Casting Castings: A Classroom Hands-on Activity

Craig Johnson
Central Washington University
Industrial & Engineering Technology
400 E. University Way
Ellensburg, WA 98926-7584

Abstract:
This module provides a quick technique to teach casting concepts. Similar to the common scenario of casting dental implants on-site while the patient waits, this module manufactures 'casting sinkers' (e.g. fishing weights) during a class. This module on 'Casting Castings' brings the casting process out of the foundry and into the classroom with a 'take-home' fishing weight ready for use. Using casting concepts and terms, participants form a simple clay mold with a wire insert, then a small amount of solder is melted and a usable product is cast. A debrief of the process addresses pour media, technique and a mold quality.

Objectives:
Upon completion of this activity, students be able to:

- demonstrate their ability to apply knowledge of casting concepts to the manufacture of a casting.
- design and then fabricate an appropriate mold for the intended casting.
- cast a usable part and evaluate its quality.

MatEd Core Competencies Covered:

0.B Prepare tests and analyze data
1.C Demonstrate laboratory skills
5.A Apply safe methods of chemical handling
7.A Identify the general nature of metals
7.E Describe the general nature and behavior of ceramics
7.J Demonstrate how materials properties are used in engineering design
16.A Explain effects of processing and manufacturing variations on material properties
17.B Describe techniques used in metals processing

Type of Module/Mode of Presentation: This activity includes in-class, demo and hands-on lab aspects.

Key Words:
Casting process, casting technique, fishing weights, mold quality

Time Required: One hour.

Prerequisite Knowledge:
Students must be aware of basic lab activity policy, including safety. Although the low-temperature solder is only 170F (50F less than boiling water), there is still a possibility of injury if incorrectly handled.

Target Grade Level:
10-14 (secondary school and undergraduate technology courses)

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Equipment and supplies needed (per participant or team):
Environment: Each student or team will need
tabletop space with appropriate ventilation,
safety glasses and gloves
0.5mm diameter copper wire (about 5 inches per student)--
it is best to pre-bend the wire to form an eyelet.
Note: nominal clay is inert, but if a product reacts, use appropriate protocols.
Molds: Each student or team will need
one-half cubic inch of modeling clay (or other moldable clay),
bread knife for cutting the mold
pencil with a point,
thin copper wire (~0.5mm) for eyelet,
Casting:
Lead-free plumbing solder (170F melt, not electrical solder, 1/8 oz/student),
Ex: Oatey Safe-Flo® plumbing solder #29025 1lb wire spool 1" pieces
heater/ladle (minimum 200F and a quarter cup),
Ex. Hot Pot® 2 by C. Palmer, West Newton, PA (or google 'hot pot')
extension cord,
heat resistant working surface (e.g. silicone pad or cutting board)

Curriculum Overview and Instructor Notes:
Many students never participate in creating a 'manufactured' product. One easy method of creating a product is to cast it. Students that participate in these activities early in their education have a better understanding of possible societal needs and opportunities. Students may watch television and see a part cast, but with regard to Bloom's Taxonomy (1), this type of

‘knowledge’ and ‘comprehension’ are at the bottom of the hierarchy. This activity targets the upper part of Bloom’s hierarchy, and the harder ‘application’ and ‘evaluation’ behaviors.

In a traditional casting lab approach, a movie may be shown that describes safety issues as well as casting techniques (e.g. green sand molding and induction melting of aluminum). Afterwards, a demonstration in a foundry is common. For groups of students on tours, safety is more problematic. Eyewear is provided for green sand molding activities, where students can get their hands dirty, but a protective screen is used while they observe the pouring process, keeping them remote from the process.

This module addresses outreach by taking casting out of the foundry, and putting it into the hands of students. To that end, a suitable melt and mold was selected for a hands-on classroom activity. Plumbing solder is chemically safe and has a relatively low melting point (170F). A common electrical heater (see equipment list) can supply a suitable melt pour media. A ‘solder pot’ will both melt the metal and offer a handle with which you can pour. The instructor should melt the solder and pour it into the molds made by the students.

A suitable mold material, determined by trial-and-error, was found to be modeling clay, selected because it is safe, cheap and easily formed.

This activity can take different amounts of time, depending on particular objectives. Also, it may be appropriate to have a teaching assistant to monitor the pouring station while the instructor is helping students around the classroom.

The activity may be expanded to include different objectives. A common issue concerns the ‘melt temperature’, and its affect on the product quality. A special type of mold can be made (e.g. troughs) to illustrate this effect.

Although there are a multitude of skills related to casting operations, this module was intended to offer an experience of casting a usable device in a short time and with limited resources using a technique that all students can follow. A ‘casting sinker’ was the first product chosen (Figure 1). But experience has shown that many students desire to make jewelry (earrings).

Procedure:
Preparation includes reviewing the intended classroom. Power must be available at a bench or table. The pour area can be on a separate lab bench set up for the purpose. Lay down the silicone mat, position the ladle, load the solder and turn it on 1/2 hour before expected use.

Before class, cut the modeling clay into 1x1x0.5” chunks (one per student). Also, form the copper wire ‘loops’ (used to wrap fishing line around and hold the weight). Any 1/8” round can be used as a mandrel (or the blunt end of a pencil). Just hold the wire with pliers, make two wraps, and cut the ‘crisscrossed’ ends about 1/4” out. Make one wire insert per student.

Assemble the molding tools. Students may work in teams, but there should be enough tools to complete the molds.

The casting activity is comprised of an Introduction, then the Activity, and then a Debriefing.

The Introduction includes a discussion of the casting process (2). It is appropriate to use local industries or relevant products as examples. Then show the product to be cast: a fishing weight. This provides a comparison for success. Molds and molding process should to be discussed in enough detail to meet the students' needs. Lastly, the pouring process can be critical to success, so a demo may be appropriate. The obvious safety issue concerns the pour area. Keep the solder over the silicone heat pad, pour into the mold, then wait a few minutes to cool before handling.

Notes for evaluation: Before any metal is cast, have the students consider what aspects of a casting may be important. For example, is the casting size, shape or texture important? Is it important to be able to easily make a mold? Is the mold quality (shape, texture, etc.) important? In the actual process of casting, is it important to be able to do it quickly, or pour easily?

In the Activity, a single mold impressions is made, at the bottom of which the metal wire is inserted. Students form a 3/4" cube of clay that is stable (won't tip over). Next, a tapered object (e.g. end of a pencil) is pressed into the top of the clay to form a cavity. The wire inserted (with a tweezers) into the bottom of the impression. Make sure the loop is down in the bottom, and the twisted ends are up. The mold is now ready to be poured. The activity can progress with students at various stages of preparation.

As students get ready to pour, the instructor (or aid) should monitor. Student should don personal safety protection (gloves and glasses). The mold should be placed on the silicone pad. The ladle should be firmly grasped, placed over the mold, and metal dispensed in a smooth, continuous fashion until the mold is full (Figure 2). After pouring metal into the mold, the ladle should be place back on its stand. Any spilled solder can be put back into the ladle (using tweezers). Students can move the mold, but should wait until the mold cools (about 5 minutes) before handling and extracting their fishing weight. The molding clay can be recycled.

The Debriefing is an important aspect of the module, and concentrates on reflecting about the quality of the castings and process (e.g. evaluation). At least two areas of process quality should be discussed. The quality of the mold may be important (size, shape, texture), and there are various ways to make the molds (split vs. whole, inserts or not, etc.). The pouring process can affect the product. People have different skills, and the resulting casting quality may reflect it. A quick, continuous pour may result in good castings, but a variety of concerns (ergonomics, handling, weight, smell, etc.) may be of interest. Finally, the casting itself may exhibit better or worse qualities regarding shape and texture. A variety of these casting qualities are shown in Figure 3.

Evaluation of each student's performance can be done using the Debriefing topics. Evaluation of the student's ability to meet the Activity Objectives can be done by an observer.

Evaluation of the Activity:
The 'application' aspect of casting is readily achievable during this activity. Students like casting. The higher-level domain of 'evaluation' is dependent on the whole scenario. If the students get done with enough time to have a good discussion, then aspects of quality can be

addressed. It can be appropriate to have some 'poor' castings previously done, so that common defects such as shape can be referenced.

References:

1. Bloom B. S. *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain* New York: David McKay Co Inc. 1956.
2. Schleg, Technology of Metalcasting, American Foundry Society Publ., 2003. ISBN#0-87433-257-5

Author Bio:

Craig Johnson is a Professor and Coordinator of both the Mechanical Engineering Technology and Industrial Technology Cast Metals Programs in the Ind. & Eng. Tech. Dept. at Central Wash. Univ., www.cwu.edu/~cjohnson. He has a P.E. in Metallurgy, but surprisingly also has a B.S. in Phys. Sci. and previously taught high school. His BSME is from U Wyoming, with an MSMSE from UCLA, & a Ph.D. in Eng. Sci. from WSU. Dr. Johnson. is a past ASEE Materials Division Chair. Technical specialties include test design, interface characterization/joining. & process optimization (forming & solidification). Education specialties include designs of curricula, labs and undergraduate research, with a specific interest in education process control. Phone 509-963-1118.

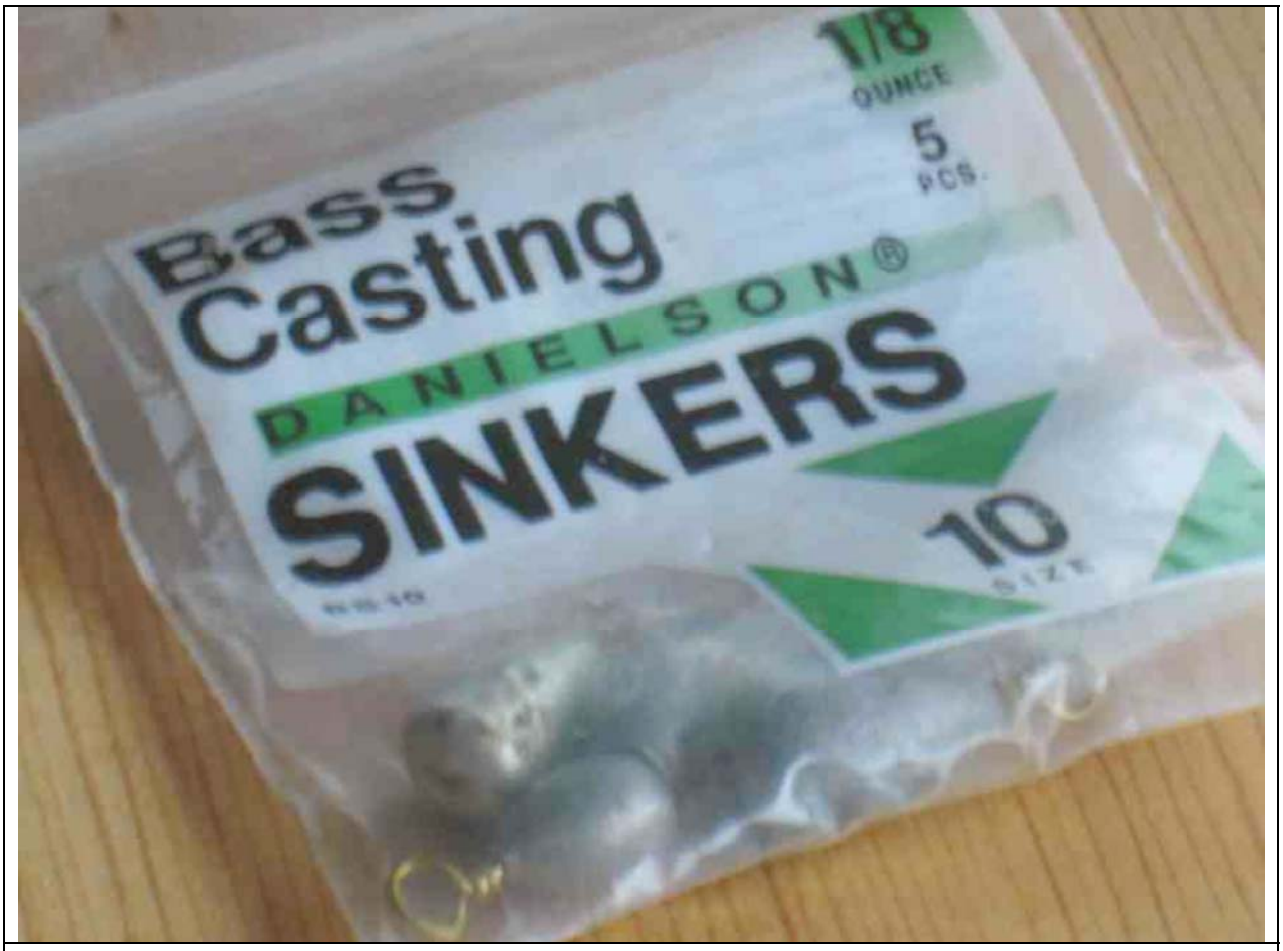

Figure 1 Fishing sinkers chosen as a cast product.

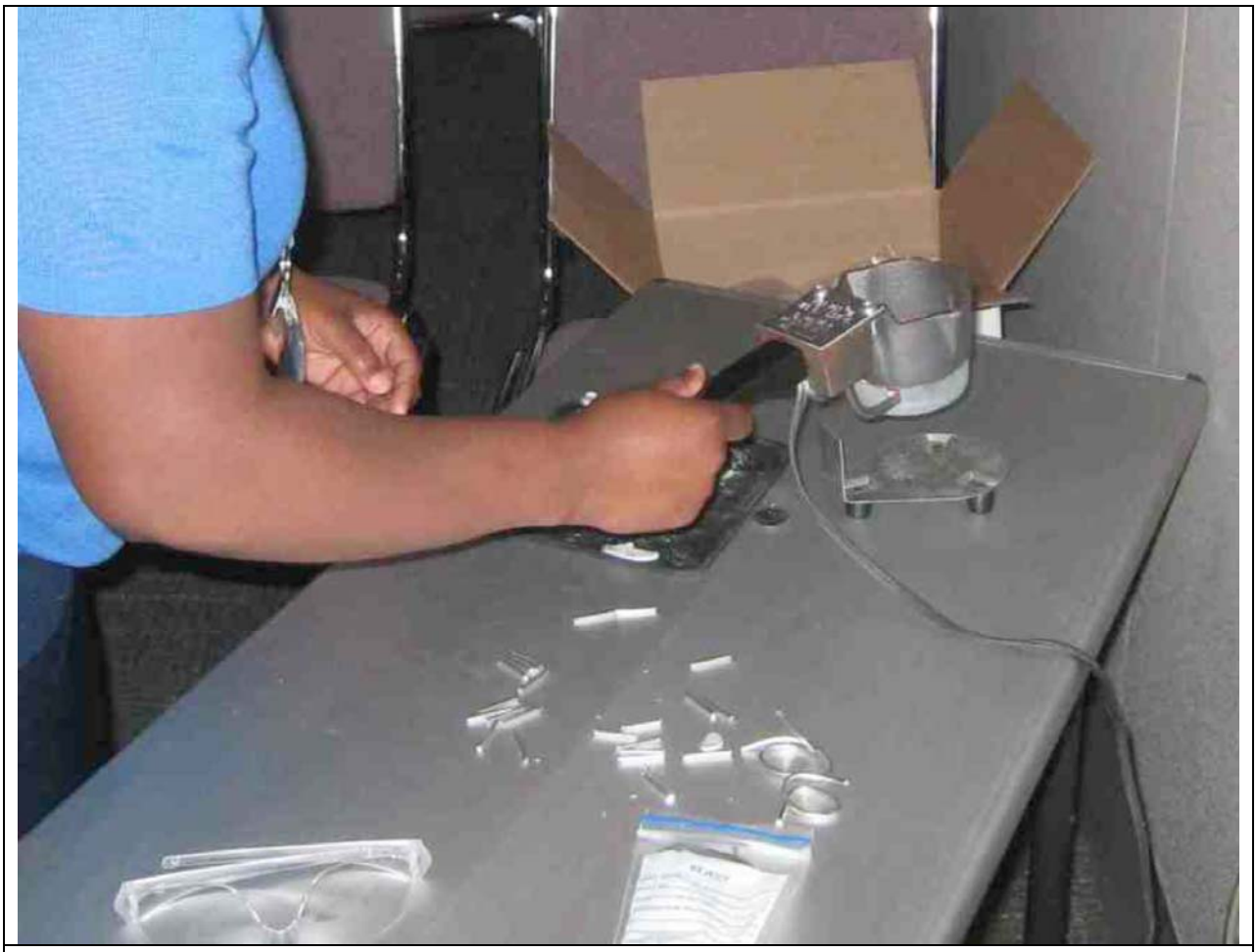

Figure 2: Pouring solder into a mold.

Figure 3: A variety of casting ‘quality’ is shown (shape, texture, size).