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PROBLEMS IN TEACHING INTRODUCTORY SCIENCE CLASSES: VIEWS OF FEW SCIENTISTS

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Abstract:
This investigation helps science instructors reflect on their experiences with teaching introductory science classes at university level. Participants were 17 science professors from five different universities in the northeastern US. Data were collected using qualitative techniques and especially semi-structured interviews. Findings show that factors such as, the large class size in the introductory classes, pressure to cover more content, the role of grants and politics in teaching science, and the unequal K-12 science and math education in US play important role in teaching effectively to freshman university students.

Keywords: reflective practice, university level introductory science teaching, science education, effective teaching, qualitative study

1. Introduction

Numbers of educators have indicated that teacher education programs are not graduating teachers adequately prepared to educate future generations (Lee, 2005). Thus, reflective teacher education has been investigated as an alternative approach in teacher preparation (Dewey, 1933; Lee, 2005; Schon, 1987). Dewey's model of reflective practice marked the beginning of reflective teacher education (Richardson, 1990; Valli, 1992). The main goal of reflective teacher education is "*to develop teachers' reasoning about why they employ certain instructional strategies and how they can improve their teaching to have a positive effect on students*" (Lee, 2005, p.699). Thus, pre-service teachers should engage in reflective activities to look back on how they were taught and also to sustain professional growth after leaving the program. However, due to the lack of a clear definition of reflection and vague criteria to assess the quality of reflective thinking, there have been problems in implementing reflective activities in teacher education programs (Lee, 2005; Rodgers, 2002). If reflective activities in teacher education programs are considered to be important it is equally important to look at reflective

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thinking activities in introductory courses, because they are the first classes that every student and presumably pre-service teacher takes and figuring out what is going on inside these classes becomes important for teacher education too. This paper is an effort to help science instructors' reflect on their teaching and to better understand what happens inside the introductory science classes. Moreover, this study may help science professor reflect on their way of instruction and the strategies they use in their introductory science classes.

In the 1980s, Schon (1987) made the term "reflective thinking" an important theme in teacher education. However, the enthusiasm for reflective teacher education has not translated into a consensus across the teacher education community of what the legitimate components of a reflective teacher education program should be (Kember, Leung, Jones, Loke, McKay, Sinclair, Tse, Webb, Wong, Wong, Yeung, 2000; Rodgers, 2002). Even though researchers adopt various definitions and theoretical frameworks for reflective thinking, there are general themes of defining and assessing the quality of reflective thinking. Dewey (1933) defined the reflective thinking process as an experience, spontaneous interpretation of the experience, naming the problems or the questions that arises out of the experience, and generating possible explanations for the problems or questions posed (as cited in Lee, 2005). Rodgers (2002) reorganized Dewey's phases as presence to experience, description of experience, analysis of experience, intelligent action experimentation.

The meaning of reflection (or reflective thinking) in educational research has changed over time: from "*careful consideration, a thought or an opinion resulting from such consideration*" (Lee, 2005) to any form of thinking. In other words, the levels of reflection include not only reflective thinking as defined by Dewey, but also non-reflective action (Mezirow, 1991; Valli, 1990), habitual action (Kember et al., 2000), and so forth (as cited in Lee, 2005). It is necessary to emphasize the recursive character of these stages (each one strongly depends on all stages before it) and the cyclical nature of the reflective thinking process (Lee, 2005; Dewey, 1933; Eby & Kujawa, 1994; Pugach & Johnson, 1990; Schon, 1987). Through the reflective process, educators aim to develop effective teaching habits (Dewey, 1933; Schon, 1987; Sparks-Langer & Colton, 1991). With regard to the level content of reflective thinking, reflection in the practical technical domain is mainly concerned with mastery and or application of technical means for achieving given educational ends, and includes a simple description of observation or a focus on behaviors or skills from past experience (Taggart, 1996). And this study will concentrate on this level to focus on behaviors of science instructors of introductory science courses in their classrooms in few northeastern universities in US and may take a small step in showing science instructors' instances of reflective thinking and what they observe inside the classroom (observing the students actions and interactions).

Additionally, the search for effective teachers has been going on for more than hundred years (Aagaard & Skidmore, 2002). Most of the literature on effective teachers argues that both personal characteristics and teaching methods seem to be important (Cotton, 1995; Gresh, 1995; Norton, 1997; Demmon-Berger, 1986; Witcher, Onwuegbuzie, Minor, 2001; Aagaard & Skidmore, 2002; Czerniak & Shriver, 1994;

Davis & Smithey, 2009; Fitzgerald, Dawson, & Hackling, 2013; Karakas, 2013). In some studies, one of the characteristics of teachers was their favorable interaction with their students (Tobin & Fraser, 1990; Treagust, 1991). In other studies, these favorable interactions were identified as helping, friendly, caring, patient, enthusiastic, flexible, engaging, and understanding (Fisher, Fraser, and Wubbles, 1993; Fisher & Rickards, 1997, Wubbels & Levy, 1993; Rawnsley & Fisher, 1997; Atwater, 2000; Waldrip & Fisher, 2003; Cone, 2012). Cone (2012) says that "*caring teachers are not necessarily seen as permissive, allowing students to have their ways. Conversely, they set limits, provide structure, have high expectations, and push students to succeed, they trust and respect students and recognize them as individuals, while building on their strengths … they are confident in their own teaching practices and believe that all students can learn and thus are persistent and resilient, even in the face of obstacles*" (p. 892). Also, Tobin and Fraser (1990) point out that effective teachers use efficient management skills, track students' understanding throughout lessons, encourage students to be engaged in their learning, and strive to maintain a positive classroom environment. Recent studies have begun to point out the importance of active learning and carefully analyzing what teachers pay attention to, especially in reference to student thinking (Coffey, Hammer, Levin, & Grant, 2011; Hammer & van Zee, 2006; Roth, Garnier, Chen, Lemmens, Schwille, & Wickler, 2011; Russ, Coffey, Hammer, & Hutchison, 2009). These studies highlight the importance of analyzing what science instructors in colleges and universities do in order to create learning opportunities that better support instructors' ability to genuinely engage with students' ideas in the classroom (Talanquer, Tomanek, & Novodvorsky, 2012).

In summary, the research on reflective and effective teaching outlined the theoretical framework of this study. This study will try to explore the views of science professors on the problems they encounter inside their introductory science classrooms. The research question is:

- What kind of problems science instructors encounter inside their introductory science classes?

2. Methodology

2.1 Participants

The study involved seventeen participants. The participants were from five different institutions, one Ivy League university (3 males), one private research university (4 males and 1 female), one state college (3 males), one private college (2 females and 1 male) and one community college (2 males and 1 female) in the northeastern United States. These participants were part of a larger study (Karakas, 2006, 2008). All participants gave their consent to participate in the study. I arranged the interview times according to participants' schedules via emails and via visiting some of the participants in their offices. Depending on the institution they came from, some participants were practicing scientists and some faculty were instructors who had done some research, but mainly were concentrating on teaching. I conducted one in-depth individual interview with each of the participants during the fall semester of 2004 and spring semester of 2005. The interview times ranged between 25 minutes and one hour and 30 minutes; the average interview time was approximately 50 minutes. I gave pseudonyms to all participants in the study to keep their identity anonymous. I conducted all the interviews in person in each scientist's office, except one, Don, who came to my office. All but two of the interviews were conducted in a single session. Jack and Pat's interviews were conducted in two sessions, because of time constraints. Table 1 summarizes the sample, grouped by discipline areas.

Table 1: Summary of scientists grouped by disciplines

Discipline	Number of participants	Average years of teaching experience	Number of male participants	Number of female participants
Biology	4	5.25	3	1
Earth science	3	13	2	1
Chemistry	4	19	2	2
Physics	6	21	6	0
Total	**17**	**15.2**	**13**	**4**

2.2 Data Collection

I employed qualitative methods, and particularly the interview aspect of ethnographic research design, in collecting data. Ethnographic designs, as Creswell (2002) describes them, "*are qualitative research procedures for describing, analyzing, and interpreting a culture-sharing group's shared patterns of behavior, beliefs, and language that develop over time*" (p. 481). The study focused on how science professors' views emerge. The in-depth/open-ended nature of interviews, as Bogdan and Biklen (2006) write, "*allows the subjects to answer from their own frame of reference rather than from one structured by prearranged questions*" (p. 3). Also, I used loosely structured interview guides (see Appendix A), as recommended by Bogdan and Biklen, in order to "*get the subjects to freely express their thoughts around particular topics*" (p. 3). In this study, the topic was problems encountered when teaching introductory science classes. The researcher developed the loosely structured interview questions used in this study. I recorded the interviews on a digital voice recorder and later transferred them to a personal computer.

2.3 Data Analysis

Present study used qualitative methods in analysis of data. The first step in the analysis was data organization procedures recommended by Bogdan and Biklen (2006). In organizing the data, I revisited each interview and listened to each audiotape while reviewing the transcripts to ensure the accuracy of data. Each participant's interview transcript was later analyzed according to data analysis procedures described by Bogdan and Biklen, which call for development of coding categories, mechanical sorting of data, and analysis of data within each coding category. Initial codes were supplemented with emergent main categories and sub-codes (Bogdan & Biklen, 2006). For example, while reading a transcript, I coded certain views as math in science, the role of grants, politics in science, pressure to cover content, class size, lack of teaching skills, teach the basics of science, and lack of teaching skills. In average, there were identified more than 40 codes for each participant. Later on, these codes were collapsed into categories such as, math in science, the role of grants and politics in science, problems of time limitations and pressure to cover content, class size effect, unequal K-12 science education, lack of teaching skills. In this study, I used a realist mode to represent the participants' perspectives through closely edited quotations and interpretations of those quotations (Creswell, 2002; Van Maanen, 1988). Thus, in this study I neither claim to be an arbiter nor assesses the right answers, but rather I let the participants share their thoughts. On the other hand, I share Roth and Lucas' (1997) view that informants' talk about attitudes and beliefs are dependent on context and are highly variable within a given individual. Rather than reflecting individual beliefs, informants' "*talk reflects the communities and language games in which they participate, for there are no private languages*" (Roth & Lucas, 1997, p. 147). Thus, I make no claims that the data gathered represents informants' permanent and deep-seated views; rather I read them as socially constructed in the moment. Although, I lead the reader regarding what meaning to make from participants' quotations, I try to put as many quotations from the participants as possible for every emerging theme, so that the reader can form his or her own meanings from those quotations and read them from their own background, because they may be different from my interpretations. I present the results as a description of emergent themes that developed through the analysis. I coded and collapsed the interviews into categories to give more accurate representation of faculty's thoughts about the problems in science education as each one of them bring their individual experiences in their specific contexts.

3. Results

All the seventeen scientists in this study highlighted various problems they encountered while teaching introductory level science classes, such as the importance of mathematics in science, the role grants and politics play in science, the pressure to cover content prevents them of utilizing various teaching techniques, the problems the large class sizes produce in introductory level science courses, the problems that the unequal K-12 science education produce between inner-city and suburban school students , and lack of teaching skills among the faculty in colleges.

3.1 Math is science

The importance of mathematics in science came up a lot during the interviews. Below are excerpts from the interviews that highlight those views:

> "*I mean in high school had a lot of math, had a lot of science, but I think that math is probably the most important thing. And I actually ah (pause), the long story short ended up taking summer classes to make sure I got in more math courses voluntarily, because it was an important base for the thing that I found that I was liking, which was science. So the math is almost as important as the science, if you don't understand the math it keeps you from applying it to sciences.*" (Pat)

"I don't believe you can do science without doing math. It is the tool you need...
I – What goals do you have for your students in this introductory science class?
P – I am rethinking those goals, but I have a number of them. One goal is I would like them to believe in mathematics and numerical quantitative analysis is an integral part of the scientific method, you have to know the numbers, you have to do the numbers. They have to believe that numbers are important." (Frank)

"I – How do you see students' understanding of science before they came here?
P – Well, it is mixed there is no standardization in American education, there is no national norm or exams that they all take, at least SAT's approach that. Their preparation is mixed ah I wish in some way they had less chemistry and more mathematics." (Rich)

"I - How do you think we can make students more scientifically literate people?
P - …. One though that occurs to me, this may be little off track, but looking back I really wish somebody would have told me, somewhere in maybe in the end of grade school what mathematics is all about. You know it is a study of number and form, it is not you know doing division and subtraction. There is number of big ideas involved. And couple of things I really whished that I had known about earlier, like very simple probability theory could have been worked in certainly high school, probably in grade school too, it is just about flipping coins, it is interesting concepts there about randomness, and longer we observe most likely to break. And probability and symmetry, and that is a really good connection with part of geometry. I wish I had known this sort of things that you know elementary geology in crystals, different types of symmetry, and it is a really good unifying concept. And probability and (pause) most of all to get the idea that mathematics is about form and number, not you know the mechanic things." (Josh)

"There are two levels, there is no science without mathematics, and some people are better in that then others. You have to present the same stuff, generally speaking, mathematically and not mathematically. In my opinion you do both, generally speaking, when you can." (Jack)

"I – What do you want your students to learn about science?
P – Well, in terms of physics as I said it is closely related to being able to solving problems. The words aren't, kind of mathematical problems, the words really aren't adequate to completely describe scientific and physics ideas. That is closely related to mathematics, of course you have to give the interpretation of the mathematics and the words, but ultimately it is mathematics and it is not just talk. It is a question of can you produce something or theory or an explanation of something that seems reasonable.
I – So what do you want your students to learn about the research process?
JS – At this stage (pause) I am trying to indicate how the discoveries are made, ah (pause), but I don't want to go overboard on this. A lot of it, at the beginning of this stage there is a lot of very elementary staff that they had to know. They had to know how to set

a problem, mathematical equation, just simple things that usually makes mathematician successful and not successful." (Joel)

"One of the things that is major stumbling block for several classes is mathematics. They are very reluctant to take mathematics and that makes very hard to do science." (Max)

The importance of mathematics in being able to do science was made clear by the most of the scientists in this study and the lack of mathematical skills among the students was mentioned a lot. Thus, it is not enough to teach science it is also important to give students some mathematical skills in order for them to understand some scientific concepts. And so, improving science and mathematics education should go hand in hand in our schools.

3.2 The role of grants and politics in science

Majority of the scientists in this study pointed out the important role that grants and politics play in how and what kind of science they do. Below are excerpts from the interviews that highlight those views:

"I – Do you think that society effects the way science is produced?
P – Society affects how much money you get to do it, which in a long run effects what you do. If you are trying to do basic core science it is hard to get founding for it. So, in a way society directs what research is done, because if your research doesn't have an application, if it is just pure we want to learn why this happens, but it doesn't have end goal you don't get the founding for it even though it might be a noble aspiration to try to explain this thing, it is hard now to get the money for it. So, in that effect society hugely effects what scientists do." (Pat)

"Ah, the biologist that I worked with in the research that I did was always transferable and grand founded. And the process of getting grand on this means that you are goanna be predictable for years no matter what you are planning on working on, but to some extend and there is some flexibility to deviate from that intended research path. Ah but in terms of making day to day observations, and make some day to day changes in the direction of the study I think that the things a little bit more point out and a little bit less spontaneous and a person simply looking at the description of the scientific method." (Liam)

"I – Thank you. Any final thoughts, anything you want to add?
P – Oh, final thoughts. Ah I think we have to get administrators, those who many times control the M.O.N.E.Y. to understand the nature of science. They are the ones who sometimes think that I can change something overnight; dollar here, dollar there will change everything. I think that they don't realize that probably sometimes it takes a long time for things to just develop. Especially in the scientific area, things don't always work. So, I think we need to spend time with our administrators and I have done a little bit of

that here by bringing them out for tours. I think that is probably one of the, and the school board members understand the nature of science that we have just been describing and may be understand the illustration of the Faraday or the Newton and to realize that we need to be more scientifically literate. So, I would aim at those people, you might say the people of power how many scientists do you have in congress very few, I can count them probably in one hand. Scientists people in congress, you know there is 500 and some people there. So those types of things we need, but we can't do that unless we are affecting the students basically. So that is the final comment." (Ron)

"Another factor that is where the money comes from you can't, you can get money if you can think of a good reason to collect data and you goanna need graduate students and post-docs, there is something that you can get a couple of people if you want, and there is something that the university will be very happy to have (laughingly) you know bringing all of the money to support all over there. And I think that had a real impact on what people think of what is to do with science; because it provides a lot of the financial whereabouts is you actually do science. I had a little science from way back, I have only one student now, grad student, and I don't maintain a laboratory, I used to when I was doing a lot of work with collections." (Josh)

"I – Do you have any final thoughts?
P – About the context of the nature of science and teaching it? Yeah, I think that, I do have. I think that more then ever, it amazes me, but it is true. In 2004 there is probably as much confusion among the general population as there ever was, and I think that it is very sad. Some people would argue they are modern, technologically oriented, informationally oriented society, and the fact that we can even have some discussions that we have, and appears to me as a society that there can be any confusion whatsoever between what is and what is not science, utterly amazes me. That there can be anyone who would want to discuss whether you would feel the importance in a, if you give children an objective education you would imagine that you can tell them that creationism is just as likely to be true as evolution is the (laughingly) most amazing thing that you can imagine, but it comes up all the time in government. People don't know the difference between; even people say the nature law as if something, you know that is amazing to me you know people who were charlatans and cracks and mix religion with everything else, because they can get their ideas across. And if there is anybody stupid enough, or ignorant enough, not educated enough to be swayed by those kinds of arguments utterly amazes me. But if they are politician and people who get themselves even elected or put in a position to decision making and power who in fact intentionally take advantage of that kind of ignorance, the fact that they even exist amazes me. So it means that it is something that we have to continue to teach if we need to improve public we have to always continue to teach it. People have a tendency to lend to, to come up with explanations to things that are false as opposed to what probably more likely to be true, you know, (laughingly) they want to believe in what they want to believe. And the fact that that is the case makes me wander for long time may be in the nature of business why

they do that. I think that is one of the reasons why people try to gamble if they had a chance, because what you possibly get by rolling the dice is because you never know how its goanna come out. So why would you, you know, even any superstition, or any recourses, or something like that, the outcome of some random event, I think it is because people want to think that "well I am lucky" as if there is something deterministic about being lucky as if the law of averages won't come around and meet anyone, eventually. So, I think it is in the nature of people to find that interesting, to find that mystical if you will. And there is a mystical sort of aspect in people and they like it. I think for that reason there always will be people tendency to mysterious and intentionally cut the barrier between what is science and what is not, and it is unfortunate I think. Politics in particular that require in retrospect how people get along with each other, but and we will see how we do, I like to think." (Jack)

"I mean it is obvious that politics has an influence on science; a lot of the funding comes from the government. Physics is relatively free of these compared to other fields, I mean sociology, biology and so on, there is a lot of politics involved in it." (Joel)

"I think it is privilege to do science, and funding comes from grant to grant, National Science Foundation. The students will be paying for these grants through taxes, and their parents are paying, I just hope that, I am grateful for that, and hope that I put something back, give some appreciation and some of them will think about science." (Max)

In various parts throughout their interviews, scientists mentioned the importance of grants and politics in choosing what kind of science they do, and how politics decides what gets taught in schools about science. They also recommended that "*we have to get administrators, those who many times control the M.O.N.E.Y. to understand the nature of science*," because they are the ones who think that "*dollar here, dollar there will change everything*" overnight, and pointed out how "*some people would argue they are modern, technologically oriented, informationally oriented society, and the fact that we can even have some discussions that we have, as a society that there can be any confusion whatsoever between what is and what is not science*" is utterly amazing.

3.3 Problems of time limitation and pressure to cover content

In various parts throughout their interviews some scientists pointed out the time limitations and pressure to cover content limits them of utilizing new innovative teaching styles. They also pointed out to the mile wide inch deep problem in education. Below are excerpts from the interviews that highlight those views:

"Anytime you are trying to teach all about life in one two semester series you have to make a lot of cuts in what you cover. I do talk about a few of the big eureka moments in biology… Making the way science works more part of ah how one covers material would be one of the best ways to do that. Ah I think if you want to make that explicitly a goal, which you know it is explicitly a goal, it is not necessarily the central goal, ah you need to

limit how much objective facts you are trying to get across to them and specific biological concepts, because you just don't have time." (Donna)

"Ah in this class "The Nature of the Biology" class the biggest problem, from a teaching stand, is that there is so much information to cover. It is very broad or it has been, it has been like just about everything is important more or less, so it is hard to find time to focus on just talking about science, but the way that I suppose that is to some extend addressed is in teaching students about sort of major experiment that has led to important discoveries in biology." (Tom)

"I - Looking back at your high school or college years how would you describe the best science teacher or teachers you had?
P - ….. I have to say though, you know, because I know you try to learn about teaching and you try to learn about how you present stuff. And I was always thinking this; some people will try to put so much into a period, in a certain amount of time, thinking that by giving more they are going to accomplish more. And I feel like there is a limit, there is a law of diminishing comes in, if you put in too much over a certain limit, everything over the limit detracts from what was under the limit and so you end up teaching less for having given more. And I think, the road to Hell is paved with good intentions, but you have to assume that there is a limit to the how much people can get into their head in a given time period. And there is also a limit to how well you can explain it. It has to come up and had a sense of closure in a one period time scale, whether it is a Tuesday, Thursday hour and a half or whether it is a Monday, Wednesday fifty minutes, it can't be too much for the time period that it is, and if you do a whole semester, I am teaching physical chemistry lab now, if I, some, another one of my colleagues will try to do ten labs, twelve labs in sixteen weeks. It is too much, nobody does a good job and then they have a hard time getting a lot of what they do. I do eight, seven or eight depending and I space them out and give people more time to work up the data and all that, because I think it is more effective. I don't know that I have quantitative measure to proof that, but I do think that it is. I guess it is a sense of mine, when you speak with students after the fact and you see how much they actually know, as opposed to when you give them so much they learn a lot too, but they can't talk to it about as much as the semester goes on, because they move on to something else now. Everything is relative; you might be able to take the average MIT students and show them ten labs and they will be fine, you might be able to take the average SU student and do eight and do well, and some other university, somewhere in between, and some other university only six. You have to know what your student base is like. Despite what anybody wants to say, we are not all created equal in everything, we are just not, and you know, I think, we all created if you will, and I don't want to sound religious about it, but just to put it in other terms. May be wee all created equal in the eyes of God, but when it comes a time to take a test (laughingly) we are not all equal and I am not as good as other people in certain things and in certain things I am better than other people. And we all understand that, so it is not to be at indictment to people when I say you know we had some very excellent students who come

to our university, who compete with the best students from anywhere and we have other ones who are less. And the same can be said of Caltech, and MIT, and Harvard and so fort. So I want to put it and make sure that the context is clear, having said that. Works for us, generally speaking, in my opinion having done this probably at least ten times, I think it is about eight plus or minus. And depending on how many tests you give, quizzes and things like that and final, just how much you put in that, you can't do much more or less than that. So ah (pause) and I think that that is also has been an important thing that all the other professors that I have had have done it. You have to choose a pace that you can maintain. It has to be challenging enough so that if you don't cover enough material in a given period then you haven't accomplished what a person needs. Everything has to be measured in four years against what a person needs to be able to go out in the world and be able to compete successfully. We have invested interest in our students' success, in this university's students' success. So we have to give them, we have to make sure that they can go out in the world and compete, and so if we don't cover enough then we short change them, if we cover too much then they won't learn it well enough. So we need to make sure they have enough experience; that is way you can't cover too little, you have to cover as much as you possibly can without giving up the capacity to absorb it all. You know, so all that having been said, you know there is a question of pace, there is a question of total content, there is a question at the level you present..." (Jack)

"But in some respects the general chemistry courses at least are so broad that we never delve into anyone subject to any great depth. It is more like teaching them little bit about everything if they go on they have that to build on." (Pat)

Clearly, curriculum and time constraints were seen as a problem to some of the scientist in this study. Thus, some curriculum changes and pacing the teaching time will help in teaching science to freshmen students, because as Jack said *"you have to assume that there is a limit to how much people can get into their head in a given time period, and there is also a limit to how well you can explain it."* He recommended that teaching some scientific concept *"has to come up and had a sense of closure in a one period time scale."*

3.4 Class size effect

Few scientists, pointed out implicitly how large class sizes limit their teaching and ability to interact with their students, and how having small classes can help them utilize more hands on science activities in their lectures. Below are excerpts that highlight those views:

"I – So, both in college and high school these were their best qualities?
P – Yeah, in high school, ah as far as sciences their abilities were different in some ways. There were a lot more hands on examples, because obviously at the college level you tend to have larger classes, but in the high school level I remember the hands on examples, the things that they were used to show basic physics principles and those are the things that

make an impression even now, you know stick with you. So, if I remember it twenty some years later, you know it was, it made an impression…..
I – Are they science major or non-science majors most of them?
P – It is difficult to assess, because especially here when I taught the few classes that I have here most of them are not science majors. You know you have a lecture hall of the hundred and thirty people and during the regular semester very few of them are science majors. Ah they are there to get their science requirements and get out. Ah so it is hard to tell if we are talking to science majors or not." (Pat)

"I – What kind of strategies do you use to teach about nature of science?
P – I use a lot of different. I use anywhere, it depends upon the subject, it depends upon the level. In various section classes, it is usually purely lecture; ok may be some outside activities, but usually lecture based. Those tend to be the more introductory classes, where you have to serve great number of students." (John)

"Ah, again this is something where, it is difficult for me in a large size class like I tend to have in physical geology should be real active learning, exercises where you carry stuff to its creational roods, because (pause) I found that…, from the stand point of my personality I am not very good at calling things to order. I think that people who are better at putting order and putting students on track that way are more able to do that without disorder in the classroom. I find it hard to do the classical active learning exercises, but at the same time I try to do as much as I can in terms of demonstrations, in terms of giving analogies….
I – How do you assess your students understanding of science?
P – Ah, well that is ah (pause). I guess the way that I am doing it is through examinations and that again is one of the real limitations in having a large size class that you can't do that much outside of giving examinations… So, class size is important limitation of how I can assess, how well students are doing…. The upper level class we can work really with the individual, our department is small enough that our upper level classes allow us to hear the point of the student and you can go to the individual and put pressure on them and say "let's talk about how we are going to change this, because you are not getting where other people are." In the 90 person class there are going to be people who are separated and silenced by half way through the class there is no exactly who they are, but you are put in the spot right now and you can say you could be doing so much better if you only give the rest. That is a challenge, because there is something that I think I recognize now and working towards solution to that..." (Peter)

Clearly, again the large classes were seen as big problem to some of the scientist. Furthermore, they made clear that having small classes could help them utilize more hands on and demonstration type science activities in their lectures, which in turn can help their students better understand how science works.

3.5 Unequal K-12 science education

Tom was the only one who raised the problem of unequal K-12 science education in the U.S., but couldn't point out to the solution for that problem:

> "*I – So, how do you see your students' understanding of science before they came to this university?*
> *P – … Ah (pause) so, I mean, I think it really seems to vary a lot from state to state or even from school to school how strong their science education at the middle school and high school level would be. Ah you know some people have or school district have lots of resources and they do really you know high level work, and interesting labs, and have good teachers and other students might be very great, but just simply don't have access to those resources. I do wonder or I am little bit afraid that probably students from some of the more disadvantaged areas are not even taking any science classes here, because their background is so poor that they feel like they can't compete and that is unfortunate. I mean, I don't know how to solve it, but you know think that could open at least ah (pause) that people who could be scientists are avoiding the field just because they are not exposed to the right situation early in their lives and that is a shame, because some of those people might, you know, might have the potential to do really dissent work. Ah (pause) so you know, I think that is a priority that should be or a problem that should be addressed and make more of a priority, but I don't know how to do really (laughter).*"
> (Tom)

3.6 Lack of teaching skills among the science faculty in college

Donna was the only scientist who raised the problem of lack of training in teaching among the professors who teach in college level:

> "*I – Any final thoughts? Do you have any final thoughts to add?*
> *P – Well, I have to say that my final thought is that, I think that future teachers as well as students of all kinds would probably be well served if those of us who teach on a college level received a little bit more training in teaching then we do. Ah (pause) we learned the science, but we don't know how to teach except by being tossed in the defense as a, well that means the shallow end, as teaching assistants. And then kind of gradually move up, but they don't train us to teach at all and many of us could probably do better if we had more of an educational training. Because I am pretty sure that those science education people know something that we can learn.*" (Donna)

4. Conclusion

Data from the questions that sought to explicate the problems that the scientists encountered while teaching, reveal the importance of mathematics in being able to do science, and therefore, the lack of mathematical skills among students. Furthermore, scientists also pointed out the important role that grants and politics play in how and what kind of science they do. Moreover, scientists voiced the view that pressure to cover content and time limitations prevents them of utilizing new innovative teaching techniques. Additionally, they implicitly pointed out how large class sizes limit their teaching and ability to interact with students, and how having small classes could help them utilize more hands on and demonstration type science activities in their lectures. Likewise, scientists saw the lack of motivation by the students and their fear of science as main obstacles in their teaching, and pointed out again that large classes make it harder to overcome those problems. In addition, one scientist voiced the problems that the unequal K-12 science education produces between inner city and suburban school students, and another pointed out the lack of teaching skills among faculty in colleges.

In this study instructors were very eager on reflecting about their teaching and reflected thoughtfully on their thinking process as an experience, spontaneous interpretation of the experience, naming the problems or the questions that arises out of the experience, and generating possible explanations for the problems or questions posed, as was recommended by the researchers on reflective teaching (Mezirow, 1991; Valli, 1990; Kember et al., 2000; Lee, 2005; Dewey, 1933; Eby & Kujawa, 1994; Pugach & Johnson, 1990; Schon, 1987; Sparks-Langer & Colton, 1991; Taggart, 1996; Rodgers, 2002).

Most of the literature on effective teachers argued that both personal characteristics and teaching methods seem to be important (Cotton, 1995; Gresh, 1995; Norton, 1997; Demmon-Berger, 1986; Witcher, Onwuegbuzie, Minor, 2001; Aagaard & Skidmore, 2002; Czerniak & Shriver, 1994; Davis & Smithey, 2009; Fitzgerald, Dawson, & Hackling, 2013; Karakas, 2013). However, this study points out that other factors such as, the large class size in the introductory classes, pressure to cover more content, the role of grants and politics in teaching science, and the unequal K-12 science and math education in US play important role in teaching effectively to freshman university students.

References

Aagaard, L., & Skidmore, R. (2002). Preservice teachers' perceptions of their best and worst K-12 teachers. Paper presented at the Annual Meeting of the 29th Mid-South Educational Research Association, Chattanooga, TN, November 6-8, 2002.

Atwater, M.M. (2000). Equity for Black Americans in precollege science. *Science Education, 84,*154 -179.

Bogdan, R.C., & Biklen, S.K. (2006). *Qualitative research for education: An introduction to theory and methods.* (5th ed.). Boston, MA: Allyn & Bacon.

Coffey, J.E., Hammer, D., Levin, D. M., & Gtant, T. (2011). The missing disciplinary substance of formative assessment. *Journal of Research in Science Teaching 48(10)*, 1109-1136.

Cone, N. (2012). The effects of community-based service learning on preservice teachers' beliefs about the characteristics of effective science teachers of diverse students. *Journal of Science Teacher Education, 23*, 889-907.

Cotton, K. (1995). *Effective student practices: A research synthesis.* Retrieved May 5, 2010, from http://home.comcast.net/~reasoned/4410/PDFonCRM/Effective School Prac.pdf

Creswell, J.W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Merrill Prentice Hall.

Czerniak, C., & Shriver, M. (1994). An examination of preservice science teachers' beliefs and behaviors as related to self-efficacy. *Journal of Science Teacher Education, 5(3),* 77-86.

Davis, E.A., & Smithey, J. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education, 93(4),* 745-770.

Demmon-Berger, D. (1986). *Effective teaching: Observations from research.* Arlington, VA: American Association of School Administrators.

Dewey, J. (1933) *How We Think. A restatement of the relation of reflective thinking to the educative process* (Revised ed.). Boston: D. C. Heath

Eby, J.W., & Kujawa, E. (1994). Reflective planning, teaching, and evaluation: K-12. New York: Macmillan Publishing Company.

Fisher, D., Fraser, B., & Wubbles, T. (1993). Interpersonal teacher behavior and school environment. In T. Wubbles, T. & J. Levy (Eds.), *Do you know what you look like?: Interpersonal relationships in education* (pp. 103-112). London: Falmer Press.

Fisher, D., & Rickards, T. (1997). Cultural and gender differences in teacher-students interpersonal behavior in science classrooms. In D. Fisher & T. Rickards (Eds.), *Science, mathematics and technology education and national development* (Proceedings of the International Conference on Science, Mathematics and Technology Education, Hanoi, Vietnam) (pp. 1-9). Perth, Australia: Curtin University of Technology.

Fitzgerald, A., Dawson, V., & Hackling, M. (2013). Examining the beliefs and practices of four effective Australian primary science teachers. *Research in Science Education, 43(3),* 981-1003.

Gresh, D.K. (1995). *The perceptions of adults with learning disabilities regarding their learning experiences.* . Doctoral dissertation, Pennsylvania State University.

Hammer, D., & van Zee, E. (2006). Seeing the science in children's thinking: Case studies of student inquiry in physical science. (book and DVD) Portsmouth, NH: Heinemann.

Karakas, M. (2006). *College science professors' understanding and use of nature of science.* Unpublished doctoral dissertation, Syracuse University, NY.

Karakas, M. (2008). *Science professors' understanding and use of nature of science*. Saarbrücken, Germany: VDM Verlag.

Karakas, M. (2013). Prospective elementary teachers' views on their teachers and their effectiveness. *The Qualitative Report*, 18, 1-17.

Kember, D., Leung, D.Y.P., Jones, A., Loke, A.Y., McKay, J., Sinclair, K., Tse, H., Webb, C., Yuet Wong, F.K., Wong, M., Yeung, E. (2000). Development of a questionnaire to measure the level of reflective thinking. *Assessment & Evaluation in Higher Education, 25(4),* 381-395.

Lee, H.J. (2005). Understanding and assessing preservice teachers' reflective thinking. *Teaching and Teacher Education, 2*, 699-715.

Mezirow, J. (1991). *Transformative dimensions of adult learning.* San Francisco, CA: Jossey-Bass.

Norton, J.L. (1997). *Learning from first year teachers: Characteristics of the effective practitioners.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association. Memphis, TN, November.

Pugach, M.C., & Johnson, L.J. (1990). Developing reflective practice through structured dialogue. In R.T. Clift, W.R. Houston, & M.C. Pugach (Eds.), Encouraging reflective practice in education: An analysis of issues and programs (pp. 186–207). New York: Teacher College Press.

Rawnsley, D., & Fisher, D.L. (1997). Using personal and class forms of a learning environment questionnaire in mathematics classrooms. In D. Fisher & T. Rickards (Eds.), *Science, mathematics and technology education and national development* (Proceedings of the International Conference on Science, Mathematics and Technology Education, Hanoi, Vietnam) (pp. 1-9). Perth, Australia: Curtin University of Technology.

Richardson, V. (1990). Significant and worthwhile change in teaching practice. *Educational Researcher, 19 (7)*, 10-18.

Rodgers, C. (2002). Defining Reflection: Another look at John Dewey and reflective thinking. *Teachers College Record, 104 (4)*, 842-866.

Roth, K.J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. Z. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching 48(2)*, 117-148.

Roth, W.M., & Lucas, K.B. (1997). From "truth" to "invented reality": A discourse analysis of high school physics students' talk about scientific knowledge. *Journal of Research in Science Teaching*, *34*(2), 145-179.

Russ, R., Coffey, J., Hammer, D., & Hutchison, P. (2009). Making classroom assessment more accountable to scientific reasoning: A case for attending to mechanistic thinking. *Science Education, 93(5)*, 875-891.

Schon, D.A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the profession.* New York: Basic Books.

Sparks-Langer, G.M., & Colton, A.B. (1991). Synthesis of research on teachers' reflective thinking. Educational Lea- dership, 48, 37–44.

Taggart, G.L. (1996). Reflective thinking: A guide for training preservice and in-service practitioners. Doctoral dissertation, Kansas State University.

Talanquer, V., Tomanek, D., & Novodvorsky, I. (2012). Assessing students'' understanding of inquiry: What do prospective science teachers notice? *Journal of Research in Science Teaching 50(2)*, 189-208.

Tobin, K., & Fraser, B.J. (1990). What does it mean to be an exemplary teacher? *Journal of Research in Science Teaching 27*, 3-25.

Treagust, D.F. (1991). A case study of two exemplary biology teachers. *Journal of Research in Science Teaching 28(4)*, 329-342.

Valli, L. (1992). *Reflective Teacher Education: Cases and Critiques.* Albany, NY: SUNY Press.

Van Maanen, J. (1988). *Tales of the field: On writing ethnography.* Chicago: University of Chicago Press.

Waldrip, G.B., & Fisher, L.D. (2003). Identifying exemplary science teachers through their classroom interactions with students. *Learning Environments Research 6,* 157-174.

Witcher, A.E., Onwuegbuzie, A.J., & Minor, L.J. (2001). Characteristics of effective teachers: Perceptions of preservice teachers. *Research in the Schools. 8(2),* 45-57.

Wubbels, T., & Levy, J. (1993). *Do you know what you look like?: Interpersonal relationships in education.* London: Falmer Press.

Appendix A

In my interviews, I asked my participants questions, such as the following:

- Where are you from?
- Where did you finish your elementary, middle, and high school education?
- What type of school did you go to (public, private, home schooling etc.)?
- Where did you go for undergraduate education?
- Where did you go for master's education?
- Where did you go for PhD education?
- Do you have post doctorate?
- How long have you been teaching this course?
- Did you teach science classes anywhere else, different from this institution?
- Looking back at your high school or college years how would you describe the best science teacher or teachers you had? Why was he/she so good?
- Can you describe her/his or their best qualities?
- What interested you in science?
- How do you define science?
- Why did you choose this particular field of science?
- How did your family affect you in pursuing science?
- How did your educational experience prepare you to understand science?
- What kind of science books do you read for enjoyment?
- What scientific controversies have you followed?
- How do you see scientists do science?
- What goals do you have for your students?
- What do you want your students to know about science?
- How do you see your students' understanding of science before they came here?
- What kind of strategies do you use to teach about nature of science?
- How do you think we can make students more aware of how science works?
- How do you think we can make students more scientifically literate?
- What role do you see yourself playing in teacher preparation?

I also asked them probing questions during the interviews when I saw it as necessary. Probing questions such as:

- Can you elaborate more on the issue?
- How exactly is that?
- What do you mean by that?
- Can you explain?