

Science Bowl Academic Competitions and Perceived Benefits of Engaging Students Outside the Classroom

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Abstract

The National Science Bowl® emphasizes a broad range of general and specific content knowledge in all areas of math and science. Over 20,00 students have chosen to enter the competition and be part of a team, and they have enjoyed the benefits of their achievements in the extracurricular Science Bowl experience. An important question to ask, in light of the effort it takes to organize and participate in regional or national science competitions, is whether the event makes a difference to the student. And if it does make a difference, does it improve student learning or student attitudes about science? In a preliminary survey, students competing in a Regional Science Bowl Competition report that the event has a positive impact and fosters learning in science and mathematics. These data support findings for other forms of extracurricular academic competitions associated with science and mathematics.

Introduction

Since 1991, the Department of Energy's (DOE) National Science Bowl® has been sponsoring annual regional and national competitions for high school students across the United States of America, including Puerto Rico and the U.S. Virgin Islands. In addition to seeing the pragmatic value of increasing the "feed" of science-educated personnel into DOE research facilities, the DOE recognized that the improvement of science education, broadly, would be of great benefit to the nation. Expanding its focus beyond formal science education at the college level, the DOE started the Science Bowl program to encourage high school student participation and interest in math and science. The idea was to increase science literacy in general and to encourage science- and mathematics-related careers specifically. The success of the high school competitions resulted in the expansion of the program to include middle schools in 2002.

The competitions feature teams of four to five students answering multiple choice and short answer questions in the areas of science, mathematics, energy, and technology. There are currently 67 regional high school and 36 middle school competitions. The high school competitions involve more than 15,000 students and the middle school contests more than 6,000. The winning team from each regional event is invited to Washington D.C. to compete with other winners.

Participation in Science Bowl involves working as a team, and a team's level of success is determined not only by scientific knowledge, but also by teamwork and gamesmanship. The students' engagement in group work directly benefits the individual team members, their social groups, and society as a whole (Greif and Ephross 2011, 6). The actual team formation and function is itself a model for both future community engagement and civic activism. In fact, creating teams is one of the three principal strategies for successfully placing students in service-learning opportunities within communities. (Harris 2009).

The National Science Bowl® emphasizes a broad range of general and specific content knowledge in all areas of math and science. Science Bowl experiences are independent of the classroom environment and generally occur because the students have volunteered to enter the competition and become part of a team. Each team must have a coach, who can be a parent or other interested person, but is usually a high school science teacher. The volunteer aspect of the competition as an extracurricular activity means that it is similar to robotics competitions, the Science Olympiad, and other interdisciplinary, multi-disciplinary, and applied endeavors. All of these programs stress the collaborative and communal nature of the projects over the content, a characteristic shared by other civic engagement and volunteer endeavors (Jacoby and Ehrlich, 2009).

An important question to ask in light of the effort it takes to run regional or national science competitions is whether the event makes a difference to the student. And if it does make a difference, does it improve student learning or student attitudes about science? The literature on science competitions is not extensive. Abernathy and Vineyard (2001, 274) asked students who competed in the Science Olympiad why they did so. The number one reason for participating in the Olympiad was that it was fun. The number two reason was that the participants enjoyed learning new things. These findings held for both male and female participants; they seemed

to think learning science and math in this context was enjoyable. Abernathy and Vineyard suggested that competitive events “may be tapping into students’ natural curiosity and providing a new context for them to learn in, without rigid curriculum or grading constraints (2001, 274).”

Competitive events such as the National Science Bowl® may provide the “initial motivation” and catalyst for helping students to discover the joy of learning (Ozturk and Debelak, 2008). Academic competitions can provide motivation for students to study, learn new material, and reinforce previously learned material so that they will be ready to compete (and collaborate) with their peers from other schools both regionally and nationally—not just in games but also in academic and work environments. This type of motivation is difficult to provide in a normal classroom environment. While it can be argued that this is solely extrinsic motivation and that students should not be dependent on it, it can nevertheless serve as the spark that ignites a discovery of the joy of learning science and math.

One of the more important effective benefits of competitions like the National Science Bowl®, is that the participants, who may be the academic elite at their home schools (big fish in a little pond), must test their knowledge and skills against the students from other schools who will be their peers once they get to college and the workplace. Ozturk and Debelak (2008) note that students “learn to respect the quality of work by other children and to accurately assess their own performance in light of the performance of their intellectual peers. They achieve an accurate assessment of where their level of performance stands in the world of their intellectual capacity and, in turn, develop a more wholesome self-concept” (51). Developing a more accurate and grounded self-concept is an important stage for children to go through on their way to becoming healthy and mature adults. This realistic and comparative self-assessment can be difficult to foster in the case of elite students who have never faced stiff competition or external challenges to their academic abilities in their home institution.

Students in academic competitions also benefit from learning not only how to succeed, but how to accept failure, learn from it, and, “subsequently, grow as a person and improve in performance” (Ozturk and Debelak 2008, 52). This, again, may be one of the most important aspects of intramural academic competitions, one that cannot be easily provided in a typical classroom environment; learning to fail and being able to cope with the emotional aftermath may be riskier in a

classroom environment than in a games environment where the experience of failure is shared among the group. Being thrust into a situation where participants must deal with failure (even after they have prepared and done their best) promotes the healthy development of a student's resilience and self-awareness. Academic competitions like the National Science Bowl® and its many regional competitions may provide the type of environment that helps students to reflect on their knowledge and abilities and self-evaluate their performance, promoting improved personal growth and development for the participants.

Certainly, extreme competitiveness can cause anxiety and undue stress (see for example Davis and Rimm, 2004). Many of us can remember learning in our Psychology 101 course about test anxiety and how it can negatively affect student performance and achievement and lead to low self-esteem. But Davis and Rimm also report that competition can increase student productivity and achievement. Some students seem to need to compete with others in order to push themselves to produce at a higher level. It would follow that socially organized competitions like the National Science Bowl® and its many regional competitions could help to promote high levels of achievement and productivity in the participating math and science students. Some of the increased levels of achievement and productivity may be due to the practice in teamwork and study skills promoted by participation in this type of academic competition. Bishop and Walters (2007) report that the students involved in competition increased their ability to be leaders and team players, especially in the areas of directed studying ("cramming"), communication, and stress management.

Most studies of this nature tend to be based on student reporting of their own perceptions, and Bishop and Walters also discuss the viability of using a self-report, Likert scale survey to investigate how the National Ocean Sciences Bowl (NOSB) influenced the participants' choice of major and courses in college. They further triangulate their data using follow-up interviews, information on the colleges the students attended, and lists of the college courses the students took following their participation in the NOSB. Their longitudinal study, which took place from 2000–2007, establishes the credibility of the students' self-reported data using this type of survey (Bishop and Walters 2007).

What Do the Students Get from This Competition?

A brief survey was developed for the students who compete in the Northern New England Regional Science Bowl Competition, for the purpose of gathering information about the students' perception of the impact the competition has on them and other students. The questions were developed by the Regional Science Bowl coordinators and distributed to the students (also to coaches, volunteers, and audience) on the actual day of the competition, which takes place each year in late February or early March. The students in the Northern New England Regional Science Bowl Competition come from the three northernmost New England states, Maine, Vermont, and New Hampshire. The competition is an extracurricular activity; the students in grades 9–12 have self-selected to be part of a team that practices and competes during non-school hours. The students making up the teams tend to be academically successful. As might be expected, these students usually like mathematics and science and are predisposed to participate in activities involving these subjects. The teams of students compete in a one-day event at the University of Southern Maine, which culminates in a single elimination tournament round. The winning team is offered an all-expenses-paid trip to Washington D.C. to compete with other regional winners for the national championship. Students at the regional bowl are given the survey. Completing and returning the survey is voluntary, although the students and coaches are made aware that their responses will help improve the event.

The Instrument

The first part of the survey was designed to collect general background information about the students and their role in the day's competition. This section was a simple checklist:

- This is my first experience.
- I've been at previous science bowls here.
- I was a volunteer today.
- I am a spectator/guest.
- I was one of the student competitors today.
- I am a coach of one of the teams.

The next set of items was intended to gain insight into the students' perceptions of how the regional competition affected the students who were taking part in the day's activities and events. The questions consisted of three Likert-type response choice items:

1. I think this competition had a positive impact on the students:
2. Quiz competitions foster student learning about science and mathematics:
3. Quiz competitions are stressful in a negative way:

Each of these questions had a five-choice scale that ranged from strongly agree to neutral to strongly disagree. There were also two open ended questions:

The thing I enjoyed most about today was:

What I would recommend for next year:

And finally a yes/no question:

I'd like to come back next year.

Findings and Discussion

Data collection began with the 2004 Northern New England Regional Science Bowl Competition and continued through 2009. (After this year the Bowl was restructured and focused exclusively on Maine students, although participants continue to be surveyed.) This six-year longitudinal study has provided data representing a constant mix of new and returning students. Throughout the course of the study, there was an almost equal distribution of first-time and returning students who responded to the survey. Although the survey was distributed to students, coaches, and other volunteers who took part in the events, only the results of the student surveys were used as part of this report. The voluntary nature of conducting the study produced an average of fifteen percent of the

students per year completing and returning the survey. Interviews with coaches and students indicate that the low response rate is most likely a result of its collection at the end of a long, intense day, when many teams were eager to start their journeys back to homes throughout northern New England.

Of the students participating in the Northern New England Science Bowl who responded to the survey during the study period, 93 percent either agreed or strongly agreed that the competition had a positive impact on them (Table 1).

Campbell and Walberg (2011) suggest that this type of positive impact follows the students throughout their life. Willingness to participate in events on their own time, especially during the weekend, demonstrates a high level of positive engagement that would foster feelings of positive impact. Akey (2006,16) reports that "student engagement and perceived academic competence had a significant positive influence." on achievement. The survey results also suggest that the students perceive themselves as academically competent in math and science, and that is why they participate. This mirrors the findings of Abernathy and Vineyard (2001) who report that academic competitions tap into the natural curiosity and inclinations of students and provide an arena for them to learn new things. The science bowl event could provide the platform for these students to excel and receive recognition. Further, Ozturk and Debelak (2008) report that academic competitions may provide the motivation to find the joy in learning. Curiosity and motivation are important aspects of learning that would presumably have a positive impact on the lives of the participants in academic competitions like the National Science Bowl®.

Most (91 percent) of the respondents reported either that they agreed or that they strongly agreed that the Regional Science Bowl Competition fosters student learning in science and mathematics (Table 2).

TABLE 1. Table 1: Perception of positive impact of competition. Based on a 5 point Likert scale with 5 being the highest.

Year	2004	2006	2007	2008	2009
Mean	4.1	4.7	4.8	4.3	4.7
SD	.60	.42	.40	1.1	.45

TABLE 2. Agreement that the Science Bowl Competition fosters student learning in science and mathematics. Based on a 5 point Likert scale with 5

Year	2004	2006	2007	2008	2009
Mean	3.9	4.6	4.8	3.8	4.6
SD	.98	.49	.40	.98	.49

These data again appear to support the research done by Abernathy and Vineyard (2001), indicating that academic competitions provide a forum to stimulate the students’ natural curiosity about learning new things, as well as the work of Ozturk and Debelak (2008), who have concluded that academic competitions may motivate students to discover the joy of learning.

The high positive response rate of these two questions indicates that the student participants in the Regional Science Bowl Competition are developing a strong positive sense of self. These responses, reinforced by our interviews of participating coaches, indicate that the students are reflecting on their experiences and developing a more complete self-image and perhaps an increased sense of their personal competence. Bishop and Walters report that an enhanced and comparative sense of personal competence or capability “translates as a very high factor influencing career choice” (2007, 69). It may well be that academic competitions such as the National Science Bowl® and its associated regional competitions provide experiences that positively influence student career choices.

Interestingly, the same students who reported that the Science Bowl Competition had such a positive effect on them in general, and a positive effect on their learning, did not necessarily think the competition was unstressful. Only 61 percent disagreed or strongly disagreed that the quiz competition was stressful in a negative way (Table 3).

Perhaps the wording of the question led students to equate “quiz” with “test,” which affected their response. It could also be that the students consider any kind of stress

negative, and if they perceived that the competition created even a low level of stress, they would conclude that this was a negative effect.

In the open-ended question that asked what they enjoyed the most about the Science Bowl, the number one response was competition, the second most frequent response was meeting like-minded people, and the third was the hands-on nature of the activities. These students seem to be saying that they feel that testing their knowledge and skills in science and mathematics against other students of similar ability is fun! Maybe this is because they are beginning to form a deeper understanding of and respect for the quality of their work, as suggested by Ozturk and Debelak (2008). Academic competitions (such as the Science Bowl) may give students the opportunity to compete mentally the way athletic competitions allow them to compete physically (Parker 1998). Perhaps these students get the same kind of “high” that athletes get during competition, and the thrill of academic competition releases endorphins much the same way that athletic competition does.

The data indicate that a statistically significant portion of the students competing in the Northern New England Regional Science Bowl Competition report that the event has a positive impact on them and fosters learning in science and mathematics. These data support findings that have been reported for other forms of academic competitions that are involved with science and mathematics (e.g. Campbell and Walberg 2011). Self-reporting indicates that the students have a high level of perceived personal competence, a high level of

TABLE 3. Perception of Science Bowl Competition as stressful in a negative way. Based on a 5 point Likert scale with 5 being the highest.

Year	2004	2006	2007	2008	2009
Mean	2.3	2.0	2.1	2.6	2.1
SD	.79	.69	1.17	1.02	1.1

engagement in mathematics and science activities, and a high level of motivation toward these academic subjects. In addition to increased involvement in the community, competence, engagement, and motivation are factors that have been linked to academic achievement, personal growth, and career choices. If the education community is seeking to increase student interest and participation in science and mathematics majors and in science and mathematics careers, and ultimately in complex science-related public policy discussions, then academic competitions like the National Science Bowl® may be an important part of the overall strategy bringing the nation closer to that goal.

A Proposal for Further Study

A key aspect of the Science Bowl competition is its role in building a social community of contestants, which leads one to wonder whether the competitions contribute to increased involvement in the larger community and whether they encourage participants to become more effective and engaged citizens. Participating schools are likely to return to the event, as are alumni who come back as volunteer officials. Further, with the release of recent studies, such as “Steady as She Goes? Three Generations of Students through the Science and Engineering Pipeline” (Lowell et al., 2009), we (the authors of this paper) feel an ethical responsibility to continue the investigation of whether science competitions represent meaningful contributions to the experience of students and their disposition towards science.

To better understand the impact of the Science Bowls on both STEM learning and civic engagement, we recommend that surveys be administered for all the National Science Bowl® middle school and high school competitions. The surveys should be standardized, with optional regionally based questions, and should be part of a well-designed study that can inform future science bowl decisions. An existing instrument, the Student Assessment of Learning Gains (SALG, <http://www.salgsite.org/>), has survey questions that are geared towards formal academic courses but are a no-cost, accessible means to obtain data on students’ attitudes about science. Social media also provides opportunities for assessment and self-reporting of students. Surveys can be followed

up by focus group interviews that could provide greater depth to our understanding of the findings. Such longitudinal studies could serve to verify whether or not these informal and volunteer learning experiences correlate with continued interest and involvement in science and mathematics, including choice of college majors, careers, and enhanced awareness and involvement in our most pressing science-related civic challenges, including climate change, public health, and technology.

About the Authors



Robert Kuech (Bob) taught middle and high school physics, chemistry, physical science, biology, ecology, computer programming for 20 years before returning to Penn State to work on a Ph.D. in science education. In 1999, when he finished his studies at Penn State, he came directly to USM and has served as the science educator in the Teacher Education Department since that time.



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