FFP12 2011
Udine 21-23 November 2011

ACTIVE LEARNING BY INNOVATION IN TEACHING (ALIT)

Dina Izadi, *Ariaian Young Innovative Minds Institute (AYIMI),Tehran, Iran*
Marina Milner-Bolotin, *Faculty of Education, University of British Columbia, Vancouver, Canada*

Abstract
Today more than ever before, the future depends on students' ability to apply the knowledge they learn in the classroom to solve real life problems such as global warming, climate change, air pollution, waste disposal, energy generation, world poverty and food production. In the incessantly changing world, students of the 21st century are very different from the students of the past. This requires educators to think continuously about how to change their teaching to empower and engage modern students, which makes educational innovations imminent. Contemporary students must be proactive in seeking relevant information and applying it to solve real life problems. However, the way we teach hasn't changed sufficiently to reflect these changes. Like in the earlier centuries, the dominant pedagogy in many contemporary science classrooms is still teacher-centered instruction, relying on route memorization and passive learning.To help science educators make a transition from passive to active learning in order to engage students in meaningful learning process, "Active Learning by Innovation in Teaching" (ALIT) model is introduced. This model offers a way of finding different approaches to engage students in meaningful science learning and apply their knowledge to solve real life problems.

1. Introduction
In order to be able to solve the problems faced by modern societies, the students should learn how to apply science they learn in the classroom to the world around them. Unfortunately passive learning strategies and the testing systems utilized by many science teachers, create a gap between the "classroom science" and the "real world science" that has a potential to affect modern society. In countries such as Iran students who passed the entrance exam (Konkoor) with higher scores are more likely to be accepted to universities. However, most of the times the majors these students choose do not entirely reflect their interests. Often, students pass science courses and study science topics in the syllabus without acquiring any deep and meaningful knowledge of the subject. This lack of conceptual understanding is also reflected in how students' success is measured: via end of semester grades obtained by solving plug-and-chug problems on science exams. An important aim of modern education should be helping students acquire and develop science knowledge, skills and abilities that they can apply to solve real life challenges. Research shows that students also need to develop communication and collaboration skills. This can be achieved via encouraging them to engage in active and creative learning in as many ways as possible(Ramsier, 2001). A key emphasis in active learning pedagogy is placed on the combination of the theoretical knowledge with experimental - practical skills, which are crucial for motivating students. Active learning environment also requires a cooperative and collaborative atmosphere, where students are encouraged to ask questions and work together to seek answers. One of the challenges active learning pedagogy aims to address is helping students see and critically examine the environment around them, think about the phenomena they encounter in the real life as scientists, and solve the problems faced by the society using novel approaches.
A growing number of modern high school and college teachers have already realized the importance of moving from a passive to an active learning environment in order to motivate students via engaging them in a meaningful learning process. However, many teachers feel a need for support in implementing active learning pedagogies in the classrooms: designing and implementing activities to be used inside and outside of the classroom, as well as choosing pedagogically effective activities relevant to their science curriculum from the plethora of activities produced by other educators (Freeman et al., 2007; Hoffman & Goodwin, 2006; C. Kalman, Antimirova, & Milner-Bolotin, 2009; Perkins et al., 2006; Ramsier, 2001; Sokoloff & Thornton, 2004).

2. Active Learning by Innovation in Teaching" (ALIT) model to develop student-centered education

In a teacher-centered learning environment, such as the traditional instruction, the teacher's primary functions are lecturing, designing assignments and tests, and grading. Some instructors use short quizzes at the beginning of every period for this purpose; others who don't want to spend a lot of class time administering and grading quizzes prefer to include questions on the readings assignments in their regularly scheduled examinations. In the student-centered learning environment, the students must take responsibility for their own learning (Kember & Gow, 1994; Voogt, Tilya, & van den Akker, 2009) . The students must identify what they need to learn to have a better understanding of the problem, and determine where to get the necessary information (books, magazines, teachers, other students, the internet, etc.) This approach forces students to become active learners, to take ownership of their learning and to work cooperatively. This process also increases students' motivation to learn, improves their retention of material, promotes deep conceptual understanding, and encourages more positive attitudes toward the subject (Bonwell & Eison, 1991; Bonwell & Sutherland, 1996; McKeachie, 1994).In a teacher-centered learning environment, instructors often have implicit expectations about what students should learn and how they should learn it (Kember & Gow, 1994). At the first glance, this approach seems to be a safer one. Yet it is less efficient, if we want to encourage our students to acquire critical thinking skills and develop positive attitudes about science. Sometimes, however, the students who have been accustomed to traditional pedagogies may resist student-centered pedagogies and collaborative learning approaches. They might prefer to learn individually without cooperating with other students. These students like to be more distinguished among other students and might not see how they will benefit from collaboration with peers. How can we encourage more students to become active learners instead of sitting in class, listening to their instructors, transcribing and memorizing meaningless formulae in order to get a passing score on the final exam? As educators we should consider how to help students become independent learners while applying their knowledge to solve real life problems, such as global warming, generation of renewable energy, reduction of carbon dioxide emissions.

Ariaian Young Innovative Minds Institute (AYIMI) is a scientific institute located in Iran. It was founded in 2009 (http://www.ayimi.org).It aims at improving science learning via providing opportunities for the students to apply science to solve real life problems. Its other goal is to investigate students' views about the nature of science and about what it takes to learn science (Buffler, Lubben, & Ibrahim, 2009; C. S. Kalman, 2009; C. S. Kalman et al., 2012). Assessment of student learning is completely different in AYIMI activities. To make a transition from passive to active learning, and engage students in the learning process, "Active Learning by Innovation in Teaching" (ALIT) model is introduced (Figure 1). This model offers students different approaches to solving problems and to investigating suggested science topics. AYIMI follows the ALIT model for science teaching. In this model, the students learn to use science to improve their society and solve some of its most important problems. ALIT pedagogy encourages students to work cooperatively to achieve common goals.

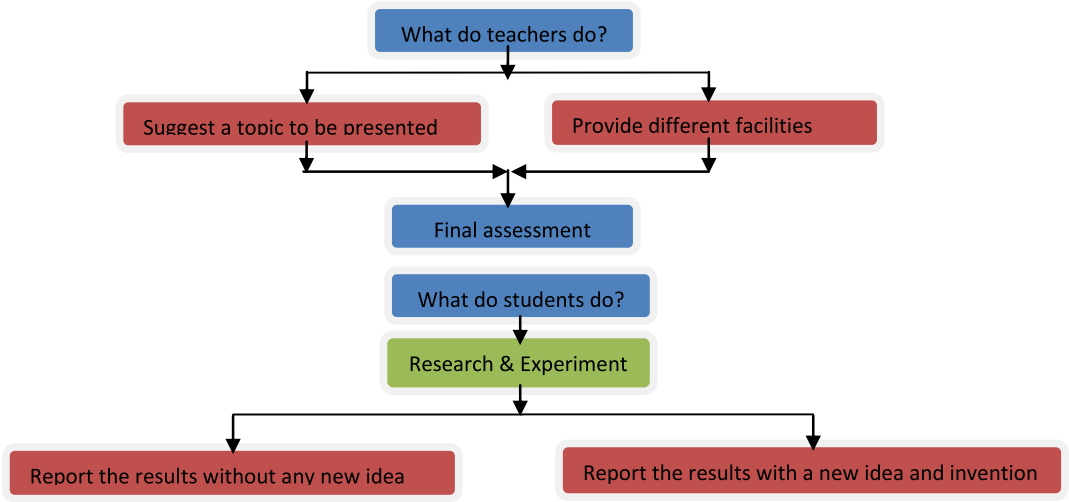

Figure 1: Active Learning by Innovation in Teaching (ALIT) Model

2.1. What Do Teachers Do?

A- Suggest a topic to be presented

A science teacher discusses with the students different topics relevant to the curriculum and relevant to the students that might require further investigation. The class can brainstorm possible problems that the students will investigate and later present to the class. Alternatively, a teacher might suggest a topic for investigation in class and then ask the students to think about possible experiments that they can perform to investigate this topic. These experiments might be conducted by the students working in groups outside of class, or a teacher might support the students by providing them with necessary facilities at school. To help the students build on their prior knowledge and motivate them to explore the topic of interest to them, a teacher might ask the students to think about the topic and write down what they already know on this subject. Then the students discuss their notes with peers and research related subjects to this topic in scientific books or on the internet. Teachers can devise a method of approaching the subject from the students' point of view. It is important to consider what was taught in previous classes, how the topic might be of interest to the students, how the topic of investigation might link to other school subjects. Then the teacher invites the students to discuss what they need to study and perform their experiment in front of the entire class.

B- Provide different facilities

According to the topic and what the students need to do to conduct an experiment, a teacher might provide them with different facilities and resources. These resources are used in order to conduct the preliminary experiments in class. However, students can design a more complicated experimental apparatus by themselves in order to obtain more advanced results. In a laboratory, the students work in groups to design their own experimental setup and collect the best possible results to address the problem under investigation.

C- Final Assessment

In traditional learning environments, the focus is most often placed on summative assessment: quizzes, exams, final papers (Angelo & Cross, 1993). For many students, this feedback is not useful in terms of their learning outcomes. A formative, ongoing assessment has been proven to be more effective in helping students learn science (Beatty et al., 2008; Etkina, 2000; Feldman & Capobianco, 2008; Mishra, Koehler, & Henriksen, 2011; Rodriguez, 1998).

In ALIT model teachers can provide continuous ongoing feedback on students' work: evaluate the groups' interpretations, their results, their experimental setup, etc. At the capstone event of the ALIT model, different groups present their projects in a competition. Students and teachers also comprise the jury that judges the projects. Students' performance, the quality of their team work, the performance of project-related practical tasks, introduction of novel approaches in solving problems which can help them in real life, as well as students' confidence in project presentation are the most important parameters that guide the evaluation process.

The final assessment has the following components:

- Individual responsibility of team members
- Quality of student collaboration
- Quality of face-to-face interactions
- The level of students' self- confidence
- Quality and quantity of student learning
- The approach in finding the best solution
- The quality of the design of a method or apparatus related to the topic

2-2: What Do Students Do?

A- Research & Experiment

Unlike the traditional teacher-centered learning environments, in the proposed model, teacher's primary role is to direct student thinking and help them integrated their prior knowledge, find useful resources via conducting independent research and do independent investigation. This model is akin to Project-Based Instruction discussed elsewhere (Blumenfeld et al., 1991; Krajcik et al., 1998). The students take notes and build models which are consistent with their preliminary findings. They brainstorm ideas in their groups to define the research focus – the problem they will

investigate. The next step is conducting experiments which help students integrate science concepts and apply them to solve a specific problem. For example, a teacher asked the students to design an experiment that involved a ball. One of the teams decided to find parameters that help describe the collisions of this ball with different objects made of different materials. In physics, elasticity is defined as an ability of a material to return to its original shape after the stress (e.g. external forces) that made it deform has been removed. The weft and warp of different fabrics have been measured and with a high speed camera the falling objects (different balls) which heating targets (different fabrics) have been clearly analyzed. Then in laminar flow the relation between resilience coefficients and weft and warp of different fabrics have been analyzed with MATLAB (www.mathworks.com) software. Other students built a gun which is made from a solenoid and a ball and found the optimum velocity of this electromagnetic gun. Another group suggested a model to use tidal energy, as a renewable energy, to generate electricity by making the tidal water enter a specially designed cylinder with a piston. In these experiments the students have an opportunity to show their creativity. Engaging in a long-term project with a team of 3-6 students allows them to apply scientific concepts more thoroughly while solving a meaningful science problem under the guidance of a teacher.

B- Report the Results

The results from students' independent or group investigation are reported in class. Some of the results will show known relations between different parameters. However, sometimes the experiment will allow the students to unveil new previously unknown relations. Students are invited to take part in a competition with other groups and defend their projects. The groups who have worked in depth and are able to defend their findings and illustrate the research process in depth will win the competition.

3. Students' Role in ALIT

The students' role in ALIT can be described as follows:

- Forming a group in which each member takes specific responsibility
- Carrying out the research projects in each group
- Talking in class and producing a first stage report
- Designing a model to explain the observations
- Carrying out different experiments and explaining observations
- Collecting data
- Analyzing data and sometimes comparing these data to a simulation
- Presenting the results of the investigations in front of other teams and jury to challenge their topics with different team members
- Writing a final report

4. Conclusions

To help students grow as scientists, teachers can suggest different project topics and encourage students to design experimental setup, to conduct the experiments on the topic and to find the best approaches and solutions to the problems. To support this process, the students are encouraged to collaborate with their peers inside and outside of class. "Active Learning by Innovation in Teaching" (ALIT) model, will persuade students to act as a teacher in a way to help others understand science better. Cognitive research shows that memorizing information does not promote meaningful learning. However, when this knowledge is used to solve a practical problem relevant to students' lives, it becomes more meaningful. In conclusion, in ALIT model the students are encouraged:

1- To solve more practical problems and find solutions using a combination of theoretical and experimental approaches.
2- To find new methods in solving problems. This makes the students think more critically while trying to invent novel solutions to real problems. It also helps extend their scientific abilities.

3- To combine qualitative and quantitative approaches and deductions, to learn how to evaluate their data statistically and compare theoretical predictions with the collected data.
4- To report the results in front of audiences in competitions. This positively affects students' communication skills and their self-confidence about science learning.
5- To acquire collaborative and leadership skills while working in a group to solve a science problem.

In conclusion, from our experience, the ALIT model helps promote conceptual science learning, excite students about science and allow them to apply what they learn in the classroom to solve real life problems.

References

Angelo, T. K., & Cross, K. P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers* (Second ed.). San Francisco: Jossey-Bass Publishers.

Beatty, I. D., Feldman, A., Leonard, W. J., William J. Gerace, Cyr, K. S., Lee, H., et al. (2008). *Teacher Learning of Technology-Enhanced Formative Assessment*. Paper presented at the National Association for Research in Science Teaching. Retrieved from http://arxiv.org/ftp/arxiv/papers/0806/0806.4924.pdf

Blumenfeld, P. C., Soloway, E., Max, R. W., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning. *Educational Psychologist, 26*(3,4), 369-398.

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom* (ASHE-ERIC Higher Education Report No1 No. Report One). Washington DC: The George Washington University, School of Education and Human Development.

Bonwell, C. C., & Sutherland, T. E. (1996). The Active Learning Continuum: Choosing Activities to Engage Students in the Classrooms. In R. J. Menges & M. D. Svinicki (Eds.), *Using Active Learning in College Classes: A Range of Options for Faculty* (Vol. 67, pp. 3-15). San Francisco: Jossey-Bass Publishers.

Buffler, A., Lubben, F., & Ibrahim, B. (2009). The Relationship between Students' Views of the Nature of Science and their Views of the Nature of Scientific Measurement. *International Journal of Science Education, 31*(9), 1137–1156.

Etkina, E. (2000). Weekly Reports: A Two-Way Feedback Tool. *Science Education, 84*(5), 594-605.

Feldman, A., & Capobianco, B. M. (2008). Teacher Learning of Technology Enhanced Formative Assessment. *Journal of Science Education Technology, 17*, 82-89.

Freeman, S., O'Connor, E., Parks, J. W., Cunningham, M., Hurley, D., Haak, D., et al. (2007). Prescribed Active Learning Increases Performance in Introductory Biology. *Life Science Education, 6*(Summer 2007), 132-139.

Hoffman, C., & Goodwin, S. (2006). A clicker for your thoughts: technology for active learning. *New Library World, 107*(1228/1229), 422-433.

Kalman, C., Antimirova, T., & Milner-Bolotin, M. (2009). *Comparison of Two Active Learning Teaching Methods: Conceptual Conflict Collaborative Group and Peer Instruction*. Paper presented at the Canadian Association of Physicists Congress 2009.

Kalman, C. S. (2009). Reading the Book of Nature: The Hermeneutical Circle In Science. In M. Gueldry (Ed.), *Languages Mean Business: Integrating Languages and Cultures in/for the Professions*. Lampeter Ceredigion, Wales, United Kingdom: The Mellen Press,.

Kalman, C. S., Milner-Bolotin, M., Antimirova, T., Aulls, M., Charles, E. S., Huang, X., et al. (2012). *Understanding the Nature of Science and Nonscientific Modes of Thinking in Gateway Science Courses* Paper presented at the National Association for Research in Science Teaching Annual Conference.

Kember, D., & Gow, L. (1994). Orientations to Teaching and their Effects on the Quality of Student Learning. *Journal of Higher Education, 65*(1), 58-74.

Krajcik, J., Blumenfeld, P. C., Max, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in Project-Based Science Classrooms: Initial Attempts by Middle School Students. *The Journal of the Learning Sciences, 7*(3,4), 313-350.

McKeachie, W. J. (1994). *Teaching Tips: Strategies, Research, and Theory for College and University Teachers* (Ninths edition ed. Vol. 1). Lexington, Massachusetts Toronto: D.C. Heath and Company.

Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The Seven Trans-Disciplinary Habits of Mind: Extending the TPACK Framework towards 21st Century Learning. [Reports - Evaluative]. *Educational Technology, 51*(2), 22-28.

Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., et al. (2006). PhET: Interactive Simulations for Teaching and Learning Physics. *The Physics Teacher, 44*(January 2006), 18-23.

Ramsier, R. D. (2001). A hybrid approach to active learning. *Physics Education, 36*, 124-128.

Rodriguez, A. J. (1998). Strategies for Counterresistance: Toward Sociotransformative Constructivism and Learning to Teach Science for Diversity and for Understanding. *Journal of Research in Science Teaching, 35*(6), 589-622.

Sokoloff, D. R., & Thornton, R. K. (2004). *Interactive Lecture Demonstrations: Active Learning in Introductory Physics*: John Wiley and Sons, INC.

Voogt, J., Tilya, F., & van den Akker, J. (2009). Science Teacher Learning of MBL-Supported Student-Centered Science Education in the Context of Secondary Education in Tanzania. [Reports - Research]. *Journal of Science Education and Technology, 18*(5), 429-438