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Inquiry-Based Approach for Civil Engineering Students: A Case Study

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Inquiry-Based Approach for Civil Engineering Students: A Case Study

Over the past few years, the enrollment of engineering students in the United States has experienced a decrease[10,17]. Approximately 60% or less of all engineering students graduate with an engineering degree[3,13,18]. With a decline in both the engineering enrollment and graduation rate, the U.S. government, industry, and academia have become more dependent on the foreign engineering workforce[16]. As a result, the National Science Foundation (NSF) has funded numerous projects with the goal of recruiting and retaining students in this field[10,11]. While attracting students to engineering majors requires an increase in outreach and an improvement in the overall perception of engineers in society, retention can be enhanced by increasing engagement in engineering curricula[11]. This paper describes a course curriculum improvement case study involving an introductory geotechnical engineering course where an inquiry-based approach is used. The purpose of this study is twofold: (1) to describe how the inquiry-based approach is used in the classroom including student perspectives of the use of this approach; and (2) to examine the relationships between student performance on the final exam with student self-efficacy beliefs and self-regulatory behaviors.

The inquiry-based pedagogy model is based on Bloom and Krathwohl's Taxonomy and Bloom's Revised Taxonomy[2], which focuses on student-centered learning activities and interactive skills. Bloom's taxonomy is used in education as a valid benchmark to measure a student's level of understanding. It consists of six cognitive levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. The American Society for Civil Engineers (ASCE) adopted Bloom's taxonomy as the basis for defining levels of achievement associated with the body of knowledge necessary for entry into the practice of civil engineering at the professional level[1]. ASCE expects civil engineering students to remember previously learned material (Knowledge), to grasp the meaning of material (comprehension), to use learned material in new and concrete ways (application), to break down material into component parts so that the organizational structure may be understood (analysis), to put material together to form a new whole (synthesis), and to judge the value of material for a given purpose (evaluation)[1].

In addition to content learning, the inquiry-based pedagogy claims to develop important skills that include critical thinking, problem solving strategies, self-regulated learning, and collaborative learning in teams, the skills which are not always assessed in traditional, lecture-based classrooms. Some studies suggested that the inquiry-based approach is an effective pedagogy to help students become self-regulated learners and develop problem-solving skills[15,27,31]. Other studies noted some weakness of this pedagogy. Dahlgren and Oberg argued that the students generated very few solution-oriented questions (only 6% of the total number of questions)[9]. The majority of the questions generated by the students happened to be encyclopedic (31%) and meaning-oriented (24%). The authors maintained that making use of encyclopedic questions indicated surface approach learning. This argument was echoed by Nuy[20] who posit that as far as content knowledge was concerned, the traditional methods may be more realistic. They further maintained that even though the traditional approach may lack motivation, it taught basic science in a more coherent way.

While the use of an inquiry-based approach may be controversial in engineering classroom, most researchers agree that this approach helps develop self-regulated learners. Self-regulation involves the interaction of personal, behavioral, and environmental triadic processes[4], and has been defined as a process that involves "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals"[33]. When used for student learning, the process of self-regulation "includes planning and managing time; attending to and concentrating on instruction; organizing, rehearsing, and coding information strategically; establishing a productive work environment; and using social resources effectively"[26] . Previous studies suggested that self-regulated learning behaviors facilitated students' motivation and academic achievement[21,22,24,25,29,32]. Teaching students about different cognitive and self-regulatory strategies can improve actual performance related to classroom academic tasks[23]. Student performance had been shown to significantly improve after the training of SRL strategies[7,19], and students trained to use these strategies became more self-regulated[28].

As part of a four semester long course curriculum improvement research grant funded by the National Science Foundation (NSF) Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) Program, this study evaluates the first two semesters of data collection. The first two semesters serve as the control group while the last two semesters serve as the treatment group. Similarities and differences between the implementations of the inquiry-based approach in the treatment and control groups were discussed in a separate paper[30]. The instructor used an inquiry-based approach to motivate student learning and facilitate the learning through scaffolding during problem-solving processes.

Participants

A total of 84 students (13 female and 71 male) in an introductory geotechnical engineering course at the University of North Carolina Charlotte, a large southeastern university in the United States, participated in this study. Most (71%) were European American, the rest of them were African American (7%), Asian (4%), Hispanic (2%), and identified with other ethnicities or did not report this information (16%). Of the 78 students who identified their levels of study in their programs, one student was a freshman, 56 were junior, and 21 were senior. The distribution of age was approximately normal with a mean of 22 years and a standard deviation of 4 years.

Assessment Instruments

Quantitative instruments include 1) pre and post student surveys, 2) short answer quizzes, 3) content module tests, and 4) the final exam. Three surveys were administered in class (pre and post) to measure the student's self-efficacy related to the content of the course and their use of self-regulated learning strategies (described in more detail below). A short-answer, pre-quiz was administered during the first class to measure the student's content knowledge and skills related to the course. A test was given at the end of each of the four geotechnical engineering content modules (soil structure, seepage, effective stress and consolidation, and shear strength) and one final exam was given at the end of the course. Short answer questions on the final exam (20% of the exam) were matched with parallel short answer questions on the pre-quiz to evaluate student gains in knowledge and skills across the semester. Longer, more involved problems on the final exam (80% of the exam) were matched with parallel problems on the four tests to examine student comprehension and retention of the material.

Quantitative data were analyzed with descriptive and inferential statistics (paired sample *t*-test, repeated measured multivariate analysis of variance, and multiple regressions). Paired-sample *t*-test was used to compare student gains on knowledge skills as a result of taking this course (pre-quiz was regarded as pretest and items on the final matching the pre-quiz were regarded as post-test). Four dependent variables were computed using the mean scores on the achievement of the tests at the end of each module. Tests were regarded as pre-test whereas final exam was regarded as post-test in repeated measures analysis of variance. Finally, their scores on the final exam were treated as the dependent variable whereas their performances on each of the four tests were treated as independent variables in the multiple regression analysis. Since the number of items varied across tests, all scores were converted to percentage out of the total possible score in each test.

Three surveys were given to the participants of this study at the beginning and at the end of each semester. The 'Student Self-Efficacy for Cognitive Ability' survey is based on Bloom's taxonomy, which is a multi-tiered model that measure six levels of cognitive ability including knowledge, comprehension, application, analysis, synthesis, and evaluation. The reliability and validity of this survey has been tested in previous research[2]. This survey includes 30 questions measuring students' degree of self-efficacy to remember and understand course content as well as to solve, analyze, evaluate, and create a problem related to the main topics presented in the course. Students were asked to rate themselves on a five-point Likert scale where "1" stands for "cannot do at all" and "5" stands for "certainly can do". A second 'Student Self-Efficacy for Application of Knowledge' survey includes 21 questions that were developed by the research team to measure student self-efficacy to accomplish specific tasks associated with the content in the course. Students were asked to rate themselves on a five-point Likert scale where "1" stands for "cannot do at all" and "5" stands for "certainly can do". The last survey evaluated 'Self-Regulated Learning Strategies'. Thirteen questions were developed according to Zimmerman's social cognitive theoretical framework of self-regulation[33] in order to measure student use of self-regulated learning strategies in college. Students were asked to report the frequency that they used the 13 strategies described in the survey where "1" stands for "not at all" and "5" stands for "all the time".

Qualitative data were collected from 1) observation field notes acquired by the assessment expert and the internal evaluator in the classroom, 2) instructor teaching logs that document instructor perceived successes, failures, and challenges, and 3) student interviews conducted by the assessment expert. Interviews were conducted with 27 randomly selected students and classroom observations were conducted at the end of each content module. Qualitative data from student interviews and classroom observations were analyzed using thematic analysis based on grounded theory[14]. Constant comparison method was used in coding so that themes can be merged and changed during the process of data coding and analyses.

Description of the use of Inquiry-Based Approach in the Classroom

An inquiry-based approach was used throughout the course. The class met two times a week in a lecture-style environment. Prior to class, the professor posted her lecture notes on the course website with purposefully inserted blank spaces for the insertion of notes during each lecture. Students print the notes and fill in the blanks while participating during the lecture (also known as information-gap activity). Whole-class group activity was always used by checking comprehension through questioning and allowing students to ask further questions. Pictures of large testing equipment (e.g. triaxial cells), manipulatives (e.g. a stack of paper to represent the structure of clay, foam peanuts to represent soil particles during undrained shearing), sketching (e.g. flow of ground water in a one and two dimensional soil medium), and additional desk-top models were used to facilitate the comprehension of fundamental concepts. The professor used metaphors such as "Imagine the clay as a stack of paper" to help explain key concepts. The professor also challenged students to think creatively by asking questions like, "What's one way to do this? What's another way to do this? Why do I have to strengthen the soil?" At the end of each lecture, every student was required to complete a 5-point, short answer quiz. Students had ample opportunities to explore the subject matter on their own and bring their own experiences or questions to the classroom sessions.

Student Perspectives of the Course

Regarding the pace of instruction, most students thought that the pace was good. One student said, "She does a really good job explaining everything. It's a tough class and I mean she makes it tough but still it's expected because it's a tough course. I've learned a decent bit, a good bit". Even a non-native speaker of English does not think it too fast, "I don't think it's too fast. I think for me it's fast because of the language. I need to translate everything back to my mother language which is much easier for me." One student wished that it was slowed down a bit, "un maybe not quite as rapid maybe slow things down a little bit because I think that like myself I think most of the students in there are new to geotech, and it's totally new to everybody I mean I think I could be wrong but a lot of the kids I think it's new to them so maybe slowing down a little bit."

Regarding content knowledge, most students thought that the content was delivered very effectively. One student commented, "Actually I'd have to say Dr. W is one of the more articulate teachers I have had. She is very organized. I feel like the material in progressing at a very logical methodical way and, ugh, I can't say that for a lot of the other courses I am taking so as far as delivery." All students interviewed said that they could answer most of the questions in the class. When asked to explain why sometimes they could not answer the instructor's questions, one student responded, "there were maybe a few I didn't know but you know I learned after she answered the questions or after the question was answered that I was able to understand it and know what she was talking about." Another student added, "a lot of it depends on how I concentrate during the class. I think if I didn't pay attention to it then it's going to be really complicated." Most students (79%) thought they were well prepared for the tests. One student said, "I feel pretty good … yeah I just have to memorize like some of the equations and things … I guess I just feel like you don't, you should have to memorize those questions because if you're in the field you can easily look them up and do them so I can easily do the problems. It's just memorizing the things all the equations that I will have to work on."

Regarding student interest, most of the students interviewed (79%) had some difficulties keeping themselves focused during the class whereas four students (21%) interviewed said that they were highly interested in the class. One student responded to the question by "Oh yeah definitely. I am very interested in all the topics that are covered in the curriculum and I'm and it's definitely it's definitely something I am interested in that that helps." When asked about why they were sometimes not focused, one student replied, "ugh just tiredness or laziness on my part. You know I don't know I don't think it's necessarily the instructor's job to always be working for our attention you know have signed up for this course I believe that it's the students responsibility to pay attention in class."

Regarding classroom activities, a lot of students liked the examples in the class. One student said, when I just see the lecture I don't know how that's going to apply to the real world, but when I see the example it clicks together and what's going on in the class." Some students liked the notes, "ugh yes still she printed out notes ugh like she gave us the notes beforehand and then she just write down the notes during the lecture. I like that because some because some there are some blanks and the blanks are always the important stuff so we write it down we wrote it down and then we knew these are important stuff that we need to memorize or something yeah I like that." Some students were taking the lab course at the same time and found that the lab was extremely helpful.

Some students suggested having more examples while some other students hoped to go over homework in the class. One student said, "she doesn't go over homework at all so I mean, she'll, she'll, you'll take the homework back and she'll grade it and if you have any questions go to her, but I think a lot of people don't go to her or don't have the time, so yeah so the homework, go over a few things on the homework in class." Some students hoped to have more visual experience, "yeah I mean I think that would be un helpful to actually go out and like see what she's talking about in the class or if she could bring in like because obviously like we have a lab, but we don't actually. That's so like quick pace so you don't actually get to visually see it, so maybe if she had an example this is like, this is soil, instead of her telling us you know sand structures like you know marbles in a bag if she could visually bring something in and be like look at this. This is how it is and all of us be able to feel it and touch it be like, ok, so it soaks in a little bit more I think that would be help."

Reliability and Validity of the Surveys

Student self-efficacy for cognitive ability survey was found to be reliable. The Cronbach's alpha was .99 for all items and .94, .95, .97, .96, .96, .96 for the sub constructs of knowledge, comprehension, application, analysis, synthesis, and evaluation, respectively. Student self-efficacy for application of knowledge survey was also reliable with a Cronbach's alpha value of .96. Although the Cronbrach's alpha value for the self-regulated learning strategies survey was a bit lower (.81), it is still considered reliable taking into the consideration that students do not always use all categories of strategies all the time. The Pearson correlation coefficients between the pre-quiz results and responses to the surveys suggest that these surveys had concurrent validity: .27 with student self-efficacy for cognitive ability survey, .29 with student self-efficacy for the application of knowledge survey, and .31 with the self-regulated learning strategies survey. The Pearson correlation coefficients between the final exam score and the responses to the surveys support the concurrent validity: .46 with the student self-efficacy for application of knowledge survey, .38 with student self-efficacy for the cognitive ability survey, and .29 with the self-regulated learning strategies survey. All these Pearson correlation coefficients were statistically significantly different from zero, $p < .05$.

Student Gains in Knowledge and Skills

Descriptive statistics for the measurement of student content knowledge and skills throughout the course are presented in Table 1. Students gained significantly in their knowledge and skills by taking this course when comparing the pretest and final exam, $t(83) = 36.84$, $p < .001$, Cohen's $d = 6.68$. When end of Module 1 test was compared with prequiz, $t(82) = 26.73$, $p < .001$, Cohen's $d = 2.93$. When end of Module 2 test was compared with prequiz, $t(83) = 37.06$, $p < .001$, Cohen's $d = 4.04$. When end of Module 3 test was compared with prequiz, $t(83) = 43.85$, $p < .001$, Cohen's $d = 4.78$. When end of Module 4 test was compared with prequiz, $t(83) = 41.85$, $p < .001$, Cohen's $d = 4.57$. All the above Cohen's d values suggest very large effect sizes[8].

Table 1. Descriptive Statistics of Student Knowledge and Skills (n = 84)

	Prequiz	FinPre	PreT1	T1Pre	T1Fin	FinT1	PreT2	T2Pre	T2Fin	FinT2
M	7.13	74.32	17.89	75.36	86.35	86.34	6.90	73.57	74.68	82.02
SD	6.63	11.96	14.19	13.90	13.27	13.57	8.28	14.90	16.96	14.11
	Final		PreT3	T3Pre	T3Fin	FinT3	PreT4	T4Pre	T4Fin	FinT4
M	79.73		2.08	75.65	85.23	72.32	1.79	68.63	86.10	82.25
SD	11.06		4.80	14.95	16.30	25.59	5.24	14.44	10.49	15.28

Note. (a) Pre-quiz is the pre-test at the beginning of the semester, and FinPre is part of the final exam that matches the prequiz; (b) PreT1 is part of the prequiz that corresponds to the end of Module 1 test, T1Pre is part of the end of Module 1 test that corresponds to the prequiz, T1Fin is part of end of Module 1 test that corresponds to the final exam, and FinT1 is part of the final exam that corresponds to end of Module 1 test; (c) PreT2 is part of the prequiz that corresponds to the end of Module 2 test, T2Pre is part of the end of Module 2 test that corresponds to the prequiz, T2Fin is part of end of Module 2 test that corresponds to the final exam, and FinT2 is part of the final exam that corresponds to end of Module 2 test (d) PreT3 is part of the prequiz that corresponds to the end of Module 3 test, T3Pre is part of the end of Module 3 test that corresponds to the prequiz, T3Fin is part of end of Module 3 test that corresponds to the final exam, and FinT3 is part of the final exam that corresponds to end of Module 3 test; (e) PreT4 is part of the prequiz that corresponds to the end of Module 4 test, T4Pre is part of the end of Module 4 test that corresponds to the prequiz, T4Fin is part of end of Module 4 test that corresponds to the final exam, and FinT4 is part of the final exam that corresponds to end of Module 4 test; (f) Final is the total final exam score.

Short-Term Retention versus Long-Term Retention of Knowledge

Student performances on the final exam (long-term retention) were significantly different from their performances on the tests at the end of each module in general (short-term retention), F (4, 79) = 9.30, p < .001, η^2= .43. Specifically, student short-term retention was not statistically significantly different from their long-term retention on soil structure (Module 1), t(83) = 0.01, p = .99, d < 0.01; student short-term retention was worse than their long-term retention on seepage (Module 2), t (83) = -4.63, p < .001, d = 0.51; student short-term retention was better than their long-term retention on effective stress and consolidation (Module 3), t(83) = 4.88, p < .001, d = 0.53; and student short-term retention was better than their long-term retention on shear strength (Module 4), t (83) = 2.97, p = .004, d = 0.32. All the above Cohen's d values suggest medium effect sizes[8].

Predictors of Student Performance on the Final Exam

Results from the multiple linear regression analysis suggested that student performance on tests at the end of each content module and student attendance were significant predictors of their performance on the final exam, but their homework scores were not statistically significantly related to their performance on the final test when the test scores and attendance had already been accounted for (Table 2). The model explained 56% of the total variance on student performance on the final exam with adjustment considering the sample size. This conclusion was reached by stepwise regression where only statistically significant predictors were retained in the final regression model. Pairwise correlations indicated that student performance on the final exam was statistically and positively related to each of the following predictors: homework grade (r = .43); attendance (r = .34); and average score of all four module tests (r = .73); student self-efficacy for cognitive ability (r = .38), and student self-efficacy for application of knowledge (r = .46). Student performance on the final exam, however, was not statistically significantly related to their self-regulated learning strategy use (r = .08);

Table 2. Predictors of Student Performance on the Final Exam

	B	t	p
Test Average	.69	9.20	< .001
Attendance	.18	2.37	.02

Note. R^2 = .57; Adjusted R^2 = .56; F (2, 81) = 53.48, p < .001.

Concluding Remarks

As many students indicated in the interviews, the instructor made this course interesting and challenging through an inquiry-based approach. The information-gap activity forced the students to read the textbook before class as well as pay attention to the instructor during the class. The use of real-world examples helped the students make the connection between what they learned from the textbook and what they were expected to do in the actual civil engineering field. Students had a lot of opportunity to explore the problems on their own and tried various methods to solve the problems. Those students who were taking the lab course simultaneously found this course extremely helpful because they had more exposure to the use of the knowledge.

During the second phase of this project (the treatment group), the instructor will integrate desktop models, three dimensional visuals, and interactive teaching techniques to increase student engagement and impact student comprehension and retention. These tools will make this course even more captivating and informative. Both the qualitative and quantitative data suggest that students learned a lot from this course and that the instructor successfully retained the students' interest in the civil engineering field. This is very encouraging as preparing future workforce for civil engineering is the goal of civil engineering education[1].

Student performance on the final exam, a measure of the knowledge and skills learned during the course, was positively related to their attendance, homework grades, test scores, self-efficacy beliefs for cognitive ability as well as self-efficacy beliefs for the application of knowledge. These results suggest that students who are self-regulated, who keep their goals in mind, and know what they are doing and why they are doing it feel competent and do their work at a level that would enable them to do well in the class. This finding aligns well with empirical studies in cognitive science[29]. The implications of these findings suggest the importance of motivation, self-regulation, and self-efficacy in student learning process. While content knowledge is important, keeping students motivated, self-regulated, and efficacious would certainly help students reach their academic and career goals.

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References Cited

1. American Society of Civil Engineers (2008). *Civil engineering body of knowledge for the 21st Century preparing the civil engineer for the future*. Rep. Prepared by the Body of Knowledge Committee of the Committee on the Academic Perquisites for Professional Practice. ASCE, Reston, VA.
2. Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives*. New York: Longman.
3. Astin, A. W., & Astin, H. S. (1992). *Final report: Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences.* Los Angeles, LA: Higher Education.
4. Bandura, A. (1986). *Social foundations of thought and action.* Englewood Cliffs, NJ: Prentice-Hall.
5. Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.
6. Bloom, B. S., Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners. Handbook 1: Cognitive domain.* New York, NY: Longmans.
7. Butler, D (1998). A strategic content learning approach to promoting self-regulated learning by students with learning disabilities. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievements: Theory, research, and practice* (pp. 143-167). New York: Springer.

8. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.
9. Dahlgren, M. & Oberg, G. (2001). Questioning to learn and learning to question: structure and function of problem-based learning scenarios in environmental science education. *Higher Education, 41,* 263-282.
10. Davis, C. E., Yeary, M. B., & Sluss, J. J. (2012). Reversing the trend of engineering enrollment declines with innovative outreach, recruiting, and retention programs. *IEEE Transactions on Education, 55,* 157-163.
11. Dewoolkar, M. M., George, L., Hayden, N. J., & Neumann, M. (2009). Hands-on undergraduate geotechnical modules in the context of effective learning pedagogies, ABET outcomes, and our curricular reform. *Journal of Professional Issues in Engineering Education and Practice, 135,*161-175.
12. Ferguson, C. (2002). Using the revised taxonomy to plan and deliver team-taught, integrated, thematic units. *Theory into practice, 41,* 238-243.
13. French, B. F., Immekus, J. C., & Oakes, W. C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education, 94,* 419-425.
14. Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago, IL: Aldine Publishing Company.
15. Hmelo, C. (1998). Problem-based learning: effects on the early acquisition of cognitive skills in medicine. *The Journal of the Learning Sciences, 7 (2),* 173-208.
16. National Science Board (2003). *The science and engineering workforce realizing America's potential.* Retrieved from http://nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf
17. National Science Board (2004). *An emerging and critical problem of the science and engineering labor force: A comparison to science and engineering indicators.* Retrieved from http://nsf.gov/statistics/nsb0407/nsb0407.pdf
18. National Science Board (2007). *Moving forward to improve engineering education. Retrieved from* http://nsf.gov/pubs/2007/nsb07122/nsb07122.pdf
19. Neilans, T. H., & Israel, A. C. (1981). Towards maintenance and generalization of behavior change: Teaching children self-regulation and self-instructional skills. *Cognitive Theory and Research, 5,* 189-195.
20. Nuy, H. (1999). Interactions of study orientation and students' appreciation of structure in their educational environment. *Higher Education, 22 (3),* 267-274.
21. Pape, S. J., & Wang, C. (2003). Middle school children's strategic behavior: Classification and relation to academic achievement and mathematical problem-solving, *Instructional Science, 31*, 419-449.
22. Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36,* 89-101.
23. Pintrich, P. R., & DeGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33-40.
24. Schunk, D. H. (1996). Goal and self-evaluative influences during children's cognitive skill learning. *American Educational Research Journal, 33,* 359-382.
25. Schunk, D. H., & Ertmer, P. A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In M. Boekaerts, P. Pintrich, & M. Seidner (Eds.), *Self-regulation: Theory, research, and applications* (pp. 631-649). Orlando, FL: Academic Press.
26. Schunk, D. H., & Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychologist, 32*, 195-208.
27. Sobral, D. (1995). The problem-based learning approach as an enhancement factor of persona; meaningfulness of learning. *Higher Education*, 29 (1), 93-101.
28. Travers, N. L., Sheckley, B. G. (2000). *Changes in students' self-regulation based on different teaching methodologies*. Paper presented at the 40th Association for Institutional Research Forum, Information for the Next 100 Years. Cincinnati, Ohio: May 21-May 24, 2000.
29. Wang, C., Hu, J., Zhang, G., Chang, Y., & Xu, Y. (2012). Chinese college students' self-regulated learning strategies and self-efficacy beliefs in learning English as a second language. *Journal of Research in Education, 22*(2), 103-135.
30. Warren, K., & Wang, C. (2013). Use of interactive classroom models and activities to increase comprehension of geotechnical engineering concepts. *Conference Proceedings of the 120th ASEE Annual Conference.*

31. Wood, R., Bandura, A., & Bailey, T. (1990). Mechanisms governing organizational performance in complex decision making environments. *Organizational behavior and Human Decision Processes, 46,* 181-201.
32. Yeung, E., Au-Yeung, S., Chiu, Th., Mok, N., Lai, P. (2003). Problem design in problem-based learning: evaluating students' learning and self-directed learning practices. *Innovations in Education and Teaching International*, *40*(3), 237–244.
33. Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 13-39). San Diego, CA: Academic Press.