Elementary Educators' Perceptions of Design, Engineering, and Technology: An Analysis by Ethnicity

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Abstract

This mixed-methods pilot study extends researchers' understandings about elementary teachers' (K-6) perceptions of design, engineering and technology. In the first phase of the study, a reliable and valid survey was given to thirty-five participants in a teacher professional development academy sponsored by the Institute for P-12 Engineering Research and Learning at Purdue University. Quantitative results suggest that minority teachers are more enthusiastic, more interested and more motivated to pursue design, engineering and technology opportunities and to teach these concepts to their students than majority teachers. In phase two, qualitative inquiry, via narrative analysis and open coding, was used to expound upon the responses from one majority and two minority academy participants. Teachers identified university and industry's disinterest in connecting to local student populations, poverty in the community, missing family units, opportunities to obtain a well-rounded education, and disadvantages within minority populations as factors that impact students' eventual success in design, engineering and technology.

Keywords: K-12engineering education, teacher perceptions, minorities in engineering

Introduction

Calls to increase the representation of minorities in engineering are not rare. The National Action Council for Minorities in Engineering (NACME) refers to the problem of minority underrepresentation in engineering as "the 'new' American dilemma." John Brooks Slaughter, NACME president and CEO, explains:

> The 'New' American Dilemma is this nation's failure to educate and develop a growing proportion of its potential talent base—African Americans, Latinos and American Indians—as its need for people with skills in science and engineering is escalating (National Action Council of Minorities in Engineering, 2008, p. 1).

Despite the convocations to promote policies conducive to increasing the numbers of African-Americans, Hispanics and Native Americans in engineering, many of the current reports and persuasive statements to innovate the teaching of engineering do not include arguments or provisions focusing upon the underrepresentation of minorities (Basken, 2009; Sheppard, Macatangay, Colby, and Sullivan, 2009). Their foci, however, seem to be solely in the low supply of students compared to the projected demand for these students in engineering.

Numerous reports recognize the importance of precollege experiences in student career choices. Teachers' understandings and perceptions are important aspects to consider in the development of student attitudes and knowledge in engineering since teachers' subject knowledge greatly influences their students' abilities in that subject (U.S. Department of Education 2001; National Research Council 2002; National Academies Committee on Science Engineering and Public Policy 2006).

The purpose of the current pilot study is to shed light into teachers' perceptions of design, engineering and technology. These three terms are used to acknowledge the inclusion of design and engineering within technology education (Yasar, Baker, Robinson-Kurpius, Krause, and Roberts, 2006). More specifically, differences in teachers' perceptions by gender and ethnicity are explored. This mixed-methods study builds upon results of a reliable and valid design, engineering and technology (DET) survey developed at Arizona State University (Yasar et al., 2006). Within this study, the DET Survey was given to 35 elementary teachers who participated in a week-long teacher professional development workshop at Purdue University in the summer of 2007. Extending survey findings, the researchers interviewed two minority teachers and one majority teacher to explore more in-depth perceptions the teachers had of design, engineering, and technology.

Literature Review

There is consensus about the importance that precollege experiences have in the preparation of scientists and engineers, specifically among minorities. The 2005 Nation's report card states that:

> In 2004, approximately 7 percent of Whites, ages 18 through 24 who were no longer in elementary or secondary school, had not graduated from high school. The corresponding percentage for Blacks was 12 percent. For Hispanics, it was 24 percent, and for Asian/Pacific Islanders, it was 4 percent… Black and Hispanic graduates were less likely than White graduates to have completed calculus or advanced science courses and to have higher GPAs…(National Center for Education Statistics, 2007, p 28).

Authors have recognized many factors as possible causes of underrepresented minorities' disadvantages in science and engineering. Among these factors include the low socioeconomic status of minority families, an absence of parental support (especially within single parent households), language and cultural barriers, low socioeconomic status of schools, (particularly inner-city or rural schools), and a lack of role models and mentors, including little to no representation of minorities in the teaching profession (Gasbarra and Johnson, 2008; Matthews, 1990; Dix, 1987; Jones, Mullis, Raizen, Weiss, and Weston, 1992; National Science Foundation, 1999;Ramirez, Laurel, and Rodriguez-Aguilar, 1999). In a study of barriers for African-American students, Hall and Post-Kammer (1987) noted that the students were not entering science careers because of poor academic preparation, differing career interests, a lack of educational and career planning, and an absence of role models and career opportunities.

Despite the barriers that minorities might have entering science and engineering careers, research points to the positive attitudes that many students have about science and about curricular changes that can be made to assist these students' chances for success in science or engineering careers. Using National Educational Longitudinal Survey (NELS) data from 1988-1992, Hanson and Johnson (2000) found that compared to White women and to African-American males, African-American women were not disadvantaged on a variety of science measures, and, when compared to White women, had more positive attitudes about science. Jones, Mullis, Raizen, Weiss and Weston (1992), and Kahle and Lakes (1983) found that White and African-American females were more motivated to continue taking science courses when they engaged in science activities outside of the classroom or engaged

in inquiry-based, hands-on classroom activities (Greenfield, 1996). Newbill and Cennamo (2008) recommend that when designing curriculum for girls, instructors recognize and examine the negative emotions that girls have about science, connect girls to positive female role models who demonstrate positive attitudes about science, and acknowledge the current attitudes that girls have about science.

Related to teachers, a factor that has gained interest is that of their perceptions and the influence of their perceptions on minority students. Matthews (1990) reported the inequalities in teachers' counseling and feedback between minorities and non-minorities in Chicago metropolitan area schools. Authors identify the classroom environment and teacher perceptions or "teacher warmth as factors related to minorities' attitudes about science and/or engineering (Gilmartin, Li, and Aschbacher, 2006; Weinburgh, 2003; Weinburgh and Steele, 2000; Brown, 2002; Brown, 2008). For the case of Hispanics, the roles that teachers play in the students' acquisition of a scientific or engineering identity were found to be comparable to the roles of the family (Brown, 2002; Brown, 2008). For this reason, misconceptions or negative attitudes of teachers toward their students can cause devastating effects in the career interests of minorities and in their subsequent pursuits of an engineering career.

Literature in engineering education emphasizes the role of preschool to 12th grade teachers in the attitudes of minorities in precollege classroom. In 2004, the American Society for Engineering Education published an analysis of current practices and guidelines for the future of engineering in the K-12 classroom (Douglas, Iversen, and Kalyandurg, 2004). A portion of this report included a survey about teachers' thoughts of engineering as an academic career pathway for students. Shockingly, from the 522 respondents (92.3 percent of them White), 56.9 percent thought that "some" of their students could succeed as engineers. For their perspectives on women and underrepresented minorities, engineering had the lowest "accessibility" score compared to professions such as law, medicine, finance and teaching. In other words, to the majority of surveyed teachers, only some students could succeed in engineering since women and minorities have limited access to the field. Similar teachers' perspectives are reported by Yasar et al., (2006). In this study, teachers were asked whether most people feel that minority students (i.e., African American, Hispanic/Latino and Native American) can do well in design, engineering and technology. The authors reported that within their sample, teachers do think that "most people have stereotypical perceptions of the lack of ability of females and minority students to do well in engineering" (p. 212). This situation is surprising given the influence that many teachers have over students and their career paths.

Pilot Study Design

Because the purpose of this pilot study was to examine teachers' DET (Design, Engineering, and Technology) perceptions, as well as to understand qualitatively why some of the teachers responded as they did to a portion of a design, engineering, and technology (DET) survey, a sequential-explanatory-integrated mixed methods approach was used (Creswell, 2003). More specifically, this approach "begins with a quantitative method in which theories and concepts are tested, to be followed by a qualitative method involving detailed exploration with a few cases or individuals" (Creswell, 2003, p.16).

Phase 1: A Quantitative Exploration of Teachers' Perceptions of Design, Engineering, and Technology

Research Question

This phase examined elementary teachers' perceptions of the importance of DET, their familiarity with DET, stereotypical characteristics of engineers, and characteristics of engineering using a survey developed to understand K-12 teachers' perceptions of design, engineering and technology (Yasar et al., 2006). Human subjects' approval was obtained prior to administering the survey. Although the participants were motivated to attend the workshop, many of the teachers had not engaged in K-12 content with a primary focus on engineering prior to the summer of 2007. Given this lack of exposure and the diversity of the teachers and the environments in which they teach, the authors expected to note differences across teachers relative to their familiarity and excitement about DET concepts. The research question for this phase asks, "What are majority and minority elementary teachers' perceptions of design, engineering and technology?"

Sample

Thirty-four participants were included in this phase based upon their participation in the summer of 2007 in a national professional development academy sponsored by the Institute for P-12 Engineering Research and Learning (INSPIRE). INSPIRE is a research center with two primary missions: (1) to build theory related to engineering education, and (2) to inspire diverse students to pursue engineering through formal P-12 engineering experiences (Institute for P-12 Engineering Research and Learning, 2009). The purpose of the academy is to enable elementary teachers to convey a broad perspective of the nature and the practice of engineering; to articulate differences and similarities between engineering and science thinking, to develop a level of comfort in discussing what engineers do and how engineers solve problems with preschool to 6th (P-6) grade students, and to use problem-solving processes (i.e. science inquiry, model development and design processes) to engage P-6 students in complex open-ended problem solving. The academy consists of a week-long workshop in which teachers are informed of the nature of engineering and what engineers do. It includes team-based, hands-on design activities that emulate the work of an engineer.

The team aspect in the selection of participants was important since teams of teachers could work together to implement engineering concepts in their schools and to provide support each for other. The national academy consisted of 35 participants or nine educator teams from Indiana, Louisiana, Missouri, New Mexico, Pennsylvania and Texas. Teams were selected based on a number of criteria, including evidence of a desire to improve student learning and access to engineering; evidence of a team plan for working together on the implementation of engineering activities during the 2007-08 academic year; school demographics, potential student impact, and participant demographics.

Tables 1 and 2 display information about the gender, teaching experience and ethnicity of academy participants. Female teachers outnumbered male

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	Preschool, Kindergarten, 1st	2nd	3rd	4th	5th	6th	7th	Multi-grade
National	0	2.94%	35.29%	29.41%	2.94%	5.88%	0	23.52%

Table 1. The Percentage of 2007 national academy participants teaching in each grade.

Total National	Gender	Years of Teaching	Ethnicity
34participants	26 female 8 male	15 (≤ 5 years) 12 (6-10 years) 3 (11-15 years) 4(≥ 16 years)	10 minority (6 African-American and 4 Hispanic-American) 24majority (White)

Table 2. Self-reported demographics of national academy participants.

teachers, majority teachers outnumbered minority teachers, and the majority of the elementary teachers taught third and fourth grades.

In order to provide impact and relevance, we looked into national trends for gender and ethnicity among teachers. The representation of INSPIRE National Academy participants by gender and ethnicity mirror national trends, thereby increasing the likelihood that results can be generalized in further research. According to the 2000 U.S. Census, approximately 21 percent of elementary and middle school teachers are male, and 79 percent are female. Approximately 82 percent are White non-Hispanic (majority), 5.5 percent are Hispanic, and 9.1 percent are Black non-Hispanic (US Census Bureau, 2009). Of the National Academy participants, 23.52 percent were male and 76.47 percent were female. Seventy-one percent were majority, and 29.41 percent were minority.

Adding to the diversity of the teachers was an exploration of the schools where the sample of teachers worked. Using data extracted from the National Center for Education Statistics (2009), information about the location of the national academy participants' schools, the race/ethnicity of students within these schools, and student eligibility for free or reduced price lunch is presented (see Table 3). In all, nine national schools are represented. Seven schools have more than half of their students falling into the category of free or reduced price lunch, and student representation in six schools is composed primarily of minority students. (Note that all six schools had more than half of students under free or reduced price lunch).

Data Collection

The instrument used to analyze the quantitative responses of the academy participants was given to participants at the beginning of the academy. The survey consisted of 41 items using a four-point Likert scale rating and was designed, developed and validated by a research team at Arizona State University in an effort to find K-12 science teachers' perceptions of engineers and their familiarity with teaching design, engineering and technology (Yasar et al., 2006). Items on the survey were rated from "1" to "4" depending on respondents' levels of agreement, interest or perception of importance where "1" represented the lowest rating and "4" represented the highest rating. Of the

	Location (State)	Amer. Ind./ Alaskan	Asian	Black	Hispanic	White	Eligibility Free or Reduced Price Lunch	Total Number of Students
School 1	TX	0.14%	1.6%	17.32 %	76.3%	4.5%	93.97%	681
School 2	MO	0.69%	0.69 %	57.3%	7.1%	34.1%	55.9%	431
School 3	IN	0.16%	4.4%	6.4%	3.4%	85.5%	9.7%	644
School 4	IN	0.25%	0.25 %	9.3%	5%	85%	71.7%	403
School 5	NM	0	0	0	99.4%	0.56%	99.5%	710
School 6	LA	0	0.42 %	85.4%	0	14.1%	73%	234
School 7	IN	0.45%	5.4%	0.56%	6.1%	87.4%	19.5%	905
School 8	PA	0	1.6%	50.8%	27.1%	20.3%	71.39%	423
School 9	TX	0	0	80.5%	19.4%	0	54.6%	406

Table 3. Student demographics for schools represented by national academy participants.

98 respondents in the Yasar et al.'s study, 61 percent of the respondents who completed the original survey taught first through eighth grades, and the remaining 39 percent taught nineth through 12th grades. Because the DET has been used among elementary and middle school teachers, teacher respondents represented diverse schools and districts, and results noted significant differences between these groups of teachers, the authors deemed this survey to be an appropriate one for use among academy participants.

Items on the survey were classified into one of four DET themes or factors (according to factor analysis). The first factor was the *importance of DET to teachers*. The 18 items that loaded on this factor related to teachers' motivation for teaching DET and teachers' perceived importance of DET in K-12 education. The second factor, *teachers' familiarity with DET*, is comprised of 12 items that explored teachers' prior and current experiences using DET in their environments. The third factor, *stereotypical characteristics that teachers might have of engineering*, includes five items that explores teacher perceptions of engineers' skills along with their views of minorities and women to do well in DET. The final factor, *teachers' perceptions about the characteristics of engineering,* represents six items that relate to typical engineering skills.

Analysis and Results

Authors replicated a previous study by using independent t-tests to analyze survey data such that teachers' race/ethnicity were independent variables for the national academy sample. Descriptive statistics were run for each of four factors identified within the Yasar et al. (2006) study for race/ethnicity as well as factor analyses. The overall alpha for the 41-item survey among academy participants was 0.84 for the sample, and the alpha values for each factor were 0.84 (Factor 1- The Importance of DET), 0.74 (Factor 2- Familiarity with DET), 0.61 (Factor 3-Stereotypical Characteristics of Engineers), and 0.60 (Factor 4-Characteristics of Engineering).

Table 4 reports ethnicity differences among 24 majority and 10 minority participants in the national academy sample. All items in which significant differences were found loaded on factor 1, *the importance of DET.* For each item, the mean per group, the standard deviation of respondents within that group, the standard error of the mean within that group, and the p-values are presented. Minority teachers, more than majority teachers, rated each of the items higher. All 10 minority teachers rated three items, (1) interest in learning about DET in workshops, (2) wanting to teach students to understand the design process, and (3) wanting to teach students about the use and the impact of DET, with the highest rating (i.e., "4"). More variation was found across majority teachers, particularly related to the importance of using engineering to develop technology and in learning about DET via peer training. For each of these items, minority teachers, more than white teachers, identified the importance of integrating engineering and technology, wanted additional information about DET topics via workshops and peer training, wanted to teach their students about DET-related concepts, and saw science as a way to prepare their students for the world of work.

Discussion of Quantitative Results

In Yasar's et al. study, no differences were reported between minority and majority teachers (from a sample of ninety eight teachers, 30 percent of minority groups and 60 percent White). In the study, however, stereotypical results (all groups) were reported and calls to improve this situation were done.

Following this call, in INSPIRE, the authors were fascinated with the en-

Item	Majority (White)				Minority				p-value
	N	Mean	SD	SEM	N	Mean	SD	SEM	
(a) Is important to include the use of engineering to develop technology	24	3.14	0.54	0.110	10	3.78	0.52	0.106	0.0022**
(b) Interest in learning about DET in workshops	24	3.45	0.51	0.104	10	4.00	0	0	0.0034**
(c) Interest in learning about DET via peer training	24	3.08	0.76	0.155	10	3.84	0.42	0.085	0.0067**
(d) Want to teach students to understand the design process	24	3.52	0.50	0.102	10	4.00	0	0	0.0144*
(e) Want to teach students the use and impact of DET	24	3.60	0.49	0.100	10	4.00	0	0	0.0236*
(f) Motivation for teaching science is to prepare students for the world of work	24	3.61	0.51	0.104	10	3.96	0.31	0.063	0.0352*

Table 4. Significant items parsed by ethnicity among national academy participants.

Significant at $p < 0.05$*, Significant at $p < 0.01$**

Scales for the items in the table are listed as follows: (a) "1"=not at all important to "4"=very important; (b), (c) "1"=not at all interested to "4"= very interested; (d), (e), (f) "1"=strongly disagree to "4"=strongly agree

thusiasm that minority teachers in the sample demonstrated for working with their students, specifically of those teachers providing the highest ratings. However, given the barriers for underrepresented students entering careers in science and engineering, and given the nature of the survey, the authors could not tell if the teachers had personal experiences working with students who would not have access to DET experiences or if they intuitively believed something about their students that majority teachers did not believe.

In order to better comprehend how minority teachers responded in the manner they did, and in order to understand how minority teachers' perceptions of DET might relate to the barriers of underrepresented students in science and engineering careers, the second phase of this study was conducted.

Phase 2: A Qualitative Investigation of Minority Teachers' Perceptions of Minorities in Engineering

Sample and Data Collection

Convenience sampling occurred via the identification of representative groups (majority and minority teachers). After sending recruitment e-mail messages to potential participants, three teachers agreed to participate in the second phase of the research study. Minority teachers, who had provided the highest ratings in survey questions included Connie, an African-American female, and Lorraine, a Latina. The majority teacher was Marsha, a White female teacher.

At the time they responded to the survey, all teachers worked in schools composed primarily of minority students and schools with more than half of their population under free or reduced price lunch. Therefore, in terms of work scenarios, all teachers shared a common background. Confidentiality was maintained and all participants received pseudonyms. The three interviewees completed informed consent forms prior to being interviewed.

The interview protocol consisted of asking participants why they had responded in the manner that they had for the survey questions, specifically those where differences among groups were relevant. In all cases, participants were reminded of the questions and their responses. Connie's interview had a duration of 27 minutes, Lorraine's was 41 minutes long, and Marsha's was 27 minutes long. Both open coding and narrative analysis were used to interpret the data. Narrative analysis was selected as one of the qualitative analysis techniques since minority participants felt compelled to provide their own representation of events in the form of stories, in other words, their "own life story, organized temporally and thematically" (Rappaport, 1995, p. 803). This type of analysis consists of the reduction to the core narrative or skeleton plot. Elements of this analysis include the following:

1. *Abstract:* One or two clauses summarizing the whole story.
2. *Orientation:* Identify in some ways the times, places, persons, and their activities or situations.
3. *Complicating action:* Then what happened?
4. *Evaluation:* The means used by the narrator to indicate the point of the narrative, its *raison d'être*, why it was told.
5. *Result or resolution*: What finally happened.
6. *Coda:* Options open to the narrator for signaling that the narrative is finished. Codas may also contain general observations or show the effect of the events on the narrator (Labov, 1972, p. 364)

Narrative analysis was just one technique of interpretive analysis that the minority teachers gave the opportunity of using because of their story-like inputs. Open coding was also selected as another analysis technique because qualitative data, not provided in the manner of stories, was obtained from all teachers, particularly during the interview with the non-minority participant (Strauss and Corbin, 1998).

Analysis

Minority Teachers' Responses

Making use of narrative analysis, a framing of responses for Lorraine and Connie are provided in Figures 1, 2, and 3 below.

Story 1 – A Tale of University and Industry Disinterest	
Abstract:	**Interviewer**: Why do you think people thought differently? [*Regarding minorities in Design, Engineering, and Technology*] **Connie**: I am not sure. I am wondering if it's anything with this being heavily an engineering area with Purdue. They are very visible there.
Orientation:	**Connie**: You see we have engineering companies but they aren't as visible, and they are not as hands-on and involved in the community and in the area.
Complicating Action:	**Connie:** And I don't think we have in Arlington in Texas. I don't think we have that focal point.
Evaluation:	**Connie:** Because we have Doskocil, we have Lockheed Martin, we have Bale & Textron; but we don't have anyone that's really vested into the community and getting out there telling the kids and showing interest in the education of the kids**.**
Resolution:	**Connie:** Purdue seemed like a step forward, when we were there visiting. It was a like a center part that held all that area together.

Figure 1. Story 1 – A tale of university and industry disinterest.

Story 2 –A Tale of Poverty	
Abstract:	[*Participant previously talking about her personal parental support to succeed in her education*] **Interviewer:** So you think that's what is lacking in these other minority students; that push from their parents. This is the gap that you would see?
Orientation:	**Lorraine:** I think a lot of families find that, well, they need to survive. So their sons or daughters get to working age in high school and the whole family unit is to support each other.
Complicating Action:	**Lorraine:** And so once the child is able at 15 or 16 to start working, and they are bringing some money, then they also have become dependent on that money. Also the child's aware of that…I mean, I'm thinking of Mexican-Americans here…
Evaluation:	**Lorraine:** If they start looking at college, the expense becomes so great even with financial-aid, and they don't always have the information.
Resolution:	**Lorraine:** I think the parents generally speaking want more for their kids, they want better for their kids…but I think the day-to-day survival and financial challenges that they face are sometimes too great for them moving on {sic} with their education.

Figure 2. Story 2 –A tale of poverty.

Story 3 –A Tale of Lack of Family Unit	
Abstract:	[*Linear Continuation from Story 2*] **Interviewer:** Do you think this is also applicable to the African-American community? **Lorraine:** Oh yeah definitely...I work with a Title One school that is probably the poorest school where I work…
Orientation:	**Lorraine:** Just showing up for school, their parents are not there when they wake up for whatever reason. Whether they are at work or they didn't even come home. They feel like they are just on their own, that they are already little adults that they have to go to school so they don't have the family unit for one and then also the financial…
Complicating Action:	**Interviewer:** What is the family unit you are referring to? **Lorraine:** Uh, having a parent and I don't necessarily mean a mother and a father, just having a parent, an adult at home. Umm that cares for them, and I mean like I said, the area where I teach has high crime.
Evaluation:	**Lorraine:** African Americans a lot of times generally speaking, umm, you know you have the exceptions to the rule, but generally speaking parents are never there, the kids are walking by themselves sometimes in the rain, in the cold.
Resolution:	**Lorraine**: They are very much more on their own than some of the Hispanic students…We can still call a mother or father for a Hispanic child…

Figure 3. Story 3 –A tale of missing family units.

The two minority interviewees responded to why they rated their interests in learning about DET in workshops and peer-training highest on the survey. Lorraine mentioned that she was weak in DET and considered many other teachers to be weak as well. Therefore all possible ways to learn DET were valuable to her. In her own words, "The more that I know about it, the more that I can share, and the more I can teach." Connie mentioned that she responded in the way she did because she valued the camaraderie and the fellowship of workshops and peer-training, in which partners help each other. She did not value in-service training because, in her view, it consisted of a mere passive reception of information, which she considered to be a waste of time.

Lorraine and Connie also responded to survey questions about wanting to teach students to understand the design process and to know about the uses and the impacts of DET. Lorraine said that everything was integral and that, "all those pieces come together for everybody." Connie said that she taught in an economically disadvantaged neighborhood, and she wanted students to know, "all it is about science, everything, every avenue that they can possibly learn." She also said, "I would like for them to have a well- rounded, well-formed education so that they can advance, so that they can get out of their environment, and so that they can get out of their surroundings that they are in."

Finally, Lorraine and Connie were asked about their high motivations for preparing students for the world of work. They were asked if the visions they had for their students were to go from high school directly to the world of work in contrast to preparing them for college. Both participants responded categorically to this example that such was not the case. Both of them wanted students to be prepared for college. Lorraine mentioned that, "if they go into the field like engineering, then they are well-rounded engineers." However, both acknowledged that realistically speaking, this scenario probably was not going to occur. Lorraine said, "We need to give them as much as we can while we still have them," while Connie mentioned, "They need to be prepared to be an asset to the community, not a burden".

Majority Teacher's Responses

Marsha's responses differed from the responses of Lorraine and Connie. Marsha did not remember exactly why she rated low both forms of professional development experiences related to DET, but she said that after the academy she would change her responses. She assumed she has not had positive experiences involving workshops. When asked about her motivations, she rated her motivation to promote an enjoyment of learning for her students above all other motivations, including the motivation for preparing students for the world of work.

Marsha, being the last interviewee, was repeatedly asked why she thought minority teachers differed in their ratings from majority teachers on items listed in Table 4. She mentioned working in a low-income and minority school by the time she attended the academy (this was corroborated by the analysis of school demographics of Table 3.) She repeatedly responded that she would not know why she had rated differently than minority teachers, but when asked about possible differences in teachers' motivations, her response showed agreement with what Connie and Lorraine had previously expressed:

> "Ok, alright so maybe part of it is because sometimes there aren't the advantages that some other kids get, so maybe this is the way that those kids get advantages in that sense."

At the end of the interview, Marsha made a case of why the enjoyment of learning was also very important for minorities.

> "But I mean, I, teaching in like a higher minority level, I still feel like the enjoyment is very important, even especially kids that come from families of low poverty. Like to understand low poverty you understand {sic}, if the parents have any money they will buy possessions, they don't save it like they don't value money like the middle class. They don't value it in the same way so if they have money, they buy possessions because they value possessions. And this is just, this is Ruby Payne, I don't know if you've ever heard of her but she has a whole study on teaching minorities or teaching low income. But so I mean, I mean the families that I taught they may have had, you know, like 42 inch flat screens, Wii's, Play station 2's, all that stuff. So I mean even these, these kids need even more motivation when they are away from that kind of stuff. So I feel like you have to let, you have to show the enjoyment of it and then, I think you can really show how it applies to what they are going to be doing in the real life."

Interpretation

Using member's checks as the validity mechanism, our interpretations are as follows (Lincoln and Guba, 1985). Building upon the initial study, five themes emerged from the qualitative analysis. Narrative analysis helped in the identification of (1) university and industry's disinterest in connecting to minority students, (2) poverty, and (3) missing family units. Open coding, in addition, helped in the identification of common ideas such as, (4) the importance of getting a well-rounded education, and (5) recognition of the disadvantages of the minority population.

In our case, a well-rounded education refers to the emphasis given to all areas that are supposed to be taught in school. This emphasis reflects teachers' desires for students to get the most out of their precollege education. This theme is also consistent with the responses given to, "getting students prepared for the world of work" in which there are two tacit implications:

1. An acknowledgement that the system will, "loose them once they complete 12th grade," and
2. A latent risk to become a burden, which can be interpreted as dependence on the welfare of others.

The last theme from the open coding, "disadvantaged population status," can be seen as an explanation for both minority teachers being eager to learn from different sources and to teach as many DET-related concepts as possible. Lorraine's reference to her own weakness in DET areas and Connie's references to the disadvantaged neighborhood where she and her students are located are two instances of this theme. Interestingly, Marsha also recognized that minority teachers could be more enthusiastic because of this condition of disadvantage among their students.

Study Themes and Implications

Although this is a pilot study, it provides a foundation for future conversations exploring how differences in teachers' perceptions might impact their views about introducing DET concepts to students who might represent diverse ethnic and socioeconomic backgrounds. This work also might begin discussions about ways to use DET to help underrepresented students to obtain a well-rounded education, even if they must face challenges in or out of school. The motivations for minority teachers to be more interested and more enthusiastic about teaching and learning DET were related to their conditions of disadvantage and their ambitions to overcome several limitations. Poverty, lack of family unit, and disinterest of surrounding universities and industries (marginalization) were the underlying tenets in their stories. The theme of poverty aligns with the findings of Gasbarra and Johnson (2008), Matthews (1990), and Dix (1987). Disinterest of surrounding universities and industries can be linked to established paradigms such as critical theory and Freire's pedagogy of the oppressed (Merriam and Caffarella, 1999). A lack of a family unit aligns with the work of Matthews (1990), Jones, Mulis, Raizen, Weiss, and Weston (1992), and Gasbarra and Johnson (2008) and confirms the role of family in the educational success of minority students. In summary, the three tenets are

in accordance with what other researchers have found as causes that limit minorities' success in science and engineering.

Recommendations

Expansion of Current Work

Future work might extend beyond across the K-12 continuum and in different locations to see if current trends prevail. Appropriate surveys may be used to explore quantitatively how various groups of teachers are engaging in and thinking about DET before and after their participation in professional development workshops related to DET topics. This data would be especially interesting if parsed by gender or by ethnicity/race. A subsample of the respondents could then be interviewed to obtain detailed information about how they proposed to engage diverse populations in DET concepts.

Creation of Future Outreach and Research Programs

Expanded studies could be used to inform the design of future outreach programs and research initiatives. Such programs might expose elementary students to DET concepts early. Given the personal connections between teachers and their students, school systems might collaborate with university and industry outreach programs to develop initiatives that will expose minority and majority teachers to some of the challenges facing underrepresented groups and to assist in the creation of resources that will allow pre-service teachers from all backgrounds to overcome some of the inherent challenges facing students who they will teach. External funding also could be a source for creating such programs and could be used to assess the impact of these programs on targeted populations.

Development for Pre-Service and In-Service Teachers

Similar to efforts in engineering to increase the representation of underrepresented groups in science and engineering careers, efforts to increase the representation of minority teachers with interests in DET are needed in elementary classrooms. In addition, teacher professional development programs might include specific topics related to DET and pedagogical implications for working with diverse populations in elementary education.

Collaboration with National Organizations and Agencies

National organizations and funding agencies might partner with policy makers to engage multiple stakeholders in conversations about ways that science and engineering diversity efforts can begin in K-12 education. Task forces of teachers, parents, scientists and engineers may engage in conversations about the most promising practices for engaging diverse populations in DET activities. Additional conversations about the need to expose young, underrepresented groups to DET concepts could be the plenary topic at national education and engineering education meetings. Subgroups of practitioners and researchers interested in these topics also might be created to develop national and international K-12 initiatives that align with policies (e.g., creation of national engineering standards in K-12 education) that are of interest to the targeted groups.

Conclusions

Researchers noted differences between minority and majority teachers within this pilot study. Quantitative results indicate that minority teachers might have more enthusiasm and be more motivated to learn and teach Design, Engineering and Technology. Qualitative results indicate that part of the reasons could be understood as their own condition of disadvantage and their ambition to overcome limitations. Findings confirm a need to explore further how teachers from diverse backgrounds interact with students who differ from themselves and how such teachers can most positively influence their students, especially those who demonstrate interest in DET in their early academic years. Research implications of this pilot study might involve testing this hypothesis within a larger sample. Practice implications might involve pre-service and in-service teacher training accompanied by university and industry collaborative opportunities. Authors expect this work advances the understanding and representation of minorities in STEM fields.

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