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Why Olympiad: Investigating Motivations and Benefits of Coaching Elementary Science Olympiad

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ABSTRACT

Science Olympiad is a K-12 science, technology, engineering, and mathematics (STEM) competition that engages approximately 7,000 teams across the U.S. in individual and team challenges at regional, state, and national levels. Science Olympiad began expanding to include elementary students in 2008. Yet, little is known about the adults who volunteer to coach elementary Science Olympiad teams or their coaching motivations. The purpose of this study was to investigate who coached elementary Science Olympiad teams, what motivated them to volunteer, and how their participation influenced their science teaching self-confidence, knowledge, and practices. This mixed-methods study investigated 125 Elementary Science Olympiad coaches' beliefs in the southeastern U.S. Survey items were based on the Coach Motivation Questionnaire (CMQ). Open-response questions following the survey items were coded in two ways; inductively and based on a priori motivational codes. Participant coaches were most likely to be teachers (92%), female (85%), and White (85%). Survey findings indicate that coaches' most significant motivating factors were intrinsic (M = 4.33/5); minor differences were based on gender, role, and length of time coaching. The qualitative responses supported the survey findings and gave more insight into teacher-coaches' thinking. The coaching experience had many positive effects on the teachers, such as enhancing their science and pedagogical content knowledge in science and other subjects, strongly influencing their self-confidence, and increasing their use of hands-on science and STEM activities.

KEYWORDS

Academic competition; Elementary Science Olympiad; elementary science teachers; out-of-school science education; volunteer motivation

Introduction

There are many benefits and advantages for students who participate in out-of-school educational opportunities at all grade levels (Afterschool Alliance, 2011; Sahin et al., 2013). STEM-specific out-of-school programs or clubs can positively impact students' enthusiasm and interest in STEM content areas and careers (Sahin et al., 2014). Research from informal STEM programs reports numerous positive outcomes from participating middle and high school students. Students reported an increased sense of belonging,

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enjoyment of hands-on explorations, and social benefits (e.g., Blanchard et al., 2018; Gutierrez et al., 2022; Krishnamurthi et al., 2014). Earlier interventions are also influential in stimulating STEM interest (DeJarnette, 2012; Pantoya et al., 2015). Informal STEM programs during elementary years are critical in changing students' attitudes toward STEM (Chen et al., 2011; Karp & Maloney, 2013; Maltese & Tai, 2010; Pantoya et al., 2015) and are equally important in increasing confidence and content knowledge of participating teachers (Avraamidou, 2015; Barr, 2013; Breyfogle, 2003; Downing, 2011; Feldman & Pirog, 2011; Karp & Maloney, 2013).

A well-regarded informal science competition program, Science Olympiad involves students and their teachers (and sometimes parents) as coaches. Science Olympiad (SO) is a national nonprofit organization dedicated to improving the quality of K-12 science education, increasing opportunity and diversity in science, creating a technologically literate workforce and providing recognition for outstanding achievement by both students and teachers. These goals are achieved by organizing daylong tournaments where teams of 15 students from participating schools gather to compete in 23 different events from various STEM fields. Regional team tournament winners advance to state-level tournaments and state-tournament team winners advance to the National Science Olympiad tournament, which is held at a different university each year, and national levels. The Science Olympiad began expanding to include elementary students in 2008.

A number of studies have investigated the influence of participation on the students involved. Sahin et al. (2014) focused on high school students who participated in the International Science Olympiad (ISO). Students reported that their participation in ISO helped them to develop and improve their twenty-first century skills and encouraged them to pursue a STEM major in college. Wirt (2011) surveyed almost 650 students, college students and adults who had been involved with SO in middle or high school. Analyses showed that participant involvement increased perceived levels of learning and interest in science and STEM areas, 21st century skills, and overall positive benefits (e.g., communication, collaboration). Participants expressed that SO had an impact on the career choices of participants. Similar findings of college students' informal experiences with Olympiad (Smith et al., 2021) were influential in their choice of college majors and STEM interest (Forrester, 2010).

Self-Determination Theory (SDT) is used to study motivation in sport coaches and athletes (Bentzen et al., 2016; Rocchi & Pelletier, 2017; Rodrigues et al., 2020) and is applied to many domains including education, organizations, religion, health and medicine, parenting, virtual environments and media, close relationships, and psychotherapy. Despite the use of SDT to study the motivation of *athletic* competitions, coaches, and participants, there is a shortage of motivational research on *academic* competitions, coaches, and participants. Science Olympiad (SO) is one of the largest K-12 STEM academic competitions in the U.S., and coaches and participants invest a lot of personal time, energy, and effort to participate. This study examines what motivates elementary SO coaches since little is known about motivation in academic coaches. Understanding coaches' motivations is essential for schools and youth-serving organizations offering STEM academic competitions and similar programs to recruit and retain volunteers.

Literature review

Pre-service teachers

Science Olympiad has been used to promote learning and growth with pre-service chemistry teachers (Breyfogle, 2003). During a science methods course, pre-service teachers facilitated the state SO tournament to understand the amount of teacher/coach planning and preparation the event requires. Once they became in-service teachers, all of the participants reported that the experience was beneficial in their teacher preparation.

A particularly relevant study by Downing (2011) examined the relationship between pre-service teachers' anxiety of teaching science in elementary school before and after using SO events. Students in the methods class expressed significantly lower anxiety upon completing the course. These results suggest that the use of SO events in an elementary science methods course can be beneficial in easing anxiety about teaching science in the elementary classroom.

Secondary science teacher-coaches

Robinson (2003) investigated the nature of coaching high school SO. He interviewed nine high school teacher-coaches and asked them questions about the relationship between coaching and teaching, the rewards and challenges, and their beliefs and needs. They found that rewards included getting students excited about science and working together to solve problems. Teachers described funding and competition from other after-school activities as challenges. They reported that it was challenging to integrate the SO events into their classroom because they had little room to teach outside of the mandatory curriculum. Some SO events aligned with the school curriculum, and teachers transferred them to the classroom. Teachers explained that the "Experimental Design" SO event was an example of direct overlap with the science curriculum, which enabled teachers to use this activity in the classroom.

A SO coach conducted a self-study of the middle school SO program he coached (Barr, 2013). Barr reported on aspects of the team, events, and responsibilities. In the "Implementation into the classroom" section, he wrote:

> By employing Science Olympiad events into the curriculum, I was able to shift my teaching practices from a teacher-centered to primarily student-centered environment which revealed one profound finding I had not previously considered . . . I found that the Science Olympiad team members were all "A" and "B" students in their school science classes. In my trial implementation of integrating the Science Olympiad model into the classroom, I observed several "low achieving" students thrive in the learner-centered environment that invites students to be creative problem solvers. (Barr, 2013, p. 42)

This quote exemplifies how the coaches in SO can learn from the events and implement them in their classrooms or adopt the discovery-based, student-centered teaching style.

Elementary teachers

Surveys of elementary teachers suggest that relatively few (33%) feel prepared to teach science and even fewer feel prepared for teaching physical science (Banilower et al., 2013; Trygstad et al., 2013). While many conversations about elementary teacher preparation

have focused on the issue of limited science content preparedness (Appleton, 2006; Hechter, 2011), close attention has also been paid to self-efficacy beliefs (Cantrell et al., 2003; Kazempour & Sadler, 2015; Leonard et al., 2011; Palmer, 2006). Elementary teachers' lack of preparation to teach science combined with limited science content knowledge leads to low self-efficacy and heightened anxiety. Downing (2011) examined the relationship between pre-service teachers' anxiety of teaching science in elementary school before and after using SO events in their classroom. These pre-service teachers expressed significantly lower anxiety upon completing the course, suggesting that exposure to SO events helps ease anxiety about teaching science. To date, no study has investigated the elementary science teachers who coach Science Olympiad.

Theoretical framework

This study sought to understand motivating factors driving Elementary Science Olympiad (SO) coaches' decisions to lead teams. Self-determination theory (SDT; Ryan & Deci, 1985) is a framework for analyzing and understanding human motivation and behavior. There are several mini-theories within SDT, including Organismic Integration Theory, which is most salient for this study. Ryan and Deci (1985, 2002) developed OIT to understand the different ways in which extrinsically motivated behaviors were regulated. Extrinsically motivated behaviors are associated with instrumental outcomes (e.g., practicing with your SO team to become a better competitor). Within OIT, motivation is a multidimensional construct, reflecting different forms of extrinsic motivation according to varying levels of self-determination (Deci & Ryan, 2008; Ryan & Deci, 1985). These different forms of extrinsic motivation help researchers further understand an individual's motivation influencing their behavior. For example, an individual could be motivated to coach because they think it will be enjoyable (intrinsic) or highly motivated to try to win tournaments (extrinsic). Figure 1 presents the self-determination continuum that delineates an understanding of intrinsically and extrinsically motivated behaviors as well as amotivation. The continuum is arranged from left to right in terms of the extent to which motivation for a behavior emanates internally.

At the left end of the continuum is amotivation, the state of lacking intention to act. When individuals are amotivated, they either do not act at all or act passively. For example, someone may strongly agree that their coaching efforts are a waste of time or don't know why they coach. Amotivation results from feeling either that one is unable to achieve desired outcomes because of a lack of contingency (Rotter, 1966), a lack of perceived competence (Bandura, 1977; Deci, 1975) or not valuing the activity or the outcomes it would yield (Ryan, 1995).

The other five points on the continuum refer to classifications of motivated behavior. Each describes a theoretically, experientially, and functionally distinct type of regulation. At the right end of the continuum is intrinsic motivation, which is when individuals are doing an activity out of interest, enjoyment, not dull, optimally challenging, and innate satisfaction (Ryan & Deci, 2002; Ryan et al., 1995). For example, they would find coaching SO as highly enjoyable or bringing them joy. Intrinsic motivation is the most self-determined form of motivation.

Four types of regulation characterize extrinsically motivated behaviors along the self-determination continuum between amotivation and intrinsic motivation. Extrinsically motivated behaviors can vary considerably in their relative autonomy via four regulatory

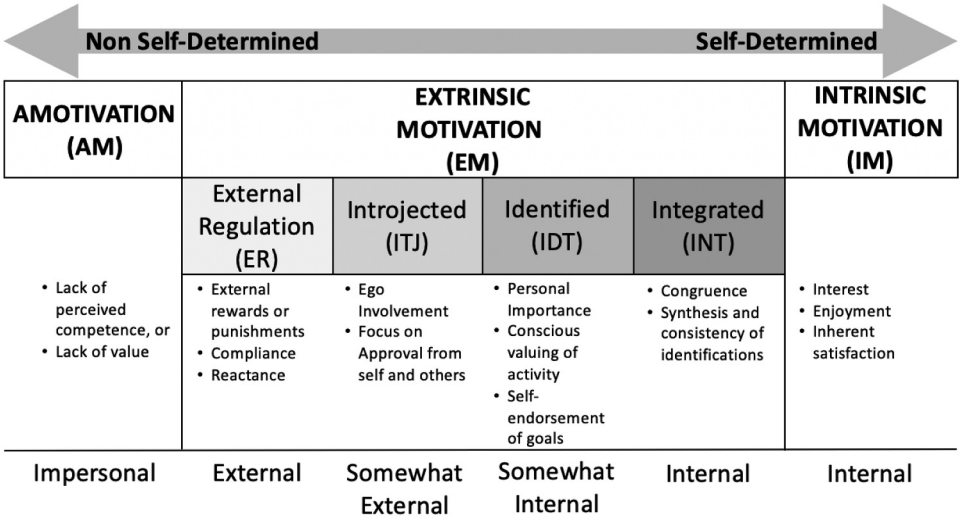

Figure 1. The self-determination continum (adapted from Ryan & Deci, 2000, p. 72).

styles: external regulation, introjected regulation, identified regulation, and integrated regulation. External regulation and introjected regulation are clearly compelled by an external perceived locus of causality or outside forces. They are considered to be associated with controlling behaviors, such as intimidation and pressure to control athletes (Bartholomew et al., 2009). The most controlling form is external regulation, whereby action is compelled by external contingencies, such as tangible rewards or avoidance of punishment; for example, some coaches seek media attention and recognition. Slightly more internalized is introjected regulation. Like external regulation, introjected regulation is controlled by external consequences; however, these emanate from the self rather than from others. Typical examples of introjected regulation are contingent self-worth (pride) or feelings of guilt or shame (e.g., coaches can feel personally responsible for their athletes' performances).

Conversely, identified and integrated regulation have an internal perceived locus of causality. The most autonomous form of extrinsic motivation is integrated regulation. Behavior motivated by this regulation is fully integrated into the self and coherent with one's values and identity (Deci & Ryan, 2008). For example, a coach may decide to remove a player from a game because of his lack of fair play. With identified regulation, people begin to identify underlying values of behavior and their actions are self-endorsed. However, they are still instrumental for an extrinsic goal (e.g., athletes who play sports perceive that this involvement is vital for their personal development; Pope & Hall, 2014). Subsequently, identified and intrinsic regulations are autonomous (self-determined) extrinsic motivation.

Research questions

Given what we know about the importance of coaching for academic competitions and the scarcity of information about Science Olympiad coaches, we investigated:

(1) *What motivated individuals to coach Science Olympiad elementary school teams?*
(2) *How did teachers describe the Science Olympiad's influence on their science teaching knowledge, self-confidence, and practices?*

Methods

Research design

This mixed-methods study used a convergent parallel design (Creswell & Plano Clark, 2011). The purpose of selecting the convergent parallel design was to provide a comprehensive analysis of the research problem—what motivated individuals to coach Science Olympiad teams—by converging quantitative and qualitative data. Following this design, both forms of data were collected simultaneously, the methods were equally prioritized, and the data analysis was conducted independently. Following analyses, the results were compared to enhance the overall interpretation of the findings and to look for convergence, divergence, contradictions, or relationships of two data sources in the discussion of the findings.

Participants

Participants included coaches of elementary North Carolina SO teams. They completed the survey at their regional SO tournament. Coaches who did not complete the survey at the regional tournament were invited, through e-mail, to complete an online version. The survey was voluntary, and participants who completed the survey were entered into a prize drawing. 136 participants filled out either the paper-pencil questionnaire or the web-based questionnaire. Both surveys were identical in content and structure. This study was approved by an Institutional Review Board office #7776.

Data collection

Instrument

The Coach Motivation Questionnaire (CMQ; McLean et al., 2012) was used to measure participants' motives for volunteering to coach SO, is based on SDT (McLean et al., 2012), and was used for several reasons (see Appendix). It has: 1. a six-factor structure (intrinsic, integrated, identified, introjected, external, and amotivation) that best reflects theorized constructs, 2. an overall satisfactory internal consistency, the convergent, discriminant, and nomological validities established, a satisfactory long-term stability for most scales and finally, 3. a factor structure reinforcement through CFA with an independent sample. Furthermore, several studies have supported the psychometric properties of the CMQ (Ferguson et al., 2015; McLean et al., 2012; Pope & Hall, 2014; Rocchi & Pelletier, 2017). To make the survey relevant for SO coaches, the word "student" was inserted for the word "athlete" and the stem sentence was changed from "Why do you coach your sport?" to "I volunteer to coach Elementary Science Olympiad . . ." with prompts to follow. Participants completed the 22-item CMQ and were asked to reply to each statement (see Table 1) on a five-point Likert scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, and 5 = *strongly agree)*.

Table 1. Exploratory factor analysis results.

Motivation Items	AM	EM	INJ	ID	INT	IM
Stem: I volunteer to coach Science Olympiad . . .						
Because I find it stimulating						.53
Because I get a good feeling out of it			.31			.39
Because I enjoy the effort I invest						.51
Because I enjoy the interaction I have with students						.72
Because coaching is fundamental to who I am					.79	
Because coaching is integral to my life					.85	
Because it personifies my values and beliefs				.50		
Because it allows me to achieve my personal goals				.79		
Because it contributes to my development as a person				.78		
Because it is moving me toward my personal goals				.82		
Because I don't want to let my students down						.49
Because I feel pressure from myself to win			.89			
Because I feel responsible for the students' performance			.57			
Because if I quit it would mean I'd failed			.62			
Because I want to be appreciated by others		.54	.35			
To be respected by others		.97				
To get recognition from others		.70				
Even though I often think my coaching efforts are a waste of time	.73					
Even though sometimes I don't know why I coach anymore	.79					
Even though sometimes I feel the costs outweigh the benefits	.81					
Even though sometimes I question my desire to continue coaching	.80					

Absolute values less than .3 suppressed. AM = Amotivation, EM = External, INJ = Introjected, ID = Identified, INT = Integrated, IM = Intrinsic.

Open-ended questions

In addition to the CMQ, participants completed demographic questions about their age, school, district, race, and gender. They also responded to three open-ended questions about their perceptions of the influence of SO on their self-confidence, science content knowledge, and teaching practices.

Data analysis

Quantitative

After removing surveys with missing data (n = 11), descriptive statistics and an exploratory factor analysis were conducted (N = 125). Using SPSS 19, each motivational factor construct was analyzed for mean, standard deviation, and range, as well as an Exploratory Factor Analysis and Cronbach's alpha. An exploratory factor analysis was completed since there were changes to the nature and focus of the survey items and their potential to alter the original factor structure (Burnett & Dart, 1997). A one-way ANOVA was used to compare motivational factors across demographic data.

Exploratory factor analysis. An exploratory factor analysis by means of data reduction was conducted on the 22 survey items using principal axis factoring with Promax with Kaiser normalization rotation. One item, the "Because I like the extrinsic rewards (i.e., money) associated with winning" item, received the lowest mean score (M = 1.870, SD = 1.0319) but failed to load on any major factors and thus, was removed from the survey for subsequent analysis. It is believed this happened because coaches did not know how to respond, as there is no money associated with winning a SO event and rarely associated with volunteering to

become a coach. This item was also removed due to low factor loading in work completed by Da Silva et al. (2018). After several iterations were run and the scree plot was analyzed, it was determined that the optimal factor structure was six and accounted for 68.85% of the variance.

Based on this exploratory factor analysis, the six-factor structure yielded the optimal solution, and thus, the factors were identified. The six-factor labels were the six motivational factors on the SDT continuum that delineate an understanding of intrinsically and extrinsically motivated behaviors and amotivation. See Table 1 for factor solution and loadings.

Internal consistencies. Cronbach's alpha for the factors of the CMQ ranged from .68 to .87, which are considered satisfactory. Except for INJ, all were above .70. Each of the subscale items was investigated to see if removing an item increased the internal consistency. Only three items brought down the Cronbach's alpha of the overall motivational regulation. However, all of the items were performed at an acceptable level, so all remaining survey items were retained. The CMQ overall Cronbach's alpha was .81.

Qualitative

The open-response question responses were coded in two ways. First, coded inductively using ATLAS.ti. Next, coded statements were grouped by themes to answer the second research question. As the researchers analyzed the open-response questions, they found the responses further elucidated survey results and provided a deeper understanding of elementary SO coaches' motivations. This led researchers to additionally code the teacher-coaches' open-ended responses using a priori categories from the SDT continuum. A subset of the data (approximately 30%) was independently coded and compared for inter-rater reliability in both coding processes. The first pass had 82% agreement, and the statements that disagreed were discussed and negotiated until 100% agreement was reached (Patton, 2002). The first author then coded the remaining data.

Results

Participant demographics

The sample included a broad sample of coaches across the state. At least one lead coach from each of the US state's 18 regions participated, representing 109 public, five private, and one homeschool in 26 school districts. Of coaches who completed the survey, most of the participants self-identified as teacher-coaches (90%), followed by parent-coaches (8%), or both (2%). Coaches identified as female (85%) and male (15%). In response to an open response item labeled race, participants indicated White or Caucasian (85%), African American or Black (4%), Asian (2.5%), Hispanic (2.5%), and seven individuals declined to respond or put N/A (see Table 2).

Coaches ranged from 25 to 66 years old, with a mean age of 42.7 years. Coaches tended to have five or fewer years of experience, usually less than three years as head coach.

Quantitative results

The individual motivational constructs are shown in Table 3, with mean, standard deviation, and range for each subscale. These results mirror the overall motivational regulation categories.

Table 2. Demographics of SO coaches.

Demographics (N = 121)		
Role	Teacher-Coach	**90%**
	Parent-Coach	8%
	Both Teacher & Parent-Coach	2%
Gender	Female	**85%**
	Male	15%
Ethnicity	Caucasian or White	**85%**
	African American	4%
	Asian	2.5%
	Hispanic	2.5%
	No Response	6%
Age Range	25–66	42.7 Mean
Involvement Science Olympiad*	0–1 years	11%
	1 to <3 years	**38%**
	3 to <5 years	24%
	5 to <10 years	23%
	>10 years	3%
Time as Head Coach*	0 to <1 year	14.4%
	1 to <3 years	**48%**
	3 to <5 years	22.4%
	5 to <10 years	14.4%

*1 respondent did not answer.

Table 3. Mean, standard deviations and range from CMQ results.

Motivation Items	Mean	SD	Range
Stem: I volunteer to coach Science Olympiad . . .			
Intrinsic			
Because I find it stimulating	4.272	.7000	1–5
Because I get a good feeling out of it	4.315	.7027	2–5
Because I enjoy the effort I invest	4.312	.7231	2–5
Because I enjoy the interaction I have with students	4.648	.5426	2–5
Integrated			
Because coaching is fundamental to who I am	3.816	.9279	1–5
Because coaching is integral to my life	3.416	.8724	1–5
Because it personifies my values and beliefs	3.880	.8576	1–5
Identified			
Because it allows me to achieve my personal goals	3.208	1.0104	1–5
Because it contributes to my development as a person	3.640	.9622	1–5
Because it is moving me toward my personal goals	3.328	.9737	1–5
Introjected			
Because I don't want to let my students down	4.256	.7921	2–5
Because I feel pressure from myself to win	2.848	1.2382	1–5
Because I feel responsible for the students' performance	3.744	.9580	1–5
Because if I quit it would mean I'd failed	2.496	1.1117	1–5
External			
Because I want to be appreciated by others	2.800	1.0395	1–5
To be respected by others	2.456	1.0511	1–4
To get recognition from others	2.040	.9193	1–4
Amotivation			
Even though I often think my coaching efforts are a waste of time	1.872	.8704	1–4
Even though sometimes I don't know why I coach anymore	1.968	.9240	1–4
Even though sometimes I feel the costs outweigh the benefits	2.112	1.0642	1–4
Even though sometimes I question my desire to continue coaching	2.352	1.2132	1–5

Means are based on a Likert scale from 1= strongly disagree to 5 = strongly agree.

SO coaches' mean score was highest on the item, "Because I enjoy the interaction I have with students" (M = 4.648, SD = 0.5426). The lowest retained item was "Even though I often think my coaching efforts are a waste of time" item (M = 1.872, SD = 0.8704). The highest

variance was found on items, "Because I feel pressure from myself to win" (M = 2.848, SD = 1.2382) and "Even though sometimes I question my desire to continue coaching" (M = 2.352, SD = 1.2132).

Means were compared by demographic data, which revealed few differences. When comparing results by gender, the only regulation with a significant difference was introjected regulation (p = .029). Male coaches were more motivated by introjected regulation than female coaches. The only significant difference found between parent and teacher-coaches was amotivation. Teacher-coaches were significantly more influenced by amotivation than parent coaches (p = .011). Caucasian coaches reported a significant influence from a motivation unlike African American, Asian, or Hispanic coaches (p = .027). Results indicated no difference in outcomes based on years of involvement with SO or coach age. However, years as being head coach showed a significant difference; the longer the coach acted as head coach for their team, the higher they reported being intrinsically motivated (p = .049).

Analysis of the CMQ showed that the most significant motivating factor for coaches is intrinsic motivation (M = 4.388) and integrated regulation (M = 3.704). Both of these are considered "self-determined" by Deci and Ryan (2008). Coaches' motivational category means decreased as items moved toward amotivation, as shown in Table 4.

Qualitative results

The survey's open-ended questions were intended to understand elementary teachers' (92% of sample) perceptions of how their involvement as a SO coach influenced aspects of their teaching. Teachers responded to prompts about how they believed SO coaching had influenced their knowledge for teaching science, self-confidence, and science teaching practices. A summary of major subthemes identified and exemplar quotes are in Table 5.

Influence on science content or pedagogical content knowledge

The majority of SO elementary teachers' responses (55%) described gains in content knowledge due to their involvement, such as increasing knowledge of new topics or how their improved knowledge led them to try new ideas in their classrooms (see Table 5). The next most commonly described influence of SO (15%) was a deeper knowledge of science. One teacher commented that this made them "*better able to convey that knowledge to my students*."

They also described improved pedagogical content knowledge, which accounted for 12% of their comments. For instance, one teacher explained that SO had "*strengthened my classroom instruction*." The events' interdisciplinary nature also helped teachers learn more about areas outside of what they usually taught, such as topics from a different grade level, which enabled them to align their instruction with grade levels above or below theirs. One teacher described the newfound ability to "*apply some concepts and real-*

Table 4. Motivation category means.

Motivation Overall Means					
Amotivation	External	Introjected	Identified	Integrated	Intrinsic
2.076	2.432	3.336	3.392	3.704	4.388

Means are based on a Likert scale from 1 = strongly disagree to 5 = strongly agree.

Table 5. Teachers' perceptions of SO influence on science content or pedagogical content knowledge, self-confidence, and practices.

Subtheme	% of Quotes	Example Quote
Influence on Science Content or Pedagogical Content Knowledge		
Gains in content knowledge	55%	*My personal knowledge of science topics has increased through my involvement in Science Olympiad and is something I really enjoy about S.O.*
Deeper level of teaching science	15%	*I have learned a lot about how to find resources related to science that I can share with the general education teachers and I have learned how to go deeper when teaching science content.*
Increased pedagogical content knowledge	12%	*I am much more aware of what/how I am teaching and how I can promote lifelong scientists.*
Curriculum Exposure	10%	*It has forced me to delve deeper into content and also into areas that are not in my grade level (5th) curriculum- good for me to know what comes before!*
Learning alongside the students	8%	*I am learning right along with the kids & it is a fun experience. My resources have grown as I gather data and information for various subjects.*
Influence on Self-Confidence in Teaching Science		
Felt more Confident	73%	*I feel more confident in my science classroom as a result of my involvement in Science Olympiad.*
Already felt confident	22%	*None really- I feel comfortable and confident in teaching science.*
Minimal Effect on confidence	5%	*It has boosted a little. I feel as though the coaching institutes could offer a little more of the why certain events work like they do.*
Influence on Science Teaching		
More Robust Science or Science Integrated Lessons	42%	*My participation makes me want to continue to utilize inquiry-based learning and allow students opportunities to develop their own thinking and understanding.*
Student-centered focus	40%	*It has made me become more hands on with my teaching. Students are doing more creating and problem solving.*
SO events in the classroom	14%	*As a Gifted Education Specialist, I integrate many science elements into the language arts and mathematical reasonings we need to grow as thinkers using strategies to understand as much as we can.*
Time to fail (like authentic science)	4%	*I believe you have to allow students to be hands-on in their investigations and designs and allow them to fail throughout the way . . .. It is a better microcosm of what scientists truly do at higher levels.*

life experience to my math classes." 10% of teachers' statements referenced exposure to other curriculum areas. Lastly, teachers recounted learning alongside their students (8%). One teacher wrote, "*I am learning right along with the kids & it is a fun experience. My resources have grown as I gather data and information for various subjects*."

Influence on self-confidence in teaching science

When prompted to report on the influence of SO on their confidence in teaching science, teachers responded in one of three ways. The most commonly coded response (73%) was that SO increased their confidence in teaching science. One teacher commented, "*Since I do have a better understanding of certain science concepts, I am more confident in my abilities to teach the subject*." The next most common response was that teachers already felt confident teaching science (22%). Although one teacher acknowledged, "*I have always felt comfortable teaching K-3 science lessons*." The third and least common response (5%) was minimal or no increase in their science teaching confidence. One teacher admitted, "*It hasn't helped in my confidence because I feel that I still do not know enough about science concepts*." Other teachers (Table 5) also referred to needing more professional development or science instruction.

Influence on science teaching

Teachers also described the influence of SO on their science teaching practices in the elementary classroom. Some wrote how SO encouraged them to use more robust science and STEM activities in their classrooms (42%). For example, one teacher wrote, "*It's encouraged me to continue inquiry-based learning, collaboration, and encouraging students to do research outside of [the] classroom*." Teachers also described ways to incorporate more student-centered approaches (40%). One wrote, "*I found that I need to let my students explore more on their own instead of telling them how things work. I want them to discover and ask more questions*." Some teachers reported using SO events to supplement teaching strategies (14%). As one explained, "*I have gone more in-depth with some topics. Also, I have adapted some of the events for classroom use. I have also incorporated more S.T.E.M. in my teaching*." Lastly, teachers mentioned that they wanted more time for students to fail and learn from that process (4%). One wrote, "*I allow the students to fail in order to learn from their mistakes rather than tell them exactly how to do everything*."

Qualitative analyses by motivational construct

As was described in the methods section, while coding the data for research question 2, it was evident that teachers' comments closely matched the motivational constructs in the CMQ. Teachers' open-ended responses were analyzed for explanations of the CMQ findings. This section presents results of independently coding the qualitative data using a priori categories from the self-determination continuum that delineates an understanding of intrinsically and extrinsically motivated behaviors and amotivation. All statements were able to be coded into one of these categories. Table 6 summarizes the prevalence of each of the qualitative codes and gives exemplar quotes.

In Table 6, you can see that the Identified category was the highest motivational construct (47% of coded items), followed by Introjected (16%), then Integrated (14%), Intrinsic (10%), Amotivation (8%) and External (5%). This was somewhat different from what was found in the CMQ results. In those results (see Table 4), the top motivational construct was Intrinsic, which decreased in order along the SDT continuum. Therefore, the results, although reasonably consistent, varied by data source.

In the findings, the open-ended responses were coded with the SDT motivation constructs. This revealed somewhat different results from the CMQ survey results. The findings suggest that allowing for open-ended responses resulted in more nuanced understandings of teachers' motivations, which for these teachers, indicated slightly less intrinsic motivations for coaching SO than suggested by the survey results.

Limitations

Our findings should be viewed in light of several limitations. Our choice of outcomes and how we decided to measure them provides a limited picture of teachers' motivations and benefits of coaching Science Olympiad. The number of participants was relatively small, located in one state, and was self-reported. Therefore, the generalizability of our findings may be limited to the population in the current study.

Table 6. Qualitative data coded by regulation type & frequency, with a description and representative quote.

Regulation Type (PLOC)	Percentage of coded statements	Description	Representative Quote
Identified (Somewhat Internal)	47%	Coaching SO helped to achieve teachers' personal goals & enhance their professional knowledge and skills.	*My science content knowledge has been increased and enriched by my involvement in Science Olympiad.*
Introjected (Somewhat External)	16%	Coaches' described reasons for SO involvement related to their interaction with the students, school, and other competitors.	*The whole student body looks up to me and wants to be in my class just so they can be around all the Science Olympiad stuff. They always want to talk about Science Olympiad with me.*
Integrated (Internal)	14%	Coaches described ways that SO aligned with their personal values and beliefs and how coaching SO reflected who they were as a person.	*I have always been a project based learning teacher so this helped me create new ways to integrate projects and experiments in my own classroom.*
Intrinsic (Internal)	10%	Teacher-coaches' reported personal feelings of enjoyment around coaching SO, disconnected from others.	*My confidence has increased and the excitement has been instilled again another year or more.*
Amotivation (Impersonal)	8%	For some, coaching generated negative feelings; lack of control, discouragement, or wasn't a good fit for them because they didn't teach science or topics were too challenging for them.	*It actually has decreased my confidence. Our school always performs so poorly.*
External (External)	5%	A few teachers described external motivations for coaching SO, such as improved test scores or external rewards (e.g., student engagement).	*This year all of our 5th grade students who were on the team had a* [state exam] *score of 4 or 5 on their science EOG (end-of-grade test).* [4–5 is on track for college readiness].

Discussion

What motivated individuals to coach Science Olympiad elementary school teams?

The 125 Elementary SO coaches from a southeastern US state who participated in the study were primarily teachers who identified as female and White/Caucasian. Quantitative analyses of the modified CMQ indicated that the teachers were most often motivated by *intrinsic* factors (M = 4.388) or internal regulators, such as finding it stimulating and enjoying interactions with students. There was strong evidence that the coaches found joy in the challenges and learning associated with coaching SO.

Although teachers' coded responses to the open-ended questions also supported their intrinsic motivation for coaching, it was not the most prevalently coded category (see Table 6). One teacher wrote, "*I have always loved teaching science and loved inquiry-based learning, so SO is a good fit*." Another teacher wrote, "*My confidence has increased and the excitement has been instilled again another year or more. This has been a wonderful experience for all involved."*

The next highest motivational category on the survey was *integrated* (M = 3.704). Items on this subscale related to coaching being fundamental to the person, their life, and reflective of their values. Teachers' written comments, although they were less prevalent than suggested by the teachers' survey results, supported the survey results. *"Again, nerd here! Was tickled pink when they* [SO] *opened the field to elementary kiddos,"* wrote one teacher. Another asserted, *"I have always been a project-based learning teacher so this helped me create new ways to integrate projects and experiments in my own classroom."* In survey responses and, to a lesser extent, in open-ended responses, these teachers affirmed that their motivations for coaching were often motivated by internal motivations that involved personally held values or goals.

Closely following the survey's *integrated* motivational category, SO coaches somewhat agreed (M = 3.336; M = 3.392) with motivational items categorized as *identified* and *introjected*. Identified items measured perceptions that coaching allowed the person to achieve their personal goals and personal development. Teachers' comments were most likely to be coded into these motivational categories (47% Identified; 16% Introjected). As a way to understand how teachers thought about their motivations, teachers' comments provided some insight. One teacher wrote, *"My science content knowledge has been increased and enriched by my involvement in SO."* Another wrote,

> Due to the large amounts of research needed to prepare for the competition, I have learned a lot about 3–5 science curriculum. I know more about weather, increased my knowledge of fossils, forces and motion, and inquiry science.

One teacher described how their SO experience had helped them to develop: *"I feel more confident and if I am not I will do more research and find a way to make learning the material more interesting and fun."*

Open-ended items supported survey findings (integrated regulation) of coaches not wanting to let their students down, feeling internal pressure to win, and feeling responsible for their success. Teachers' comments accounted for 14% of these codes. To help explain how teachers wrote about these constructs, one teacher wrote, *"Knowing that my students can compete with some of the most affluent schools in the district had boosted not only my confidence as a teacher but my student's confidence in their academics."* One teacher referred to their prominent role as a SO coach at their school: *"The whole student body looks up to me and wants to be in my class just so they can be around all the SO stuff. They always want to talk about SO with me."*

Factors that were least descriptive of coaches' motivations were *external* and *amotivation*. External motivators were tied to being appreciated and respected by others and receiving recognition. These findings are consistent with teachers' coded comments and least commonly coded motivational constructs. Only a few teachers' comments reflected external motivators, which resonated with the slightly disagree (M = 2.432) rating of the survey's motivational construct. One explained, *"I can see a difference in test scores."*

The lowest category was *amotivation* (M = 2.076) which measured perceptions of coaching being a waste of time, the costs outweighing the benefits, and questioning one's desire to coach. Open-ended comments helped to understand what teachers were feeling. One teacher referred to performing poorly at the SO competition, writing, *"It actually has decreased my confidence. Our school always performs so poorly."* Another referred to a common competition with the comment, *"Bottle Rocket physics was never in my vocabulary."* Some teachers wrote comments about not being a science teacher and how some coaching duties (such as balancing their teams) were challenging.

Overall, elementary SO coaches were most likely to be motivated by internalized factors, from intrinsic to identified, and least likely to be motivated by external or amotivation factors. These results seem consistent because SO coaches were volunteers and therefore chose to coach based on their enjoyment, fit with their perception of themselves, and desire for personal development. It was evident from their qualitative responses that teachers were strongly oriented to the needs of their students. This is similar to results that have been documented in other studies using SDT with charitable volunteers (Oostlander et al., 2014), youth sports coaches (McLean et al., 2012), and sports coaches generally (Pope & Hall, 2014; Da Silva et al., 2018).

How did teachers describe the influence of Science Olympiad on their science teaching knowledge, self-confidence, and practices?

Elementary teachers overwhelmingly described benefits from coaching experiences through open-ended question responses. First, the influence of coaching SO on science content or pedagogical knowledge was analyzed. Over half of the teachers described gains in content knowledge. Less often, teachers described gaining a depth of knowledge of science, improving instruction, and exposure to other curriculum areas. Breyfogle (2003) involved preservice chemistry teachers in a state SO tournament and found they learned along with their students. Once in the classroom, all of these new teachers reported that the SO experience had been beneficial preparation.

Next, nearly three-fourths of the elementary science teachers in this study reported increased confidence in their teaching of science. Approximately one-fourth expressed that they already felt confident about their science teaching; perhaps this was one of the reasons they had volunteered to coach an elementary SO team. A small fraction of the teachers felt they could have used more professional development on coaching the events. Although there is not a similar published study, Downing (2011) found similar results with pre-service teachers, whose anxiety of teaching science in elementary school was significantly lower after using SO events in their classroom.

Finally, teachers also described the positive influence of SO on their science teaching practices. These influences encouraged more than 40% of the teachers to use more challenging science or STEM activities in their classrooms. These teachers described ways they incorporated more student-centered approaches in their teaching, such as encouraging

more discovery and asking students more questions. Slightly over 10% of the teachers described going into more depth on their topics, with a smaller percentage of teachers describing allowing their students to experience failure in order to learn. This study differed from the study by Robinson (2003), who investigated teachers who were trying to integrate SO events in their classrooms. The teachers in Robinson's study found it very challenging to integrate SO lessons in their classroom, and the teachers in this study were more positive about implementing new practices. However, in both this study and that of Robinson, the teachers noted the rewards for their students. Resonant with the findings of this study, Barr (2013) reported employing SO events in his middle school classroom, after having coaching experience, with great success and a greater focus on a student-centered learning approach.

Overall, the elementary teachers in this study felt more confident and knowledgeable as a result of their Science Olympiad coaching experience, and this translated into their classroom practices. Thus, this SO coaching experience addressed, for many, doubts about their science knowledge (e.g., Appleton, 2006; Hechter, 2011) and doubts about their ability to teach science that have been documented in the literature (e.g., Banilower et al., 2013; Trygstad et al., 2013).

Conclusions and implications

A number of conclusions are drawn from the findings of this study:

(1) Coaching Science Olympiad generally resulted in positive improvements in self-efficacy, content and pedagogical content knowledge, and teaching practices.
(2) Teachers often used SO activities and materials in their classrooms to enhance instruction.
(3) A small percentage of teachers had negative experiences in SO related to poor performance at competitions, not feeling supported, and needing more professional development in science content knowledge and pedagogy.

These findings suggest that encouraging elementary teachers to coach Science Olympiad has a strong potential to enhance their content knowledge, pedagogical content knowledge, self-efficacy, and science teaching practices. However, it is recommended that elementary coaches receive additional support and professional development. These findings also suggest that using qualitative data with the CMQ may have given a more holistic reflection of the teachers' motivations than simply using the quantitative data. Why coach Science Olympiad? The findings of this study indicate the potential for personal and professional benefits as well as many benefits for their students.

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Appendix

Elementary Science Olympiad Lead Coaches' Questionnaire

Thank you for taking the time today to complete the lead coaches questionnaire. When finished, please remember to return this questionnaire and consent form to the check-in desk before leaving today!

Are you a:
- ☐Parent Coach
- ☐Teacher Coach
- ☐Other ____

Are you a:
- ☐Female Coach
- ☐Male Coach

Your School Name: ____

Your School District: ____

How long have you been involved in Science Olympiad? ____

How long have you been lead coach for Science Olympiad? ____

What is your age? ____

What is your race? ____

Please complete the questions 1-22 using the stem question below:

I volunteer to coach Elementary Science Olympiad…

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Because I find it stimulating	☐	☐	☐	☐	☐
2	Because coaching is fundamental to who I am	☐	☐	☐	☐	☐
3	Because coaching is integral to my life	☐	☐	☐	☐	☐
4	Because I don't want to let my students down	☐	☐	☐	☐	☐
5	Because I enjoy the effort I invest	☐	☐	☐	☐	☐
6	Because I enjoy the interaction I have with students	☐	☐	☐	☐	☐
7	Because I feel pressure from myself to win	☐	☐	☐	☐	☐

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
8	Because I feel responsible for the students' performance	☐	☐	☐	☐	☐
9	Because I get a good feeling out of it	☐	☐	☐	☐	☐
10	Because I want to be appreciated by others	☐	☐	☐	☐	☐
11	Because I like the extrinsic rewards (i.e., money) associated with winning	☐	☐	☐	☐	☐
12	Because if I quit it would mean I'd failed	☐	☐	☐	☐	☐
13	Because it allows me to achieve my personal goals	☐	☐	☐	☐	☐
14	Because it contributes to my development as a person	☐	☐	☐	☐	☐
15	Because it is moving me toward my personal goals	☐	☐	☐	☐	☐
16	Because it personifies my values and beliefs	☐	☐	☐	☐	☐
17	Even though I often think my coaching efforts are a waste of time	☐	☐	☐	☐	☐
18	Even though sometimes I don't know why I coach anymore	☐	☐	☐	☐	☐
19	Even though sometimes I feel the costs outweigh the benefits	☐	☐	☐	☐	☐
20	Even though sometimes I question my desire to continue coaching	☐	☐	☐	☐	☐
21	To be respected by others	☐	☐	☐	☐	☐
22	To get recognition from others	☐	☐	☐	☐	☐

Open-ended questions:

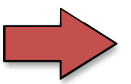
Please describe how your school's involvement in Science Olympiad has influenced your school's students.

Please describe how your school's involvement in Science Olympiad has influenced your school's teachers.

Please describe how your school's involvement in Science Olympiad has influenced your school's culture.

Answer the following three questions only if you are an elementary teacher:
Please describe how your involvement in Science Olympiad has influenced your teaching of science in your own classroom.

Please describe how your involvement in Science Olympiad has influenced your self-confidence of teaching science in your own classroom.



Please describe how your involvement in Science Olympiad has influenced your science content knowledge.

You are now finished with the questionnaire! Please remember to return this questionnaire and consent form to the check-in desk before leaving today!