Bringing Students to the Mountain: Developing Partnerships to Introduce Students to Cutting-edge Research

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ABSTRACT

Many materials science education and outreach activities are designed to be easy and cost-effective to implement in K-12 classrooms. While these activities are extremely effective at teaching broad materials science concepts such as size and scale, materials properties, and the use of tools in science, they do not connect very closely to the work being done in materials science research laboratories. In an effort to more closely connect our outreach efforts to the work being done by our researchers, the University of Wisconsin–Madison's Materials Research Science and Engineering Center (UW-MRSEC) has developed a partnership with Hitachi High Technologies America, Inc. This partnership allows us to introduce public audiences to a state-of-the-art tabletop scanning electron microscope (SEM) that is being used by UW researchers. In this paper, we describe the partnership including the use of the SEM in our Research Experience for Teachers (RET) program and in our community outreach programs.

Keywords: outreach, education, SEM, K-12, materials science

1. INTRODUCTION

The NSF-sponsored Materials Research Science and Engineering Center at the University of Wisconsin – Madison (UW MRSEC) investigates the structure and properties of materials interfaces at the molecular and atomic levels. The UW MRSEC is comprised of three interdisciplinary research groups (IRGs 1-3), which focus on a wide array of materials from inorganic semiconductors through liquid crystals[1]. In addition to the research groups, UW MRSEC has an interdisciplinary education group (IEG) that creates and disseminates a broad range of educational materials that arise from the materials science research and expertise in the center[2].

1.1 IEG vision and philosophy

The vision of the UW MRSEC IEG is to increase the number and diversity of individuals knowledgeable about materials science and interested in pursuing careers in the field. As a center, the MRSEC approaches education and outreach with the same dedication and creativity as research and all members of the center participate in these efforts. To realize our vision, IEG uses an iterative "create, disseminate, and evaluate" approach. New materials science activities and curricula are developed in close collaboration with the researchers in the MRSEC, the new material is disseminated to age-appropriate audiences, the efficacy of the material is evaluated through a variety of methods, and the activity is refined based upon the results of the evaluation. We disseminate material through a wide range of venues including our highly regarded website[2] which reaches over 100,000 people each year, large science festivals that impact several thousand people, workshops for educators, and field trips on the UW campus. Through these varied dissemination methods we are able to reach a broad audience including K-12 students, college students, educators and the general public.

1.2 IEG approach

The IEG has been creating educational materials for well over a decade. Our philosophy has been to create simple, cost effective activities that teach basic materials science concepts such as materials properties, size and scale, and the applications of materials science and nanotechnology research. These materials are easily disseminated via our

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education website[2], at large events such as science fairs, and during workshops for teachers. These educational activities are also easy and cost-effective for teachers to introduce into their classrooms. In Fig. 1, a UW MRSEC graduate student is teaching a third- grade boy about hydrophobic and hydrophilic materials using dried lotus leaves, hydrophobic sand (magic sand), instant snow polymer, and sodium polyacrylate (water lock diaper gel). All of the materials required for this activity are non-toxic, readily available, and easy to obtain.

Fig. 1 A UW MRSEC graduate student teaches a third grade boy about hydrophilic and hydrophobic materials using safe, simple, cost-effective materials.

Although these activities are very effective and engaging, UW MRSEC recently began to explore ways to expand the scope of our activities to give K-12 and public audiences a more authentic research experience. To do this, we developed a partnership with Hitachi High Technologies America that allowed us to introduce the public to the TM3000 tabletop scanning electron microscope (SEM).

2. METHODOLOGY

The TM3000 SEM has several features that make it ideal for educational environments. It is compact enough to be moved by automobile and simple enough for elementary-aged children to operate. The TM3000 SEM is able to magnify up to 30,000x and it plugs into a standard outlet so no special equipment or electrical alterations are needed for its use.

Hitachi loaned the SEM to the UW MRSEC IEG for three months during the summer of 2012 as part of their involvement in Change the Equation (CTEq), a non-profit organization comprised of members of the business community. The stated mission of CTEq is "Through our coalition of CEOs, Change the Equation pledges to foster widespread literacy in science, technology, engineering and mathematics (STEM) that sparks an innovative spirit in students and prepares them for postsecondary options."[3]

3. RESULTS

Since Hitachi loaned the TM3000 SEM to IEG with no conditions on its use, we used the instrument for a broad range of education and outreach activities including our Research Experience for Teachers program, a College for Kids summer camp, and large community outreach events.

3.1 Research Experience for Teachers (RET)

Our NSF-funded RET program is a cross-site collaboration between the University of Wisconsin- Madison (UW) and the University of Puerto Rico- Mayagüez (UPRM) that gives the participants research experience, as well as new tools and resources for their classrooms. The program partners K-12 teachers with UW and UPRM faculty, postdocs, graduate students, and staff for a six-week, on-campus, professional development experience.

Figure 2: a) Teachers in the RET program used the TM3000 SEM throughout the six-week program to collect images for the classroom curriculum they developed. b) UW RETs trained the UPRM RETs to use the SEM during capstone week and the UPRM teachers were able to collect images for their projects.

During the program, the teachers conduct research and develop cutting-edge curriculum for their classroom based upon their research. The cross-cultural aspect of the program improves the participants' cultural literacy and leads to the development of bilingual, culturally relevant education resources. In the fifth week of the program, the teachers meet at one of sites to present their research and curriculum to each other and to exchange ideas and resources about the educational systems in their respective regions. Capstone week was held in Madison, WI during the 2012 program.

The UW RET participants were trained to use the TM3000 SEM during the first week of the program and were granted access to the microscope throughout the entire six-week program (Fig 2a). Many of the teachers used the instrument to collect images that enhanced the curriculum they developed for their classrooms. During the capstone week, the teachers from UW trained the UPRM teachers to use the SEM to collect images for their projects as well (Fig 2b).

3.2 Examples of RET projects utilizing the SEM

UW RET Kira Jacobson worked in the lab of Professor Nader Behdad where she researched the unique structure of the *Ormia ochracea* fly eardrum. The structure of this fly eardrum is being used as a model for new antennae arrays. As part of her activity, Jacobson took images of the *Ormia* fly's eardrum for a high school lesson on antennae and biomimicry (Fig. 3).

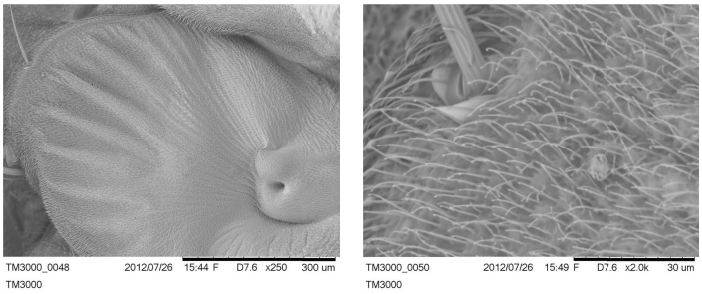


Figure 3. The left eardrum of the *Ormia* fly at 250 x (left) and 2,000x (right) magnification.

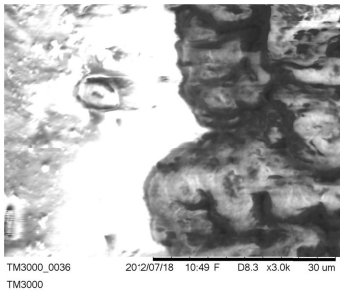


Figure 4. Printed Shrinky Dink film at 3,000x magnification.

UW RET Melissa Hemling developed an activity where high school students made their own microfluidic devices using Shrinky Dinks film to create the templates. The device patterns were printed on the Shrinky Dinks film using a laser printer. The Shrinky Dinks films were then shrunk in hot oil, which caused the ink to be raised to a height that could be used to form channels in the polydimethylsiloxane (PDMS) that was poured over the template to make the device. Hemling used the TM3000 SEM to collect images of the ink on the shrunken Shrinky Dinks film to show the students that the ink is not the smooth, straight line it appears to be at the macroscale (Fig. 4).

UPRM RET Brenda Estévez Moreno developed a classroom module to teach her students about the elastic properties of materials. She soaked an egg in vinegar for seven days and compared the elasticity of the treated egg to an untreated egg

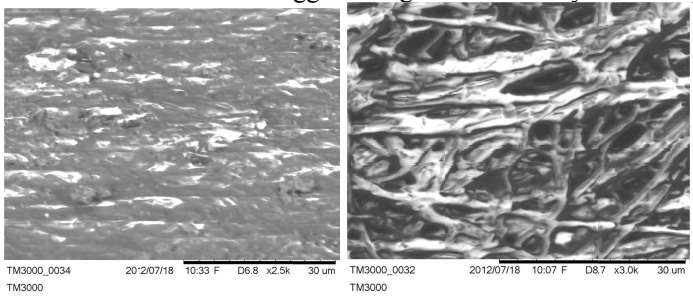


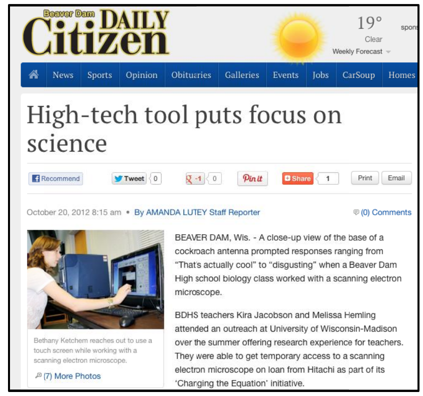
Figure 5. Vinegar treated egg membrane at 2,500 x magnification (left). Untreated egg membrane at 3,000 x magnification.

using a device she had created to measure force on an object. Estévez Moreno used the SEM during capstone week to collect images of vinegar-treated and untreated egg membranes to show her students changes that were occurring with treatment (Fig. 5).

All three of these classroom curriculum modules were enhanced by the images the teachers were able to collect for their projects. In addition, the students were able to see how the tools scientists use enable them to gather information about the topics they study.

3.3 RET participants take the SEM into their communities

During the academic year, two teachers from the RET program borrowed the SEM for two weeks to use in their high school. Staff from IEG transported the TM3000 SEM to Beaver Dam, Wisconsin, a rural community of approximately 16,000 people, set up the microscope, and trained the teachers to use it. During the time the instrument was in Beaver Dam, 553 high-school students, 669 middle-school students and 55 community members interacted with the SEM; thus approximately 8% of the Beaver Dam population was impacted through this program. The local newspaper published two articles on the TM3000 SEM and its impact on the Beaver Dam community. (Fig. 6)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High-tech tool puts focus on science

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Bethany Ketchem reaches out to use a touch screen while working with a scanning electron microscope.
(7) More Photos

BEAVER DAM, Wis. - A close-up view of the base of a cockroach antenna prompted responses ranging from "That's actually cool" to "disgusting" when a Beaver Dam High school biology class worked with a scanning electron microscope.

BDHS teachers Kira Jacobson and Melissa Hemling attended an outreach at University of Wisconsin-Madison over the summer offering research experience for teachers. They were able to get temporary access to a scanning electron microscope on loan from Hitachi as part of its 'Changing the Equation' initiative.

Figure 6. A screenshot of one of the two articles written about the TM3000 SEM in the local Beaver Dam newspaper.

3.4 Summer programs

As part of our vision to introduce K-12 and public audiences to materials science, IEG participates in various summer camp programs. In June 2012, fifteen middle school students came to campus for a weeklong materials science module as part of a three-week College For Kids experience that exposed the students to various disciplines on the UW campus. As part of the materials science module, the students synthesized ZnO nanoparticles and observed them by optical and scanning electron microscopy (Fig 7a). The students were able to see the difference in resolution between the two types of microscopes and gain a better understanding of the types of tools materials scientists use for research. Hitachi, Inc. used a description and photographs of this activity in an article about the TM3000 SEM that was published in a Japanese newspaper similar to the American Wall Street Journal (Fig. 7b).


「理科離れ」対策。科学教育プログラムの最前線｜日本経済新聞 電子版特集

日本経済新聞
日立ハイテク
特集
社会を豊かにするハイテクソリューション 02
理科教育支援の いまここ

先進国で浮上する理科離れ問題
科学教育プログラムの最前線

電子顕微鏡で世界トップクラスの実績を誇る日立ハイテクノロジーズ（以下、日立ハイテク）が、4年ほど前から取り組んでいるのは、いまや先進国の共通課題となった「理科離れ」対策だ。卓上型の電子顕微鏡の貸し出しを通じて、世界各国の科学振興イベントを支援してきた。ハイテクソリューション事業におけるグローバルトップを目指す同社は、日本国内のみならず、その支援範囲を北米・南米・ヨーロッパにまで広げている。

ミクロ世界の不思議 1 | STEM教育プログラム 2 | その先のわくわくする世界へ 3

世界中の子どもたちに
ミクロの世界の不思議発見を

いまアメリカでは、ひとりでも多くの子どもたちに科学の素晴らしさを体験、実感してもらおうと、様々な理科教育イベントが全米各地で開催されている。その中でも、身のまわりにある日用品や繊維・プラスチックなどの素材、植物、昆虫などを、卓上顕微鏡「Miniscope®」（以下ミニスコープ）で観察する理科教室は、子どもたちの人気の的。科学に対する子どもたちの関心を高め、興味を喚起する「理科離れ」対策の効果的なプログラムとして、教育機関や教育者のみならず、学会組織、民間団体、州政府までがその成果に期待を寄せている。

先月行われたウィスコンシン大学マディソン校のサイエンス・キャンプには、24名の子どもたちが参加した。同キャンプの理科教室プログラムでは、ホウ珪酸塩といった試料を硝酸亜鉛などの溶液に浸した時、試料がどのように変化するかを「ミニスコープ」で観察するという実験が行われた。

実験、観察の指導は化学を専攻する大学院生ボランティア

劇薬を扱うため、白衣と手袋、メガネの着用を義務づけられた子どもたちは、最初、緊張した面持ちだった。しかし、実験と観察が進むに連れ、その瞳はキラキラと輝きはじめ、パソコンのディスプレイに映しだされた画像を食い入るように見ていた。キャンプに参加したとある女の子は「こんな形が、世の中にあるなんてすごい」とミクロの世界の造形美に感動する。地元の野球チームに所属する男の子は「こんな装置がある

http://ps.nikkei.co.jp/hightech/v2-01.html[2012/08/29 8:49:57]

「理科離れ」対策。科学教育プログラムの最前線｜日本経済新聞 電子版特集

なんて知らなかったよ」と「ミニスコープ」に興味津々だった。

「ミニスコープ」の画像にアートを感じたという女の子
「こんどは自分の野球グローブをこの顕微鏡で見たい」という男の子

米国では科学技術分野の人材育成を
国家戦略のひとつに挙げている

こうした理科教育イベントを全米で支援しているのが日立ハイテクの米現地法人である日立ハイテクノロジーズアメリカ会社（以下、日立ハイテクアメリカ）だ。同社のスタッフは、販売代理店の営業と「ミニスコープ」のプロモーションを展開するかたわら、全米の短大や大学などの高等教育機関を訪問し、「ミニスコープ」を貸し出すなど、独自に理科教育の支援活動を継続している。こうした地道な活動により、「ミニスコープ」は「理科離れ」対策に最適なツールとして、全米で認識されるようになったのだ。

2010年4月から出荷を開始した卓上顕微鏡Miniscope®『TM3000』

先進国で「理科離れ」が浮き彫りになったのは2000年頃のこと。OECD（世界協力開発機構）の国際的な学習到達度調査が始まり、子どもたちの理数系教科における学力や意識の国際比較が可能になったからだ。今では、各国の産業基盤を揺るがしかねない深刻な問題として受け止められている。こうした傾向に危機感を抱いた日米欧をはじめとする各国は、科学技術政策における重点課題のひとつに理数系教育の充実を取り上げ、科学技術分野の人材育成と確保に力を注いでいる。

とりわけアメリカは、1950年にNSF（全米科学財団）が設立されて以来、理科教育プログラムに対する支援が本格化。各省庁はSTEM（科学・技術・工学・数学の英語頭文字）教育プログラムを実行に移している。

オバマ政権下となった現在、すでにSTEM教育は科学技術分野の人材を育成するための国家戦略と捉えられ、科学技術に対する子どもたちの動機付けや理解促進から、国民全体の科学技術リテラシー向上に至るまでを包括した取り組みとして国民に浸透しつつある。

次ページ「STEM教育プログラム」へ 2
<<前のページへ 1 2 3 次のページへ>>

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Figure 7. a) A middle school student uses the SEM to observe ZnO nanoparticles he synthesized. b) An article Hitachi, Inc. published in a Japanese financial newspaper about the SEM and its use in the IEG summer program.

3.5 Community events

During the time the TM3000 was at the University of Wisconsin-Madison, it was used in two large community events. On the first Saturday of every month, UW hosts a Science Saturday with a particular theme. When the theme was size and scale, MRSEC faculty brought the SEM to Science Saturday and taught members of the public about the microscope and how to operate it. In addition, over 1000 members of the public had the opportunity to interact with the instrument during the biennial Engineering Expo event held on the UW Engineering campus (Fig 8).

Figure 8. Middle school students learn about the TM3000 SEM during Engineering Expo on the UW-Madison campus.

Another type of community activity in which the SEM was utilized, was a Nerd Nite event. Nerd Nite is a monthly event held in more than 50 cities across the world including Madison, WI[4]. Members of the public are invited to attend and listen to local experts talk about their favorite scientific topic in local taverns. Ben Taylor, the assistant director of IEG, gave a talk on honeybee evolution using SEM images of bee anatomy that he had collected on the TM3000 SEM (Fig. 9). Due to the popularity of his talk, Taylor has been invited to present at the international Nerd Nite convention in August 2013.

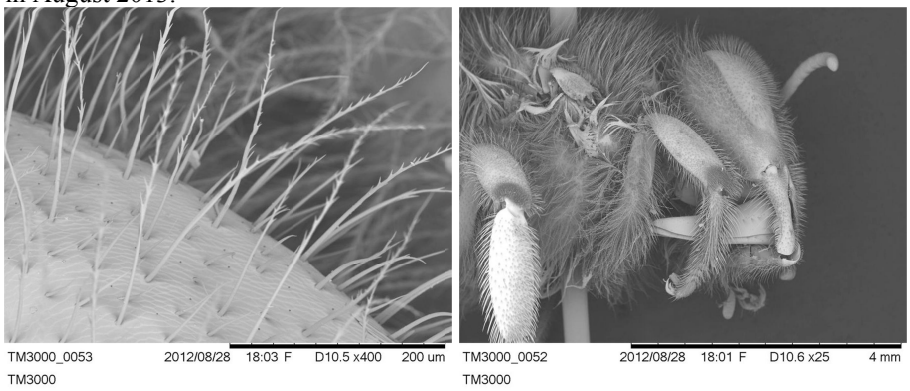

Figure 9. SEM images used during a Nerd Nite talk on honeybee evolution; bifurcated bee leg hairs (left) and a bee tongue (right).

4. CONCLUSIONS

During the time IEG had the TM3000 SEM, over a thousand K-12 students and members of the general public had the opportunity to use an instrument that is often only available to scientists and engineers. Through these interactions participants learned about size and scale, the challenges of working at the nanoscale, and the tools materials scientists use to do this type of work. Due to the level of excitement generated by the SEM, these events were covered in three newspaper articles. Many members of the UW community and educators in Wisconsin have express interest in borrowing the SEM for use in education and outreach activities.

As a result of the interest and excitement generated by the TM3000 SEM, the UW College of Engineering and the UW Materials Research Science and Engineering Center collaborated to purchase the microscope in February 2013. The SEM is being used for research, instruction in an undergraduate engineering course, and for outreach events. IEG is beginning to develop new materials science curriculum that incorporates the SEM. Finally, the UW is developing a process that will allow local schools and communities to borrow the SEM for up to two weeks.

REFERENCES

[1] "University of Wisconsin Materials Research Science and Engineering Center on Nanostructured Interfaces" <http://mrsec.wisc.edu> (29 April 2013)

[2] "University of Wisconsin – Madison Materials Research Science and Engineering Center Interdisciplinary Education Group <http://education.mrsec.wisc.edu/Edetc/ > (29 April 2013)

[3] "Change the Equation, Our Mission and Goals" < http://changetheequation.org/our-mission-and-goals> (26 April 2013) http://changetheequation.org/

[4] "Nerd Nite – be there and be square " < http://nerdnite.com/ > (28 April 2013) on 4-28-13