocative threads along which the teacher and the students disputed in verbal dialogues or over the web regarding teaching and learning. The disputes could be explicit or implicit with ideological conflicts. Therefore, the paper is organized into three parts: the accounts of the professor, dialogues among and reflections of all participants in the research, and new understanding of the issue

V. THE ACCOUNTS OF THE PROFESSOR

1. Prof. Aliang's Teaching Principles—Teaching The "Workable"

1) All that is learned must be workable, namely applicable in practice.
2) Students must do application problems
3) Students must start to deal with problems that are to occur in the professional field of engineering. Students must also be prepared to design tools and equipment.
4) Theoretical description must match reality. Students must learn to analyze their practical experiences so that they apply logical thinking in debugging their experimental works.
5) The design of course materials goes by the principle of "aim high, shoot low". It means that he would, at first, develop course materials as complete as necessary and possible with intended distinctive hands-on style - his main teaching goal. However, in the delivery, he would at least try to introduce to the students the integrity of the course while he does not expect the students to learn everything well. He wishes the students would be impressed by the broad spectrum of concepts and hands-on tips applicable in their long professional life ahead.

2. An Overview Of The Students' Learning Difficulties—Implications Of Lowering Quality Of Undergraduates

The students express that they do not understand what is being lectured in class and see no connection between lectures and textbooks. Even if they have prepared for exams, they do very badly. They also complain that instructions during the labs are much too tedious and do not help them to carry out the experiments properly. Frustrations in class, exams and labs make them simply give up. One proof of this frustration is that immediately after the second mid-term, the attendance went down to 20%.

After the second midterm, the students started to shut off during the professor's instructions in the labs. They even stopped trying to do the experiments. If somebody came up with the desired results, the others copied the data and handed in the reports. Ideally, in the lab session, the students need to work out some reasonable results, they need to verify the data with theoretical analysis, and also pass an oral test. However, when the teacher was not energized, the teaching assistants were not necessarily capable of discovering and resolving the students' lab problems. At the end, the students do not obtain a successful experience. They feel that they did not even know how to apply the instruments in the lab, not to mention the circuits they have experimented on.

With many years' teaching experience, Aliang described the characteristics of the undergraduates' difficulty in learning as follows:

1) They do not know how to take notes. In the class, they listen to me as if I am "telling stories". After class, they are only reading, not studying, the course materials.
2) They do not know how to deal with application problems. For example, if the problem is a literal description of a physical phenomenon or an engineering task, the students would not be able to analyze the situation and to formulate the equations to solve the problem.
3) They generally do not know how to double-check their answers in exams. The students at the most can re-calculate once more, but do not know how to check their answers by approaching the problems differently. If the problems in exams look different from the examples they have done in class or homework, they are unable to shift perspective and thus, fail to solve them.
4) They only know how to do problems with numbers. When numbers are replaced by variable names, they fail to relate the variables to the physical quantities.
5) They do not study the textbooks on their own, not to mention organizing synopses into their own "concise pocket notes". When the professor does not follow textbooks in lectures, the students get lost just like flies lost their senses.
6) According to his students, they used to depend heavily on cram schools, where the teachers organized all studying materials and they only needed to memorize the cram teachers' cook book recipe. Therefore, they are not used to studying on their own.
7) They do not try different ways of solving problems. Once they see unfamiliar questions, they get paralyzed. They would not experiment and observe and correlate on the solution based on relating course materials. Instead, they would only try to come up with one direct answer from existing experience, otherwise, they fail.
8) They give up a course easily, once they find it difficult to pass. As course work pressure is mounting up, they start to escape psychologically by procrastination.
9) Some of the students accepted to the department did surprisingly poor at math and physics in their entrance

examination. Since they were accepted according to the ranking of their total score.

10) They do not ask questions even when they do not understand. Some students explain that never had anybody told them that they could ask questions in the class. Now even if they have chance to, they do not know how and what to ask. So they resign.
11) Three types of problems that frightens the students: those quite different from text book excercises, those involving more than two concepts, and those with only literal descriptions without formular.

VI. DIALOGUES AND REFLECTIONS

In this section, we demonstrate the ideological difference between Prof. Aliang and his students by interweaving excerpts of the students' opinions and the professor's descriptions of his teaching methods and beliefs. The students' opinions come mainly from Web discussions

1. The Lab Manual By Prof. Aliang—What He Considers The Students' Resource Of Exploration And What The Students Consider Obligatory Reading.

This course has an emphasis on the labs. Besides studying theories in class, the students must write "lab previews" with the help of the lab manual and class handouts. During the labs, they also must complete "lab reports". The manual of Prof. Aliang is an accumulation of projection slides he has written during the lectures in the past few years. It also includes catalogues of lab equipment, name cards of manufacturers, receipts from purchasing component parts, etc. Prof. Aliang is always adding new things to the manual and considers all of them extremely precious. Sometimes his students come to me with the lab manual, in order to " expand my horizon." They say jokingly, "Professor, see the book from Heaven."

The experiment of each week is an independent unit. Therefore, the students must go through the process of compiling a new "lab preview" with the information from the lab manual. Frustrated by the disorganization of the manual, some of them said angrily,

> *"I think that our professor's manual contends too many confusing things!! Can he consider using some reference book available in the market and then adding to it complementary information that he thinks important? It will be much easier for us to study. We'll have better ideas about course materials and what will be covered in the exams (RC0304)."*

Prof. Aliang knows how the students feel, but he does not see it as the "difficulty" they talk about. He believes that looking for information in the lab manual is in itself a kind of training. And there are many ways of going about it. He claimed, *" The problem is that nowadays it's impossible to ask students to do something just because 'it's good for [them]."* Basically, Prof. Aliang understands how the students feel, but does not sympathize with them.

It is Prof. Aliang's belief that teaching sufficiently and thoroughly course materials is very important. Regarding this, his colleagues have concluded another characteristic of his teaching methods: Prof. Aliang uses "addition" when preparing teaching materials. His constantly adding new information reflects that he expects the students to have a hunger for learning. Unfortunately, the attitudes he confronts are often like this: Don't give me too much, just enough for me to pass exams.

2. Exams—Prof. Aliang Offering Chance Of Experiencing "Trial And Error" While The Students Pursuing The Sense Of Achievement.

Exams are indispensable to the completion of the course credit. Therefore, they can motivate the students to cooperate with him as well as produce conflicts between them. Prof. Aliang's course, like other engineering courses, has a high incomplete rate, due to bad exam grades. With respect to this phenomenon, a student corresponded:

> *"I think that the sense of achievement is desirable to every student. When one attains the sense of achievement, he becomes confidant. So far as he has confidence, he will be more interested in the subject. However, it is not at all the case in this midterm where almost everybody failed. After such a defeat together with the frustrations already present in class, it is not surprising that everyone finds his confidence almost entirely corroded. Hoping merely not to flunk the class, how many of us do you think can be happy (RC1501)?"*

After the midterm, Prof. Aliang posted on the blackboard:

> *"You are allowed to think more and to work further on the exam problem 2B without the stress of taking an exam. I'll post the problem on the door of my office this afternoon. Please bring it back with you. First make a preview of it. This problem not only includes the concept of experiment design, but also underlines the influence of equipment on the circuits it measures. Make sure to follow the instructions on the paper. After making an actual attempt to solve the problem, you will certainly see what I really want to ask. If you do not try, you will not know what to do when I ask you to examine whether or not your results have served the purpose of the experiment. It is a good example of an 'open-ended' problem, a really practical one (tlyeh, L8933031)."*

When sharing with us, Prof. Aliang said:

> *"When I ask them to do problems in class, they don't necessarily do it. Only in exams can I expect them to try hard. Without trying, how would they ever learn? If I were one of them, I couldn't even do it nor do it beautifully at the first time! I think it's a matter of mental construction, they need brain wash. If you don't wash their brains like this, how could they possibly strip away that layer of old habits? How can we use this*

'shock therapy' to produce an experience of success in overcoming failure? After all, leaving school with what they had, 90% of the students will be shocked by their feeling of being useless. If I don't give them some vaccination right now, am I not avoiding teaching them some real important thing? I can try not giving them a complete guidance until after an exam. Then I let them do the exam once more. Will such a 'shock therapy' be a successful breakthrough? Or should I give them complete guidance the very first time they do the problems, in order to avoid great frustration?"

Prof. Aliang is actually in dilemma between giving them experience of success and the shock therapy. How can he maneuver so as to give the students a proper dose of shock in order to prepare them for the challenges after school? Nevertheless, the students who starve themselves for getting credits may not be capable of seeing that far. One said:

" The feeling of buying books for nothing? I have not a clue of what he's taught us. How would I understand the subject if I have no clue? Knowing nothing about the experiments…how would that help…? Even if I know how to do them…what appears on the exams is always different from what I do in the labs…. What's the use of it all? There are even stuff never heard of…which means that he never talked about. To sum it up in one sentence, electronics makes me half-dead (moppet, L8933019)."

The students wish for the sense of achievement in exams. Only when they do well in the exams can they have confidence in and affinity for the course, and meanwhile, can they be enthusiastic about studying hard. On the contrary, Prof. Aliang sees exams as the students' opportunities of experiencing the process of "trial and error," knowing that they only try their best in exams. He does not realize that the tough exams have become fatal attacks to the studying morale. How extremely different the definition of learning for the teacher is from that for the students!

3. Expectations Concerning Class Attendance—Prof. Aliang Hoping For The Students' Perseverence While The Students Skipping Classes Under Protest

Prof. Aliang analyzes his teaching believes to his colleagues:

"The essence of my teaching is that I show the students the logic, the flow, the key point and the applications of the course. As for the textbooks, the students can read by themselves anytime they want. What I am guiding them to learn is the concept of integration and the construction of systematical thinking. I don't intend to be responsible for anything other than that!"

Nevertheless, have the students channeled their learning attitudes and habits into Aliang's teaching methods? A student said:

"Since long time ago, lectures have always been arranged according to textbooks. If there is something I don't understand in class, I can turn to textbooks and try to clarify my doubts. It's always been like this, but it doesn't work in Aliang's class. There are only class notes, which are identical to the lectures. If I don't understand the lectures, I certainly don't understand the notes, either. And I don't know where to look for information in the textbooks (ccworker, L8930919)"

A colleague Prof. Jiang said:

"Prof. Aliang organizes his teaching with his practical experiences, but not with logic. You can't stop him from thinking randomly. Even if he had a script, he wouldn't follow it. He likes to talk about details in a random manner. For example, when showing students a map, normally you show the whole map first, and then zoom in to 1-1 for details. Aliang doesn't do this. He jumps right into 1-1-1, 1-1-3, 1-1-5…."

Aliang's logic of organizing class, based on the practical experiences inside his "black box", appears to his students random thinking. The idea can be perceived in their complaints:

"In my point of view, he only gave us one example, but one that took two classes to explain…Most important of all…when he demonstrates examples, he never tells us why we have to connect the filter, why it's connected to the ground, and why the speakers and amplifiers are set up like that…We all came from normal high schools without much experience with electronic stuff (at the most in artifacts classes…) Now we have two weeks to absorb the essence of what he has taught in class today. Even if I told myself that I understood, I wouldn't be convinced, because if I were asked now to set up a stereo in my room, it'd be like a war-time hospital, filled with burnt soldiers…(GCYC, L8930209)."

Aliang has complained also in private:

"The students of the class always pretend to be "babies", not at all resistant to difficulties. Damn it!"

As far as Aliang is concerned, teaching is like feeding chickens with grains of rice. He articulates, " Even if I am spreading grains to the ground, the chickens won't get fed unless they run after the grains." Reverberating with this statement is Aliang's definition of learning—a process of "boot camp to overcome difficulties". "You gain new insights only after you try!" Aliang exclaims. Few students are able to persist to the last minutes, not understanding the concepts taught in the course and not catching up with the progress. One day many people skipped class. Aliang said gloomily, "If you come to class, at least something enters your head, but if you skip, it means that you don't know how to deal with challenges psychologically (O8951802)!" What he said seemed accurate. However, understanding is one thing and guiding the students to cope with difficulties is another.

4. Rate Of Returns To Investments—The Professor Only Caring About His Course While The Students Having Other Courses To Study For

No teacher would deny the fact that students nowadays are a lot more "occupied" than in the past. They are not only divided between studies and other activities, but also facing clashes of different courses.

> *"Maybe [you] have never noticed this. Your teaching methods often require us to be "spontaneous", but we hardly have time for that many readings…(Other courses also consume a lot of time.) You always ask us to do inefficient things, thinking that they can make us learn more…. The fact is that these things are too pricey! We think so maybe because we don't know how to study. We think that since we will never learn it well, we might as well give up from the very beginning (Qeyo, L8952517) (weiryo, L8932308)!"*

The phenomenon is to some degree similar to the learning ecology in high schools under the stress of entrance exams—If certain teachers give more quizzes and more punishment, students study their subjects harder. In university, when there is chance of failing every course, some students "abandon the Pawn to save the King." In other words, they will investigate the situation and give up the less promising courses in order to concentrate on those they might be able to pass. When this happens, a professor who cares much about teaching will modify his course in such a way that his students find higher "return rates" for investing in this course than in the others. Consequently, motivation of studying for it will increase, and so will the competition in the course.

The differences in the expectations mentioned above of the professor and of his students are actually quite common between many other university professors and their students. As much as the professors have varied values, their reactions differ as well. Some lower the level of course requirements and sacrifice the integrity of their courses. Just like some student said "There is no use teaching too much when we don't understand." Others consider university education significant to national competiveness and productivity, and so they are responsible of maintaining its level. Prof. Aliang belongs to the latter group. His colleague Jiang described, "The stairs that Prof. Aliang has built seem to have a very high first step only because the ground has sunk (i.e. the pre-university levels have lowered in general)."

VII. SELF AWARENESS AND CONCEPTUAL GROWTH OF PROFESSOR ALIANG

Insistence, Compromise And Transformation In Aliang's Teaching

1) Prof. Aliang insists on being the guiding lamp that lights up the students' career path and opens up their views into the future.
- Aliang introduces keywords of professional concepts. Even if the students do not understand thoroughly, they have at least some basic ideas about those concepts. Besides, realizing that it takes great effort to comprehend all the professional concepts, the students would be inspired to strive or to pay respect to those who can.
- After all the frustrations, can we, the students and the professor, be proud of ourselves? Can there be a reward for our endeavor?
- "Teachers have no right to limit students' future development (Prof. Han-Hsiung Wu)" — Every single key concept must be covered by the Professor, otherwise, the students become handicaped in his potential.

2) Prof. Aliang must lower the level of the first step for the students to step on his stairs. Otherwise, the students' frustration may crush them completely.
3) Frustrating situations bring forth experiences of overcoming difficulties. Frustrating experiences are precious learning.
4) Discussion of complex theories and practices in detail should come after the students have acqired hands-on experience in the lab (Prof. Shi-Biao Jiang). Even though the teacher's pacing in class directly influences the students' energy and willingness to learn, the students must be patient when the lectures are progressing inefficiently.
5) Hands-on lab should be designed to establish the student's sense of achievement (Prof. Shi-Biao Jiang) Each lab session accomplishes a functional block of a useful system whose integration is the final episode at the end of the semester.
6) It is necessary to ask experts of teaching "methodology" for assistance.
7) Without discipline, all teaching efforts can be wasted, not to mention improvisation, creativity or teaching styles.
- For regular level students to be successful, teaching should follow the discipline of the execution of an engineering plan. It must not simply be scientific exploration, philosophical debate or improvised creativity. Lecture notes, text books, selected exercises, practice sessions, and timely clinical consultation are the guidance critical to the students' learning efficiency.
- The professor should take into consideration learning efficiency of the students. The course materials must be ready in each class and responses to the students' questions must be immediate.

8) The professor should have interest in building personal relationship with the students.

Knowledge Of Teaching Undergraduate Engineering Courses

1) Differentiation between basic courses and advanced courses is necessary. Teaching goals are different,

general education v.s. professional training, therefore, teaching methods and the usage of textbooks need to be adjusted accordingly.

2) Help students transition from reliance on teacher's systematic organization for their comprehensive learning into active learning relying on their own spontaneous trials and observations.
3) Be aware of the mismatch between teachers' emphasis on understanding vs. students' emphasis on the rate of returns to investments. Need to go with the students' values or to shift students' focus.
4) Be aware that students have start points different from those the teachers have expected, without making up the differences, the teachers' leaps and hops would bring desaster.
5) Students expect teachers taking action to notice their existence, to be well organized and to make improvements.
6) Teachers expect students to be well motivated to learn, like chickens running after rice. The teachers also wish that the students would dig for information autonomously instead of memorizing what is given.
7) Unsettled dilemma: teaching to make the students understand and teaching all that is critical to their professional future.

The Knowledge Of Improving The Teaching Quality Of Undergraduate Teachers

The variety and autonomy of teaching styles and the values proliferated into the university professors' professional practice. They are indeed the un-negligible determinants of teaching quality. On diversed university campuses, a single set of values cannot prevail as much as a professor's values should not dictate his interactions with the students. However, university teachers' professional autonomy and confidence often make them ignore students' expectations, resulting in stand still strangling between the reform of teaching by the professors and the expectations of the students. They are forever pulling in different directions.

VIII. CONCLUSION

The expectation on education as perceived by the teachers and the students can be disputed forever. In the primary and secondary schools, where there is less professional autonomy, the quality of teaching can be maintained on the surface by demanding a standard of teaching skills of the teachers. While university teachers who do enjoy full autonomy, their academic beliefs dictate their teaching strategies and often become the dominant factor on their teaching quality. This paper, therefore, uncovers the underlying beliefs of an engineering professor by analyzing his teaching and his interaction with the students and his colleagues through out this action research. The research that follows up will intend to develop practical knowledge of teaching university-level engineering courses based on the effectiveness of the modification of the engineering professor's teaching performance after his realization and reflection reported in this paper.

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