



Hybrid Course Design in Manufacturing Courses to Improve Learning in the Classroom

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Introduction

Purdue Polytechnic Institute has recently begun embarking on an innovative journey for transforming the higher education for our students. Multiple reasons govern the need for this pedagogical shift. Current student body that the faculty members are interacting with is entirely different from the previous generations. Our students are constantly exposed to highly digitized - social and scholar - media which results in a cohort that seeks new ways of learning other than sitting in conventional classrooms. In addition, recent technological advancements have enabled information to be readily available. Thus, knowledge on its own does not provide a competitive advantage in today's world. Instead, the skills set that the students utilize while implementing knowledge to practice determines the level of future success. Furthermore, employees favor professionals who are equipped with experience in team work environments, seamless communication skills, and leadership. Consequently, traditional methodology of teaching falls short of delivering to these expectations on both ends. The scope of this study focuses on our efforts as we target higher student participation; thus a more active and engaged learning experience in our classrooms. The student success was assessed utilizing quizzes, tests as well as in class discussions. A conclusion was drawn based on the comparison of the final grades received in the past four semesters these courses were taught. Student participation in terms of volunteering to answer questions was also used as an additional feedback. A sample data set is displayed in the Results and Discussions section.

As the whole College, we have decided to transform the undergraduate learning experience in a disruptive fashion for the broadest impact. Mili and Bertoline (2014) defines eight major principles for such a transformation:

1. Students are encouraged to be autonomous. As opposed to faculty making all the decisions, students get actively involved in the learning process.
2. Learning is led by students. Faculty members serve as “mentors” who facilitate learning.
3. Students learn in an environment that is integrated; within context. Relevance is the key for involvement.
4. “Learning by doing” is essential as science and technology change at a very fast pace.
5. Learning is an individualized process as each student has unique preferences while still being enrolled in an integrated environment.
6. Networking is essential as students need to practice and master belonging to community.
7. Learning is a global activity. Boundaries within cultures and languages impede advancement.
8. Students are mentored in clearly identifying the “purpose” of learning. Problem and project based learning strengthens intrinsic motivation; thus field experience is extremely valuable

Similar to ours, multiple institutions of higher learning in the United States are realizing that the conventional means of teaching may result in a superficial and passive learning experience (Bransford et al., 2000). To combat this issue, they are actively involved in adopting novel strategies in teaching to motivate student engagement. These methodologies include “student centered teaching”, “project-based teaching”, “problem-based teaching”, and “experiential teaching”. One may quickly realize that these methods are not necessarily separate entities. On the contrary, most of the time, when an institution is engaged in pedagogical innovation, teaching is targeted to be transformed from conventional format to student-centered, problem (or project)-based; thus an experiential setting.

Armbruster et al. (2009) implemented student centered teaching pedagogy in an Introductory to Biology course for science freshmen at Georgetown University via three main elements: 1) teaching the broad conceptual themes in specific steps by reordering how the course content was presented, 2) involving case studies that enable problem-based teaching in every lecture, 3) focusing heavily on student centered environment by clearly identifying the course goals and expectations. Their three year study showed that these methods motivated students to participate more actively; thus in return increased their success in this course.

Similarly, Austin and Rust (2015) described in detail the milestones and challenges of implementing an Experiential Learning Scholars Program (EXL) at the Middle Tennessee State University. Experiential learning is arguably the most studied innovative teaching methodology in the past forty years. Though, the definition of experiential learning has changed quite some over the years, the main motivation stayed the same since was first defined by Dewey (1971): “the student learns by doing”. Therefore, if the students are immersed in an environment where they are mentored to reflect, collaborate, and assess (Qualters, 2010), learning may then become a lifelong process. According to Kolb and Kolb (2005), experiential theory allows students to approach learning as a holistic process of adapting to the world. Hence, they, not only comprehend information more effectively, but also take active roles in creating further knowledge through synergistic interactions with their environment.

One recent pedagogical approach that encompasses novel techniques of teaching is “hybrid course design”. If online courses are at one end of the spectrum while full time classroom experience is at the other end, hybrid courses are the one that incorporate both online and classroom experiences in their formats. However, “outside the classroom” teaching does not have to be merely online. A blend of multiple environments may be utilized as long as the course provides a provocative learning environment for the student and the mentor. Caulfield (2011) defines hybrid courses as

“the courses that have decreased face time and replaced it with time spent outside the traditional classroom.”

The motivation behind restructuring a course as hybrid is not limited to creating a stimulating environment but also to enable the roles of the student and the mentor to become more fluid. Traditional teaching settings as classrooms create a rigid separation between the teacher and the student which may in turn diminish the sense of learning responsibility a student should possess. Once implemented effectively, hybrid courses offer students interactive environments where they may engage with each other and their mentors during evaluating and analyzing the course principals. This is a great advantage over traditional settings where students may get accustomed to being spoon fed (Caulfield, 2011). The student centered, experiential learning style empowers participants with significant soft skills such as initiative and leadership which are being highly valued by every organization.

At Aeronautical Engineering Technology within the School of Aviation and Transportation Technology, my colleague and I are currently teaching three courses whose learning objectives are briefly summarized as below:

1. AT 205 Statics for Aero Structures
 - a. Construct free body diagram and identify forces on a body about a reference point
 - b. Utilize geometry and trigonometry for evaluating forces acting on a body
 - c. Analyze stresses and strains acting on systems and structures
 - d. Distinguish between external and internal forces
 - e. Demonstrate structural analysis on systems in equilibrium

2. AT 272 Introduction to Composite Technology
 - a. Define basic composite materials
 - b. Describe processes of composite manufacturing
 - c. Classify basic steps in composite design
 - d. Review the stages in composite manufacturing and design

3. AT 472 Advanced Composite Technology
 - a. Learn Computer Numerical Control (CNC) programming
 - b. Utilize CNC; set-up and operate composite parts manufacturing machinery.
 - c. Analyze tool and composite part design
 - d. Illustrate essential steps in part manufacturing
 - e. Revise composite repair technologies

These courses were all delivered in traditional classroom settings that demand the faculty member to be “the sage on stage”. This conventional pedagogical methodology was not sufficient in immersing students in real life situations as it heavily relied on textbooks and lectures. We have

observed that in the past five years, the student success - measured by the distribution of letter grades received - is not increasing. Moreover, our Advisory Board Committee has brought to our attention that the aerospace industry has significantly elevated expectations which extend well beyond technical skills, thanks to the fast paced growth in technology.

Our college’s current efforts in transforming undergraduate learning experience, lack of enthusiasm we were witnessing in our classrooms, and the growing demands of aerospace industry motivated my colleague and myself to restructure our courses. In 2014, we decided to implement a hybrid course pedagogy for each course.

In hybrid course design, the percentage dedicated to face to face experience as well as to the outside the classroom practice is determined by the learning outcomes. Thus, the first step we took towards course redesign was to specify these percentages for our courses. The first two courses listed above (AT 205 Statics for Aero Structures and AT 272 Introduction to Composite Technology) are sophomore level courses which are mostly focusing on the “knowledge” and “comprehension” actions of Bloom’s Taxonomy. AT 472 Advanced Composite Technology is a senior level course that is tasked with mentoring students in “application”, “analysis”, and “synthesis”. As the course level increases, the effectiveness of outside the classroom format becomes more apparent since the students already have surpassed the primary stages of learning.

Following table summarizes the structure that we established for our courses. There are two main outside the classroom settings currently being used: 1) Composites Laboratory which is equipped with real life CNC composite manufacturing machines, tools, and work benches, 2) Computer Laboratory that students utilize for design simulations in CATIA, CAD, CAM, and CAMWorks.

Table 1. Hybrid Course Design of Manufacturing Courses

	AT 205 Statics for Aerostructures	AT 272 Introduction to Composite Technology	AT 472 Advanced Composite Technology
Classroom (weekly)	50 minute lecture 2 sessions	50 minute lecture 1 session	50 minute lecture 1 session
Composites Lab (weekly)	50 min project 1 session	50 minute project 1 session biweekly*	3 hour project 1 session
Computer Lab (weekly)	2 hour CATIA 1 session	50 minute 1 session biweekly*	1 hour 1 session

*the Composites Lab and the Computer Lab sessions interchanged between weeks for 272 Introduction to Composite Technology Course.

Results and Discussion

Table 2 displays a sample data set from the four most recent semesters for the “205 Statics for Aero Structures” course offered every semester. We can see that implementing a hybrid format has favorably affected the student success as there is an increasing trend in the percentage of higher grades. Likewise (it may be statistically insignificant due to the low number of data points but still, we believe it is worth mentioning that) no students have been failing this course for the past two semesters. It is important to note here that we have not changed the format of our exams and have very cautious about keeping the level of difficulty very similar between the semesters. The grades were calculated utilizing the weekly homework and quiz points as well as the two tests given.

Table 2. Grade Distribution in AT 205 Statics for Aero Structures

Academic Semester	Number of Students	A	A%	B	B%	C	C%	D	D%	F	F%
Fall 2014	21	4	19	6	29	8	38	2	9	1	5
Spring 2015	23	8	35	8	35	6	26	0	0	1	4
Fall 2015	38	19	50	15	39	3	8	1	3	0	0
Spring 2016*	21	14	67	5	24	2	9	0	0	0	0

*this semester only displays the midterm grades as it is still ongoing

Conclusions

Since the first semester (Fall 2014) of implementing the redesigned hybrid manufacturing courses, we have observed a significant increase in the motivation our students. Compared to the previous, silent cohort of students, we have been observing an active crowd who volunteer to answer questions during in and outside classroom settings. Working in groups outside the classroom has created a much more productive environment, enabling our students to assume active roles in their learning process. Besides, their positive attitude carried over into the classroom environment, facilitating them to filter through the principals for solving a real life project. Hybrid course format is clearly a great option for the cohort of students at our college who are known to enjoy learning by doing rather than heavy theoretical upload. We should also share that hybrid format pedagogy requires meticulous attention and dedication of the faculty member. Faculty needs to be willing to spend the extra time in adapting to the new role of the “mentor”. We believe this innovative teaching technique would require more than one attempt to reach a seamless operation. For us, the next step is to collaborate with the industrial partners and assign our students industry projects that they may work in groups at the off campus locations, gaining field experience.

References

1. Armbruster, P., Patel, M., Johnson, E., and Weiss, M. (2009). Active Learning and Student –centered Pedagogy Improve Student Attitudes and Performance in Introductory Biology, *CBE-Life Sciences Education*, 8, 203-213.
2. Austin, M. J., and Rust, D. Z. (2015). Developing an Experiential Learning Program: Milestones and Challenges, *International Journal of Teaching and Learning in Higher Education*, 27(1), 143-153.
3. Bransford, J. D., Brown, A. L., and Cocking, R. R. (2000). How People Learn: Brain, Mind, Experience, and School. Committee on Developments in the Science of Learning. Washington, DC: National Academies Press.
4. Caulfield, J. (2011). How to Design and Teach a Hybrid Course: Achieving Student-centered Learning through Blended Classroom, Online and Experiential Activities. Sterling, VA: Stylus Publishing LLC.
5. Dewey, R.E. (1971). Accredited experiential education: Some definitions. *The Urban and Social Change Review*, 5(1), 10-15.
6. Kolb, A. Y., and Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning and Education*, 4(2), 193-212.
7. Mili, F. and Bertoline, G. (2014), “Purdue Polytechnic Educational Research and Development”, <https://polytechhub.org/resources/15>
8. Qualters, D. M. (2010). Making the most of learning outside the classroom. *New Directions for Teaching and Learning*, 2010(124), 95-99.