2018 ASEE Annual Conference & Exposition
June 24-27, 2018 Salt Palace Convention Center Salt Lake City, UT

Paper ID #23619

Experience Gained in Teaching in an Introductory Plastics Engineering Technology Course

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Abstract

Teaching an introductory plastics engineering technology course can be very challenging because many students, for whom this may be a required course, have the preconceived notion that they will be bombarded with "chemistry," and not many students like chemistry, particularly, organic chemistry. So, over the years I have learned that it was not wise to start an introductory plastics course with a study of plastic materials and their chemistry. Rather, I would start the course with an overview of the plastics industry and then delve into plastics processing techniques because students seemed to enjoy learning how plastics are made into useful products. Processing techniques that were covered in this course include injection molding, extrusion, blow molding, thermoforming, rotational molding, and compression molding. Right after a mid-semester exam, about nine weeks into the semester, the author would start exploring plastics materials with the students using rudimentary organic chemistry. The course was completed by examining issues dealing with managing plastics wastes and sustainability.

In recent years, the author has adopted the flipped classroom approach in delivering the course contents. This paper also examined the impact of this new teaching approach on students' learning outcomes.

Assessment of learning outcomes:
Students' learning outcomes were assessed with a survey instrument, students' exam performance, and students' course evaluations.

Introduction

While the author's academic background may not be essential to this paper, it might provide useful context to it. Hence, a brief background about the author. The author has a degree in polymer science and has worked in an integrated manufacturing plastics company. Specifically, the company made personal care products and manufactured its plastics containers and closures in-house. Following his industrial experience, the author has taught plastics and engineering materials courses at the undergraduate level at two academic institutions. This paper was based on the author's experience in teaching these classes, particularly, introductory plastics courses at two educational institutions that offered engineering technology programs.

For many academic institutions, offering a full-fledged plastics engineering technology program may not be a reasonable option, but offering a course or several courses in plastics may be a viable option given the needs of their local industries. However, for many of these academic institutions that offer bachelors' degree programs in manufacturing and mechanical engineering technology, a good understanding of engineering materials and plastics are required, and this paper may be of benefit to them and the general public. The reason for this assertion is because at these institutions organic chemistry is not a prerequisite for plastics courses. Often, students at these academic institutions have taken only a 100-level chemistry course before taking their first course in plastics. So, the challenge for an instructor of an introductory plastics course is how to make the course relevant to the students enrolled in his or her plastics course without the students having a strong background in chemistry.

A Modified Science-Led Traditional Approach

A science-led traditional approach can be described as a "bottom-up" approach that starts with the basic science of atoms, molecules, and compounds of common substances such as table salt (sodium chloride, $NaCl$). To explain how molecules and compounds are formed requires introducing the students to the concepts of chemical bonds. Namely, ionic, covalent, and metallic bonds. Specific to plastics, which is primarily the chemistry of carbon, the focus is on covalent bonding. Within this area, students are further introduced to monomers (building blocks of plastics/polymers), polymers, and polymerization. Following this step, students are then introduced to the properties of plastics and their additives. After the fundamental understanding of plastics have been covered, students are then introduced to the manufacturing processes of converting plastics resins to useful products such as beverage bottles, PVC pipes, and safety helmets.

Since the author learned about plastics through the science-led traditional approach, it was natural to have adopted this approach in his early years of teaching plastics courses. For the first couple of years (1995 - 1997), even though the author started the course with a lot of enthusiasm, it was his experience that two-four students in maximum class size of 20, chose to drop the course within the first two to three weeks of the semester, even though it was a required course. When asked why they dropped the class, these students complained that they had difficulties visualizing and understanding plastics molecules and their chemistry, and thought that the remainder of the semester was going to be similar to the first two to three weeks of the semester. To prevent future occurrences of students dropping the plastics course, the author re-arranged the sequence of presenting the course contents. So, instead of going from plastics industry overview to the basic science of plastics materials, plastics industry overview was followed by plastics processing techniques, which students seemed to like because they can identify with the workings of the processing machines via videos and hands-on labs. After the change was made, the students' drop rate was significantly reduced as the data in Table I shows. In fact, rarely do students drop the plastics course after the change was made. An example of a semester schedule for a plastics course that incorporates the change is shown in Appendix A.

The modified science-led traditional approach that was used to reduce the students drop rate in the plastics course is similar to the design-led approach used by Ashby and Johnson[1] to teach students about materials and material selection in product design. With this approach, Ashby and Johnson start the materials' selection process by first considering the required applications for the materials, before delving into the underlying science to understand why the chosen materials have properties that would make them suitable for the required applications. The authors' idea was that the desire to succeed in the project would motivate the students to delve deeper to understand the science behind the materials' properties.

Table I. The effect of changing the delivery sequence of the course contents

Year	Maximum Class Size	# Class Sections per year	Total # Students per year	# Students Dropping Class
1995 -1997	20 students	4	80	4 - 8
1997 – 2003	20 Students	4	80	0 - 2
2003 -2010*	20 Students	2	20 - 30	None

* Low students enrollment in the manufacturing engineering technology program. The program was terminated in 2014.

Active Learning

In 2015 the author was employed at a different institution, where he taught an introductory (100-level) plastics course using the modified science-led approach described in the previous section. However, at this institution faculty were encouraged to incorporate the “active learning” approach in their courses to improve students’ academic performance. Thus, starting in 2016 the author incorporated active learning into the introductory (100-level) plastics course. For some, the pertinent question could be: What do institutions consider as active learning?

In a review of the research on active learning, Prince[2] defined active learning “as any instructional method that engages students in the learning process.” He further suggested that “the core elements of active learning are student activity and engagement in the learning process.” While there are several strategies for achieving active learning in a classroom, some authors have adopted a “flipped classroom” approach to reach this goal. For example, Bishop and Verleger[3] defined the flipped classroom approach as “an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom.” In their scoping research of the flipped classroom approach, O’Flaherty and Phillips[4] remarked that "flipped classrooms take what was previously class content (teacher-led instruction) and replace it with what was previously homework (assigned activities to complete) now taking place within the class.” Based on these previous studies, the author defined active learning as course activities that promote students’ active participation in a course instead of “passively” listening to an instructor’s lectures. These course activities may include team project-based learning, in-class assignments, research, and presentations. By applying the said definition to the plastics course under consideration in this paper, students were encouraged to watch videos and take associated online quizzes with immediate feedback on relevant topics before class time. For the quizzes, students were allowed three attempts to complete them. In this manner, they could always re-visit the videos for questions they got wrong in their first or second attempts. Since the frequency of attempts for any questions was recorded on Blackboard, the instructor could easily determine the concepts or aspects of a topic that the students were having difficulties with and spend more on these concepts or aspects of a topic during class time. The scores for the quizzes counted toward the course final grade. Therefore, the students took these quizzes very seriously because it reflected on their course performance.

For team project-based learning, the students were assigned a task on materials' selection using the Prospector® Materials Database[5] or the CES EduPack[6] software. An example of a material selection activity was based on the author's experience with an industrial client that wanted a choice of plastics materials to use as a substitute for an automobile component. The criteria for selecting the appropriate materials were that the materials should: (1) be processed by injection molding, (2) have maximum continuous use temperature of 230 – 350 ºF, (3) have coefficient of linear thermal expansion (CLTE) flow of 14 x 10^{-6} – 16 x 10^{-6} in/in ºF, (4) be filled or unfilled with reinforcing additives, and (5) cost less than 500 cents per pound (lb).

Another activity that students conducted was to research and present to their classmate's information about a specific plastics material that was randomly assigned to each student. Examples of assigned materials were acetals, acrylics, acrylonitrile, acrylonitrile-butadiene-styrene (ABS), polyvinyls, polysulfones, polystyrene, polyetherimide, polycarbonates, polyamides, polyesters (thermoplastics), polyimides (thermoplastics), polypropylenes, polyetheretherketone, and epoxy. The information presented about these plastics materials include their generic names, product names (trade names), manufacturer, types of plastics: thermoplastics or thermosets, type of polymerization, cost per pound, applications, primary processing techniques, and if the plastics can be recycled. Both students and the instructor (the author) scored each presentation using a rubric provided by the instructor. The students were also requested to submit two exam questions per student based on their presentations. Some of these questions were used in the final exam for the course.

Assessment of Learning Outcomes

Three instruments were used to assess students' learning outcome for the 100-level introductory plastics course. These were a survey by the students, online university students' course evaluations, and students' exam performance.

For the online course evaluation, Table II shows that students rated the course 4.4/5.0 in 2016 and 2017, respectively while it was rated 4.3/5.0 in 2015. Despite the difference in class sizes in 2015 vis-à-vis 2016 and 2017, there was a slight increase of 2% in students' evaluation of the course after incorporating active learning into the course. Similarly, there was an increase of 7% in students' exam performance over the same period. From the author's perspective, the students' course evaluation and students' exam performance suggested good learning outcomes for students that took this course. While these metrics look good, they also show that students' learning outcomes could still be further improved.

Table II. Online course evaluations and exams average scores for 2016 and 2017

	Modified Traditional Approach	Active Learning Approach	
	2015	2016	2017
Number of students	5	13	15

Retention Rate (students completing the course)	80%	100%	100%
Average Exam Score	71.0% ± 8.5%	76.7% ± 9.5%	76.0% ± 7.7%
Online course evaluation by the students	4.3/5/0	4.4/5.0	4.4/5.0

Using the in-class survey, the author sought to identify the components of the course instructional methods that helped the students in understanding the course contents. The results of the survey are shown in Table III. The results of the survey were based on a Likert scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. The results showed that homework assignments, which was done outside of class, were the least likely to help students to understand to course content. In both years, lab activities were rated the highest among the instructional components for helping the students understand the course materials. Rated next to lab activities were in-class activities, which often involved collaboration among team members or classmates to find a solution to a problem. For the 2017 class, the next ranked component was "quizzes" while it was "videos" for the class of 2016. The take away from these results was that students preferred labs and in-class activities as vehicles to help them understand the course contents. It did seem that the new addition to the list of instructional components, namely, presentations was not well received by the students compared to other components. The author would try to determine the reasons for the comparatively low ratings of presentations by the students.

Table III. In-class survey results for 2016 and 2017. No survey was used in 2015.

	Modified Traditional Approach	**Active Learning Approach**	
Instruction Component	**2015**	**2016**	**2017**
Number of Students	5	13	15
Videos	NA	4.38±0.77	3.93±0.80
Quizzes	NA	4.23±0.60	4.13±0.83
In-class activities	NA	4.62±0.51	4.40±0.91
Lab activities	NA	4.77±0.44	4.67±0.72
Homework assignments	NA	4.08±0.76	3.33±0.90
Presentations	NA	Not used in 2016. Started in 2017	3.53±1.30

Conclusion

Results in Tables I shows that for an introductory plastics course, it was possible to reduce the dropout rate among students who dread organic chemistry or have elementary chemistry background by switching the sequence of presenting course information to students since students' retention rates were 100% in 2016 and 2017, respectively. In 2015 when the traditional approach was last used to convey course information to students, the retention rate was 80% (four out of five students completed the course). Also, there seemed to be a slight increase in students' exam performance and course evaluation after incorporating active learning into the course. However, there is still room for improvements in these metrics.

Regarding students' learning outcomes, results of the students' survey in Table III suggest that in-class and lab activities were the preferred methods for improving students understanding of the course materials. The least preferred method were homework assignments. To further strengthen the course shortly, the author would consider enhancing or increasing in-class activities while reducing or removing homework assignments altogether. Table III results show that more work was needed to develop the presentation component of the course because the author strongly believed that it was a good vehicle for learning about specific plastics materials. Also, the presentation component partially fulfills ABET Criteria 3g[7] for bachelor's degree programs in engineering technology.

References

1. Ashby, Michael, and Kara Johnson. "Materials and Design." *Plastics Engineering*, vol. 59, no. 3, 2003, pp. 83–83.
2. Prince, Michael. "Does Active Learning Work? A Review of the Research." *Journal of Engineering Education*, vol. 93, no. 3, 2004, pp. 223–231.
3. Bishop, Jacob L, and Matthew A Verleger. "The Flipped Classroom: A Survey of the Research." *120th ASEE Annual Conference & Exposition*, June 2013, pp. 23.1200.1–23.1200.18.
4. O'Flaherty, Jacqueline, and Craig Phillips. "The Use of Flipped Classrooms in Higher Education: A Scoping Review." *Interner and Higher Education*, vol. 25, 2015, pp. 85–95.
5. Prospector Materials Database, https://www2.ulprospector.com/prospector/default.asp
6. GRANTA Materials Intelligence, http://www.grantadesign.com/education/edupack/
7. ABET Criteria 3g for bachelor's degree programs in engineering technology programs. http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2018-2019/#outcomes

Appendix A: Class Schedule

Week	Topics & Reading Assignments	Homework Assignments
1	Course Information	
1	Introduction: Why Plastics? **Reading Assignment**: Chap. 1	Homework 1: Due 08/28
1	Lab 1: Introduction to Plastics Resources	Lab 1 due on 08/30
2	Injection Molding. **Reading Assignment**: Chap. 10 – pages 147-160	Homework 2: Due 09/11
2	Lab 2: Injection Molding	Lab 2 due on 09/13
3	**Labor Day (No Classes)**	
3	Lab 3: Extrusion	Lab 3 due on 09/20
4	Extrusion **Reading Assignment**: Chap 11 – pages 173-188	Homework 3: Due 09/18
4	Thermoforming Conference	No lab
5	Blow Molding. **Reading Assignment**: Chap 11 – pages 189-200	Homework 4: Due 09/25
5	Lab 4: Blow Molding	Lab 4 due on 09/27
6	Rotational Molding. Chap. 14 Thermoforming. KS: Chap. 15	Homework 5: Due 10/02
6	Lab 5: Rotational Molding	Lab 4 due on 10/04
7	Exam Review	
7	**Mid-Term Exam**	
8	Compression/Transfer Molding. **Reading Assignment**: Chap. 10 – pages 162-168	
8	Lab 6: Thermoforming	Lab 6 due on 10/18
9	Plastics Composites **Reading Assignment**: Chap 13	Homework 6: Due 10/23
9	Lab 7: Compression Molding	Lab 7 due on 10/25
10	Plastics Materials. **Reading Assignment**: Chap. 2, 8, Append E & F	Homework 7: Due 10/30
10	Lab 8: Material Selection I	Lab 8 due on 11/01
11	Plastics Materials **Reading Assignment**: Chap. 2, 8, Append E & F	Homework 8: Due 11/06
11	Lab 9: Materials Selection II	Lab 8 due on 11/08
12	Bio-Plastics/Polymers **Reading Assignment**: Chap 2 and Handout	Homework 9: Due 11/13
12	Lab 10: Materials Selection III	Lab 9 due on 11/15
13	Properties of Plastics. **Reading Assignment**: Chap 6 & Appendix D	Homework 10: Due 11/27
13	Additives of Plastics. **Reading Assignment**: Chap. 7	Project due on 11/27
14	**Thanksgiving Break**	
14	**Thanksgiving Break**	
15	Plastics Waste Management	
15	Class Project Presentations	
16	Class Project Presentations	
	Final Exams	