

# Engaging learners inside and outside the classroom

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## Abstract

In the teaching of engineering in Portugal, many, if not most, engineering faculty implicitly adopt a broadcast model and lectures are often essentially expository with students in a passive role. This approach suffers from some weaknesses in that it does not prepare learners for autonomous work and may contribute to high failure and attrition rates. One way to combat this is through the application of Active Learning (AL) methodologies which encourage student engagement through greater involvement in what is being taught. This approach can also promote autonomous work outside class by extending active learning beyond the lesson period.

In this paper results are presented for two student cohorts from the application of an Active Learning Methodology in the classroom and outside it for a curriculum unit of the last year of a BEng degree. A Learner Activity Monitoring Matrix, which the authors of this study are involved in developing, has been used for the purpose of monitoring in-class learner activity. Also described is the implementation of active learning outside class using the survey function of the Moodle Online Learning Management System which permits voting by students on the quality of solutions proposed by their peers to resolve engineering problems posed by the lecturer. In addition to providing motivation for learner participation in critical analysis outside class-time, this procedure furnishes empirical data regarding the online participation in the process of each learner. This work also presents results obtained by conducting a pre-post survey to reveal student perceptions regarding these methodologies.

*Keywords:* active learning, engagement, classroom observation, Moodle

## 1 Introduction

### 1.1 Background

Since the appearance in 1988 of Felder's paper on Learning and Teaching Styles in Engineering Education (Felder and Silverman, 1988) which concluded that there was a mismatch between most engineering education and the learning styles of most engineering students, there has been an increasing interest in developing teaching techniques to address all learning styles with a particular emphasis on the importance of active learning supported by pedagogies of engagement, often involving a cooperative or problem-based approach, with the aim of improving the outcome of Engineering Education in Europe, the US and Asia.

Felder carried out a longitudinal study following the effect of active and cooperative techniques designed to address a broad spectrum of learning styles on a cohort of students over 5 semesters (Felder et al., 1998) and found that an experimental group using these techniques in chemical engineering subjects outperformed a comparison group on a number of measures, including retention and graduation, and many more of the graduates in this group chose to pursue advanced study in field. He also notes that academic performance in other course subjects was better in the groups studied. Various authors have described studies which show the effectiveness of active and cooperative learning in engineering education as an important element of course design in encouraging engagement of undergraduate students and contributing to active learning (Johnson et al.; 1991; Paulson 1999; Prince 2004).

### *1.2 Active Learning*

"Learning is not a spectator sport. Students do not learn much just sitting in classes listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must talk about what they are learning, write reflectively about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves" (Chickering and Gamson, 1987). Active Learning has been defined as any strategy "that involves students in doing things and thinking about the things they are doing" (Bonwell and Eison, 1991) and this broad definition can be taken to include a very wide range of teaching and learning activities including collaborative and problem-based learning. In this work, however, we follow Paulson (Paulson and Faust, 2007) in using the term more narrowly to refer to a number of techniques that can be incorporated in the lecture context so as to give students a more active role in their learning process.

### *1.3 Context*

The academic year 2006/07 was the first year in which new ministry-approved Bologna Process courses were run in Portuguese higher education institutions. In the teaching of engineering in Portugal, the classes are traditionally classified into theoretical and practical. The theoretical classes are devoted to transmission of the concepts needed to solve problems students will work on in practical classes. Thus, the lectures are often essentially expository with students in a passive role.

One way to combat the high failure and attrition rates is through the application of Active Learning methodologies. The application of active learning in the classroom encourages student engagement through greater involvement in what is being taught. The application of this approach can also promote autonomous work outside class by extending active learning beyond the lesson period. Thus, it is also possible to consolidate the teaching program content with greater availability of time for classroom activities. The active learning methodologies implementation described here were implemented in a Structural Concrete curriculum unit (4 hours per week). This is a one-semester subject of the third (last) year degree course leading to a Portuguese Licenciatura (B Eng) in Civil Engineering. A Learner Activity Monitoring Matrix (LAMM), which the authors of this study are involved in developing, was used for classroom observation.

## **2 Research Questions**

As mentioned above, several authors noticed that the learning is more effective if students adopt an active role. Thus, the main research questions formulated are: (i) Can the application of AL strategies place students in an active role in lecture-type classes in the Portuguese engineering education context? (ii) Can a Learning Management System like Moodle be effective in encouraging student engagement outside class using an online environment?



The observations cover the first 60 minutes of a scheduled lecture class, irrespective of the actual length of the class (usually 1.5 or 2 hours). An Activity Index is calculated by assigning a weighting of 1 to passive listening, 2 to individual work and 3 to pair or group work. Thus thirty activity recordings are made in each LAMM. Consequently, Activity Index values of 30, 60 e 90 would represent exclusively listening, individual activity and group activity respectively.

Several observations of lecturer classes were made and they are shown in Table 1. Initial classes followed a traditional lecture format and AL activities were gradually incorporated and this is seen in the Activity Index values that were initially around 30 and tended to increase with time. It should be said that during the period under study, the LAMM itself was under development and later it was decided that an additional Participation Parameter be introduced to capture data on learner participation in the form of questions and answers during periods of class time when a more traditional lecture mode is employed. More detailed information on the use of the LAMM, currently in the process of validation using videoed classroom vignettes with a variety of observers, can be found in (Carvalho and Williams, 2009).

Overall, the lecturer’s perception of increased learner activity and engagement over the period under study is clearly reflected in the semi-quantitative data obtained from the LAMM-registered observations.

Table 1. LAMM results before (i and ii) and after (1 to 17) Active Learning activities

Observations	i	ii	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Activity Index	30	30	44	30	38	35	35	31	35	31	48	66	35	53	68	48	34	54	45
Participation Parameter	-	-	-	-	-	-	-	-	-	-	-	-	-	18.5	11.5	11.5	24	23	6.5

When attendance data, shown in Figure 2, for students enrolled in the Structural Concrete curriculum unit during 2008/09 and 2009/10 are compared with students enrolled in the previous year of 2007/08 (same lecturer) there are clear similar patterns over the semester. However there is less of a decline in the final weeks in those where AL techniques were introduced.

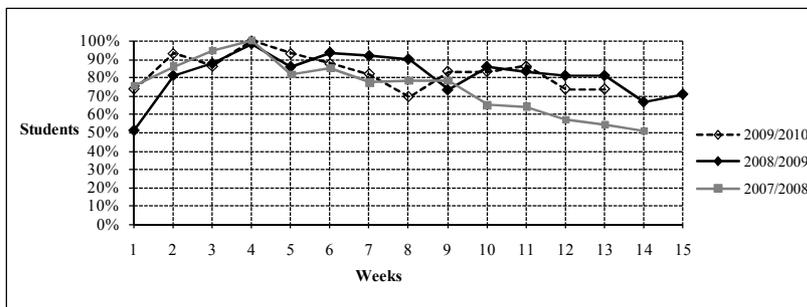


Figure 2. Semester attendance with (2008/2009 and 2009/2010) and without (2007/2008) application of Active Learning methodologies.

Although these initial results represent a relatively small population, around 75/ cohort students, it is interesting to see that they reflect findings from other studies involving Active Learning and Audience Response Systems (clickers) which reported improvements in attendance when student activity in lectures was recorded by clicker responses (although only in cases where this activity contributed to more than 5% of the final grade) (Caldwell, 2007).

### 3.2 Engagement outside the classroom

The evaluation methods for the curriculum unit are common for various lecturers and are mainly summative with a written exam predominating in determination of the final grade. It was felt that there was a need for additional practice in resolving quantitative technical calculations in a range of contexts as in exams of previous years it was noted that students often had difficulty when confronted with applications of learned procedures in less familiar contexts. Accordingly Moodle was used to provide learners with additional practice in critical analysis and allow them more flexible time management.

The Moodle survey function allows one to increase learner engagement with the material under study by introducing a peer voting process. This is essentially an online application of what Paulson refers to as Active Review Sessions (Paulson and Faust, 2007) – “In the traditional class review session the students ask questions and the instructor answers them. Students spend their time copying down answers rather than thinking about the material. In an active review session the instructor poses questions and the students work on them in groups. Then students are asked to show their solutions to the whole group and discuss any differences among solutions proposed”. The online asynchronous implementation has the additional advantage that it allows more time for learner reflection than conventional review. A three-stage procedure was applied: Stage 1: Individual Critical Analysis - students were given a problem online and had a week to post their solution. Once students post their solution they can see those of others. The solutions remain online but cannot be altered; Stage 2: Peer Selection – students are allowed 2 weeks to vote for the best solution posted; Stage 3: Completion – the lecturer comments on the winning solution and gives a model answer. A symbolic prize may be awarded to the most successful contribution.

Figures 3(a) and 3(b) show the learner participation level in the first two Stages: Individual Critical Analysis and Peer Selection. Figure 3(a) shows the level of participation from students for the different problems posted online as the semester advanced along with the class attendance levels. We note a similar participation pattern in the two cohorts. Although the majority of the students were involved in solving Problem 1, there was a gradual fall in participation along the semester.

Figure 3(b) compares the Critical Analysis and the Peer Selection stages. The voting procedure proved to be popular as for Problem 3 more students read their peer solutions than actually posted their own. The number of students logging and reading solutions was significantly higher than the number of students who completed the process by reading all the solutions and voting on the best one.

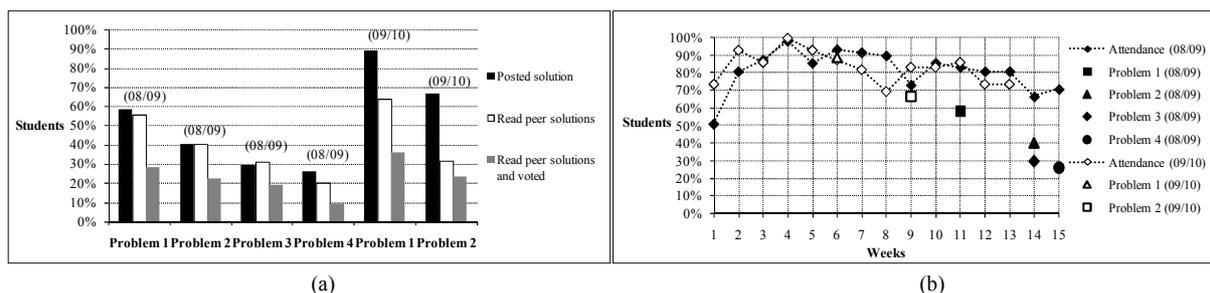


Figure 3. (a) Level of participation in Individual Critical Analysis. (b) Participation levels for Critical Analysis and Peer Selection.

The decrease of online critical analysis over time (as well as class attendance) is strongly dependent on external factors like tests and assessed assignment deadlines for other curriculum units. Problem 4 was actually voted on at the end of the semester when formal classes had already ceased. In future iterations of this approach, online critical analysis will be implemented early in the semester.

Overall, the benefit of this procedure is that it increases student engagement by encouraging them to compare their own solutions to the problems posed by the lecturer with those of their peers.

### 3.3 Pre/post test of student perceptions of in-class activity

At the end of the semester the students of Structural Concrete completed a questionnaire with a “How would you describe what happens in this class to a colleague who will be doing the subject next year?” format concerning the average amount of class time devoted to student activity when compared with time spent “just listening” to the teacher in the classes they attended. For comparison a cohort of students from the previous year were asked the same questions about what they anticipated for the curriculum unit on arriving in the third year. From the results in Figure 4(a) it can be noted that the perceptions of the students who had completed the unit tend to support the data captured in the LAMM and exceed the expectation of those in the previous year. The student’s answers concerning the time involved in individual activities and group activities allow one to estimate a corresponding value of the Activity Index (Carvalho and Williams, 2009). An average time of 18 minutes and 22 minutes were obtained for time involved in individual activities and group activities, respectively. Thus, by application of the Activity Index calculation formula, a value of 71 is obtained. This value is higher than the one obtained directly from LAMM observation data which give an average value of 50, considering the data presented in Table 1.

Incidentally, although second year students (Figure 4(b)) anticipated a more passive role in the subject it may be worth commenting that both anecdotal evidence and our initial data on lecture classes in the school would have led us to anticipate that students would expect a “theory class” to be almost 100% listening which was far from the case according to the 2nd year questionnaire results. It is not clear at this stage whether these results represent a Hawthorne Effect (Mayo, 1977) or are perhaps due to the fact that although only a minority of faculty are engaged in Active Learning teaching, it is having a larger effect on the school culture and student perception than was hitherto realized.

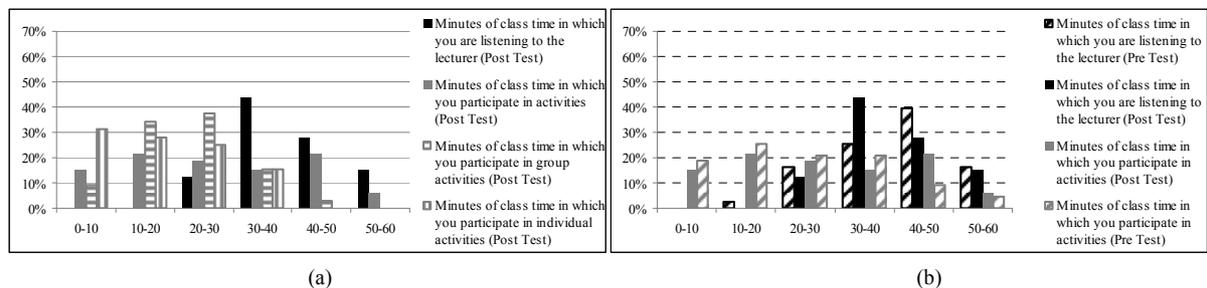


Figure 4. (a) Post-Test Results. (b) Comparison between Pre and Post Results. (Note: Results discarded due to large internal inconsistencies: Pre-Test:10%, Post-Test: 4%)

## 4 Discussion

Obtaining credible quantitative data to measure the effect of teaching innovation on student test-scores and retention rates is generally accepted to be problematic when based on small samples like we are working with (Prince 2004; Wankat et al., 2002). Accordingly, it is not our aim to attempt to demonstrate unequivocally that AL techniques are as beneficial in the Portuguese engineering education context as they have been shown to be internationally in larger studies, because the generation of valid, credible data on aspects like student grades and attrition would imply a timescale, number of participating students and scale of project we are not in a position to undertake at this stage. Although there is no published work to date demonstrating the value of these techniques within the specific context of Portuguese engineering education, given the existence of a large and credible body of research, including longitudinal and meta-studies, showing their value in engineering education in other countries, particularly in the US (Felder et al., 1998; Paulson 1999; Prince 2004;

Springer et al., 1998), we believe we can be confident of the qualitative benefits to student learning from employing these techniques in the Portuguese context to increase learner engagement.

## 5 Conclusions

The initial results presented for the use of Active Learning techniques in lecture classes of a curriculum unit in the final year of a civil engineering degree allied with the use of an online outside class learning environment (Moodle), show that this implementation brought about an increase in student engagement as measured by the LAMM semi-quantitative observation system and a pre/post questionnaire of student perceptions. Initial results also suggest that this approach may lead to increased student attendance at lecture classes.

The LAMM observation system is currently in the process of validation to establish the consistency of Activity Index and Participation Parameters determination and to what extent it can distinguish between traditional and Active Learning centred teaching. The results reported suggest that it could represent a fruitful line of development to support engineering faculty members involved in the introduction of innovative pedagogical practice within a traditional lecture-based structure.

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## References

- BONWELL, C. AND EISON, J., 1991 Active learning: Creating excitement in the classroom. *ASHE-ERIC Higher Education Report No. 1*. Washington, DC: George Washington University, p. 2.
- CALDWELL, J. E., 2007. Clickers in the large classroom: current research and best-practice tips. *American Society for Cell Biology, Life Sciences Education*, 6.
- CARVALHO, I. S. AND WILLIAMS, B., 2009. Facilitating the Adoption and Dissemination of Active Learning Methodologies in Engineering Education using a Classroom Observation Approach. In: *SEFI 37th Annual Conference, 1 – 4 July, 2009, Rotterdam, The Netherlands*.
- CHICKERING, A. AND GAMSON, Z., 1987. Seven Principles for Good Practice. *AAHE Bulletin*, 39 3-7, ED 282 491.
- FELDER R. M. AND BRENT R., 2006. *Active Learning*, Available online: [www.uwf.edu/cutla/workshops/Active%20Handout.pdf](http://www.uwf.edu/cutla/workshops/Active%20Handout.pdf), Last accessed: February 2007.
- FELDER R. AND BRENT R., 2003. Learning by Doing. *Chemical Engineering Education*, 37(4), 282 -283.
- FELDER, R. M, FELDER, G.N. AND DEITZ E. J., 1998. A Longitudinal Study of Engineering Student Performance and Retention, V. Comparisons with Traditionally-Taught Students. *J. Engineering Education*, 87(4), 469-480.
- FELDER, R. AND SILVERMAN, L. K., 1988. Learning and Teaching Styles in Eng. Educ.. *J Eng. Educ.*, 78(7), 674-681.
- JOHNSON, D. W., JOHNSON, R. T. AND SMITH, K. A., 1991. Cooperative Learning: Increasing College Faculty Instructional Productivity. *ASHE-ERIC Report on Higher Educ., Washington, D.C.: The George Washington University*.
- MAYO, E., 1977. *The Human Problems of an Industrial Civilization*, New York, Arno Press, 55 – 98.
- PAULSON, D. R., 1999. Active Learning and Cooperative Learning in the Organic Chemistry Lecture Class. *J. Chem. Educ.*, 76, 1136.
- PAULSON D. R. AND FAUST J. L. *Active Learning for the College Classroom*, Available online: [www.calstatela.edu/dept/chem/chem2/Active/](http://www.calstatela.edu/dept/chem/chem2/Active/), Last accessed: February 2007.
- PRINCE, M., 2004. Does Active Learning Work? *A Review of the Research, J. of Engineering Education*, 93 (3), 223-231.
- SPRINGER, L., STANNE, M. E. AND DONOVAN, S., 1998. Effects of cooperative learning on undergraduates in science, mathematics.
- WANKAT, P., FELDER, R., SMITH, K. AND OREOVICZ, F. S., 2002. The Scholarship of Teaching and Learning in Engineering. In: Huber M. T., Morreale, S., eds. *Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground*. Washington, DC: AAHE/Carnegie Foundation for the Advancement of Teaching, Chap. 11.