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Incorporating Autodesk Moldflow as a Tool for Promoting Engaged Student Learning

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Abstract

In this paper, we provide a discussion on implementation of Autodesk Moldflow^{TM} Software for enhancing and promoting teaching activities and enhancing course content offered as one of mandatory courses in Manufacturing Engineering curriculum of one of the Higher Education Institution in United States. The target audience of the course is undergraduate students at junior or senior level. In the paper, implementation of Autodesk Moldflow^{TM} as an instructional tool for promoting a dynamic interactive classroom environment and providing seamless integration of classroom activities such as traditional classroom teaching, computer simulation of manufacturing process, and actual physical laboratory experience related with the process. In that regard, Autodesk Moldflow^{TM} is used as one of the tools that would be used for promoting positive outcomes associated with the student learning. Autodesk Moldflow^{TM} is used for modeling and simulating of the plastic injection molding process. During computer simulation laboratories, specific examples of Autodesk Moldflow^{TM} is introduced for providing ideas to students on how the manufacturing process would be improved by employing the tools based on computer simulation of associated process. In that regard, corresponding examples on discovering potential manufacturing problems that might arise are introduced. Role of software for providing visual aid for understanding filling, packing, and cooling stages of the manufacturing process is emphasized. In order for promoting active learning experience, and providing association between classroom teaching, physical laboratory demonstration, and computer simulation of plastic injection molding process, required references are made. Feedback obtained from the oral communication and Student Evaluation of Instruction Report indicate that suggested approach help achieving learning outcomes and promote a classroom environment conducive to engaged student learning.

Introduction

Providing a classroom atmosphere that supports engaged student learning is an important consideration in the higher education. In this paper, we outline how the Autodesk Moldflow^{TM} can be incorporated as one of the educational tool for a junior level introductory level course for the manufacturing engineering. The instructor has been teaching this course for several years, and is interested in developing an integrated approach in which various educational tools might be incorporated to support the theoretical and hands-on aspects for the engaged student learning.

In this paper, we would be discussing how the Autodesk Moldflow^{TM} might be integrated as a learning tool for building a platform for effective and efficient teaching of a course material with educational value. We provide a framework for developing an integrated approach for promoting an engaged classroom teaching. For this purpose, a triad of the approaches that might help reaching this educational goal has been implemented. Those consist of the traditional classroom teaching, the hands-on experience for plastic injection molding and incorporating Autodesk Moldflow^{TM} software for simulating the plastic injection molding process. Moldflow^{TM} in that regard can be used for the improving plastic part design, injection mold design and simulation of the plastic injection molding process [1]. The Moldflow Company has been founded in 1978 in Melbourne, Australia, and has been acquired by the Autodesk in 2008 for 297 million USD [2]. Autodesk Moldflow^{TM} consists of two core modules. The first module is the Moldflow Adviser^{TM}, where the module provides the manufacturability guidance and directional feedback [3]. The second module is the Moldflow Insight^{TM} which can focus on more technical aspects such as warpage analysis, cooling, insert overflow, heating elements, two-shot sequential overmolding and flow analysis. The version that we use in this study is the Autodesk Moldflow Adviser Ultimate^{TM} 2016 which has been obtained from Autodesk under Educational License [5].

The organization of the chapter is as follows. In the next section, we discuss the literature that focuses on developing integrated approach which combine various elements such as physical hands-on laboratory sessions, traditional classroom teaching, and use of the software for promoting engaged student learning. In the third section, we provide the background and discuss about the classroom setting. In the fourth section and fifth section we will provide more information on the actual physical hands-on laboratory sessions and Autodesk Moldflow^{TM} respectively. In the sixth section, we discuss the feedback obtained from the students and discuss ABET related outcomes. In the seventh session we provide further discussion on the significance of the approach for promoting active learning environment. In the last section, we point out our conclusions on our findings. Moreover, we outline future research directions that might help other researchers pursuing research on developing suggested approach.

Literature Review

Various authors have conducted the research for enhancing the classroom environment for engaged student learning by combining various tools such as hands-on laboratory sessions which features actual physical experiments, incorporating various software for supporting teaching activities and the traditional classroom teaching. In that vein, Feisel and Rosa discuss the main aspects on how the laboratory teaching might be used for promoting an enhanced learning atmosphere and facilitate classroom teaching. The authors argue that the recent technological advances change the role of the laboratory sessions. The authors point out that current engineering laboratory sessions should be modified and improved based on the distance education and the new opportunities arise due to incorporating computers in the laboratory sessions for simulating various processes. In that regard, authors point out that setting laboratory sessions which have computer simulations might be used for providing the students a pre-laboratory experience to provide ideas about what to expect in the actual laboratory sessions, drawing a comparison of the students’ performance, and simulating experimental studies of systems that are too large, expensive, or dangerous to perform physical experiments [6-11]. Authors indicate that the lack of objectives in the instructional laboratories necessitate ABET committees to define the fundamental objectives of Engineering Instructional Laboratories [6].

Shin et al. developed a methodology for implementing web based, interactive virtual laboratory system for unit operations and process systems engineering education for the Chemical Engineering and validate the effectiveness of the approach by surveying the students [12]. Authors argue that web based interactive virtual laboratory might be used for replacing the traditional costly laboratory sessions on unit operations with increased educational effectiveness. Authors also point out that simulated laboratory sessions also help increasing students' adaptability to working in real process plants after graduation. In a similar vein, Rocha et al. develop a simulated laboratory session for determination of the correlation between oxygen transfer rates, aeration rate and agitation power in a reactor, whereas other virtual lab consists on the determination of the residence time distribution (RTD) in continuous stirred tanks series for bio (chemical) engineering education. The difference between these laboratory sessions is that the former replaces the physical laboratory, whereas the latter is implemented to support the physical experiments rather than replacing it. Authors indicate that an assessment of the virtual laboratories is conducted using questionnaires in form of surveys and on the average, 93% of the students consider virtual labs of great utility [13].

The approach taken in this study is rather than replacing the physical laboratory by the virtual laboratory, as in the case of the determination of the residence time distribution in continuous stirred thanks, developing a methodology for integrating them. These two laboratory sessions support each other to provide a holistic perspective to students which enables them to understand various aspects of the manufacturing process under consideration (i.e., plastic injection molding).

The educational value of integrating physical hands-on laboratories with the virtual ones has been also examined by Abdulwahed and Nagy [14]. In their paper, using Kolb's experiential learning cycle, the authors have developed a model for integration of the virtual, hands-on and the remote laboratory sessions for building a constructivist learning approach for chemical engineering education. Authors indicate significant success is obtained on experimental group of students as compared to the control group. The authors also suggest that additional activities, such as pre and post laboratory tests contribute to the learning process through constructivist learning.

There has been some studies on developing alternatives and complementary approaches for replacing and supporting the actual hands on physical laboratory sessions for Manufacturing Engineering. In that vein, Saygin and Kahraman provide a generic model for the accessing programmable logic controllers for the automated manufacturing systems using the web based architecture. This approach has been cited as an educational aid for supporting hand-on laboratory exercises for manufacturing systems. The authors indicate that the proposed architecture might be used for teaching automated manufacturing systems for distance education. The authors also indicate that the web based access to the actual laboratory sessions would provide several advantages such as increased utilization of similar devices because it can be accessed by different group of students and educators being in different geographical location. Thus, it enables forming the pools for the costly devices, thus leading to effective use. This in turn reduce the need for investing in those devices which are not used very often. In addition, those virtual labs provide a means for actually simulating the system before running those systems, thereby reducing the possibility of the damage to the equipment. Authors also point out that the remote access might provide non-educational uses such as remote access might provide opportunities for remote monitoring, controlling, and diagnosing manufacturing systems located at different geographical locations [15].

De Jong et al. indicate challenges associated with the integrating the virtual and hands-on laboratories. According to the authors, three challenges are presented as follows [16];

- Creating online environments that use stored data to guide them for virtual experiments
- Determining ideal balance between the virtual and physical investigations for courses in different areas
- Determining and understanding the skillset and applying the corresponding strategies for implementing a curriculum that combine elements of physical and virtual laboratory sessions that need to be revised for conducting existing courses.

Erdem and Sirinterlikci develop an integrated methodology for combining hands-on physical laboratories, the computer laboratories featuring simulation of the die casting process using CastView^{TM} software, and traditional classroom teaching. Author indicate that forming an integrated approach and covering specified manufacturing process from different perspectives actually provide additional venues for the students for understanding subject matter. Moreover, the student feedback based on the Student Instructional Report II (i.e., SIR II^{TM}) indicate that the students feel quite satisfied. As such, positive student reaction varies between 40 – 80% throughout the survey. According to the student feedback, 80% of the students indicate that the course promotes active learning and independent thinking skills, and they make progress towards course objectives [17].

While acknowledging the previous work, in this study, we embark an integrated approach that feature using the Autodesk Moldflow^{TM} for the one of the processes that has been introduced in the traditional classroom sessions. The approach taken by Erdem and Sirinterlikci has been expanded to incorporate the plastic injection molding as well as casting process. To the best of author's knowledge, few studies that conduct similar approaches in Manufacturing Engineering Education has been undertaken. By conducting such a study, it is possible to develop the generalized framework for bringing an integrated approach for increasing the educational effectiveness and value of the introductory manufacturing engineering course offered in the Manufacturing Engineering department. By doing so, overall fabric based on the previous teaching experience and individual integration attempts on various manufacturing processes can be generalized. Additionally, lessons learned from those type of approaches might be expanded for other courses offered in the Manufacturing Engineering department and other engineering disciplines.

Background

The introductory course in Manufacturing Engineering is usually offered in Fall semesters. Primary objectives of the course are providing the students basic knowledge of the fundamental manufacturing processes, associated tooling and the manufacturing materials, and introducing the metrology, quality, cost, and safety aspects. The author have been teaching this course since Fall 2014 semester. The length of the course is 16 weeks excluding the finals week. There are primarily three aspects of the course, the traditional classroom sessions, the hands-on physical laboratory sessions and the simulated laboratory sessions. In Fall 2014, the CastView™ software is incorporated for simulating the die casting process. Starting with the Fall 2016 semester, Autodesk Moldflow™ is adapted. Various manufacturing processes, such as casting, welding, finishing processes, plastic injection molding, powder metallurgy processes, and sheet and bulk metal forming processes are introduced in the context of the course. Figure 1 provides the basic information related with the course whereas Table 1 indicates laboratory sessions incorporated within the course.

Robert Morris University
ENGR3600
Production Engineering

Course Description:

This course presents the techniques of production engineering, and fundamental manufacturing process concepts, at an introductory level. Methods of production are introduced, and productivity improvement methods are explored with an emphasis on quality, efficiency, and product cost. Basic manufacturing metrology principles are also introduced. Credits: 2 lecture, 1 lab Course

Course Objectives:

After completing this course, the student will be able to:

1. Demonstrate competency of manufacturing processes used in making of consumer products and machine elements
2. Understand the concepts of productivity, metrology, quality, costing, and safety as they relate to manufacturing processes
3. Demonstrate competency in associated tooling and manufacturing materials
4. Understand the history, current status, and future of manufacturing processes and systems

Figure 1. Core syllabus information

Table 1. List of physical hands-on and computer simulation laboratories

Laboratory Session 1	Sand Casting Laboratory
Laboratory Session 2	CastView^{TM} Computer Laboratory
Laboratory Session 3	AutoDesk Moldflow^{TM} Computer Laboratory
Laboratory Session 4	Powder Metallurgy Laboratory
Laboratory Session 5	Metal Cutting-Machining laboratory
Laboratory Session 6	Welding Laboratory
Laboratory Session 7	Plasma Cutting Laboratory

As it can be inferred from Table, 1, the laboratory sessions 2 and 3 are virtual laboratory sessions which features simulation of the die casting and plastic injection molding processes.

Physical Hands-on Laboratory Sessions:

Physical hands on experience has been conducted in the Learning Factory section of the Engineering Laboratories. The laboratory sections are divided into small groups each of which consists of 6 students. The small group size facilitate interaction with the students and ensures active participation of student.

Before starting laboratory sessions, the plastic injection molding process is revisited. In that regard, brief explanation is provided. The major parts of the injection molding machine (i.e., injection and clamping units) has been introduced and steps of the process is revisited (i.e., clamping, injection, dwelling, cooling, mold opening and ejection). As well as those steps, approximate locations of feed zone, compression zone, and metering zone are shown on the injection molding machine. The hydraulic system and screws are also introduced as well as stationary and movable platen. The role of the valves is explained, and effect of forward, back, and net pressures are reemphasized. The parameters affecting those process characteristics are recapped.

The laboratory session starts with introducing molding machine to the students. The pictures of injection molding machine, molds, and bucket of raw material are provided in Figures 2, 3, and 4 respectively.

Figure 2. Plastic injection molding machine

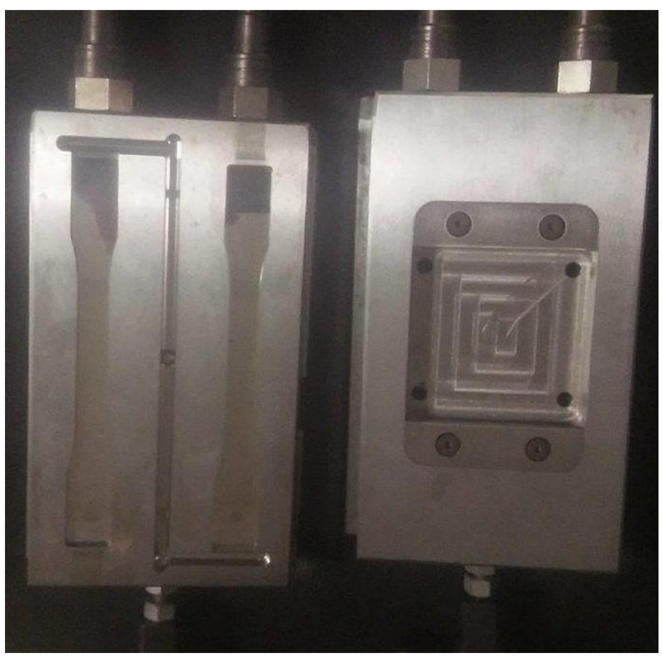
Figure 3. Molds

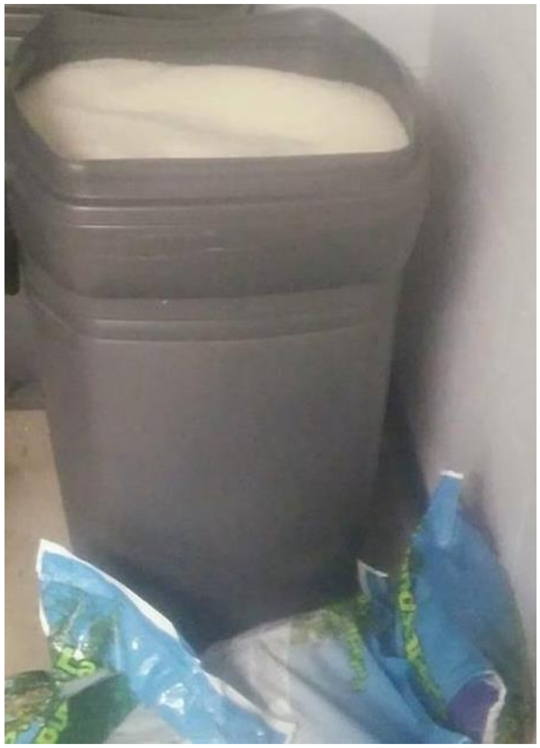
Figure 4. Bucket of plastic pellets

After revisiting those concepts previously covered in the traditional classroom sessions, the operation cycle of the machine is introduced. The role of each button on the control panel is discussed. The machine can be run in three different modes. These are; manual mode, semi-automatic mode, and continuous mode. In manual mode, by following the right sequence you can manufacture one part at a time, whereas the semi-automatic mode allows manufacturing one part without any operator intervention and the continuous mode allows manufacturing the parts until the raw material runs out automatically.

After introducing those modes, by using manual mode, a single part is produced. This process is repeated for couple of times for familiarizing the students with the process, and the students are asked to perform the steps in the manual mode. In each stage, the actual process steps that are discussed in the classroom are revisited. After completing the cycle, the manufactured parts are examined in terms of the defects such as flow lines, sink marks, vacuum voids, burn marks, warping, etc. The probable causes for those defects are also highlighted. In addition to that, parting line, sprues, gates are shown on the product. Along with those aspects, the safety precautions that need to be taken are also emphasized, and role of the engineering and administrative controls, along with necessary personal protective equipment for the manufacturing operation are discussed. The picture of the final product is provided in Figure 5.

Figure 5. Finished product with runners and gates

The Computer Simulation Software Autodesk Moldflow™

Autodesk Moldflow Adviser Ultimate™ 2016 is the software used for visualizing and simulating the plastic injection molding process. It has been used for visualizing plastic injection molding process. For this purpose, manufacturing cell phone cover is being simulated following based on a tutorial. In that regard, modules for selecting the best location for the gates and as well as the fill and pack analysis are introduced. The emphasis on selecting the materials for the optimum results with respect to the part that is being produced are discussed. The effect of the exclusion of the potential gate locations are discussed, and discussion is provided on the heat chart that provides the best locations for the gate.

Moreover, the result window that has been obtained after the fill and pack analysis is introduced. Various parameters such as the fill time, confidence of fill, plastic flow, quality prediction, injection pressure, pressure drop, temperature at flow point, orientation of skin, potential location of air traps, average temperature at ejection, time to reach at ejection temperature, and volumetric shrinkage, are discussed, and their relation with product quality are explored. The probable defects that might occur due to the poor process parameter selection and the gate location are discussed in that context. Additionally, the effect on the process and product parameters from manufacturability and the productivity perspectives are also introduced. Figures 6-8 present screenshots associated with the simulating the injection molding of the front cover of the cell phones.

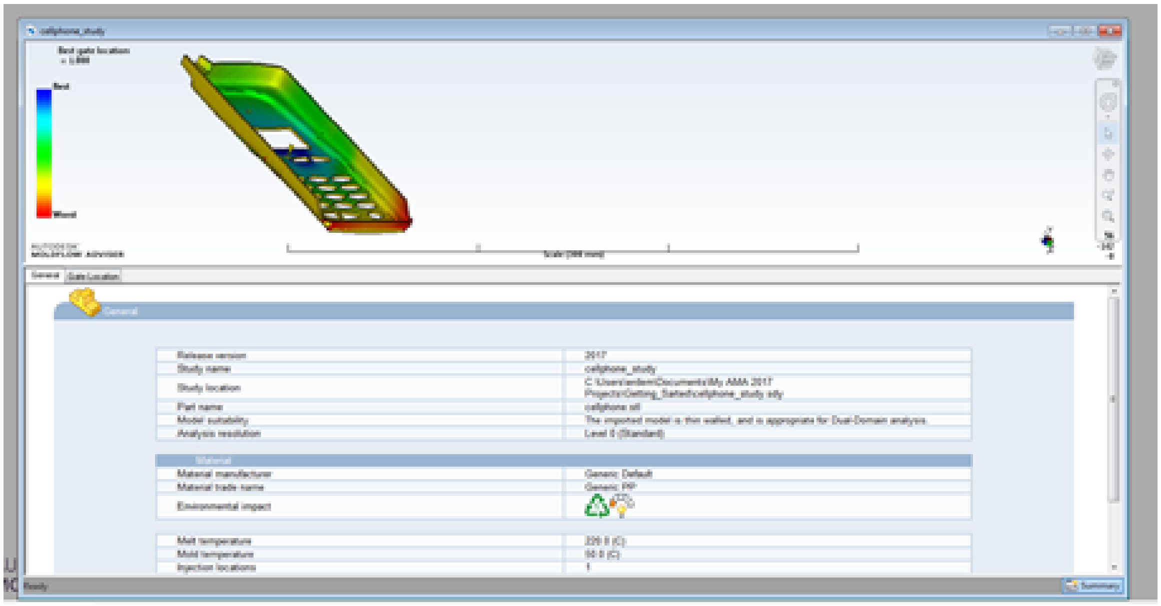

Figure 6. Heat map depicting best location of the injection for cover of cell phone

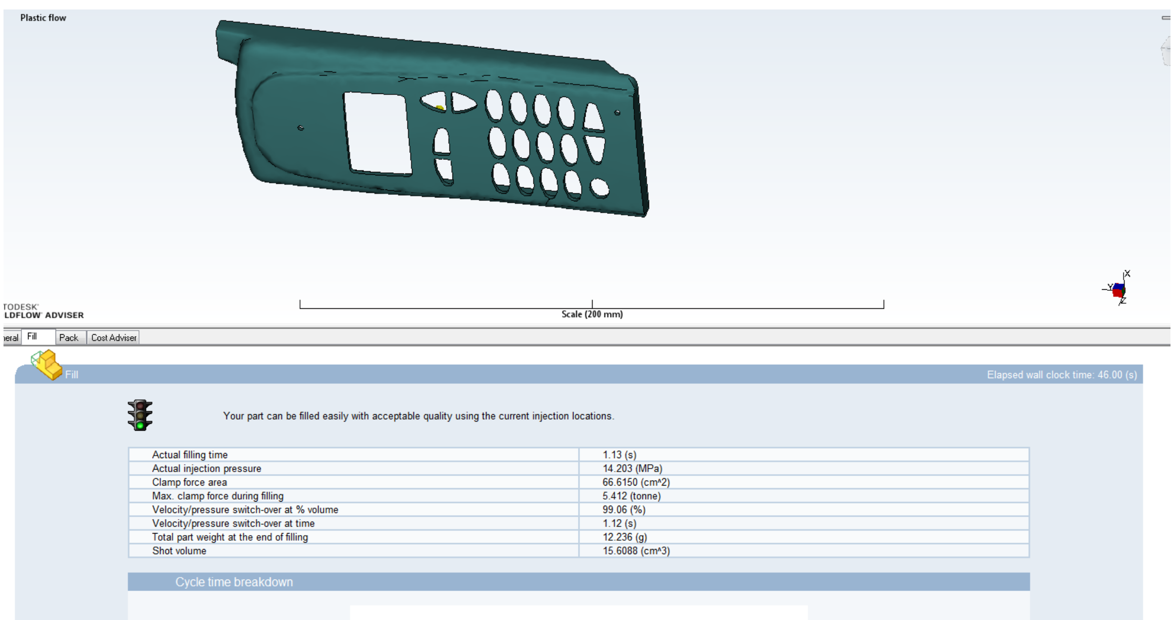

Figure 7. Parameters associated with filling stage

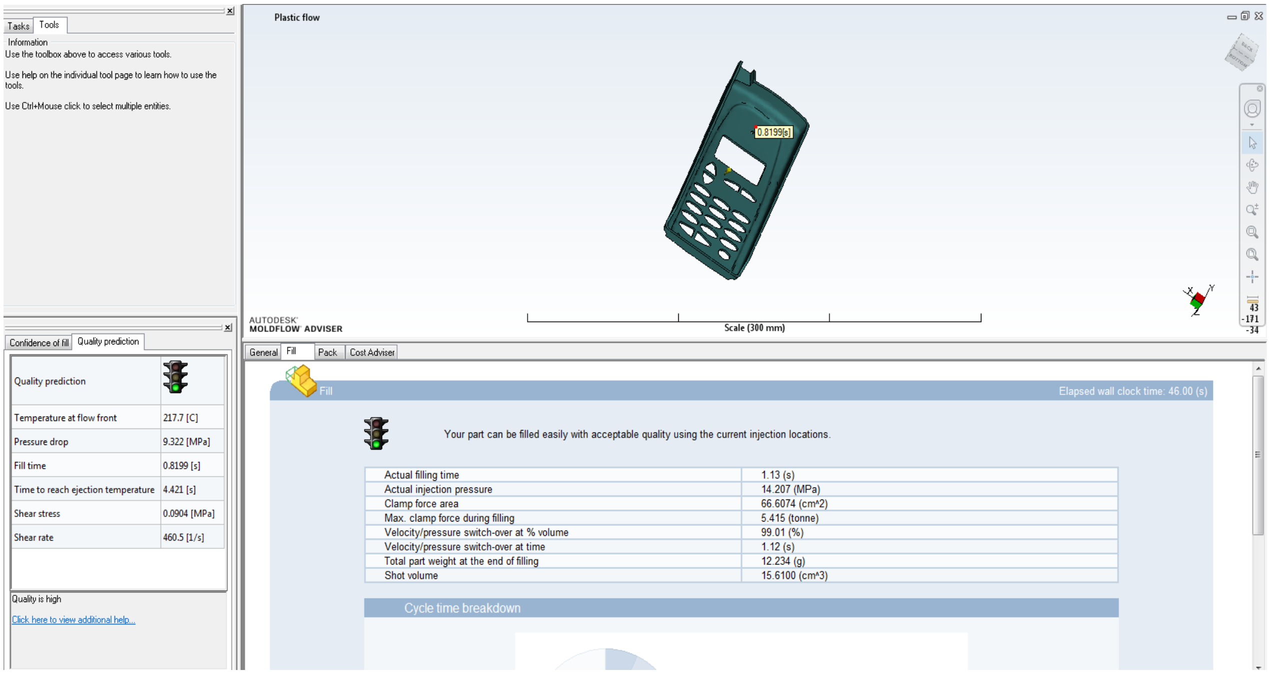

Figure 8. Filling time and various process parameters

Integration of Physical Laboratory Experiments, Classroom Instruction, and Simulation Software

As previously mentioned, a three-tiered approach has been adapted in which the traditional classroom teaching, simulated laboratory sessions and hands on physical experiments are incorporated to build an overall frame for the engaged learning activities. Special attention is paid for involving students at every stage. To cite an instance, an interactive classroom teaching environment is established as much as possible during the classroom teachings. In that regard the students are directed questions regarding various aspects of the manufacturing process. This not only provide an opportunity for obtaining instant feedback on the understanding of the students of the subject matter, but it also increase the students' interest in the subject matter by providing open discussion environment that the students are encouraged to ask questions and provide their thoughts on the factors that might affect the final product characteristics. To cite an instance, the effects of the geometric properties of the injection unit, the reciprocating screws, and mold characteristics on the quality of the final part are discussed. Cost related issues are outlined, and common product defects are highlighted. This approach in turn supports the main course objective of understanding the concepts of metrology, productivity, cost, and quality aspects of the manufacturing process. For supporting the teaching activities, the students are assigned homework, and divided into groups. They are asked to solve the assigned questions on the board following week, and a friendly atmosphere which facilitate discussion on the assigned problems is created. This approach also promotes active engaged learning activities.

Before the actual physical hands-on experiment, the computer laboratory session featuring Autodesk Moldflow^{TM} is conducted. Based on the selected characteristics of the mold geometry, and product parameters, the process is simulated and corresponding actual fill and pack process is introduced to the students. The students is assigned a homework regarding the replicating the simulation of the plastic injection molding process and additional questions has been directed based on mainly quality, manufacturability, and the productivity perspective. The main reason behind directing open ended questions is leading the student to develop a methodology for reasoning regarding the various product and process characteristics and quality and cost aspects of the final products. After homework are graded, a detailed explanation which cover answers of are provided in the class, and the graded homework are returned to students. The students might choose to improve their answers to the homework questions and additional points are granted if the student choose to do so. Based on the instructor's observation, those type of approach provide a classroom environment that is conducive to the student's participation and engaged learning.

The third leg of the integrated approach is the physical hands-on laboratory sessions. This stage actually wraps up and contributes to the prior learning experience. Based on the previous classroom teaching and computer simulation of the plastic injection molding process, the students are better prepared for grasping the experience provided by the physical hands on experiment. Moreover, in this stage, they can verify and validate their current understanding of the manufacturing process. As in the case of the previous stages, an open discussion atmosphere that is conducive to the active engaged learning process is promoted. The importance of safety precautions that should be taken is emphasized as well. The laboratory handout regarding the laboratory experiment is provided to the students. Additionally, in the midterm and final exams, questions regarding the computer laboratory sessions and actual physical hands-on laboratory experiments are directed.

Figure 9 provides the framework for developing an integrated approach that combine three facets of the teaching tools.

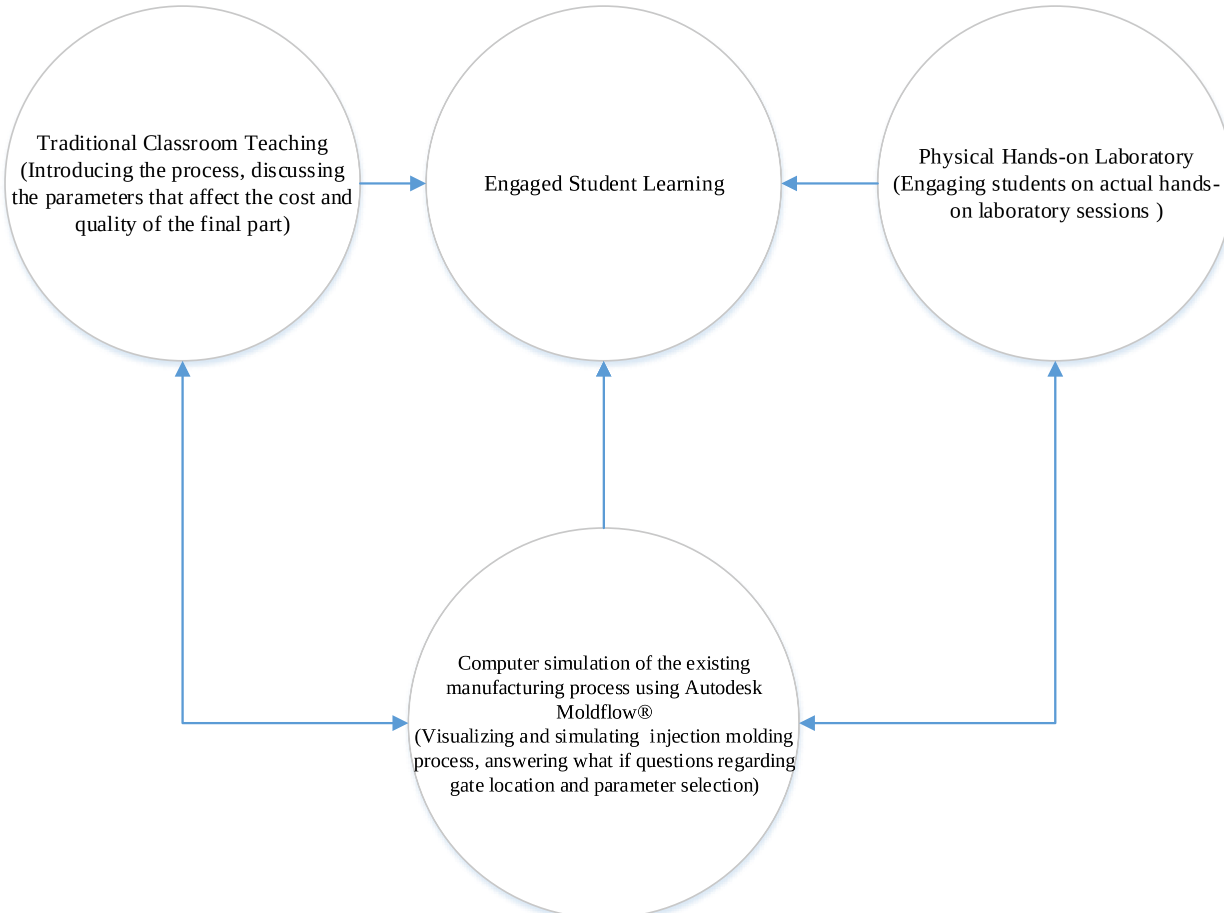

Figure 9. Three faceted approach for engaged student learning

ABET Student Outcomes and Analysis of Student Evaluation of Instruction Reports

The course is offered to junior students in two different section for Fall 2016 semester. The student count in the first section is 30 students, and the second session consist of 49 students. There were two sessions per section in a given week each of which last 1 hour 50 minutes.

In line with ABET specifications, following student outcomes are identified with this Engineering Course.

- **Student outcome M2:** Manufacturing Engineering Graduates have proficiency in process, assembly and product engineering and understand the design of products and the equipment, tooling, and environment necessary for their manufacture.
- **Student outcome M3:** Manufacturing Graduates have an ability to design manufacturing systems through the analysis, synthesis and control of manufacturing operations using statistical or calculus based methods, simulation and information technology

The assessment of the course based on the homework, midterm and final examinations indicate that 73% of the students have obtained 80% (B- letter grade) or more in assessment of the related work on the outcome M2. Similarly, when evaluated based on the student outcome M3, results indicate that 71% of the students have exceeded the level of 80% (B- letter grade). For grading laboratory work, primary points that are taken into consideration is the actual participation of the student in the classroom discussions. As previously mentioned, homework is assigned and questions related with the simulated computer and actual physical hands-on laboratory sessions are directed in midterm and final exam to assess the student's understanding of topics covered in the laboratory sessions.

Based on the feedback obtained by personal communication from the students, they indicate that they are in better position to assess themselves with respect to their level of knowledge on the subject matter after receiving the grades and they can benefit on the additional discussion that has been provided based on the fact that it provide an opportunity to them for improving their standing.

Additionally, student evaluation of Instruction Reports are being analyzed to assess the impact of the teaching methodology that has been employed throughout the semester. Please note that the University adapt a new approach for obtaining student evaluation feedback that has been test piloted in Spring 2016 and has been implemented campus wide in Fall 2016 semester. In overall, students are asked to evaluate the 13 statements, and rate it according to the Likert Scale where 1 indicates "Strongly Disagree", and 5 indicates "Strongly Agree". According to this scale, the results are obtained and compiled. For the first section, out of 30 students enrolled in the course, 26 students returned the survey and for the second section, the number of returned surveys is 31 out of 49 students. The statements that might be of interest are:

- The instructor encouraged me to think more about the subject.
- The instructor created an atmosphere that made learning easier.
- The instructor explained course material using more than one approach
- Assignments or projects helped me learn the material.

Table 2 provides the percentage of students out of these two sections who indicate that they "Strongly Agree", "Agree", "Uncertain", "Disagree", and "Strongly Disagree" for each statement listed above. The last column indicates the percentage of students who oit the question or respond "Not Applicable".

Table 2. Student evaluations of instruction report based on selected items (out of 2 sections and 57 responding students)

Statement/Evaluation (%)	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree	Omitted or Not Applicable
The instructor encouraged me to think more about the subject.	57.89%	21.05%	15.79%	1.75%	3.51%	0%
The instructor created an atmosphere that made learning easier.	52.63%	22.81%	15.79%	3.51%	1.75%	0%
The instructor explained course material using more than one approach	52.63%	28.07%	7.02%	3.51%	5.26%	0%
Assignments or projects helped me learn the material.	49.12%	31.58%	10.53%	0%	3.51%	1.75%

Examining Table 2, we see that across the statements the response rate percentages are pretty much consistent. Moreover for all the items, the percentage of the students who indicate "Strongly Agree" or "Agree" to the four statements described above constitutes more than 75% of all the respondents, even exceeding 80% mark for the statement " The instructor explained course material using more than one approach" and "Assignments or projects helped me learn the material". Additionally the percentage of the students who "Disagree" or "Strongly Disagree" to the statements above is below the 10% mark, varying approximately between 3% and 9% depending on the statement. These results indicate that the students are pretty satisfied with the approach taken during the class and indicate positive feedback. However, there is room for improvement, and student satisfaction with the course material might be further improved with more efficient teaching strategies.

Further Discussion

The approach taken in this classroom also supports the Kolb's experiential learning cycle, According to this model, the learning process requires individuals to detect, grasp, and depict their knowledge. The traditional classroom teaching is the first stage where detection, grasping, and depicting the knowledge take place. After this phase, a construction phase would be needed. The computer simulation of the manufacturing process and actual hands-on physical experiment actually fulfill this purpose. During this stage, the grasped knowledge is transformed into the mental model, and the author believe that virtual and physical laboratory sessions are strong educational tools for facilitating this transformation. Moreover, those laboratory sessions also help completing the optimal learning path consisting of Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation [14]. To cite an instance, providing the students second chance to improve their grades might set an example for reflective observation, where the student might observe himself/herself based on already received grade, and reflects and improves their standing by actually improving the answers based on the final discussion. It has been indicated that this scheme is supported by the students, and most probably lead them to the active learning process, because they know that even though they might commit some mistakes and might have lack of understanding of the subject matter, they have the second chance provided that they participate in the educational activities. Another point worth mentioning is that while building the laboratory sessions, the ABET guidelines for laboratory are taken into the consideration. To cite an instance, one of the ABET requirements state that the laboratory sessions should encompass safety component which recognize health, safety, and environmental issues related to process and activities [15]. During the classroom discussions and laboratory session, the environmental impact of the manufacturing process is acknowledged, and during physical laboratory sessions, the safety precautions that need to be taken are outlined. Another example might be the communication aspect. According to the ABET guidelines communication involves relaying information about laboratory works effectively, both orally and in writing, at levels ranging from executive summaries to comprehensive technical reports. This has been incorporated into course curriculum in the form of the assigned homework and discussion conducted during laboratory sessions [15].

Conclusion and Future Work

In this paper, we discuss multi-faceted approach for promoting active student learning on the introductory level manufacturing engineering course. The author focus on the plastic injection molding process and develop an integrated approach in which the traditional classroom sessions, hands-on physical laboratory sessions and computer laboratory sessions featuring the process are combined. Those sessions are conducted in sequence, and in each step, a summary regarding the previous sessions are provided, and this educational activity is supported by laboratory handouts. Additionally, homework is assigned for evaluating student's knowledge and understanding of the subject matter. Moreover, student is given an opportunity for improving his/her grade on assignment. It has been indicated that this type of teaching practice actually increase students' involvement and interest in the subject matter. Students, knowing that they have the second chance, actually pay more attention for the final discussion. In overall, students indicate positive response (i.e., over 75%) to the statements that are related with the proposed teaching methodology.

A potential future research direction might be expanding this research for manufacturing process for bulk metal forming. For this purpose, DEFORM-3D™ software might be used. DEFORM™ software has different modules and might also be used for simulating heat treatment and machining processes. Those manufacturing processes might be gradually introduced in the existing curriculum of the course.

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Appendix 1 Homework on Simulation of the Plastic Injection using Autodesk Moldflow™

ROBERT MORRIS UNIVERSITY

SCHOOL OF SCIENCE, MATHEMATICS & ENGINEERING

DEPARTMENT OF ENGINEERING

ENGR3600

PRODUCTION ENGINEERING

Homework 2

Assigned: October 20, 2016

Due: November 4, 2016

Please show all your work and provide screenshots wherever necessary

In this homework, we will use Autodesk Moldflow™ to conduct analysis for finding out the injection location and perform fill and pack analysis. Please find the adapter.stl file that has been located in the Announcement section on the Blackboard. Download it and using the analysis conducted by Autodesk Moldflow™, please answer the following questions

1. What is the difference between "Dual Domain Analysis Technology and the "3D Analysis Technology" in terms of the part geometry?
2. Using the advanced Gate Location Algorithm and specifying the number of gates as 1, and selecting the material being the generic polypropylene, find the suitable Gate location. Indicate the prohibited gate locations by specifying tolerance angle if you feel it is necessary. Provide a screenshot at this stage. Why might we need to specify the prohibited gate locations? Please provide an explanation as per class classroom discussion.
    a. Indicate the regions with the best gate suitability and minimum flow resistance? Specify the coordinates of the best gate location. Provide a screenshot if necessary.
    b. What is the significance of this information?
3. Designate the gate location as the most suitable location indicated by software. Please provide a screenshot.
4. Using the results obtained from the previous step, conduct fill and pack analysis. Indicate whether the part can be filled with acceptable quality by using the current injection location. What would happen if the location of injection is changed? What kind of defects can you envisage if the fill cannot be performed with acceptable quality?
5. Based on the fill and pack analysis, provide the information on
    a. Maximum clamp force during cycle
    b. Cycle time
    c. Fill time
    d. Regions marked with different confidence of fill
    e. Time to reach ejection temperature.
    f. Location of air traps and weld lines.
6. Discuss the importance of items that are listed on question 5 from quality, manufacturability, and productivity perspective.