Caribbean Teaching Scholar
Vol. 5, No. 1, April 2015, 47–59

ERA
EDUCATIONAL RESEARCH ASSOCIATION

Understanding practical engagement: Perspectives of undergraduate civil engineering students who actively engage with laboratory practicals

Althea Richardson[a] and Erik Blair[b]

[a]Department of Civil & Environmental Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago; [b]The Centre for Excellence in Teaching and Learning, The University of the West Indies, St. Augustine, Trinidad and Tobago

A key goal of engineering education is to produce graduates who have the appropriate level of cognitive development to allow them to manipulate processes, solve problems and produce new knowledge. Teaching and learning using laboratory practicals is an approach that is designed to engage students in the investigation of genuine problems. The importance of the laboratory experience in engineering education cannot be over-emphasised since the critical role of laboratories can be correlated with the fact that engineering is an applied science which requires that students attain some level of hands-on skills in their chosen discipline. However not all students see the benefit of such hands-on experiences. In the present study, Kolb's experiential learning theory was used to assess the experiences of undergraduate civil engineering students at The University of the West Indies, St Augustine, Trinidad and Tobago who had elected to undertake laboratory-based projects. The participants in this study represent a minority group within their particular cohort in that they actively engaged with practical laboratory activity. This study determined that the "engaged" students showed a lack of deliberation around laboratory work as a learning experience in itself but valued its worth as a means of developing their technical skills. For these students, it was not the laboratory practical *per se* that was their focus nor was there any focus on the improvement of laboratory skills so that they could be technically more able. Rather, practicals were used as a means of increasing their future employability through the enhancement of skills relating to project management, decision making and time management.

Key words: Engineering education, active engagement, Kolb cycle, experiential learning

Introduction

Civil engineers play a critical role in the development of a nation because of their level of involvement and responsibility for the design, construction and maintenance of the development infrastructure which supports the entire built environment. By virtue of its location, the Caribbean is particularly susceptible to natural hazards which have an adverse impact on the built environment; therefore the strategic importance of the civil engineering industry to the region is clear. The vulnerability of the region to hurricanes and earthquakes presents civil engineers with many challenges which usually require the application of learned practical skills. In this regard, effective engineering education is of importance and, therefore, the task of engineering educators is to ensure that the expected educational outcomes are achieved (Malan, 2000). One of the key goals of engineering education is to produce graduates who have the appropriate level of cognitive development to allow them to manipulate processes, solve problems and produce new knowledge (Gondim & Mutti, 2011 as cited in Lashari, Alias, Akasah, & Kesot, 2012). The importance of using the laboratory experience and other practical exercises in engineering education cannot be over-emphasised and Davies (2008, p.2) suggests that the practical component in the engineering curriculum should, by design:

> motivate students and stimulate their interest in the subject; deepen their understanding by linking theory to practice; provide opportunities for team work which students can use to analyze and solve engineering problems and foster in graduate engineers the skills and attitudes which will enable them to operate effectively and professionally in the engineering workplace.

The successful integration of practical work into the engineering curriculum can be challenging for many reasons including: the cost of procuring adequate and appropriate materials and equipment; the time required for the organisation, management and assessment of the laboratory work; limited laboratory work space; large student cohorts that require subdivision into smaller working groups; a marked disconnect between practical sessions and the associated theoretical lectures, and a distorted link between theory and practice in the mind of the student (Davies, 2008). Notwithstanding the many challenges, the application of theory using hands-on practicals remains fundamental to the delivery of the engineering curriculum. The critical role of laboratories can be linked to the fact that engineering is an applied science which requires that students attain some level of hands-on skills. The practical component of engineering courses should therefore facilitate students' engagement in deep learning and well-designed laboratory practicals may be used to improve the hands-on skills of graduate engineers.

The University of the West Indies (UWI) St Augustine (STA) is no different from any other institution in that practical exercises are a major component of most courses offered in the undergraduate civil engineering programme. Students at all levels of the civil engineering programme are required to participate in at least three compulsory practical sessions each semester. Laboratory teaching can account for as much as 50% of the contact time and a great deal of a student's study time is spent writing and researching for practical and project reports. Marks are awarded on the basis of assessment tasks associated with practical work. Generally, student learning is assessed through their submission of three or four individual laboratory reports for 15-20% of the total course marks. Additionally, in the summative final exam, one or two questions incorporate aspects of the practical work in either the calculations or process description. Through their studies, UWI STA undergraduate civil engineering students are expected to achieve certain goals.

A cursory review of these goals shows the significance of practical work to student learning and that these civil engineering students are expected to:

1. Design and conduct experiments, as well as to analyse and interpret data in several areas which include air quality, water and land quality and environmental and human health impacts.
2. Identify, formulate, and solve engineering problems and to design a system, component, or process to meet desired needs.
3. Effectively convey technical material through oral presentations and written communication.
4. Obtain the broad education necessary to understand the impact of engineering solutions in a global and societal context.
5. Gain knowledge of contemporary and emerging environmental issues and recognise the need for, and an ability to engage in, life-long learning.
6. Apply scientific and engineering principles as well as contemporary technology to the discipline.
7. Use the techniques, skills, and modern engineering tools necessary for engineering practice with an integrated understanding of professional, societal, and ethical responsibilities.
8. Understand their professional and ethical responsibility and the importance and function of multidisciplinary teams in professional practice.
9. Acquire the necessary background for admission to engineering or other professional graduate programmes.

Despite the fact that practical sessions are interwoven into the civil engineering programmes and integral to students meeting learning outcomes, one of the challenges encountered by teaching staff is the apparent indifference students show towards laboratory practicals. This nonchalance might be a display of either their demotivation or their general attitude toward the use of laboratory practicals as a teaching and learning strategy, based on their perception of the required tasks (Maehr & Meyer, 1997). Whatever the reason, a lack of motivation generally has a direct negative effect on learning and behaviour (Pintrich & Schunk, 1996). Accounts of disengaged students are well-documented with an extensive body of literature on disengagement among undergraduate students (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Salanova, Schaufeli, Martinez & Bresó, 2010; Schmitt, Oswald, Friede, Imus, & Merritt, 2008; Schreiner, Noel, Anderson, & Cantwell, 2011). Such studies have examined both psychological and psychosocial factors and have used tools such as formalised Likert-type questionnaires and structured equation modelling of GPA and exam scores; however, to fully understand the situation, it is worth problematising how we might record the lived experiences of those students who display levels of engagement with practical laboratory exercises. In addressing this particular area, this research focuses on the perceptions of civil engineering students who actively engage with laboratory practicals and seeks to find out what it is that motivates them to pursue a course to which many of their peers seem to attach such little significance.

Being an engaged student

The central purpose of practical work is to help students link two spheres: the sphere of knowledge - which they experience from things they can see and do, and the sphere of thoughts, concepts and ideas - which they acquire from their experiences (Millar, 2009). Practicals are effective when students are able to observe and do what was intended using the equipment and material provided; make appropriate observations which will allow them to recall and describe what they did and what they observed; think about what they are doing and observing while using the concepts intended or inherent in the activity, and, at the end, discuss the activity using the specific scientific ideas which the activity aimed to develop (Tiberghien, 2000 as cited in Millar, 2009). Such students might be described as “engaged” with the learning activity and might form a proto-typical extreme: with disengaged peers as their counter.

Smith, Sheppard, Johnson and Johnson (2005) note that the more engaged the student the greater the level of knowledge acquisition and general cognitive development. This is in line with Astin’s (1984) involvement theory which emphasises that students’ active participation in the learning process will have a positive impact on their development and learning and increase their retention rates. Astin’s theory was later reinforced by Bonwell and Eison (1991) who stated that when students participate they are able to engage in higher-order thinking tasks which foster the cognitive development of skills such as analysis, synthesis and evaluation. Krause (2005) held a similar view that student engagement is a fundamental pillar of higher education and a vital element in the teaching and learning framework since it encourages deeper learning outcomes. Although Biggs (1996) reports that motivated and scholarly students are generally deep learners regardless of the teaching methods used, Lucke (2010) also used the principles of active learning to make the point that students who are actively engaged with their learning are more likely to understand the concepts that they are being taught.

In drawing together the concepts of engagement and activity, this study is theoretically grounded in the experiential learning cycle (Kolb, 1984). The Kolb cycle presents learning as a cyclical model (see Figure 1) consisting of four sequential stages which include having a real experience, followed by observation and reflection during which learners review the “who, what, when, where and why” of an experience. Next, learners engage in creating new concepts from the experience and finally they plan and apply the concepts learnt to active experimentation. For Kolb (1984, p.38) “learning is a process whereby knowledge is created through the transformation of experience” and experience is central to a learning process where knowledge results from a learners’ ability to examine and transform experience.

The Kolb cycle presents learning as a continuous process in which all four aspects are necessary for effective learning (Fry, Ketteridge & Marshall, 2008.

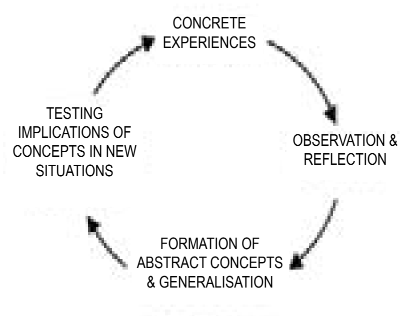

Figure 1. The Kolb cycle (Kolb, 1984)

Although, the cycle can be entered at any stage, for learning to occur all stages must be followed in sequence and there should be adequate balance of the stages. Since engineering is fundamentally an experiential discipline, the Kolb cycle is a suitable construction for understanding engineering education and is used here as a theoretical framework.

The research problem

Environmental engineering courses offered in the UWI STA civil engineering programme have clear practical components and all students are required to participate in the compulsory laboratory exercises and fieldwork. However, informal reports from the laboratory technician, facilitator and demonstrator tell that over the years many students seem reluctant to participate fully in hands-on laboratory exercises. Since students tend to learn more when they are actively engaged (Cross, 1987; Ericksen, 1984) and the level of learning that occurs in a classroom is directly proportional to the quality and quantity of students' involvement throughout the educational programme (Astin, 1984) this study was borne out of a need to determine what led to students actually engaging with laboratory exercises. The value of laboratory exercises to the engineering discipline was not in question here since this study was not intended to evaluate the effectiveness of engineering educators who use laboratory practicals for teaching. The concern was whether engaged students saw the link between practical work and their ultimate goals, interests, and concerns, which will become the focus of their practice as engineers. In seeking to understand what engaged students actually get from the experience of undertaking hands-on practical work, this research considered whether students who actively participated in laboratory practicals felt that their learning experience was enhanced because of this engagement.

Research question

What are “engaged” students’ perceptions of the benefits of hands-on laboratory work?

Methodology

Context

This study was carried out in the Department of Civil and Environmental Engineering at UWI STA over a period of the two consecutive semesters within the 2013/2014 academic year. Civil engineering is a main branch of engineering offered by UWI STA. At UWI STA, laboratory practicals are integral to most of the courses offered in the civil engineering curriculum. Additionally, in their final semester, each student is required to participate in a major practical research project which may include a hands-on laboratory component. It was within this context that the research took place.

Participants

The participants in this study were final year students. Final year students in the three-year civil engineering programme have the greatest experience of laboratory work and this is likely to increase the validity of their reflections. From the target population of 90 students registered for an environmental engineering course in the programme, ten were identified by the laboratory technician as being actively engaged with projects that involved the use of major hands-on laboratory work. The definition of engagement here is based on the criteria established by Tiberghien (2000 as cited in Millar, 2009). The identification of the participants was based on pragmatic sampling procedures, in that individuals were drawn from the set of all final year students studying the civil engineering course. The selection of the ten participants was therefore based on insider information balanced against the level of autonomy shown by students (Davies, 2008) and the types of laboratory events that the students were involved in (Millar, Tiberghien & Le Maréchal, 2002).

Data collection

The research data was collected using semi-structured face to face interviews. Each participant was interviewed once in an informal, private setting. Since the data collection was semi-structured, questions provided the impetus for an informal conversation between the researcher and participant. During the interview, participants were asked to reflect on their participation in laboratory based activities; their learning, and the value of the laboratory practicals to their entire learning experience. In a few instances, it was necessary for some prompting and probing to be utilised during the interview and, at the end, each participant was allowed to expand on the issues and to discuss their additional concerns. Participants were apprised of the objectives of the exercise as well as how the data would be used.

Analytical tools

The data produced during the interviews were analysed using two tools – an holistic overview and a template analysis. Since the data were qualitative in nature, these approaches focused on discovering the meaning within the text itself. The holistic overview pulls together all the data and attempts to find a global message that is sympathetic to all ten participant perspectives. The template analysis was theoretically grounded in the Kolb's experiential learning theory (Kolb, 1984). It was also used to identify trends within the data, and the four stages of the Kolb cycle were used to code the data. Miles and Huberman (1994) report that coding qualitative data can reduce data overload and can help clarify key responses. In this regard the four stages of the Kolb cycle were used to thematically code the interview data so as to highlight frequencies of occurrence. Adopting this approach allowed the student perspective to emerge. Table 1 illustrates the four stages of the Kolb cycle in relation to the template codes applied and the indicators that guided the application of these codes:

Table 1. Relating the Kolb cycle to the template coding process

Term	Code	Indicator
Concrete experience	CE	What students actually do in the practicals (Accounts of having experiences)
Reflective observation	RO	What students learn when they perform particular tasks (Reflections on experience)
Abstract conceptualisation	AC	What students actually learn from their reflections (Accounts that try to theorise experience)
Actual experimentation	AE	How 'new' knowledge is applied in new situations (Accounts that show the 'testing' of new theories)

Ethical considerations

Informal approval was obtained from the Head of Department to interview the participants. Prior to the commencement of the interview process each participant was advised on the purpose of the exercise, the degree of confidentiality placed on all information shared, the voluntary status of their participation, their freedom to choose not to respond to any question and their guaranteed anonymity. Identification information beyond a coded name (initials only) was not required and therefore not solicited. All participants gave their informed consent.

Limitations of the study

As with all research, this study was limited by: time and timing; sample dynamics; group dynamics; the kinds of questions asked; availability of participants; the cooperation of others; facilities, equipment and ethical considerations. Since this research examines a unique situation these factors are not limitations in the true sense of the word but boundaries within which the study takes place.

Data and data analysis

The interview data is reported here following the two data analysis tools: (1) an holistic overview of responses, and (2) *a priori* coding using the codes drawn from of the Kolb cycle.

Holistic overview of responses

Generally, participants said that, through laboratory work, they learnt technical skills in addition to project management, decision making, time management and team work. KB said, "I learnt a lot, time management, the correct way to use equipment and machinery; the ability to use what I was not taught in the classroom; teamwork and the use of proper protocols and procedures" and RM said, "I have learnt that decision making needs careful consideration - that a project supervisor needs to be technically knowledgeable and that it is very important to understand the culture of an organisation". Conversely, one participant said that he had not learnt anything new.

Even though there were issues regarding whether participants "liked" doing laboratory work, and it was reported by two students that they only did laboratory work because they "had to", most of the participants recognised that the laboratory exercises provided an important hands-on link to theory. VP said, "As I progressed I saw the purpose as providing a practical link to the theory" and RM said, "As much as I did not like having to do labs I now have a better understanding of the theory and I could see all the links". Two participants reported that the laboratories had no real value as much of the material learnt was lost in the transition from text to practice and two thought that fieldwork was more valuable than laboratory work. However, four students believed that all the laboratory work done over the three years was important and six felt that final year laboratories were particularly relevant. It is interesting that these responses are from students who were deemed to be "engaged" yet they show somewhat negative conceptualisations of laboratory work.

All of the participants said that they would apply the technical skills which they learnt. Skills such as communication, project management and team work were also part of the learning experience for some participants with FP reporting, "I am now able to link all the theory to the practical aspects and that has enhanced my knowledge significantly. I now have a working knowledge of correct techniques and it would be nice to be able to use all that I have learnt in my practice" and VJ responding, "I will always use what I learned as a check to make sure that I am on the right track. I will always focus, most of all, on getting accurate test results". Here we can see some of the practical benefits that have been drawn from the laboratory work. It might be these students, whilst not being particularly drawn to laboratory work, see the value in the long run whereas students who do not choose to do laboratory work either cannot see such benefits or feel that the effort outweighs the outcome.

Participants were asked to suggest ways in which improvements, that might support future student development, could be made to laboratory exercises. Class size was an issue for four of the participants and three suggested the use of technology in the laboratories as a solution. Five participants suggested that new equipment and an infrastructure upgrade were needed, for example SG thought that "most of the lab equipment used was out dated and needed upgrading". Four participants had issues with the programme structure in terms of work load and time allocated to develop and submit reports. Six participants thought that the lectures needed to be changed and that there needed to be an improvement in teaching methods in order to provide more effective coordination between the theory and the practicals. This position was emphasised by DT, who reported that, "Theory should be coordinated with lab exercises and each topic should include a field trip or site visit. Lecturers need to inspire students to get excited about topics….Lack of interest in theory leads to lack of interest in labs".

Overall, the picture painted here is rather bleak. In trying to understand student perspectives on the link between practical work and their future goals we can see that those who are deemed to be "engaged" students have many issues with aspects of laboratory work but that they are able to balance long-term outcomes against short-term effort and decide that, despite the challenges, they should apply themselves.

Analysis using a priori coding

In trying to understand engaged students perspectives on the value of laboratory work, the four aspects of the Kolb cycle were used to code qualitative responses. In applying the template derived from the Kolb cycle (see Table 2), we can see that the part of the cycle that was most coded was reflective observation (RO).

Table 2. Aspects of data coded using Kolb cycle template

Template codes	No. of codings
Concrete experience (CE)	30
Reflective observation (RO)	73
Abstract conceptualisation (AC)	27
Active experimentation (AE)	7

There were 73 aspects of data coded as RO with some participants making strong statements about the value of doing labs such as "I found that when I put myself into my lab reports...I got the highest marks" and "practical exercises made the course more interesting and much easier for me to recall information". One student expressed the view that "labs had no real value because success as a student is all about recall rather than the application of any concepts". All of the participants treated their lab experience as one event by making reference to “doing labs”. Generally, responses to concrete experience (CE) varied from “dislike” to “not seeing the point of labs”. Only one participant said, “I like all aspects of labs”. In terms of conceptualisation (AC), one participant said, “I can relate to all I did before”. Concrete experiences ranged from the acquisition of various skills such as technical or theory application to decision making, teamwork skills and time management. One student said that he undertook his project because he wanted to get the experience of working with a particular professor. Most of the responses were coded as showing reflective observation (RO) with participants describing their laboratory experience with terms such as “useful” and “applicable” - language that betrays an idea of practical work as a conduit to future activity. One participant reported that their laboratory project, “will be useful to the civil engineering industry” and another said, “I now have the confidence to be able to communicate with others in the field”.

Most of the participants had ideas of areas in which they could “try out” the many skills they learnt through active experimentation. Applications varied from the technical (beach morphology or water treatment) to the use of Gantt charts or focusing on obtaining accurate test results. A noted example of abstract conceptualisation came from a participant who said, “In my project, I actually saw the application of the practical aspects” – a statement that shows theory/practice integration.

In all we can see that the coded data suggests that these engaged students did not focus much on activity but preferred to use the laboratory work as a means of reflecting on the value it offered them in the long term. The high instance of data coded as showing RO suggests that, for these students, there was a great deal of focus on how laboratory work made them better and more employable engineers.

Discussion

The research found that generally those students who were identified as being “engaged” in civil engineering laboratory projects recognised the value and importance of practicals to their learning and that they felt their active participation in these exercises would have a positive impact on their overall performance. But that the key benefit in taking part in laboratory work was that they could use the skills learned to make them stronger practitioners in their future engineering careers. The emphasis was not on laboratory work *per se* but the application of the skills learned through reflecting on laboratory experiences. Although the learning experience appeared to be different for each participant there were many similarities in terms of gaining technical and professional skills and abilities. Participants also seemed to agree with Tobin (1990) that it is necessary to use laboratory practicals to teach some engineering concepts, since the laboratory activities allow students to learn with understanding and at the same time engage in a process of knowledge construction, for example, one participant stated that, “Lab exercises should be coordinated with theory and each topic should include a field trip or site visit”.

The Kolb cycle suggests that an effective learning process requires learners to go through all four stages of the cycle in sequence and proved to be applicable to this research. Ideally, for practical exercises, the learning process may be represented as shown in Figure 2:

CE → RO → AC → AE → CE

Figure 2. The flow of the learning process

Whilst a cursory look at this model suggests a consistent and regular movement through the learning process, it was found that the engaged UWI STA civil engineering students appear to spend most time engaged in reflection (RO) rather than practical activity (CE) and theory building (AC). It was also found that students gave very little focus to testing knowledge in new situations (AE). Here we can see that these "engaged" students" may perceive the benefits of hands-on laboratory work in regards to future application rather than laboratory work *per se*. Ideally, the reflective stage of the process (RO) should start after having the experience in order for there to be something to reflect upon. This might imply that if the physical experience is stymied then reflection and by extension the student's learning may be limited; however the students in this research seemed able to project future outcomes with minimal present effort.

Conclusion

This study determined that it was unclear whether the learning experiences of "engaged" undergraduate civil engineering students at UWI STA who were doing laboratory projects that required hands-on work was enhanced in itself. The lack of deliberation around concrete experiences and the small number of extracts coded as showing active experimentation suggest that these students were not engaged with laboratory work as a learning experience in itself, but as a means of developing their potential as future employees. It was found that it did not matter to the participants whether they did or did not enjoy laboratory work, what was important was that they could use practical work as a means to understand links between theory and practice, and they could draw from laboratories technical skills such as project management, decision making, time management and team work that would be used to strengthen their future careers.

References

Astin, A.W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel, 25*(4), 297-308.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*(3), 347-364.

Bonwell, C. C. & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. Washington, DC: Graduate School of Education and Human Development, George Washington University.

Cross, K. P. (1987). Teaching for Learning. *AAHE Bulletin, 39*, 3-7.

Davies, C. (2008). *Learning and teaching in laboratories*. Higher Education Academy Engineering Subject Centre, Loughborough University.

Ericksen, S.C. (1984). *The essence of good teaching*. San Francisco: Jossey-Bass.

Fry, H., Ketteridge, S. & Marshall, S. (Eds.). (2008). *A handbook for teaching and learning in higher education: Enhancing academic practice.* New York: Routledge.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

Krause, K. (2005). Engaged, inert or otherwise occupied: Deconstructing the 21st century undergraduate student. Proceedings of Sharing Scholarship in Learning and Teaching: Engaging Students. Cairns, Australia: James Cook University.

Lashari, T. A., Alias, M., Akasah, Z. A., & Kesot, M. J. (2012). An affective-cognitive teaching and learning framework in engineering education. *Journal of Engineering Education, 1*(1), 11-24.

Lucke, T. (2010). Using engineering practicals to engage students (Doctoral dissertation).

Maehr, M. L. & Meyer, H. A. (1997). Understanding motivation and schooling: Where we've been, where we are, and where we need to go. *Educational Psychology Review, 9*, 371- 408.

Malan, S. P. T. (2000). The "new paradigm" of outcomes-based education in perspective. *Journal of Family Ecology and Consumer Sciences/Tydskrif vir Gesinsekologie en Verbruikerswetenskappe, 28*(1), 22-28.

Millar, R., Tiberghien, A. & Le Maréchal, J.-F. (2002). Varieties of labwork: a way of profiling labwork tasks. In *Teaching and learning in the science laboratory*, D. Psillos, D. & H. Niedderer (eds). Dordrecht: Kluwe.

Millar, R. (2009). Analysing practical activities to assess and improve effectiveness: The Practical Activity Analysis Inventory (PAAI). York: Center for Innovation and Research in Science Education, University of York.

Miles, M. B. & Huberman, M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P. & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology, 36*(1), 36-48.

Pintrich, P. R. & Schunk, D. H. (2013). *Motivation in education: Theory, research, and applications* (4th ed.). Englewood Cliffs, NJ: Merrill.

Salanova, M., Schaufeli, W. B., Martınez, I., & Bresó, E. (2010). How obstacles and facilitators predict academic performance: The mediating role of study burnout and engagement. *Anxiety, Stress, & Coping, 23*(1), 53-70.

Schmitt, N., Oswald, F. L., Friede, A., Imus, A. & Merritt, S. (2008). Perceived fit with an academic environment: Attitudinal and behavioral outcomes. *Journal of Vocational Behavior, 72*(3), 317-335.

Schreiner, L. A., Noel, P., Anderson, E. & Cantwell, L. (2011). The impact of faculty and staff on high-risk college student persistence. *Journal of College Student Development, 52*(3), 321-338.

Smith, K. A., Sheppard, S. D., Johnson, D. W. & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education, 94*(1), 87-101.

Tobin, K. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics, 90*(5), 403-418.