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A large-scale longitudinal survey of participation in scientific events with a focus on students' learning motivation for science: Antecedents and consequences

Takayuki Goto[a,*], Kazuo Nakanishi[b], Kei Kano[c]

[a] School of Human Cultures, The University of Shiga Prefecture, 2500 Hassaka-cho, Hikone, Shiga, Japan
[b] Aketomi Junior High School, 3045-1 Mizuho-cho, Moriyama, Shiga, Japan
[c] Faculty of Education, Shiga University, 2-5-1 Hiratsu, Otsu, Shiga, Japan

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ABSTRACT

The aim of the present research was to consider whether scientific events (i.e., opportunities in which participants engage in science-related activities) can contribute to resolving the decline in students' motivation to learn science. In order to do so, we combined longitudinal survey data and participation data from scientific events to investigate whether motivation to learn science was the antecedent and/or consequence of participating in said events. The results showed that students with mastery-approach goals and a deep approach to learning were more likely to participate in a scientific event. In addition, participating in such an event enhanced the development of mastery-approach goals and the deep approach to learning. These results imply that, although scientific events can contribute to developmental changes in students' motivation to learn science, they might attract few students from the whole population. We discuss the role of scientific events and what should be addressed in future research.

1. Introduction

1.1. Background and aims

In modern society, there is a growing need for individuals with science-oriented minds who can understand and make decisions about science-based technology. However, educators in many countries are worried about an age-related decline in students' interest in or learning motivation for science (Osborne, Simon, & Collins, 2003; Vedder-Weiss & Fortus, 2011). Many researchers have attempted to understand the cause of this decline and have started looking for a way to enhance students' motivation to learn science. Some governments are also promoting educational practices that will enhance this motivation on a national level.

In Japan as well, the government has raised this decline as an important issue that needs to be resolved (Ministry of Education, Culture, Sports, Science and Technology in Japan, 2001). This was triggered by the results of the Third International Mathematics and Science Study, which showed that, although Japanese students can deliver high academic performance, they have quite a low interest in learning science (National Institute for Educational Research, 2001). In order to increase students' motivation to learn science, the government of Japan made a statement in support of the development of opportunities and activities to increase children's interest (Government of Japan, 2010). For instance, Science Agora 2015, one of the largest events in science communication in Japan, provides an opportunity for policymakers, scientists, businesspeople, media, and other citizens to interact or collaborate, with the aim of promoting general engagement in science. This event was supported by many institutes, including the Japanese government (Japan Science and Technology Agency, 2016).

The aim of the present research is to consider whether such a scientific event can help resolve the decline in students' motivation to learn science. A scientific event for the purposes of this research is an occasion in which participants engage in some science-related activities. Most scientific events are held outside of schools. Such activities are called "informal learning," in contrast to formal learning, which involves structured learning activities defined in the school curriculum (Stocklmayer, Rennie, & Gilbert, 2010). The research questions are 1) Does students' initial motivation to learn science predict whether they will participate in a scientific event?; and 2) Does participating in a scientific event contribute to the development of students' motivation to learn science? Data from a large-scale longitudinal survey were utilized to answer these questions.

* Corresponding author.
E-mail address: goto.t@shc.usp.ac.jp (T. Goto).

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1.2. Review of previous research on informal science learning

Informal learning is considered to be learner-led and intrinsically motivated, rather than teacher-led and, in most cases, extrinsically motivated, as with formal learning (Rennie, 2007). Researchers who interviewed attendees of an informal science lecture found that they were primarily motivated by intrinsic factors, such as learning or enjoyment (AbiGhannam et al., 2015). This indicates that attendees of a scientific event are likely people who are primarily motivated to learn science by intrinsic factors. Some studies classified attendees of scientific events into clusters defined by their attitude toward science and technology, comparing these proportions with those obtained through a large-scale survey. They revealed that the attendees mostly consisted of those who were highly interested in science and technology (Kano et al., 2013; Kawamoto, Nakayama, & Saijo, 2012). In another research context, some longitudinal surveys have suggested that a positive attitude toward science is the antecedent of informal science learning (Alexander, Johnson, & Kelley, 2012; Suter, 2012). These results support the notion that scientific events might only attract those who are intrinsically motivated to learn science.

As for the outcome of informal science learning, in general, scientific events and other informal science learning experiences can enhance students' learning. Cumulative evidence actually shows that out-of-school programs have a positive impact on students' learning (Lauer et al., 2006). As for science learning, Dabney et al. (2012) revealed that out-of-school science activities enhanced students' interest in science-related careers. A longitudinal survey also revealed that participation in out-of-school activities during fifth grade positively predicted subsequent science values and self-concepts (Simpkins, Davis-Kean, & Eccles, 2006). These results support the view that scientific events can enhance students' motivation to learn science.

These results imply that, although scientific events can enhance students' motivation to learn science, it seems they do not attract students with less motivation. It may be too early to conclude that, however, as past studies have had several limitations. Research on scientific event attendees tends to rely on retrospective reports. This may direct the attendees to report a more positive attitude than they actually had, which will cause biased results. On the other hand, longitudinal surveys tend to assess experiences of informal science learning using retrospective responses. As human memory can be biased by attitudes, these retrospective responses might also be biased by respondents' attitudes toward science. To know for sure whether scientific events attract students with less motivation to learn science and enhance their learning motivation, we need to collect data on learning motivation and on scientific event attendance in independent situations. By assessing students' learning motivation for science in advance, we can avoid participants' bias in responding about their initial motivation. Moreover, by directly recording who participated in scientific events, we can avoid bias in students' responses caused by the fallibility of human memory recall.

1.3. Overview of the research

As stated above, the aim of the present research is to consider whether scientific events can contribute to resolving the decline in students' motivation to learn science. In exploring this topic, we address the following questions:

Question 1: Does students' initial motivation to learn science predict whether they will participate in a scientific event?

Question 2: Does participation in a scientific event contribute to the development of students' motivation to learn science?

In order to address Question 1, we analyzed the antecedents for participating in a scientific event. We held four scientific events at four different kominkan (similar to public halls or community centers in other countries; Iwasa, 2010) in Moriyama, a city in the western region of Japan, once a month from August 2015 to November 2015. Before these events, in May 2015, we collected survey data from students at municipal schools in Moriyama. Then, we handed out flyers to inform all students in the target population about the scientific event. In this way, we were able to examine whether students' motivation to learn science was the antecedent of participation in the scientific event.

In order to address Question 2, we continued to collect data about students' motivation to learn science (in July 2015, December 2015, and February 2016). By analyzing the longitudinal data, we were able to infer the developmental trajectory of students' motivation. We examined whether participation in a scientific event influenced this developmental trajectory.

In this study, we focused on three qualitative aspects of learning motivation. This is because learning motivation can vary not only in its quantitative aspects, but also in its qualitative ones. The first of these is autonomous motivation. Self-determination theory (Ryan & Deci, 2000) posits that human motivation can be described as a continuum from extrinsically controlled to intrinsically autonomous. It further suggests that there are four types of extrinsic motivation: external, introjected, identified, and integrated. As people get motivated autonomously, they are primarily motivated by integrated or identified reasons rather than external or introjected ones. Cumulative evidence supports the notion that autonomous motivation can help students study harder and achieve better grades (Guay, Ratelle, & Chanal, 2008).

The second qualitative aspect are achievement goals. An achievement goal is a reason for engaging in achievement behavior, traditionally classified into two different types: mastery goals, aiming to develop competence, and performance goals, aiming to demonstrate competence (Ames & Archer, 1987; Dweck, 1986). In Elliot and McGregor (2001), a 2×2 achievement goal model was used, and it was found that these two goals can be bifurcated by approach and avoidance (that is, mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance). Researchers have revealed that mastery goals can contribute to academic success, though performance goals might not; on the contrary, performance-avoidance goals impair students' performance (Elliot, McGregor, & Gable, 1999). Autonomous motivation and achievement goals were assessed as cognitive aspects of learning motivation.

Finally, the third aspect is the approach to learning, a concept that describes individual differences in students' intentions and processes of learning (Entwistle, Hanley, & Hounsell, 1979). It can be classified into three distinct approaches: deep, surface, and strategic (Entwistle & Ramsden, 1983; Marton & Säljö, 1984). Researchers have mainly focused on the difference between the deep approach (intention and process used to understand information) and the surface approach (intention and process used to reproduce information). One longitudinal survey revealed that the deep approach can facilitate students' achievement, while the surface approach might impair it (Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2012). Individual differences in learning approach were assessed as behavioral aspects of learning motivation.

As we described above, the qualitative aspects of learning motivation are important to students' learning. In sum, students with higher autonomous motivation, mastery goals, and a deep approach to learning are likely to succeed in learning science, while those with less autonomous motivation, performance goals, and a surface approach might not. We focused on these three qualitative aspects as the antecedents and consequences of participating in a scientific event because these three variables are good predictors of future academic success. If scientific events only attract those who are intrinsically motivated to learn science, participating in scientific events is predicted by autonomous motivation, mastery goals, and a deep approach to learning. If participating in scientific events increases students' learning motivation for science, then it also enhances autonomous motivation, mastery goals, and a deep approach to learning, but it does not enhance performance goals and a surface approach to learning. We assessed all three of these qualitative aspects of motivation because we could not