

# **Molten Metal Magic: A Laboratory Experience for Middle School and High School Students**

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## **Abstract**

Studies have been done to relate the entry of high school students into colleges they have visited or are familiar with by more than simply name association. Encouraged by these studies and partly based on this principle, the Purdue School of Engineering and Technology at Indiana University Purdue University Indianapolis, (IUPUI) has developed a recruitment program for high school and middle school students. The Friday Laboratory Experience program serves as an organized means of getting students to visit the university, learn about various engineering and technology programs available in the school, and participate in activities similar to what they would be doing as a college student.

The Molten Metal Magic session of the Friday Laboratory Experience program at IUPUI is one of 17 sessions designed to introduce various engineering and technology programs to middle school and high school students as well as serve as a recruitment tool for the Purdue School of Engineering and Technology at IUPUI. Students and educators visit IUPUI for the Friday Laboratory Experience, many completely unaware of metal casting processes, their significance in the manufacturing industry, and the vast quantity of products and applications used daily as a direct result of these processes.

After participating in the experience, students have visited an actual university campus, met and interacted with university faculty and students, gained a new perspective on the various engineering and technology fields, and developed an appreciation for the complexity of the products available to them for their daily use. Though many schools openly admit to utilizing the Friday Laboratory Experience program simply as a field trip, most participants come away with new knowledge and materials that they will use in their classrooms and the experience affects the way they look at the world around them.

## **Background**

During the past three years, several middle school and high school groups have come to the Purdue School of Engineering and Technology at IUPUI for what is called a Friday Lab Experience. The Friday Lab Experience (FLE) program was developed as a tool to recruit high school students into the engineering and technology programs at IUPUI by giving them an opportunity to visit the campus, meet some students and faculty from the school, and take part in an actual laboratory class experience. It has also been used to generate interest and awareness in the various engineering and technology fields for younger children in grade school and middle school.

The K-12 schools work with coordinators from IUPUI to arrange the date and time for the field trip, and the students get to choose from the various experiences offered. One session that the students can choose is entitled Molten Metal Magic. This session is offered by the Department of Mechanical Engineering Technology and introduces the students to some everyday products that are made by pouring molten metal, explains some of the processes used to make these products, and then allows the students to get some hands-on experience with making a sand cast, lost foam, or centrifugal-cast part.

Since relatively few high schools and fewer (if any) middle schools have the ability to melt and pour metal, this process is completely new and very intriguing to the students and teachers. While the Friday Lab Experience program was developed as a recruitment tool for the Purdue School of Engineering and Technology at IUPUI, it is also an excellent way to increase the awareness of this critical manufacturing process.

### **Friday Laboratory Experience General Format**

The format for the FLE program has evolved over time based on comments and suggestions from students and educators from the participating schools, faculty and students running the sessions, and the organizers of the program. The program has been running for three years and originally, the schools could pick any Friday during the semester, any time of the day, any session available, and then IUPUI would work frantically to make sure everything was in order for the visit. The program, now, is much more organized, predictable, and simpler to make arrangements for. Session dates are now set during the summer for the entire academic school year – one Friday per month with the same time for all sessions. Therefore, when schools call in, they can set their trip schedule based on date and session availability. Timing for the sessions has also become more consistent and organized. The general format for a visit is as follows:

Arrival	8:45 - 9:00am
Session 1	9:00 – 10:00am
Short break/Switch sessions	10:00 – 10:15am
Session 2	10:15 – 11:15am
Reconvene as large group	11:15 - 11:30am
Lunch	11:30 – 12:00pm
Campus Tour	12:00 – 1:00pm
Departure	1:00pm

There are still exceptions to this general rule, but they have become less frequent as the program has become more consistent and structured.

### **Friday Laboratory Experience Sessions**

Although students can only participate in two sessions during a FLE visit, several sessions will be running concurrently depending on the size of the visiting group.

Sessions are designed to accommodate a small group of students, typically 10-15, so that the groups are manageable and more interaction is available.

Session Descriptions: An abbreviated description of all of the sessions is given below. Complete descriptions and additional information can be found by visiting:  
<http://www.engr.iupui.edu/engtech/community/ftours.shtml>

**Molten Metal Magic** – Watch as we take bars of solid metal, melt them down in a crucible until it's full of glowing, shimmering molten liquid, and then pour the super hot liquid into a special flask that will magically transform the liquid into a solid shape that we have chosen and created.

**Your Name in Barcode Symbols** – This session introduced students to the basics of barcode systems. Students attending this hands-on session will use standard industry barcode label software to create a sheet of bookplate labels.

**Digital Imaging** - In this session, students will use the powerful industry standard image editing program "Photoshop" to create compelling digital images with ease and precision.

**Computer Animation** – Students attending this session will receive hands-on instruction in the use of "Macromedia Flash." Participants will create images within the program and the animate their position and characteristics over time-based frames.

**Flows Over Fighter Plane and Missile Projectile** – In this one-hour demonstration, students will observe water tunnel flow visualization of flows over airplane wings, fighter aircraft, and missile projection.

**Mock Shock and BMET** – In this session you will save the life of "your patient" by learning about defibrillators, how they work, why they are used, and why you will need to say "clear."

**CAD – Solid Modeling and Rapid Prototyping** - This session begins by having students use a state-of-the-art solid modeling CAD program to design a true 3-dimensional model. They then will see their design come to life as the school's rapid prototyping system builds a physical prototype of their CAD model.

**Aerodynamic Design of Automobile** - In this session, students will study basic aerodynamic theory as it applies to automobiles. The hands-on activity will consist of designing and marking a model of a vehicle.

**Automated Playback System** - This hands-on session demonstrates using a PC as a controller for an automated voice response system.

**Distortion Generation Circuit Design** - This hands-on session discusses a distortion generation electronics circuit suitable for creating a hard rock or metal sound out of an electric guitar.

**Building a Data Driven Website** - This session introduces students to using dynamic data in the Web sites. Students will create a data driven web site, complete with graphics, hyperlinks, and the ability to update data via the web.

**Desktop Publishing** - Come to campus and learn how to create a high-quality, tri-fold brochure complete with digital graphics, articles, logos, and customized color schemes.

**Jumpin' with JavaScript** - This session exposes students to a wide variety of JavaScript tools to enhance their Web sites.

**A Cup of Java** - The most widely used object-oriented programming language will be introduced in this session that has students write a simple Java program, compile, and then run it.

**Using Surveying Instruments** - This session will introduce the participants to the different kinds of land surveying equipment and their uses in civil engineering and construction practice.

**Construction Materials** - This is an introduction to materials used in building construction including concrete, steel, and wood. A concrete slab will be cast starting with batching the ingredients and concluding with finishing of the slab.

**Testing Soils** - This is an introduction to types of soils and the kinds of tests we do on soils to determine their properties for engineering uses.

### **Outcomes of the Molten Metal Magic Session and FLE program**

Both formal and informal questionnaires and surveys are given to participants in the Molten Metal Magic session before and after their experience. An initial questionnaire is used to determine the familiarity of metal casting processes and products to the students and teachers participating in the session. Once that is complete, the session activities begin, and then another questionnaire is given at the end of the session to see what the participants learned. Formal surveys and follow-up evaluations are also given by the FLE program coordinators which are used to measure perceived learning, satisfaction with the program, and curricular applications at the middle school or high school.

Based on the initial questionnaire given to the Molten Metal Magic participants, less than 10% of all students and teachers are aware of what a metal casting process is and can identify an example of commercial products made by metal casting. Of those students and teachers familiar with the process and products, 100% had an immediate family member involved in the industry. Metal casting is the 6<sup>th</sup> largest manufacturing industry in the United States and has the unique position of being a supplier to the top five industries.<sup>1</sup>

Most students (approximately 85%) understand the general and very basic concept of how cars are made (on an assembly line), but do not realize that components such as engines, transmission cases, crank shafts, and brake rotors are all made as metal castings. The automobile industry is the largest purchaser/producer of metal castings in the United States using approximately 4 million tons per year.<sup>2</sup> Further examples were even more surprising to participants such as fire hydrants, man-hole (utility) covers, rings (jewelry), turbine blades for jets, faucets, statues, and more.

During the session, different metal casting processes are discussed as the students work on making their own sand casting, lost foam casting, or centrifugal casting. Students get to see a process from start to finish and considerable emphasis is placed on safety. Prior to participating in the session, most students do not know that the aluminum or steel cookie sheet that they used to bake a pizza on can actually be melted into a liquid similar to water. By comparing the oven temperature of 450 °F to the melting point of Aluminum (1300 – 1400 °F) and the melting point of steel (2900 – 3100 °F) participants quickly come to the realization that this metal is extremely hot and dangerous.

At the end of the session, another questionnaire is given to the participants similar to the one given at the beginning. 100% of the participants could describe a metal casting process and give an example of a product made by such processes. Students could also identify some metals used for casting purposes such as aluminum, iron, steel, and copper based alloys.

Informal discussions with the teachers were also positive and in line with the objectives of the program. Teachers were very likely to bring another class to a FLE, would recommend the program to other educators and students, enjoyed the experience, learned from the experience, got ideas for materials and discussion items for their classroom, and would liked to have participated in an activity such as this during their middle school or high school years. Most teachers felt that the Molten Metal Magic session was a great way to help younger students realize that products don't magically appear on the shelves of the stores, they have to be made and this is one way that many products are made.

### **Outcomes of the Formal Surveys**

Formal surveys are given to the participants at the end of the sessions and follow-up evaluation forms are given to the participating teachers to evaluate the success of the field trip and the relevance of the learning experience for the students as perceived by the teachers. Comments from these surveys have also been positive. Students enjoyed the activities, learned from the experience, and discussed the activities when interacting with other students who were not on the field trip. Teachers appreciated the opportunity to participate in the experience, felt as though they learned from the experience, felt that they would use the activities from the experience in their classroom, and would enjoy coming to another visit to participate in other sessions. Negative comments surrounded the perception that the sessions were not long enough and that just as students were getting into their activities it was time to end the session.

Overall, teachers and students were satisfied with the experience, agreed they learned something from the experience, would participate in another experience, and would recommend the program to others. Several teachers commented that they used the experience to augment their classroom activities and others would be recommending it to teachers they knew who could directly benefit from the experience.

### **Costs Associated with the Program**

The structure of the program is set up so that organization, marketing, and coordination efforts are handled through the Dean's Office. These administrative efforts are handled by the Director of Recruitment and Corporate Programs and the Recruitment Coordinator, who reports to the Director. This is one of the many recruitment activities that these individuals are responsible for during the course of the academic school year. The Dean's office also provides funds for the student lunches of those participating in the experience activities. Typical lunch for the students is a personal pizza from Donatos Pizza, a soda, and occasionally cookies. Cost of this type of lunch runs about \$5-6/person. Standard attendance for these events ranges from 30 – 60 students. Transportation costs are absorbed by the visiting middle school or high school.

At the session level, costs are absorbed by the departments to run these events. These costs will vary by the session, but standard costs associated with each session are faculty and student time. Even with the small session sizes, many sessions will have an undergraduate student, or in the case of the engineering disciplines, a graduate student, to assist with the sessions. This is a voluntary time commitment of three hours/month for students and faculty involved in the program, which is not unreasonable for a university service project.

The initial time investment involved with creating these sessions is not drastic either. Most of the activities in the sessions are taken from laboratory experiences that undergraduate students receive during their coursework and modified to an appropriate age level. This makes the development time required by the faculty minimal and enables a considerable amount of undergraduate student support.

The cost of the materials for the individual sessions can range from essentially nothing to dollars per student. The Molten Metal Magic session is probably one of the more expensive sessions to run. Costs associated with this session include: lost foam pattern for demo (\$4/piece), material cost of aluminum for lost foam demo (use 6 lbs. @ \$0.75/lb), electrical costs to run 35 kW furnace to melt aluminum, electrical costs to melt pewter, material cost of pewter (use 1 lbs. @ \$12/lb), and miscellaneous finishing supplies (sand paper, clear coat, key chains, wear and tear on equipment)

### **Program Tracking Efforts**

Due to the nature and size of the program, and the time between a student's experience date and matriculation from high school, the major objective of the FLE program has been rather elusive to track. At this point, it is not known how many students have

entered the Purdue School of Engineering and Technology, IUPUI because of this program or how well the program helped influence any decisions to enter an engineering or technology degree program. Positive outcomes from the individual sessions and good evaluations of the program, however, have led to the administrative decision to continue the program and increase efforts in finding better ways to track students who participate in the program. Additional tracking measures are expected to be implemented in the near future which will focus on creating a database of schools, students, and additional tracking information that can be referenced with incoming students into the school.

### **Program Improvements**

Since the program began three years ago, we have learned a lot along the way. As we have gained more experience with organizing and running the program, we've been able to make improvements in the process and in the sessions that simplify the amount of effort required from everyone involved. The major improvement has been in the organization and scheduling of experience dates. As mentioned earlier, the original format of the program was very random. Dates were scheduled sometimes only days in advance leaving little time for faculty preparation and commitment. The timing of the events would also change with each group so one week the session might be 1 hour long and the next time it might be 2 hours long. Subtle changes in the planning and organization have resulted in significant improvements in the overall efficiency. Now, rather than feeling like "organized chaos," the scheduling and standardization of the format has allowed the faculty to create a much more seamless experience for the students and a repeatable process for the program. This has simplified some of the details associated with running the program also. For example, by knowing the experience dates in advance, the task of ordering lunches becomes more routine and less stressful.

There is still room for improvement. Some schools are more organized than others and when left to fill sessions on their own, the results can lead to delays upon arriving at IUPUI. This seems to be the major timing issue once the schools arrive at IUPUI. It is recommended that students are "registered for" (or assigned to) specific sessions prior to coming to the experience. These lists can then be given to individual session faculty members so that preparations are simplified. With the Molten Metal Magic session, two separate lists of activities are utilized depending on the actual enrollment in the session. The session is listed for a maximum of 15 students. Sometimes this number has to be exceeded for unforeseen reasons: last minute additions are the usual cause. However, there is much more that the student can participate in if there are only 8-10. Therefore, one set of activities is geared more toward demonstrations with a small amount of hands-on time and the other is mostly hands-on activities with a small amount of demonstrations.

### **Conclusions**

Considerable effort is being placed in bringing engineering education and opportunities to the K-12 students.<sup>3</sup> The Friday Laboratory Experience program is one way in which IUPUI has decided to participate in K-12 outreach programs. Each FLE session

highlights an area of excellence in the Purdue School of Engineering and Technology, IUPUI and is used to promote engineering disciplines to high school and middle school students, promote the engineering and technology programs available at IUPUI, and promote awareness for the diverse applications that engineers participate in on a daily basis. The Molten Metal Magic session is one session within the FLE program which serves to meet the FLE program objectives as well as increase the awareness of metal casting processes, applications, and products commonly used in the United States and around the world. Awareness is a critical aspect in obtaining knowledge. Before you can learn about a topic, you have to know it exists.

## References

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## Biographic Information

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