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How to Establish Successful Cooperative Student Learning Centers for STEM Courses

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Abstract

Students learn more if they are actively involved in the learning process, particularly in a cooperative manner. Several UMR faculty have operated course-based learning centers (LCs) as part of the campus-wide Learning Enhancement Across Disciplines (LEAD) Program of student learning assistance and enhancement. LCs are designed to assist large numbers of students in a cost- and time-efficient manner that promotes student engagement without requiring undue amounts of faculty time. Course instructors spend time in the open learning environment of the LC, in lieu of office hours, guiding students to master course material and skills in their evolution from novice to expert techniques. The goals are to build student self-confidence through direct interaction with role models and to develop teamwork skills. LCs can be much more attractive to students than faculty office hours or traditional tutoring because they satisfy the social elements of student learning communities. However, there are a few simple practical elements instructors should orchestrate to generate high-volume LC usage. We will discuss practical issues of establishing and operating successful learning centers for STEM (science, technology, engineering, mathematics) courses.

Introduction

Learning Centers (LCs) offer open environments for collaborative learning by students in introductory courses. Discipline-based faculty and advanced peer learning assistants guide students in the mastery of course content and expert techniques during fixed hours of operation.[1] Students who use LCs improve their ability to precisely analyze problems, gain self-confidence, and enhance their professional skills. During winter 2003, learning centers were offered for introductory courses in **physics**, **chemistry**, **statics**, **computer programming**, **computer engineering, English composition, fluid mechanics, hydraulic engineering and thermal analysis**. The basic approach has been successfully transferred to another institution.[2]

Students tend to come to a learning center because they perceive benefits in doing homework there or preparing for some imminent test on which they feel (or been made to feel) they must demonstrate competence. The instructor(s) of the associated course should employ a grading/evaluation system in the course to promote paced mastery of material and techniques. This is the means of informing students of their level of mastery and pressuring/encouraging them to take advantage of the learning assistance offered by the center.

Once a student responds to the need, pressure or desire to attend an LC, its pedagogical structure is designed to channel the student into taking greater personal responsibility for his or her learning in an atmosphere of cooperative engagement and teamwork. Learning Centers:

- Stimulate cooperative/collaborative learning among students
- Promote personal responsibility, teamwork and leadership skills in students
- Encourage faculty to interact with small working groups of students
- Increase student perception of faculty as multi-faceted role models
- Use modified Socratic methods to guide students in problem-solving
- Build student confidence as academic proficiency increases
- Communicate high expectations and high standards to students
- Reinforce the unity of knowledge and skills across disciplines

Such centers are designed to improve student learning skills and understanding of the learning process at teachable moments. LC instructors guide and surreptitiously orchestrate the spontaneously formed groups into acquisition and demonstration of appropriate insight and skills without themselves becoming part of the group. The LC style is a version of Problem Based Learning[4] on focused homework problems or tasks of immediate concern to students because they know they must soon demonstrate mastery of the material and techniques needed to solve the problems.

One psychological principle underlying the successful LC approach seems to be "self-efficacy" (or reciprocal determinism), as described by Albert Bandura.[3] Students attain self-efficacy through the structured elements in an LC that direct them into overall "desirable" behavior, e.g., understanding of concepts and principles, their application through expert techniques, and personal discipline and responsibility. Through immediate feedback about their degree of achievement provided by expert instructors on duty, students receive information and validation that has the effect of improving their own, personal feelings of "self-efficacy" – continued experiences in the course, based on real performance and achievements, self-efficacy continues to improve. This enhanced feeling of empowerment has the potential of spilling over into other aspects of one's life, and most certainly would do so with regard to similar academic courses. In other words, the particular arrangement of treatments and experiences that we provide may also be serving as a real life-changing, empowering, intervening event for many of the students involved.

The goals of the learning centers are to enhance student self-confidence and self-efficacy through actual achievement. LC instructors serve as role models and mentors for a diverse student clientele, and demonstrate faculty commitment to student development, success and well-being. They are also more able to identify students who need alternative methods of academic assistance and personal counseling.

By their very structure, learning centers are cost-efficient venues that implement and promote the *Seven Principles for Good Practice in Undergraduate Education*:[5]

1) Encourage student-faculty contact
2) Encourage cooperation among students
3) Encourage active learning
4) Give prompt, frequent, informative feedback
5) Emphasize time on task
6) Communicate high expectations
7) Respect and encompass diverse talents and learning styles

Learning centers are expected to increase student mastery of academic material and skills, improve student satisfaction and retention, develop intellectual and emotional maturity, and promote cooperation, teamwork and leadership.

Practical Aspects of Starting and Running Learning Centers

There are two major issues in the establishment of a successful learning center that is a significant percentage of students in the associated course:

I. Implementation of effective methods of "encouragement" to make students aware that they are personally responsible to demonstrate their mastery of course content and methods in imminent manageable deadlines. This might well entail a grading/evaluation system that clearly conveys the expectation levels in the course and gives strong feedback to students about their actual level of mastery on short-term time scales, buttressed by continual faculty reference to the learning center as a means of attaining mastery – if the student so chooses. Here are some suggestions:

1. If the course's textbook does not provide a template that students can follow when attacking a given class of problems or tasks, then it would be very beneficial if the faculty member constructs and posts one so that he/she can point students to it as a clear "suggested" path to success.

2. The major goals of grading are to evaluate performance as a means of measuring achievement and to act as a prod to encourage students to develop their full potential. If students are "asked" to demonstrate **frequently** their current individual mastery of knowledge, techniques, and analysis in a timely and telling/informative way, they are more likely to take heed of the benefits of attending the learning center in the crucial first few weeks of a course. Prompt feedback of achievement (at least weekly) of individual performance is generally necessary to inform and prod students. Faculty sometimes are reluctant to take class time to

ensure students receive feedback, but collected homework alone may not indicate the individual student's level of achievement.
3. It is very beneficial to reiterate often to students that they will be assigned problems that probe the depth of their understanding and mastery of technique. Give specific examples as to what students typically stumble over and remind them that there is "merit" in gaining validated mastery over these. Strongly reiterate that the LC is not just for students who are doing poorly in the course. It provides a means of honing and validating skills for all. If students choose not to attend the LC or seek expert assistance, then they are gambling that they might beat the odds but should "embrace" any consequences of that decision.

II. Establishment of an appropriate learning center environment that stresses student responsibility for learning within fluid groups, fosters camaraderie among regular attendees and reveals that the instructional staff really cares about the individual development of students within a context of firm adherence to standards and expectations. The LC style is a version of Problem Based Learning on focused compact problems or tasks of immediate concern to students because they know they must soon demonstrate mastery of the material and techniques needed to solve the problems. Don't stretch the hours of operation that there is no longer sufficient student density to form groups you can move between. There should be at least 10-15 students steady state. Here are some specific tips:

1. Learning centers are not tutoring centers. At the start of the semester, students will come in to ask for assistance and expect you to sit by them and show them how to solve problems. Resist this mightily! Use a modified Socratic method that does not overly frustrate. Don't hover; amble, walk away. This is difficult for some faculty to do.
2. Take an active role in getting students to form groups. Encourage or "volunteer" students to work together in a group. When a student or group is stuck on a problem, look for a student who has already mastered it and "ask" the validated student to help the new group.
3. At first, students will tend to stare blankly at the board or their paper trying to figure everything out. Urge/demand that they put down something definite so they have to confront ambiguities and uncertainties. Let students make mistakes and discover/debate them amongst themselves. Initially, be only semi-specific as to where you see an error or inappropriate reasoning track. Learning is a struggle.
4. Stress to students, in both the classroom and the learning center, the importance of the methodology and exposition of analysis as a very important component of their career success.
5. Continuously convey solid commitment about standards, but display friendly caring about your desire to aid them in attaining those standards.

Results

Twenty-two faculty and many associated undergraduate peer instructors staffed learning centers for foundational courses in a variety of disciplines. All learning centers operated outside normal scheduled class hours. Students either received no or very few course points for attending.

Nonetheless, data from a survey administered to students in the 12th week of class in Winter 2002 indicates all the Learning Centers were well-attended by students. Students found them highly useful for **mastering** course material. In short, the students voted with their feet and their time as to the efficaciousness of LEAD learning centers. Usage and rating data for several learning centers are summarized in the tables below:

LEAD Learning Centers, Winter 2002

Winter 2002 Department – Course with a Learning Center	# of faculty participating in lieu of office hours	# students enrolled in class	% Students completing survey	% Students who regularly attended Learning Center*	Average Hrs/Wk	Rating of usefulness for mastery (out of 4.0)
Physics 23 – Engineering Phys I	4	242	89%	60±3%	3.7	3.3
Physics 24 – Engineering Phys II	4	185	70%	32±5%	3.5	3.6
Physics 101 – College Phys I	1	20	65%	32±6%	2.6	3
Chemistry 1 – General Chem [I]	1	118	84%	31±2%	2.1	3.1
Chemistry 3 – Genl Chem [II]	1	102	Not Available	Not Available	Not Available	Not Available
Civ Eng 230 – Fluid Mechnaics	2	39	82%	65±7%	2.7	3.8
Elec Eng 153 – Circuits II	1	21	Not Available	Not Available	Not Available	Not Available
Comp Sci 153 – Data Structures I	1	150	Not Available	Not Available	Not Available	Not Available
Basic Eng 50 – Statics	7	156	35%	19±9%	2	3.3
Totals and Weighted Averages	22	1033	53%	44±4%	3.1	3.4

* At least one hour/week around 12th week of class. Plus number is usage by students completing survey on day it was administered; minus is usage based on total enrollment, conservatively assuming that ***all*** regular attendees filled out survey.

LEAD Learning Centers, Fall 2002

Winter 2002 Department – Course with a Learning Center	# of faculty participating in lieu of office hours	# students enrolled in class	% Students completing survey	% Students who regularly attended Learning Center*	Average Hrs/Wk	Rating of usefulness for mastery (out of 4.0)
Physics 23 – Engineering Phys I	4	246	82%	64±6%	4.1	3.4
Physics 24 – Engineering Phys II	4	239	67%	28±6%	3	3.8
Physics 21 – General Phys I	1	42	64%	24±5%	1.4	3.1
Chemistry 1 – General Chem I	2	143	65%	31±7%	2.2	3
Elec Eng 151 – Circuits I	1	70	24%	33±20%	1.6	3.6
Civ Eng 230 – Fluid Mechnaics	2	48	60%	55±14%	2.9	3.4
Comp Sci 53 – Intro Programming	2	107	44%	15±6%	1.5	3.5
Comp Sci 153 – Data Structures I	1	89	61%	41±10%	2.9	3.8
Basic Eng 50 – Statics	5	145	83%	25±2%	2.1	3.2
Totals and Weighted Averages	22	1205	68%	37±7%	2.7	3.4

* At least one hour/week around 12th week of class. Plus number is usage by students completing survey on day it was administered; minus is usage based on total enrollment, conservatively assuming that ***all*** regular attendees filled out survey.

For course sections in which students completed the survey questionnaire, the combined weekly usage of the learning centers was 830 student-hours/wk, associated with a faculty load of 30 faculty-hours/week in lieu of office hours. If the same usage rate prevailed in all sections, about 500 students used LEAD learning centers at a weekly rate of 1500 student-hours/wk (an average of 3 hrs/wk/student), with a faculty load of only 2.5 hrs/wk/faculty in lieu of office hours. Consequently, Learning Centers are cost efficient venues to increase student engagement and active learning while promoting the *Seven Principles of Good Practice in Undergraduate Education* – without increasing demands on faculty time.

Summary and Conclusions

- Twenty-two faculty and many associated undergraduate peer instructors directly implemented the *Seven Principles of Good Practice in Undergraduate Education* by participating in collaborative problem-based learning centers in lieu of office hours.
- Some faculty struggle initially to implement effective procedures of providing frequent, timely feedback to students about their individual level of mastery that is essential to informing students about the immediate benefit of learning centers.
- In Winter Semester 2002, approximately 450 students regularly used Learning Centers for 3 hrs/wk on average, with a cost-efficient faculty load of only ~2.5 hrs/wk for each faculty member.
- Students gave the Learning Centers an average rating of 3.4 on 4.0 scale for usefulness in mastering course material. Although the Physics Learning Center enjoyed the highest volume of student usage, the Fluid Mechanics Learning Center in Civil Engineering enjoyed the highest percentage of student usage and the highest student rating.
- Survey data indicates that students are about five times more likely to "patronize" a learning center than to go for drop-in tutoring. Anecdotal information/observations imply that students prefer learning centers because of the presence of the faculty and collaborative camaraderie with fellow students who regularly show up at the same time.

References

1. See, for example, the UMR Physics Learning Center at http://campus.umr.edu/physics/plc.
2. Bieniek, R. J. Johnson J. A., 2003, "Successful model for cooperative student learning centers in physics and astronomy" *Bull. Am. Phys Soc.*. **48(2)**, 73 (2003); http://ww.aps.org/meet/APR03/baps/abs/G610024.html.
3. Bandura, A. 1997, *Self-efficacy: The Exercise of Control* (New York: Freeman). See also URL devoted to self-efficacy: http://www.emory.edu/EDUCATION/mfp/effpage.html.
4. See site devoted to Problem Based Learning: http://www.udel.edu/pbl/others.html.
5. Chickering, A.W. & Gamson, Z.F., *Am. Assoc. Higher Ed. Bulletin*, 1987, **39**(7) 3-7. See also URL devoted to the Seven Principles: http://campus.umr.edu/lead/7principles.

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