An innovative research-focused intervention for upper secondary science students

Svendsen, Pernille Maj

Science & Technology Administrative Centre – Guidance and Study Informatoin, Aarhus University, Ny Munkegade 120, 1524-110, 8000 Aarhus, Denmark

Abstract

Out-of-school interventions are often used as a supplement to in-class learning in science. The educational effect of this type of intervention depend i.a. on how well they are linked to the science curriculum at school. The present study aimed at identifying upper secondary science students' perceived outcomes of the out-of-school intervention "Cell, organism and climate", an intervention developed and implemented as an innovative model by a university and upper secondary schools. Assessment of student satisfaction and perceived outcomes were conducted using students' responses on a survey (n=63). The survey consisted of closed rating questions, presented using descriptive statistics, and open-ended questions that were analysed using a thematic approach. Overall, the students were excited about the intervention and appreciated the authenticity of the context. Student expectations had primarily been met, the level of the academic content was perceived as appropriate and they had gained knowledge about the nature of science and career options in science. Further, students were able to link in-class theory with the practical examples from the intervention. The findings indicate that the intervention had been well integrated in the in-class curriculum and that the students' had been well prepared for the intervention. The partnership model seemed to play an important role in relation to designing an out-of-school intervention that positively affected the students as well as their engagement and learning outcomes as the intervention was well integrated with in-class curriculum.

Keywords: science outreach; intervention; perceived outcomes

Corresponding author e-mail address: psv@au.dk

Introduction

Learning is an active, ongoing and personal process that is shaped by the context of the learning experience (Abell and Ledermann, 2007). A number of benefits of out-of-school interventions have been documented and interventions are often used to supplement or complement in-class learning of science, such as field trips, summer camps and university outreach-programs. Interventions held at university research facilities can offer students authentic insights into the nature of science, laboratory and field equipment and scientific research in the making that is not available in most upper secondary science courses as well as an opportunity to engage with professional scientists (e.g. Innes et al., 2012 and Jensen and Sjaastad, 2013).

Many out-of-school interventions have been developed as a way to give students supported access and enhance their achievement in science, attitudes towards science and understanding of the nature of science (Gibson and Chase, 2002). Students learning outcome is influenced by the design and structure of the intervention. If students are to learn from and connect with curriculum content during an intervention, it is important that the content build on students' prior knowledge and encouraging and quality learning activities are planned before, during and after the intervention (Jarvis and Pell, 2005). Also, it is important that students are aware of and know the learning objectives of the intervention (McLoughlin, 2014). Thus, the effectiveness of an intervention is largely mediated by the teacher.

During the last decade Danish Universities have developed and offered interventions, targeting upper secondary school students' interest, participation and achievement, especially in science and technology with the aim of attracting students into studying science and pursue a career in science. The interventions are offered to a wide range of schools, classes and teachers both regionally and nationally. However, what might seem spot-on for the developers of the interventions is not necessarily perceived as such by the teachers.

Upper secondary science teachers select intervention (-s) that align with their in-class curriculum and planned activities in the best possible way based on a description of the intervention or because they have tried it before. However, as teachers have not been involved in the development and design of the interventions, their professional perspectives and close proximity to the students and their science learning have not been considered and thus the link between interventions and in-class teaching may be jeopardized. Inviting upper secondary science teachers to participate in the development process may help qualify and broaden students' learning experiences.

In this study, students' self-reported perceived outcomes of a research-focused intervention developed and implemented as an innovative model of a university and upper secondary school partnership is discussed.

What are students' perceived outcomes of the out-of-school intervention "Cell, organism and climate"?

The intervention

The "Cell, organism and climate" is a research-focused intervention that has been developed and implemented as part of a larger intervention programme. The intervention was developed as an innovative partnership between a university research team, a didactical specialist and 8 upper secondary science teachers from 8 different schools. All partners had experience with other intervention programmes. The intervention was developed and implemented in fall 2013. The intervention has continuously been improved through iterative cycles, consisting of half-year evaluation meetings with the involved partners.

The content of the intervention was integrated into in-class curriculum and was taught over a long-term period (approx. 12 weeks). The content included an introduction to nature of science, how to design experiments, interpret findings and plagiarism using an active learning approach. The students visited a research laboratory (*cell*), where they were introduced to a research team (a lab-technician, a PhD student, a post-doctoral researcher and a senior researcher) who presented their current research projects, their roles in the team, and advanced laboratory equipment. Next, the students visited a loose-hosing livestock facility (*organism*) and a specialised *climate* livestock facility (with fistulated cows) where they were introduced to research projects and did hands-on activities using observation techniques. A PhD student gave an introductory presentation, led the visits to the different facilities, presented his own research project at the loose-housing livestock facility and finished the intervention with a short recap. The duration of the intervention was 2.5 h.

Methodology

The present study focuses on students' self-reported perceived outcomes after having participated in the intervention during autumn 2014. A total of 63 upper secondary students (ages 15-18) in their second and final year, from 4 classes with biology or biotechnology as specialized study subject (A-level) participated in the study.

Assessment of student satisfaction and perceived outcomes and gains was conducted by an in-class survey immediately after the intervention. The survey consisted of 10 questions with a combination of closed rating questions and open-ended questions to assess gains in student learning, student

satisfaction with the content, level of content and accordance between expectations and actual experience.

The present study focused on students' ratings of the questions "Was the day as expected" (better than expected, as expected, worse than expected and no expectations) and "Did you find the academic level appropriate" (too high, right and too low) as well as their written responses to three open-ended questions:

Describe your overall outcome of the day (learning, experience, other)
What was good?
What was less good?

Ratings are presented using descriptive statistics and a thematic analysis was conducted on the open-ended question to assist in the understanding of student experience and perceived outcome (Braun and Clarke, 2006). Codes are used to identify individual student responses on the surveys.

Findings

All 63 participating students filled out the survey following the intervention. In general, students' actual experience of the intervention was in accordance with or better than expected. Among the students, 41% (n=26) were positively surprised as the day exceeded their expectations and 41% (n=26) felt that their expectations had been met. Eight students (12.70 %) had had no expectations for the day and three students (4.73%) did not feel that their expectations had been met at all.

The academic level of the day was perceived as adequate by 98.42% (n=62) of the students and only one student (1.59%) reported it as too high.

The students' responses to the open-ended question about their overall outcome of the day showed that they generally were very excited and enthusiastic about the intervention and described it as a good experience. They appreciated the authenticity and the opportunity to "see how things [theory] work in practice" (S20). Students reported new views of science and scientists and said that they got a better idea of "what it is like being a researcher" (S25) and "how research is being done" (S14). Further, the students generally expressed an appreciation of being presented with "an overview of the possibilities that are available [within science]" (S5).

When students were asked what was good about the intervention, they highlighted that they were able to see how and where different types of research projects were conducted, which enabled them to link theory and practice. Further, they appreciated being actively involved during the intervention, which made them more engaged. They expressed that it was "interesting to see research being done in many different ways [from cell to climate]" (S33). In addition, they appreciated "that we got to see the things [research projects] in-stead of just sitting in a room listening about them" (S61) and "that we were asked questions, so that we were engaged [in the discussions]" (S21).

Only a few students made comments on what was less good about the intervention. Some students would have liked the intervention to be longer and mentioned, "it was a shame that we didn't get to spend more time [at the research facility]" (S36) as they "would have liked to see more of the research facility" (S27). Also, some students mentioned it would have been good "to have had a short break during the intervention" (S8). Three students mentioned that they did not like the "odour at the livestock facilities" (S51).

Discussion and implications

The present study aimed at identifying upper secondary science students' self-reported perceived outcomes and gains from an intervention that was developed and implemented as an innovative partnership model between a university and upper secondary science teachers. Overall, the students thought the intervention was very exciting and enjoyed the authenticity of the context of the intervention. Students' generally reported that their expectations had been met, the level of the content was experienced as appropriate, they had gained knowledge about nature of science, career options in science and they were able to link theory with practical and real-world examples.

Interventions provide valuable motivational opportunities for students to learn science if they are well managed and meaningful to the students and their learning context. Facilitating students' meaningful engagement in curriculum-based learning before, during and after the intervention is important (Jarvis & Pell, 2005). Further, the learning outcome of an intervention is associated with the students' ability to make links between the intervention content and the in-class curriculum (Abell & Ledermann, 2007). The more ownership students have, the more they will engage in an event or intervention. Information about the intervention, intended learning outcomes, how the intervention ties with in-class curriculum and having students reflect on and formulate questions they would like to have answered during the intervention, help students' align their expectations and build excitement (Jarvis and Pell, 2005 and McLoughlin, 2004). If a teacher does not know the curricular content and the structure of the intervention, it is difficult for him/her to plan meaningful learning activities before, during and after an intervention. Also, this means that teachers do not know whether the curricular content meets in-class curricular demands. Orion and Hofstein (1994) emphasize that experiences too far from student expectations will influence their attention, learning and attitude negatively. Taken together, the findings in the present study indicate that students had been well

prepared for the intervention. The intervention was as expected to the majority of students and they felt the level of the content was appropriate, suggesting that it was well aligned with in-class content and build upon their prior knowledge and interest. Students can easily be distracted during an intervention and engage in inappropriate behaviour if the intervention is not well prepared and -managed. None of the students revolted against visiting the climate livestock facility and seeing the fistulated cows, which can be an intimidating and distracting experience for some students. On the contrary, students would have liked the intervention to be extended, as they would have liked to see and do more. Extending the duration of the intervention would also allow for more time for reflection and consolidation of key messages, more hands-on activities as well as a short break, which some students also commented on. Further, students reported that they were able to link in-class theory with different types of real-world practical examples and not just laboratory research.

The intervention provided students with several scientific role models from different research fields, i.e. meeting a whole research team and not just the lead scientist or a single PhD student. Students got to experience that scientists are real people who depend on their team. By meeting a whole research team they were also presented with some of the many career options science provide, something their teachers cannot easily provide in their role as teachers. Students' images of science and scientists are assumed to influence their future educational choices and plans for a career in science (Reagan and DeWitt, 2015). Overall, the intervention positively affected the students general view of how science is done and on scientists, which has been highlighted in other studies of interventions as well (e.g. Jensen and Sjaastad, 2013).

In the present study, teachers had been involved in the development of the intervention. This gave them a unique opportunity of gaining valuable insight into the intervention content and structure. Thus, they were capable of preparing meaningful and engaging curriculum-based learning activities before, during and after the intervention, compared to having read about and selected a random intervention on a webpage. At the same time, the teachers' professional perspectives and close proximity to the students and their learning, knowledge of curricular demands and their perspective of the value of and impact of the interventions informed the university developers about the needs of teachers and students.

The long-term effect of interventions is of great interest to developers, but it is difficult to measure as many factors have an impact on students before, during and after an intervention. It would have been interesting to include if, how and what in-class learning activities that were done in the participating classes following the intervention. Did students get a chance to discuss what they had learned during the intervention with their teacher and peers? Also, it would be interesting to investigate whether teachers refer back to the intervention in future curricular content and activities and what student perceived outcomes are in the long run.

Together the university research team and the 8 upper secondary science teachers seemed to have been able to create an exciting intervention consisting of elements that strengthened in-class curriculum and positively affected students' engagement and perceived learning outcome.

Conclusion

In conclusion, when interventions are developed and designed well, they can have a positive impact on students' interest in science and their eagerness to learn and thus increase students' aspirations of pursuing further education or a career in science. It seemed that the innovative partnership model was important in developing and designing an out-of-school intervention that positively affected the students' engagement and learning outcome as the intervention seemed well integrated with in-class curriculum.

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