The Story of one Urban High School's Efforts to Improve Student Attitudes, Motivation, Self-Efficacy and Perceptions of Self, School, and Science through Project-Based Science Instruction

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Abstract: Odyssey High School is small inner-city school within a school in a large urban center. Over its five years of existence, Odyssey administrators in collaboration with a set of outside partners have been developing and implementing a school that focuses on project-based learning and supports its teachers in constructing interdisciplinary projects around the school's theme of environmental science. Findings indicate that older students at the school, who were with the school before this reform effort began, are not as vested in the effort as are younger students, many of whom chose to attend the school for its science focus. It appears that positive gains in student self-efficacy and interest toward science have been achieved in the few years since the reform effort has been commenced but there are significant challenges remain on improving student sense of belonging and overall engagement with the school.

Introduction and Purpose

Although there are important exceptions and some successful reform work that is underway, as a group urban high schools often fail to meet the needs of too many of their students, particularly in terms of science education. In many urban high schools with large concentrations of students who live in poverty, it is common for fewer than half of the ninth graders who enter to leave with a high school diploma (National Research Council, 2004). Dropping out of school is but the most visible indication of pervasive disengagement from the academic purposes and programs of these schools. Many of the students who do not drop out altogether attend irregularly, exert modest effort on schoolwork, and learn little.

Engaging adolescents, including those who have become disengaged and alienated from school, is certainly not an easy task. Research has shown that academic motivation decreases steadily from the early grades of elementary school into high school (National Research Council, 2004). Even though schools do not control all of the factors that influence students' academic engagement these disadvantages can be lessened by an engaging school community with high academic standards, skillful instruction, and the support students need to pursue their educational and career goals (Fashola & Slavin, 1997; Teel, Debruin-Parecki, & Covington, 1998). Educators and scholars have recommended that large urban schools be restructured into small learning communities, teachers engage students in inquiry-oriented learning processes, and focus on developing a sense of pride and ownership among students regarding their school. During the previous three years we have been collaborating with Odyssey High School, a small inner city high school, to restructure its curriculum and develop instructional projects to improve student academic engagement (Knapp & Plecki, 2001; National Research Council, 2004). The purpose of this manuscript is to report the outcomes of our work during year two of a five year longitudinal research and development study with Odyssey High and to share our findings with the larger educational research community.

Background

Urban Science Education

The problems that urban schools face have been well documented (Knapp, 1997; Knapp & Plecki, 2001). Teachers and students work under stressful conditions and often experience alienation. Students have high rates of truancy, low rates of graduation, and their achievement levels are lower than those of their peers in non-urban settings (Barton, 1998). In addition, teachers in urban schools are more likely to be underprepared and have limited access to material resources (Darling-Hammond & Sclan, 1996; United States Department of Education, 2001). In addition, teachers in high poverty urban centers, perhaps more strongly than any other group of teachers, face an increased demand for high standards across the curriculum with particular emphasis on math and literacy (Pew Charitable Trusts, 1998). An immediate outcome of this policy is that the limited resources available in the district or school are funneled into math and reading programs, with few resources, such as time, money, and people available to support science. To deal with large classes and little equipment, many urban teachers typically use whole-class instructional techniques (lectures, class reading, completing worksheets), in which students are passive learners. This situation, it has been argued, often results in a "directive, controlling pedagogy" (Haberman, 1991, p. 291) known as the pedagogy of poverty. This in turn leads to poor achievement as noted by Teel, Debruin-Pareck, & Covington, (1998, p. 480) in which they found that "one of the most important causes of African-American students' low achievement in school is inappropriate teaching strategies", which make it difficult for them to reach their full potential, thus alienating them from school.

Urban Student Academic Engagement

There is substantial empirical evidence on the educational conditions that promote intellectual engagement. The evidence suggests that the effect of the educational context on engagement is mediated by three sets of psychological variables: (1) beliefs about competence and control, (2) values, goals and interests, and (3) a sense of social and personal connectedness (National Research Council, 2004). Students tend to not exert effort in academic related work if they feel that they lack the capacity to succeed or that they have no control over outcomes. In fact, students' beliefs regarding their ability to succeed has a direct impact on their intellectual engagement (National Research Council, 2004). For example, a few educational theorists have argued that students of color, especially African-American youth, often develop anti-academic values because they do see any tangible return to school (Obgu, 1997). Obgu and others have proposed that African-American youth do not expect their own success in school to be rewarded. According to Ogbu African-American youth distance themselves psychologically from the failure they believe is inevitable in an unfair society that is biased against them by disidentifying with academic achievement value and by developing a strong identity that is "oppositional" to the dominant culture. This is particularly troublesome in terms of science education because science and the corresponding mathematical skills are often gatekeeper disciplines for social advancement in today's society (Sells, 1973). Thus, if students do not feel that they can succeed in science it is more difficult for them to obtain a career that will allow them and their children to transition out of poverty (Blustein, Juntunen, & Worthington, 2000). However, even if students believe they can succeed in school, they won't exert effort unless they are interested. For example, research has shown that students who are intrinsically interested in an activity are more likely than students who are not intrinsically interested to seek challenging tasks and exert effort to learn and understand the material under study (Downy & Ainsowrth-Darnell, 1999). Further, research has shown that students who feel a connection (either social or psychological) to their schools often show more perseverance toward staying in school and achieving academically (Davidson & Phelan, 1999).

Study Context

Odyssey High School is a small learning community that occupies the third floor of a school building that formerly housed an entire High School. Five years ago the building was split up into three separate schools that stay largely separated, creating small school communities of less than 400 students. Odyssey High is one of these theme-based (environmental science) small-schools with approximately 390 enrolled students. At Odyssey at least 14% of the students are single parents with young children of their own; over 85% of the students are from racial/ethnic minority backgrounds with 13% speaking English as a second language; 20% with disabilities; and all students are from low-income families.

To engage and motivate students, Odyssey provides a broad spectrum of experiences around environmental science topics. Odyssey has chosen to focus on environmental science because "by focusing on the environment

students will be engaged in activities that foster and support a richer understanding of how school work can impact and connect to their everyday lives" (Odyssey High School, 2003). In collaboration with community-based partners, Odyssey has developed a series of innovative project-based environmental science programs designed to motivate and engage students in studying their local environment. Odyssey administration and faculty believe that an environmental science focus coupled with their new status as a small-learning community will improve students' interest and confidence in science (particularly women) (Baker & Leary, 2003), decrease student attrition from the school (Adamson, Foster, Roark, & Reed, 1998) improve student achievement, and increase students' self-efficacy toward science.

Methodology

Data Collection

Data collection consisted of a mixed methodological strategy. First, a survey designed to measure self-efficacy, interest toward science, math, student perceptions regarding gender related issues in science, and their sense of social belongingness to Odyssey was administered. The survey consisted of a total of 60 previously validated questions (Enochs, Smith, & Huinker, 2000; Riggs & Enochs, 1990). We surveyed 174 of the 390 students with 132 of the students being the same from pre to the post survey. Complementing the quantitative data, we conducted focus groups with a random subset of students from each grade. Three focus groups from each grade (9-12) were conducted twice during the school year, once near the beginning of the year and again at the end of the year. One focus group per grade was all female, while the other two groups were mixed sex. The interviews consisted of semi-structured questions (Merriam, 1998) designed to better understand students' views of Odyssey, their beliefs regarding how well the curriculum was preparing them for a career, their beliefs regarding gender equity, their perceptions of the relevance of environmental science to their lives, and their sense of belonging to Odyssey High School. In total we have interviewed 72 students during the previous two years of our work. Unfortunately due to the significant transient nature of the students at Odyssey we have only been able to track forty of the 72 students from year 1 to year 2 of our research.

Data Analysis

Analysis of each survey item was done using chi-square tests, looking for differences among grade, gender, and race. Additionally, four theoretically constructed scales: Science/Math interest, Science/Math self-efficacy, Gender bias, and Sense of Belonging were utilized. Each scale's reliability was then assessed and items with low or negative point biserial correlations were identified. After removing problematic items the reliabilities of the reduced scales were computed. Further analysis was based on the items on the reduced scales. The final reliability of the scales were $\alpha = 0.87$, $\alpha = 0.80$, $\alpha = 0.81$, and $\alpha = 0.87$ respectively. An analysis was conducted to determine if there were differences between the three scales on issues of grade, gender, and race. The focus groups were analyzed using a grounded theory approach with the goal of looking for similarities and differences within and across grades, genders, and racial groups. Lastly, we examined the data for those students who remained enrolled at Odyssey throughout both years of this study.

Results and Discussion

In general, there were significant differences between the entire student-population between the pre-post administrations of the survey on all the scales with the interest and self-efficacy scales showing significant improvement, the gender bias scale showing a significant decrease which means meant that boys tended to perceive girls as just as capable of doing science. However, the sense of belongingness scale showed a significant decrease from the beginning of the year to the end of the year (see Tables 1 - 4)

We found that students' self-efficacy, science interest and gender bias toward girls in science all showed significant improvement during the course of year two (see Table 1). However, upon disaggregation the data we found that the overall gains made by students during the course of the year was due to the girls' scores increasing significantly across the categories of self-efficacy, science interest, with a non-significant decrease in sense of belongingness to Odyssey (see Tables 2). Whereas, the boys' scores showed modest increases but were not significant with the boy's significant change occurring regarding their perceptions of the girls' scientific ability (see Table 3). Upon further analysis we found that the African American students scores changes slightly but not significantly except for their sense of belongingness to Odyssey which decreased significantly (see Table 4).

Overall the students felt little sense of belonging to Odyssey, ownership over their learning, or reasons for studying environmental science (see Table 1). The difference was most pronounced when comparing students who chose to attend Odyssey versus those who did not choose attend Odyssey. For example, the students who chose to attend Odyssey had their sense of belongingness remain steady from the start of the year to the end of the year (M_{pre} = 3.52, M_{post} = 3.51) whereas those students who were assigned to Odyssey had their sense of belongingness decreased significantly (M_{pre} = 3.22, M_{post} = 2.95, $p < 0.05$). We will explore this latter result in more detail in the qualitative portion of our analysis.

We also examined the students who remained at Odyssey from year 1 to year 2 of this study (see Table 5). Given that Odyssey high school has a 45% transience rate it was difficult to maintain high numbers from year 1 to year 2 but we did track 40 students across the two years. The data revealed that those students who re-enrolled at Odyssey scores remained steady with the noticeable exception of their self-efficacy in science ($M_{begining\ of\ year\ 1}$ = 3.83, $M_{end\ of\ year\ 2}$ = 3.47). Given this high mobility rate, we re-examined the data without the migrant students (students who either joined the school late or left the school early in the year). This analysis revealed positive significant differences on the self-efficacy, science interest and the gender bias scale and the sense of belongingness remained steady with no change. What was most surprisingly when removing the migrant population, however, was that the boy's sense of belongingness increased slightly from the start of the year to the beginning of the year. When comparisons by race were reanalyzed we found that African-American students' interest in science increased (M_{pre} = 2.16, M_{post} = 2.23), self-efficacy increased (M_{pre} = 3.28, M_{post} = 3.47) 2.1, $p < 0.05$) and their sense of belongingness decreased (M_{pre} = 3.34, M_{post} = 3.09), though none of these findings were statistically significant.

Table 1: Pre-post results on all scales

Scale	Group	N	Mean	Std. Dev	t-test
Math and Science Interest	Pre	174	2.17	.40	2.25*
	Post	132	2.28	.40	
Math and Science Self-efficacy	Pre	174	3.27	.61	2.71*
	Post	131	3.47	.65	
Gender Bias	Pre	162	4.01	.69	3.49*
	Post	132	3.75	.54	
Sense of Belonging	Pre	172	3.35	.71	2.08*
	Post	132	3.18	.69	

*$p < 0.05$

Table 2: Female breakdown pre-post

Scale	Group	N	Mean	Std. Dev	t-test
Math and Science Interest	Pre	90	2.14	.41	2.40*
	Post	74	2.28	.39	
Math and Science Self-efficacy	Pre	88	3.31	.65	2.05*
	Post	74	3.51	.63	
Gender Bias	Pre	85	4.06	.63	2.40*
	Post	74	3.83	.53	
Sense of Belonging	Pre	88	3.36	.70	1.28
	Post	74	3.22	.70	

*$p < 0.05$

Table 3: Male breakdown pre-post

Scale	Group	N	Mean	Std. Dev	t-test
Math and Science Interest	Pre	83	2.21	.40	0.75
	Post	53	2.26	.43	
Math and Science Self-efficacy	Pre	83	3.23	.58	1.61
	Post	57	3.41	.68	
Gender Bias	Pre	76	3.97	.75	2.77*
	Post	58	3.64	.55	
Sense of Belonging	Pre	83	3.33	.73	1.75
	Post	58	3.12	.67	

*p < 0.05

Table 4: African-American Breakdown (males and females)

Scale	Group	N	Mean	Std. Dev	t-test
Math and Science Interest	Pre	56	2.17	0.37	0.75
	Post	50	2.23	0.40	
Math and Science Self-efficacy	Pre	54	3.32	0.53	1.53
	Post	49	3.49	0.62	
Gender Bias	Pre	52	3.96	0.77	1.67
	Post	50	3.74	0.56	
Sense of Belonging	Pre	55	3.36	0.71	1.98*
	Post	50	3.09	0.71	

*p = 0.051

Table 5: Table changes from year 1 to year 2 (all students)

Scale	Group	N	Mean	Std. Dev
Math and Science Interest	Pre Year 1	40	2.25	.33
	Post Year 1	30	2.27	.40
	Pre Year 2	40	2.25	.35
	Post Year 2	40	2.21	.41
Math and Science Self-efficacy	Pre Year 1	40	3.83	.46
	Post Year 1	30	3.35	.79
	Pre Year 2	40	3.47	.47
	Post Year 2	30	3.47	.51
Gender Bias	Pre Year 1	40	3.48	.46
	Post Year 1	30	3.63	.50
	Pre Year 2	38	4.06	.73
	Post Year 2	40	3.72	.55
Sense of Belonging	Pre Year 1	N/A	N/A	N/A
	Post Year 1	N/A	N/A	N/A
	Pre Year 2	40	3.38	.55
	Post Year 2	40	3.25	.49

*p < 0.05

Overview of our qualitative results

Due to space limitations we will briefly present our qualitative findings here. Analysis of the focus group data revealed that, in general, most students had little interest in science, generally did not feel proud of their school, felt safe and felt that the teachers generally cared about their well being, and felt that Odyssey would be a good school to attend if one was interested in science. The students also noted that the science classes that they took at Odyssey was aligned to a limited degree with how they believed they learned best (hands-on and in groups) but that they would like to see the classes shift more toward collaborative hands-on type of work.

A majority of the students did not know that Environmental Science was the focus of their school and found environmental science to be irrelevant. This is particularly problematic given that the nature of the school was to build student awareness and interest in science yet the students did not have a sense of a common purpose or reason for attending Odyssey over any other school in the district. For example when the students were asked if they were proud to attend Odyssey the typical response is illustrated by the following student exchange during a focus group:

Student 1:	I suppose. Though it is just a high school. You know what I mean? I didn't choose to go here but I don't know what would be different if I went to another school.
Student 2:	I personally would like a bigger school. You get to know everyone here, but there is nothing to do. You know. I like dancing and I just started up a dance club with me and my friends but the school doesn't help or anything.
Interviewer:	How about you? [asking another student in the group]
Student 3:	Yea, I don't know. The teachers here really care about you. I'm not sure you would get that elsewhere. Plus we do get to do a lot of stuff that other schools don't get to, like go the harbor islands, make those submarine things, and take care of turtles and things like that. I think it makes a big difference if you want to do science or not, if you do science then I could see this school being perfect for you, but if not then it is probably just like any other school.

The focus groups also revealed that that most students viewed school science as a pragmatic study, helpful only to someone who wants to pursue a science career, rather than seeing the skills that one develops in science can be useful in other disciplines (which is a goal of Odyssey). While all students saw science as helpful only as a route towards a science career, older students were more adamant toward the irrelevance of science to their futures. In contrast, younger students (9^{th} and 10^{th} graders) tended to view science as part of their future careers and important for them to understand.

Implications

Currently there is a significant movement within the United States to convert large schools into small learning communities. Odyssey represents the typical school-within-a-school, but as noted by the National Research Council, "the research supporting the advantages of the school-within-a-school structure is not as strong as comparing whole schools that vary in size" (National Research Council, 2004, p. 115). However, the research that does exist suggests that the school-within-a-school approach can improve student attendance, student engagement, and student satisfaction (Eichenstein, 1994). Our findings presented here suggest that small theme-based high schools do have the potential to impact students' self-efficacy and interest in science, particularly, if the school teachers and administrators are dedicated to creating a challenging environment for students using project-based learning experiences (Wasly, et al., 2000). However, the findings also reveal that significant work needs to be done in improving students' sense of belongingness. This latter point is critically important as a sense of belongingness to a school appears to be critical if students are to achieve academically and persist in school (National Research Council, 2004). This latter point will be difficult because most students that were interviewed reported a lack of school activities and culture that they could draw upon that would foster a sense of belonging to the school. Unfortunately, improving students' sense of belongingness through additional experiences will be difficult because Odyssey had to cancel its art, music, most other club support, and a good portion of their after school program due to budget cutbacks. Our results also suggest that school districts need to pay much more attention to students' career wishes and ensure that students are placed with a school that best meets their needs and interests in terms of potential careers.

In closing, this work fills a gap in the research literature in that little work has been done in examining the impact of science themed schools-within-a-school on student interest, self-efficacy, and how such schools engage and motivate students (National Research Council, 2004). Lastly, given that the Gates foundation has award millions of dollars to several large urban school districts to break their large schools into small learning communities the work presented here provides some much needed base-line upon which we can evaluate the impact of the wave of small school in regards to student interest, self-efficacy, and perception of their school.

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