A Study of CCMS Procedures in Curriculum Design and Teacher Education in Support of Diverse Learners in Science

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The work of CCMS partner institutions – the American Association for the Advancement of Science (AAAS), Michigan State University (MSU), Northwestern University (NU), University of Michigan (UM) – focuses on research and development efforts related to science teaching and learning. This work is shaped by attention to numerous principles which form the intellectual core of the Center. One of these principles specifically recognizes the changing racial and ethnic composition of enrollment in U.S. public schools (U.S. Department of Education, 2007) by focusing on the need to serve diverse learners.

The purpose of the investigation presented here was to document the nature and extent of the attention that CCMS partner institutions have given to the science learning needs of students from varied backgrounds during the five years of project activity. We also hoped to highlight the key developments and approaches that have been used to support science learning for all students, especially those for whom science instruction has not been sufficiently helpful in the past.

Procedures

In-person and phone interviews were conducted with a total of 13 CCMS personnel including six project coordinators, three professorial staff, two post-doctoral fellows, and two graduate students. On average, interviews lasted 45 minutes. Interview questions focused on four key areas of CCMS activities: research, design of science curricula and instructional materials, preservice and in-service teacher education, and preparation of new leaders in the field of science education and curriculum materials development. The questionnaire protocol is attached as an Appendix.

Attention to all learners

Work around the needs of diverse learners in science was found to exist in a range of forms reflecting the multiple facets and contexts of ongoing CCMS work. Consistent across these forms is an attention to "all learners" that is broad and inclusive, rather than a systematic focus on specific sub-populations or individual student identities defined by racial, socioeconomic, linguistic, geographic, or other criteria. However, interview responses did reveal careful consideration of these same criteria at the school- and school district-level

when attempting to ensure a broad spectrum of participation during certain research and development activities.

An explicit focus on specific population groups was associated with several potentially negative characteristics by some participants. These include risks of essentializing and stereotyping students, as well as the possibility of masking substantial differences that may exist within apparently homogenous populations. In contrast, CCMS work was described in terms of efforts to develop "general technology and supports" that are inclusive of the range of students in science classrooms.

Multiple participants referred to traits found in high quality curriculum materials and effective instructional strategies seen to work across diverse student groups. These include engaging learners with interesting and relevant scientific phenomena, relating new concepts to prior ideas and experiences, and presenting opportunities for students to make their thinking visible. For a national curriculum like IQWST, these kinds of features are important for promoting consistent learning results in a variety of contexts. To this effect, three participants made mention of the similarities they witnessed in the way that IQWST materials had played out with different students in different learning environments.

In order to successfully focus on all learners, CCMS partners have been strategic in selecting diverse sample populations for their research and development efforts. Multiple participants commented on efforts to work with students who are representative of varied geographic settings, ethnicities, academic performance levels, socioeconomic status, and grade levels where possible and appropriate. As mentioned previously, these activities necessitated consideration of demographic information at the level of the partner districts and schools. At the same time, participants consistently expressed little interest in collecting or using the demographic data of individual students in an attempt to determine or explain patterns in their data. In fact, one participant spoke of "deliberately denying" access to that kind of information in this work.

Supports for preservice and practicing teachers

The teaching force of the nation's school is known to show little of the same diversity found in the student population (Banks et al., 2005). Furthermore, racial biases, ethnic stereotyping, and negative personal views can cause some teachers to devalue the resources that minority students bring to school (Gay, 2000). Being able to recognize similarities and differences in students' backgrounds and experiences, along with a strongly held belief that all students are capable of learning, are essential characteristics of science teachers today (National Research Council, 1996). For these reasons, one of the interview

questions specifically asked about CCMS efforts to support prospective and practicing teachers in accommodating a wide range of students in effective learning of science.

Responses revealed that consideration of the ideas and experiences that children bring to science class comprised a central theme of preservice teacher education at both MSU and UM and of professional development activities for practicing teachers. Particular emphasis was placed on introducing supports that would help novice teachers elicit and value students' thinking and prior experiences, and leverage these during lesson planning and enactment.

CCMS work at MSU around preservice teacher education includes development of a planning cycle supported by various frameworks. The frameworks, described as "very specific and concrete tools," help organize preservice teachers' thinking about subject matter, learning goals, and what their students "bring with them" are as science learners. The frameworks provide scaffolding for preservice teachers to consider where a group of students is starting from, in terms of science skills and knowledge and how to help them move forward toward a particular learning goal.

A number of activities are used to complement the frameworks and foster preservice teachers' professional growth in recognizing and building on students' individual resources. These have included a book club featuring *Ways with Words* (Heath, 1983), academic readings around funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992), reflective writing assignments, and facilitated classroom discussions. Opportunities have been designed for preservice teachers to talk with various people in nearby communities to better contextualize their field placements experiences, to allow them to see the science in a variety of people's daily routines, and to provide for more personal and "generous" understandings of people who may be different from themselves along a number of indicators.

Given the poor reviews of typical science textbooks (Kesidou & Roseman, 2002), teachers' ability to engage critically with curriculum materials is important facet of their professional identity. In elementary science methods courses, increasing attention is being paid to how teachers' comprehension of students' funds of knowledge can inform this process. At the same time, preservice teachers can use the curricular goals and pedagogical approaches of instructional materials as a lens for thinking about their students. In using this "critical analysis for planning," preservice teachers may be able to move towards more culturally responsive planning and teaching. A more detailed consideration of this topic was given in the poster titled "Considering Students Strengths" by Calabrese-Barton, Gunckel, and McLaughlin at this year's Knowledge Sharing Institute.

In addition to developing skills associated with anticipating children's ideas, work at UM with preservice teachers encourages them to see the reasonableness of children's ideas. Selections from the current literature are chosen to emphasize, among other things, the diversity of students' cultural backgrounds and that different backgrounds may be associated with different resources for learning. Activities such as interviews with school children and follow-up classroom discussions are designed to help the preservice teachers better understand the diversity as well as the rationality of children's ideas about scientific phenomena. Hypothetical classroom scenarios, sometimes with a focus on difference, also have been carefully designed and used as discussion starters to develop preservice teachers' awareness of the need for problem-solving strategies.

Support for current preservice teachers, as well as novice science teachers, can be found online at UM's CASES website (http://cases.soe.umich.edu). In addition to describing students' likely alternative ideas for various science phenomena, scenarios embedded in lessons posted on the site engage teachers in thinking about ways to adapt lessons to varied student backgrounds and teaching contexts. Analyzing stories was described as one way of giving preservice teachers a head start towards developing a "professional vision" of lesson enactment that considers how specific lessons may play out with particular groups of students.

While interview participants from both universities promoted anti-deficit views of students' resources, they also acknowledged multiple challenges to developing preservice teachers who are responsive to diverse learners' strengths and needs. These include assisting preservice teachers to not only see the differences that might exist between themselves and their students, but also the variation within groups of students who may at first appear deceptively similar. As one respondent stated, "What we try to do is at least help them recognize that they can't assume that every kid is just like them. Even if all the kids in your classroom look like you, even if you're white and all the kids in your classroom are white, that doesn't mean that you're going to just have smooth sailing, and you can't just assume that they're one homogenous group."

Preservice teachers' views of science and of their roles in the classroom were both considered potentially counterproductive to getting to know students, to learning about their cultural resources, and to building on children's diverse initial conceptions. When preservice teachers lack a "nuanced" vision of science, students' ideas may be erroneously sorted into a dichotomy of right and wrong answers instead of being placed on a continuum that can be used as a starting point for learning. Also, some preservice teachers see their classroom role as one of presenting information, and controlling and directing student behaviors and

activities. When these views take priority over getting to know students and their thinking, "it makes it very difficult to 'hang out' – just watch and listen and see and ask." Part of the ongoing work at these institutions is aimed at defining experiences for preservice teachers that are potentially transformative in light of these challenges.

Professional development activities with practicing teachers identified through the interviews included opportunities to acquaint teachers with the pedagogical approaches embodied in new curriculum materials and how to use, effectively, particular features, such as driving questions. Workshops have also targeted classroom practices felt to be broadly effective, such as giving feedback, connecting science phenomena to students' backgrounds, and demonstrations of how to help students work collaboratively and have productive discussions.

Professional development also has focused on encouraging teachers to pay careful attention to how students reveal their thinking through their talk and actions. Though teachers hear children talking all day, getting teachers to appreciate what children say "as some of the best evidence we have of what is going on in their heads" represents a significant shift in behavior for many teachers. Perhaps not unexpectedly, several interview participants identified time as an important factor in the success of professional development activities. In the example previously described, progress was felt to be made in getting teachers to see the need for listening carefully to students, but not enough time was available to support them in developing and practicing strategies for how to do this.

Supports in curriculum materials

While curriculum materials are known to act as primary supports in the teaching of science (Lynch, Kuipers, Pyke, & Szesze, 2005), serious deficiencies exist in the approaches to content and instructional support offered to teachers by major textbook publishers (Kesidou & Roseman, 2002). In their work related to the design of new science curricula and instructional materials, interviewees were asked to identify some of the ways in which they have attended to the learning needs of diverse students.

Several respondents identified features intended to make IQWST materials "educative." When curriculum materials are educative, they offer important sites for teacher learning (Ball & Cohen, 1996; Davis & Krajcik, 2005). For example, materials developed through CCMS help teachers understand the pedagogical rationale for activities, further develop their own science content knowledge, and anticipate students' thinking about particular phenomena such as the nature of gases. IQWST materials are also

designed to have a "developmental focus" which takes into account students' initial understandings and assists teachers in building on these ideas over time.

While teachers directly mediate many of the interactions between students and curriculum materials, numerous features were identified in the interviews that are designed to impact students' learning more directly. During interviews, three people described an explicit emphasis in the design of materials to create opportunities for students to externalize their thinking, and thus make valued contributions to classroom discussions. This inclusive strategy encourages all students to develop their own ideas before sharing them with other classmates, before being exposed to scientifically normative ideas in the materials.

Interviewees across all four CCMS partners described the importance of taking language into account when teaching diverse students. In lower elementary grades, curriculum materials were being designed so that students would have opportunities to externalize their ideas through both writing and drawing. This approach reflects a concern for all learners by creating opportunities for expression by those who do not yet have the skills necessary to do so through text.

Since certain scientific concepts can be obscured through the use of highly technical vocabulary or references to strongly culture-bound contexts, paying attention to the words that are used to present these ideas to students is important. While using fewer words, plain language, and simple diagrams can be effective in promoting understanding, there is also a danger of unnecessarily diluting science content. Careful review of all materials intended for student use is required in order to balance these concerns. Interviewees from AAAS, NU, and UM referred to in-house and external personnel with literacy expertise who take a lead role in evaluating the accessibility of information presented to students. Some also commented on their use of student reviewers of language in curriculum materials and assessment items.

In order to capture the interests of a broad spectrum of students, much attention has been dedicated to providing multiple examples embedded and meaningful, authentic contexts throughout units of study. As one interviewee from NU explained, "We spend a lot of time crafting our materials in thinking about what will kids find interesting - How can we make this problem compelling, and how do we help them see the role that a scientific solution plays in figuring out solutions to societal problems?"

Participants described interviews with students during materials development that revealed that the students found science topics more engaging when they were personalized through connections to their own lives and, in particular, bodies. As a result, driving

questions in physical science ("Can I believe my eyes?"), biology ("How can good friends make me sick?"), and chemistry ("How do I make new stuff from old stuff?") all place the students at the center of the unit's investigations.

Materials have also been designed with situations where students are expected to have conflicting or competing interpretations of data. One potential benefit is that this will facilitate students' recognition of the diversity of ideas and explanations in their own classroom. Another is that, in combination with "carefully crafted teacher-led discussions," it can focus the class on establishing valid criteria for evaluating varied claims. This strategy can also be used to scaffold students' learning of particular scientific practices such as scientific argumentation by building on the capabilities they bring to class. A participant from NU noted, "It's not that these kids don't know how to argue – they do. They're completely able to argue in the real world and back up their ideas. … The question is how to leverage these skills in an academic setting, particularly in a science setting."

Leadership development

All CCMS partner institutions are involved in the preparation of new leaders in the field of science education through their work with graduate students and post-doctoral fellows. One of the interview questions specifically focused on the processes by which these new leaders are being developed.

Mentoring processes specific to the science learning needs of diverse students were not identified. However, interviewees consistently described an apprenticeship model of training. In this model, graduate students and post-doctoral fellows are intimately involved in the regular and authentic research and teacher education activities of the various CCMS partners including those which focus on attending to all learners. An essential component of this process is to have these future leaders visit schools and interact with students in classrooms. These experiences were seen to be especially beneficial for graduate students and post-doctoral fellows who have come to CCMS with science research background, who have limited, recent background in pre-college classrooms. At UM, the model includes a laboratory setting where collaborative work around wrestling with ideas and solving problems is done. As part of their work assignments, graduate students and post-doctoral fellows at MSU were engaged in observation and developmental work, with both preservice and practicing teachers, and some had opportunities to work directly with pre-college students. In all of these opportunities, emphasis was on helping all students learn to understand and use science knowledge in their own particular contexts.

Multiple choice question

The last part of the interview protocol asked participants to rank the centrality of the needs of diverse students in their work with CCMS. The choices given ranged from a high of 5 ("highly central") to a low of 1 ("not considered at all"). A rationale for each response was also solicited from participants. Despite the subjectivity surrounding this particular question, most respondents attempted to quantify their answer. Of ten numerical answers given, eight people chose either 5 or 4 ("moderately central"). Two people also specifically mentioned ongoing efforts to move their score upwards by giving increasingly greater or more considerate attention to diversity in their work.

It was duly noted that any answer to this question would be closely tied to how diversity was defined. For example, one respondent who initially rated themselves at "3" added that the answer depended "on which frame you use." With respect to another frame, this person changed the rating to a "5."

A number of the interviewees who rated themselves lower than 5 indicated that, though quite familiar with the issues related to teaching and learning for all students, they did not consider themselves experts or scholars on diversity or diverse learners. Expertise was associated with foregrounding issues of diversity in research work and making diversity explicit in scholarly writing. While not a primary focus of their work, participants made references to diversity being "the context of" or "playing out in" in their work.

Conclusion

The 13 interviews conducted during this study revealed that work at CCMS partner institutions strongly supports "science for all." However, it has not focused explicit attention on particular categories of the diverse student population as might be defined by geographic, socioeconomic, racial, or linguistic criteria. Instead, numerous efforts in a variety of areas continue to be made in order to attend to the science learning needs of "all learners." Evidence for this was seen in the descriptions of research and development work aimed at producing high quality, inclusive curriculum materials and assessment items, and in professional education that helps novice teachers recognize, value, and make visible, the diverse resources for learning that students bring to school. It was also found in professional development sessions that have attempted to support practicing teachers in listening carefully to children's thinking, and building on students' existing abilities to develop scientific practices and ideas.

It may be that the degree of attention being given to the science learning needs of diverse students is partially obscured by a broad focus on all learners rather than targeted

subgroups, by its somewhat implicit nature in the endeavors of CCMS partner institutions, and by the variety of forms this attention has taken in the multiple contexts of CCMS work. However, it is clear that teaching all students to learn to understand and use science is a central goal of all of the interviewees. While these interviews were effective at exposing some of this attention, they also brought to the forefront numerous challenges that impede these efforts. Innovative and sustained initiatives will no doubt be critical to facing these challenges and better serving the nation's science learners in the future.

Appendix

A Study of Procedures in Curriculum Design and Teacher Education in Support of Diverse Learners in Science

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Interview/Questionnaire

Please provide detailed, specific answers to the following questions. It would be helpful if you can provide specific examples that show how you have designed curriculum materials or activities that enhance learning for diverse students in science.

1. "Science for all" has been a principle of the contemporary reform effort in science education, since its inception. In your own work in curriculum design, teacher education, or research, how does this principle relate to meeting the needs of the diverse learners that populate our schools? Are there segments of the diverse population that receive more attention than others? If so, on which one(s) do you focus your attention?

2. How have you and members of your working group attended to the learning needs of diverse pre-college students in the design of science curricula and instructional materials during the past five years? What new approaches have you used to accommodate a wide range of students in more effective learning of science as part of your research and development efforts? (Please give specific examples, or page numbers from materials that demonstrate these points.)

   Please identify the working group that you referred to above in the answer above.
   _____

3. How have you and members of your working group attended to the learning needs of diverse pre-college students in the education of preservice and practicing teachers during the past five years? What new approaches have you used to support prospective and practicing teachers in accommodating a wide range of students in more effective learning of science as part of your research, development, and enactment efforts? (Please give specific examples that demonstrate these points.)

   Please identify the working group that you refer to above. _____

4. How have you and members of your working group attended to the learning needs of diverse students in the preparation of new leaders in the field of science education during the past five years? What new experiences have you provided for your graduate students and post-doctoral fellows in science education in aiding a wide range of students to attain more effective learning of science. (Please give specific examples that demonstrate these points.)

   Please identify the working group that you refer to above. _____

   5. During the past five years, how central have the needs of diverse students been to your thinking? (Circle one of the numbers below that best expresses the relationship between your work relating to CCMS and meeting the needs of the diversity of students in American schools.)

      5. Highly central to my work.
      4. Moderately central to my work.
      3. Of limited centrality.
      2. Rarely considered in my work.
      1. Not considered in my work at all.

6. If you have additional comments to make about any of these issues, please feel free to add them here. Thank you for your help with this study.

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