Experiential Learning: The Heart of a Successful Education - One Journey Through Graduate School

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Lynn Albers is a Ph.D. candidate in the Mechanical and Aerospace Engineering department at North Carolina State University with a passion for Renewable Energy, Energy Efficiency and K-20 Engineering Education. Albers has been active in ASEE since 2008 when she presented her first conference paper with Althea Smith in the K-12 and Pre-College Division. Since then, she has authored or co-authored nine ASEE conference papers spanning the K-12 and Pre-College, Mechanical, Minority, and Energy Conversion and Conservation Divisions; presenting all of them with the exception of one paper in 2010 when she was double-booked. Albers most recently held the position of project coordinator for the ARRA funded Student Energy Internship Program in the Mechanical and Aerospace Engineering department at NCSU. She mentored and coordinated 60+ interns with energy professionals in the private and public sectors and recruited interns to volunteer at Family STEM Nights. Prior to this experience, she was a National Science Foundation Graduate Fellow in K-12 Education working under the direction of Liz Parry, Dr. Laura Bottomley and Dr. Karen Hollebrands in the RAMP-UP program at NCSU. During this tenure she created Energy Clubs for students in grades 3-5. Albers is passionate about experiential learning and strongly encourages the inclusion of hands-on activities into a curriculum. Her dissertation spans the Colleges of Engineering and Education and quantifies the effects of hands-on activities in an engineering lecture.

Dr. Laura Bottomley, North Carolina State University

Dr. Laura Bottomley received a B.S. in Electrical Engineering in 1984 and an M.S. in Electrical Engineering in 1985 from Virginia Tech. She received her Ph D. in Electrical and Computer Engineering from North Carolina State University in 1992. Dr. Bottomley worked at AT&T Bell Laboratories as a member of technical staff in Transmission Systems from 1985 to 1987, during which time she worked in ISDN standards, including representing Bell Labs on an ANSI standards committee for physical layer ISDN standards. She received an Exceptional Contribution Award for her work during this time. After receiving her Ph D., Dr. Bottomley worked as a faculty member at Duke University and consulted with a number of companies, such as Lockheed Martin, IBM, and Ericsson. In 1997 she became a faculty member at NC State University and became the Director of Women in Engineering and K-12 Outreach. She has taught classes at the university from the freshman level to the graduate level, and outside the university from the kindergarten level to the high school level. She is currently teaching courses in engineering, electrical engineering and elementary education. Dr. Bottomley has authored or co-authored more than 40 technical papers, including papers in such diverse journals as the IEEE Industry Applications Magazine and the Hungarian Journal of Telecommunications. She received the President's Award for Excellence in Mathematics, Science, and Engineering Mentoring program award in 1999 and individual award in 2007. She was recognized by the IEEE with an EAB Meritorious Achievement Award in Informal Education in 2009 and by the YWCA with an appointment to the Academy of Women for Science and Technology in 2008. Her program received the WEPAN Outstanding Women in Engineering Program Award in 2009. In 2011 she was recognized as the Women of the Year by the Women's Transportation Seminar in the Research Triangle and as the Tarheel of the Week. Her work was featured on the National Science Foundation Discoveries web site. She is a member of Sigma Xi, past chair of the K-12 and Precollege Division of the American Society of Engineering Educators and a Senior Member of the IEEE.

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"Tell me and I forget. Teach me and I remember. Involve me and I learn." – Benjamin Franklin

Introduction

As a result of several influential experiences through two programs at North Carolina State University, the author learned and recognized the importance of experiential learning as well as the limitations of the lecture/classroom environment. She has become an advocate for experiential learning as the means for reducing the potential for miscommunication when sharing knowledge while simultaneously increasing a student's depth of intellectual development.

Experiential learning theory proposes using experiences as an educational tool. This paper will focus on the most influential experiences for the author which were created by RAMP-UP (Recognizing Accelerated Math Potential in Underrepresented People), a GK-12 outreach program at North Carolina State University and the State Energy Internship Program (SEIP) in the Mechanical and Aerospace Engineering department. The GK-12 outreach program began in 2004 with a grant from the National Science Foundation and supplemental funding from the GE Foundation. The SEIP was federally funded through the American Recovery and Reinvestment Act. The educational experiences from these two programs were more beneficial to the author than just lectures and lab work.

Before describing the programs and experiences of the graduate student, some background is given to establish the importance of communication and intellectual development.

Background

"A fundamental belief in students is more important than anything else. This fundamental belief is not a sentimental matter: it is a very demanding matter of realistically conceiving the student where he or she is, and at the same time never losing sight of where he or she can be." William G. Perry

Generally speaking, the goal of the university is to take a high school graduate and transform them into what he or she can be in order to be productive members of society. To accomplish this, the university offers an environment filled with multiple experiences for students. Outside the classroom students have the opportunity to partake in or support NCAA and club sports, poetry readings, dance recitals, instrumental concerts, musicals, plays, and student government to name a few. In addition to the extracurricular activities, there are work-study and co-op programs that provide students with real-world experiences. Inside the classroom, students acquire the knowledge necessary to ultimately graduate with a Bachelor's degree in their chosen major. All these experiences help transform the student from a dualistic to a relativistic point of view. According to Dr. William Perry, author of *Forms of Intellectual and Ethical Development in the College Years*, there are nine positions of intellectual development that can be divided into two broad categories with position 5 as the pivotal point (see Appendix for Dr. Perry's

Developmental Scheme).[4] A student typically enters the university in positions 1 or 2 with a very 'right or wrong' point of view. As the student progresses through their collegiate career and engages in experiences, they transcend through positions 2, 3, and 4; ideally graduating in position 5 (or higher) where they have acquired the ability to perceive knowledge and values as relative, contingent and contextual.[4] Because the university is an educational environment, the intellectual development of the student from positions 1 or 2 to position 5 is an important part of the transformation of the student and the goal of the institution.

Experiences play an important role in this transformation and sadly, not all experiences are positive; potentially having a negative impact on the student's intellectual development. One of the areas this can occur is in the lecture where knowledge is imparted to the student. This is an area that is very dependent on the instructor's ability to communicate and to recognize the students' ability to absorb the information. Dr. Perry firmly believed in college students and in their positionality, which is "literally one's stance with respect to knowing, making meaning, and making commitments."[4] He believed that understanding the students' positionality was key to what and how an educator should teach and to ensuring that the students learned. As L. Lee Knefelkamp observed about Dr. Perry, "He was adamantly against any notion of trying to force growth or development (the notion of force being an antidevelopmental concept). … They were simply to be seen as courageous human beings who needed company and understanding along the way. He often said that faculty make the mistake of thinking that they have only two options when grading papers or working with students: praise and blame. But Bill constantly reminded us that there is a third, more powerful and necessary option: recognition. For when the student is recognized, the conditions of respect and encouragement that make risk possible and the pain of growth endurable are present."[4] However, when the student is not recognized or misunderstood, then growth can be limited. The following example, while focused on young children and not college students, depicts the importance of the capability of the more educated individual (in this case, an interviewer and not a lecturer) to communicate with and understand the positionality of the less educated individual (in this case, the children being interviewed). The example also shows the slightly negative consequences that occur when the interviewer fails to see things from a different perspective and how he inadvertently forces growth and development on the child because of his own limitations.

In Carol Gilligan's book, *In a Different Voice*, she shares the findings from Kohlberg who sought to measure the moral development and conception of self in adolescence. In the case discussed by Gilligan, he created a fictional dilemma and presented it to two 11-year olds named Jake and Amy to record their responses and measure their moral development. Both children were in the same sixth-grade class and both bright and articulate. Amy aspired to be a scientist while Jake preferred learning English.[2]

The interviewer told each child, "In this particular dilemma, a man named Heinz considers whether or not to steal a drug which he cannot afford to buy in order to save the life of his wife."[2] The interviewer then asks each child the following question, "Should Heinz steal the drug?" During their responses, "the reasons for and against stealing are then explored through a series of questions that vary and extend the parameters of the dilemma in a way designed to reveal the underlying structure of moral thought."[2]

Jake responds to the interviewer's initial question with the following (interviewer's questions in parenthesis):

> *"For one thing, a human life is worth more than money, and if the druggist only makes $1,000, he is still going to live, but if Heinz doesn't steal the drug, his wife is going to die. (Why is life worth more than money?) Because the druggist can get a thousand dollars later from rich people with cancer, but Heinz can't get his wife again. (Why not?) Because people are all different and so you couldn't get Heinz's wife again."* [2]

Amy responds with the following:

> *"Well, I don't think so. I think there might be other ways besides stealing it, like if he could borrow the money or make a loan or something, but he really shouldn't steal the drug – but his wife shouldn't die either.*
>
> *Asked why he should not steal the drug, she considers neither property nor law but rather the effect that theft could have on the relationship between Heinz and his wife:*
>
> *If he stole the drug, he might save his wife then, but if he did, he might have to go to jail, and then his wife might get sicker again, and he couldn't get more of the drug, and it might not be good. So, they should really just talk it out and find some other way to make the money."*[2]

Jake sees the dilemma as a math problem that is easily solvable using logic and reasoning while Amy views the dilemma as a web of relationships that extends over time. Is one more right or more wrong? The answer is, in my opinion, "No, they are just different." But at the time of the study it was deemed that Jake's response was more right because it fit into, "Kohlberg's six stages of moral development trace, a three-level progression from an egocentric understanding of fairness based on individual need (stages one and two), to a conception of fairness anchored in the shared conventions of societal agreement (stages three and four), and finally to a principled understanding of fairness that rests on the free-standing logic of equality and reciprocity (stages five and six)."[2]

However, Amy's response befuddles the interviewer. He can easily relate to Jake's perspective of seeing the dilemma stemming from the "druggist's assertion of rights" however, he fails to relate to Amy's perspective of seeing it as the druggist's "failure of response".[2] Since he cannot relate to her answers he, therefore cannot ask sufficient follow-up questions. In fact, he continues to ask the same questions (perhaps expecting a different answer each time) but she holds firm to her initial conviction that through relationships, communication and with time, a solution can be found. However, as he continues to ask the same question she begins to doubt her response and her convictions and she doesn't state them with the same confidence as initially. Without realizing it, he is trying to change her, to make her fit a norm that he understands and respects. In other words, he failed to understand her positionality thereby inadvertently limiting her growth.

Amy's response puts her in a mixture of stages two and three of Kohlberg's moral development trace. Jake relies on logic and is therefore ranked a whole stage higher than Amy who relies on relationships.

> *"Both children thus recognize the need for agreement but see it as mediated in different ways - - he impersonally through systems of logic and law, she personally through communication in relationship. Just as he relies on the conventions of logic to deduce the solution to this dilemma, assuming these conventions to be shared, so she relies on a process of communication, assuming connection and believing that her voice will be heard. Yet while his assumptions about agreement are confirmed by the convergence in logic between his answers and the questions posed, her assumptions are belied by the failure of communication, the interviewer's inability to understand her response."* [2]

It is her position that confuses the interviewer. She is not responding to what the interviewer thought he had asked. She is responding with 'how' Heinz should act rather than whether or not Heinz should act at all. The question posed by the interviewer was, "Should Heinz steal the drug?" The interviewer thought he was asking, "*Should* Heinz steal the drug?" While Amy interpreted the question as "Should Heinz *steal* the drug?" The interviewer took the mode of action for granted and therefore could not relate to Amy's response that not only was she agreeing that action should be taken but she already assessed the method of action suggested to be not the best option and offered an alternative. [2]

On a side note, one could argue that Amy's response was more right or at the very least, it was more tolerant. She offered a more relativistic viewpoint, which is a sign of greater intellectual maturity according to Dr. Perry.

The interviewer not only failed to realize that his own question could be interpreted more than one way, but he then failed to recognize the logic and depth of her response. This raises many questions: why did he fail to understand the various interpretations of his own question; would a female interviewer have recognized Amy's logic and responded more positively thereby affirming her decision instead of belittling it; would a female interviewer have been unable to relate to Jake in the way that the male interviewer could not relate to Amy? While all valid questions, they are outside the scope of this paper and will not be addressed at this time. The purpose of presenting this example is to show the importance of the older, more educated individual's ability to communicate and understand the position of the younger, less educated individual. I will continue with the information presented in Carol Gilligan's book.

If a simple oversight such as this, which can have very negative consequences, can occur in just an interview then cannot the same thing happen in the classroom? Because communication is difficult in general and extremely difficult for those in the engineering world, I believe this oversight to happen frequently. And sadly, the fault primarily lies with the older, wiser individual who in Amy's case was the interviewer and in the university's case is the instructor. As Dewey states in his book, Education and Experience,

> *"The greater maturity of experience which should belong to the adult as educator puts him in a position to evaluate each experience of the young in a way in which the one*

having the less mature experience cannot do. It is then the business of the educator to see in what direction an experience is heading. There is no point in his being more mature if, instead of using his greater insight to help organize the conditions of the experience of the immature, he throws away his insight. Failure to take the moving force of an experience into account so as to judge and direct it on the ground of what it is moving into means disloyalty to the principle of experience itself. The disloyalty operates in two directions. The educator is false to the understanding that he should have obtained from his own past experience. He is also unfaithful to the fact that all human experience is ultimately social: that it involves contact and communication. The mature person, to put it in moral terms, has no right to withhold from the young on given occasions whatever capacity for sympathetic understanding his own experience has given him."[1]

Since education is so dependent on communication, then perhaps we should take communication out of the equation. This is where Experiential Learning, briefly described in the following section, can be extremely helpful in the education process.

Experiential Learning

Experiential learning theory proposes using experiences as an educational tool. It provides a means of education that removes the importance of communication between the instructor and student. David Kolb, author of the 1984 book, *Experiential Learning; Experience as The Source of Learning and Development*, based his idea of experiential learning upon the theories of John Dewey, Jean Piaget and Kurt Lewin, all of which emphasize the importance of environment and experiences that give rise to dialectics, which lead to knowledge and growth.[3]

Kolb firmly believes that people learn from their experiences and that the results of that learning can be reliably assessed and certified for college credit. His examples of experiences are "internships, field placements, work/study assignments, structured exercises and role plays, gaming simulations, and other forms of experience-based education."[3]

The next sections present several experiences that were inspirational to the author and slightly different from Kolb's definition of experiences. Some of the experiences that provided the most personal growth came from research opportunities, physical education classes and energy audits. However, this paper will focus on the experiences created by RAMP-UP (Recognizing Accelerated Math Potential in Underrepresented People), the GK-12 outreach program at NCSU and the State Energy Internship Program (SEIP) in the Mechanical and Aerospace Engineering department. Because these experiences were not constrained by classrooms or lectures, there was no limit on personal or intellectual growth due to miscommunication. It was through having these experiences that the author understood and recognized the importance of experiential learning as well as the limitations of the lecture/classroom environment.

RAMP-UP

The RAMP-UP (Recognizing Accelerated Math Potential in Underrepresented People) program began in 2004 with a grant from the National Science Foundation and supplemental funding

from the GE Foundation. RAMP-UP was unique from the other 300+ programs across the country in that it contained a hierarchical system whereby a program director mentored graduate students who in turn managed and mentored a team of undergraduate students. The graduate students and their team of undergraduates would travel to local, inner-city K-12 schools and work directly with a teacher in the classroom, not only assisting the teacher but also preparing and leading activities that helped the students learn science, engineering and math; three of the components of the STEM (Science, Technology, Engineering and Math) initiative. The program was a win-win-win situation. The graduate and undergraduate students brought fresh ideas and intellectual property from the university to the K-12 environment which benefited the teachers and students, the teachers taught the university students how 'to teach' and improve their communication skills and the K-12 students, inspired and motivated by the university students, responded more positively to their studies.

The author, as a part of the hierarchy, received valuable knowledge through interacting with the director and from managing a group of approximately twelve undergraduates. This managerial experience is something that could not have been obtained by sitting in a lecture and reading a textbook. Interacting with the director also provided valuable feedback necessary for effective management techniques that benefited the program, the university undergraduates and the teachers in the K-12 schools.

The author, through the GK-12 program, also began Energy Clubs at three elementary schools. Energy Clubs were an opportunity for students in grades 3-5 to participate in an out-of-school time (OST) program to learn about renewable energy, energy efficiency and recycling. The author prepared original activities or utilized those prepared by the Engineering is Elementary (EiE) team from the Museum of Science in Boston. The two most popular activities were building windmills from milk cartons, Popsicle sticks and index cards (an EiE idea) and building solar cars to participate in the Junior Solar Sprint at the university's campus. In preparation for the solar cars, the author prepared activities that demonstrated how gears work and how solar panels collect the sun's energy (photons) and convert it into electricity. The challenge of creating original activities, preparing existing ones and communicating to a group of 15-20 students in grades 3-5 provided valuable learning experiences that the author would not have had in just a lecture hall and with a textbook. Through the energy clubs, the author learned how to prepare lessons and communicate concepts, how to work with the administration, and how to control a crowd, all skills that translated well to the university environment when the author taught fluid mechanics to juniors. In the process of preparing lessons and communicating the science and engineering concepts to third graders, the author learned the material better. An undergraduate student in the RAMP-UP program summed the benefit of the experience up well when he stated, "If you can communicate with a third grader, you can communicate with anyone."

In addition to working with teachers in the classroom and running Energy Clubs, the author, with a team of undergraduates, ran Family STEM Nights. These were typically held in the evening for 1-2 hours and were an opportunity for parents and their children to engage in activities together that demonstrated the STEM principles. The goal of the evening and the activities was to remove the fear-factor associated with science, technology, engineering and math, to teach parents the concepts so that they could help their children, and to inspire children to love STEM.

The Family STEM Nights were also a great opportunity and experience for the undergraduate students, many of whom had to learn the concepts before leading the activities. Not only did the experience help them to understand the material better, it taught them how to communicate with children and adults. Again, these are experiences that could not have happened in a lecture hall on campus.

SEIP

The State Energy Internship Program (SEIP) at North Carolina State University was made possible by funding from the American Recovery and Reinvestment Act through the State Energy Office. The university received $1.7 million in funds of which the Mechanical and Aerospace Engineering department received $436,970. The funds were used to supplement the salary of 62 undergraduates who were placed with mentors outside of the university in the energy efficiency sector. Through the program, the undergraduates received valuable on the job experience and the mentors were able to audition an intern for potential future employment. It was a win-win situation. In addition to learning valuable on the job experience, the interns were able to finally understand why they were required to take classes such as Thermodynamics, Heat Transfer, and Fluid Mechanics when they applied the knowledge learned in these classes to real-world problems. Again, this type of understanding could not have been achieved through classroom lectures, textbooks and homework assignments alone.

In addition to the undergraduates receiving valuable experience, the author, who coordinated the undergraduates with their mentors, received valuable project management experience. In addition the graduate student mentored a few of the undergraduates while performing energy audits of three of the state's museums. This was not only a challenge to coordinate and train undergraduates in professional behavior but the museums each presented their own challenge to finding energy saving measures. The process of developing new ideas and determining their economic feasibility is an experience that would not have occurred (or been able to be recreated) in the classroom.

Conclusion

The graduate school seas were not smooth; made difficult due to communication issues. But the educational experiences were more beneficial than just lectures and lab work. It is interesting to note that the learning gained from the experiences does not involve lectures or exams nor are they contingent on an instructor properly communicating with a student. By removing the lecture setting and the possibility for miscommunication, one is free to explore and learn at their own pace. The experiences not only helped solidify basic scientific and engineering concepts in the undergraduates and graduate but they built confidence by providing positive feedback and recognition.

It was through the experiences of the GK-12 program and the SEIP that allowed the author to mature intellectually and emotionally; they helped clarify knowledge imparted in the classroom and taught her how to share it with the community for the benefit of all. In addition, the author gained valuable managerial and administration skills. It is interesting to note that both programs took the author outside the university's bubble and gave her experiences that were invaluable.

So, this begs the question, does one have to leave the university to have valuable educational experiences? The answer to this is no, and a discussion of this is outside the scope of this paper. However, because of these experiences, the author understood experiential learning, recognized it as a valuable educational tool and is now an advocate for experiential learning. It was through these experiences, that she is leaving the university having truly discovered her calling and developed the necessary skills to be successful.

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Appendix

Perry's Main Line of Development[4]

Position 1: The student sees the world in polar terms of we-right-good vs. other-wrong-bad. Right Answers for everything exist in the Absolute, known to Authority whose role is to mediate (teach) them. Knowledge and goodness are perceived as quantitative accretions of discrete rightnesses to be collected by hard work and obedience (paradigm: a spelling test).

Position 2: The student perceives diversity of opinion, and uncertainty, and accounts for them as unwarranted confusion in poorly qualified Authorities or as mere exercises set by Authority "so we can learn to find The Answer for ourselves."

Position 3: The student accepts diversity and uncertainty as legitimate but still temporary in areas where Authority "hasn't found The Answer yet." He supposes Authority grades him in these areas on "good expression" but remains puzzled as to standards.

Position 4: (a) The student perceives legitimate uncertainty (and therefore diversity of opinion) to be extensive and raises it to the status of an unstructured epistemological realm of its own in which "anyone has a right to his own opinion," a realm which he sets over against Authority's realm where right-wrong still prevails, or (b) the student discovers qualitative contextual relativistic reasoning as a special case of "what They want" within Authority's realm.

Position 5: The student perceives all knowledge and values (including authority's) as contextual and relativistic and subordinates dualistic right-wrong functions to the status of a special case, in context.

Position 6: The student apprehends the necessity of orienting himself in a relativistic world through some form of personal Commitment (as distinct from unquestioned or unconsidered commitment to simple belief in certainty).

Position 7: The student makes an initial Commitment in some area.

Position 8: The student experiences the implications of Commitment, and explores the subjective and stylistic issues of responsibility.

Position 9: The student experiences the affirmation of identity among multiple responsibilities and realizes Commitment as an ongoing, unfolding activity through which he expresses his life style.