AC 2009-2437: A MATERIALS OUTREACH PROGRAM DEVELOPED BY MSE UNDERGRADUATES FOR JUNIOR-HIGH STUDENTS FOCUSED ON GRADE-LEVEL EXPECTATIONS

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A Materials Outreach Program Developed by MSE Undergraduates for Junior High Students Focused on Grade Level Expectations

Abstract

The Material Advantage chapter at Washington State University has developed a teaching toolkit to address materials related topics for students at the 7^{th} and 8^{th} grade levels in the state of Washington. The students in the chapter surveyed junior high school science teachers in regards to topics they had difficulty in addressing in classes. Density, magnetism, and electrical conductivity were three topics noted, of which demonstrating and teaching density of materials was noted by most of the teachers. To address these needs the students chose to develop a set of materials that could be distributed in a "kit" format to teachers for use in class demonstrations. These kits, developed as part of an informal chapter outreach activity, consist of ten materials of varying density, and include materials with different magnetic, electrical and optical properties. In addition to the ten identically sized materials (cylindrical rods), a graduated cylinder, an electrical conductivity tester, and a magnet are included in the kit. An accompanying worksheet prompts the junior high school students to separate the materials using the properties noted above, and gives example applications of each type of material. This paper documents the activities and pilot scale distribution of the kits by the student participants.

Introduction

The state of Washington addresses the educational needs of students through a set of standards referred to as Essential Academic Learning Requirements, which include specific goals and targets for each grade level. At each grade level, the Grade Level Expectations (GLEs) specify a core of conceptual knowledge and abilities that students should achieve by that grade; they are not meant to detail teaching methodologies or test specifications, though they do constrain the content of statewide testing. As such, they are the subject of significant attention by teachers in the K-12 system in the state.

Engineering outreach in general is a very active area of experimentation. One only needs to examine the myriad of engineering outreach programs across the country[1] to realize that there is no "silver bullet" type activity. Within the Materials Science and Engineering (MSE) community there are several established methods of K-12 outreach[2,3]. The student chapter of Material Advantage at Washington State University, the organization representing four of the largest professional MSE societies (ASM International, TMS, AIST, and ACerS), has previously carried out various K-12 outreach programs ranging from undergraduates visiting high schools to present a one hour seminar about MSE to building a small impact tester for the local science center (the "Breakinator") for children in grades 3-5 to explore the difference between brittle and ductile materials. After carrying out activities for high school and grade school students, the WSU MA chapter decided to focus on developing an outreach program to middle schools in Washington; the choice of focusing on middle school has been shown to be an effective point in outreach[4]. It should be noted that these were not mandatory service learning projects, but voluntary activities driven by undergraduate and graduate student interest.

The students first realized that the needs of teachers are the priority in designing this outreach activity. With significant concern at the school level over meeting state standards, there is little room for "extra" activities; an activity which directly links to the standards will garner significantly more interested from teachers around the state. Therefore, they informally surveyed three junior high school science teachers asking which topic seemed to be the hardest to get across to students. All three teachers responded that density was the most difficult topic in their courses, with magnetism, conductivity, and optical properties being other areas of concern. With this information, the students developed an educational materials toolkit (the "GLE kit") useable by middle school teachers as an in-class, hands-on project for students to be exposed to these topics while providing exposure to MSE as a field through a short worksheet and handout.

Description of the kits and activities

The kits themselves consist of 10 material samples, all 0.5" rod stock in 2" lengths. The 10 materials are 6061 aluminum, 304 stainless steel, 416 stainless steel, alpha brass, an SiO_2-based glass, ABS, polyethylene, polystyrene, plexiglass (PMMA), and fiberglass. This provides a wide range of material densities as well as distinctive electrical conductivities, optical properties, and magnetic properties. All materials are purchased in long rod stock form, and then cut, deburred, and ground to a smooth finish by the WSU students, as well as marked for identification.

In addition to the materials, the kits include an electrical conductivity tester, a graduated cylinder, and a magnet. The kit is labeled with a sticker that has a ruler printed with 1 mm divisions that is long enough to be used to measure each of the cylindrical materials samples. Each kit is provided with a materials information form and a student worksheet (as well as a small promotional item describing the Material Advantage club at ***). A photograph of the kit is shown in figure 1.

Figure 1. Photograph of the kits with materials information handout and student worksheet.

The GLE kits are to be used in a hands-on activity where students are told the 10 materials present, and then they have to separate the materials based on the properties of these materials: density, electrical conductivity, optical properties, and magnetic properties. Density is calculated using Archimedes principle, the samples are sorted by if they are electrically conductive or not, optical properties are tied into color and transparency, and the magnetic properties are examined by just determining if a permanent magnet is attracted to the samples. All materials needed for the activities are provided in the kit except a scale or balance, which is available in most middle school classrooms. Additionally, a squirt bottle for filling the graduated cylinder with water and paper towels to dry the samples are handy additions for use in class, but not required. The worksheet also includes a flow chart to help students separate the materials at each point. Teachers are provided with the key relating the numbered samples to the expected density and the material identification. The flow chart is shown in figure 2.

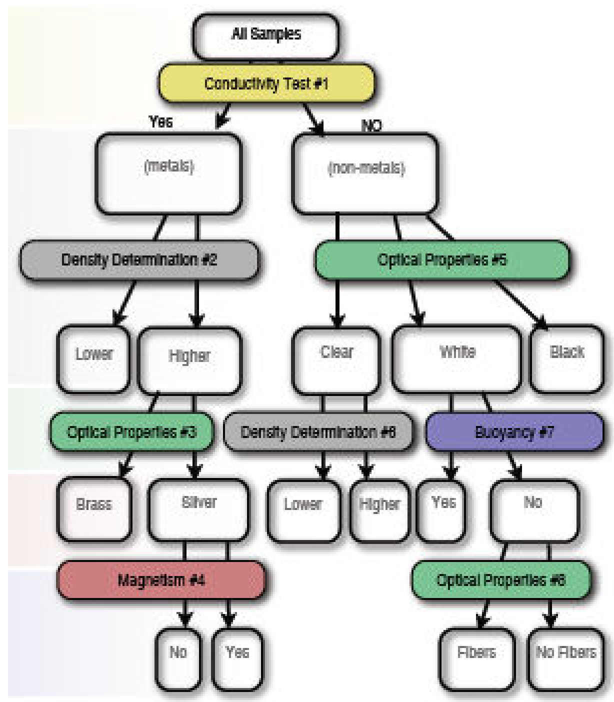

Figure 2. Flow chart for sorting the 10 materials.

Grade level expectations

The activities carried out with the kits meet many of the state's grade level expectations for science in the middle school level. According to the Washington State K-12 Standards, in grades 6-8 students should address "Matter: Properties and Change", with core content focused on "Atoms and Molecules". Table 1 shows the topics covered by the WA state standards. The older state standards were worded such that this topic addressed general topics related to the scientific method, such as "Investigating Systems: Understand how to plan and conduct scientific investigations, and gather, record, and organize data using appropriate units, charts, and/or graphs, and perform multiple trials". Additionally, the mathematical standards in eighth grade say that students should be able to "Understand the properties of cylinders, cones, and pyramids", and "Use mathematical patterns and ideas to extend mathematical thinking and modeling to other disciplines". In both cases, the exercises that accompany the kits can be related directly to specific state guidelines for grade level expectations.

Table 1. Selected standards from the Washington State K-12 Science Standards

	Content Standards	Performance Expectations
6-8 PS2A	Substances have *characteristic* intrinsic *properties*, such as *density*, *solubility*, *boiling point*, and *melting point*, all of which are independent of the amount of the sample.	Use *characteristic* intrinsic *properties* such as *density*, *boiling point*, and *melting point* to identify an unknown substance.
6-8 PS2C	All *matter* is made of *atoms*. *Matter* made of only one type of *atom* is called an *element*.	*Explain that* all *matter* is made of *atoms*, and give examples of *common elements*—substances composed of just one kind of *atom*.

Pilot program distribution

The kits have been pilot tested in two different types of venues. First,WSU students delivered and test run the kits at three junior high schools in the state, two in mid-sized cities and one in a rural location to a total of three teachers. Each teacher is responsible for between 2 and 5 classes which can use the kits (depending on school size). Over time they found that each kit can be shared by 2-3 students and the activities take approximately 2 class periods to carry out; fully equipping a classroom requires approximately 10 kits. If only the density measurements are used, the activities can be done in one class period. Over 300 junior high students have used the kits so far. All participating teachers reported that they are re-using the kits again in subsequent years.

The second venues to show the kits was in voluntary informational settings; a local science center (the Palouse Discovery Science Center) as part of an engineering and science Saturday event and a junior high Saturday program sponsored by the Society of Women Engineers to expose students to engineering students and professionals. At the PDSC the self selected student population ranged from 3rd to 7th grades, and the students went through the activities with their parents; approximately 40 students used the kits during the one day event. An anecdotal observation of the student participation suggests that students younger than 5th grade do not benefit significantly or become strongly engaged in the activity. At the SWE event participation was primarily junior high aged, and the students were engaged in the activity at a level similar to that found in the classroom settings.

A survey of the junior high school students after using the kits showed approximately 79% reported they enjoyed the activities, 12% disliked the activity, and 9% were ambivalent or had no response towards the using the kits. For those that liked the kit, positive comments focused on the team work, getting to use "real instruments", "using the electricity tester", "it was fun to play with metals", and the fact that it was "a challenge and made me think". These responses, which were not collected in a fully scientific manner, still provide promising evidence of the appeal of the hands on activity to this age group of students. Due to the nature of the distribution method and survey, we are unable to report statistically significant data at this time and hope to produce a more complete report on student learning outcomes in the future.

The current incarnation of the GLE kits costs approximately $12-15 in materials per kit to fabricate and stock, with all fabrication and assembly time done by student volunteers. The most significant cost incurred in distributing the kits was travel around the state (two of the pilot schools were over 3 hours driving distance). As the distribution program developed by the Material Advantage chapter at WSU expands, the students are exploring lower unit cost options for packaging, and should be able to lower the cost to below $10 per kit.

Summary

A set of materials, suitable for use in hands on labs for the junior high school science curriculum in Washington State, was produced by the WSU Material Advantage student chapter as part of a "Grade Level Expectation" kit. The kits consist of 10 materials and equipment to measure density, conductivity, and magnetism. These kits were primarily distributed around the state to three junior high school teachers in conjunction with visits from the WSU students. Initial anecdotal feedback has been quite positive. Kit distribution is continuing in the 2008-9 academic year to another five schools.

Acknowledgements

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