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Vocal and Quiet Students' Attitude Towards School Biology and Biotechnology Following an Intervention

Abstract

The present study set out to examine the impact of linking in-school biology and biotechnology teaching with out-of-school biology and biotechnology experiences on the attitudes towards school biology and biotechnology of 16 upper secondary science students from eight different schools. The students had all been selected by the other students from their classes to participate in an intervention as *Young Researchers* and differed in being either vocal (8) or quiet (8) participants during normal lessons. Through interviews the *Young Researcher*s shared their retrospective self-evaluations of the intervention. Findings show that combining an out-of-school intervention with in-class teaching and learning had an impact on the students involved. Vocal students' self-belief and future career plans were affected positively and they became more committed to reach their goals of achieving high grades going to university and getting a good job in science. Quiet students' self-belief and future career plans were also affected positively, but differently from vocal students, as they also changed their behaviour and became more vocal during class. It is, therefore, suggested that an experience of this kind can have a positive impact on students' attitudes towards school biology and biotechnology

Keywords: *Attitude towards school biology and biotechnology; Intervention; Self-concept; Self-efficacy; Vocal and quiet students.*

Introduction

Research into students' attitudes towards science has received attention for decades and it still remains of interest in science education (Oliver and Venville, 2011; Osborne, Simon, and Collins, 2003; Tytler and Osborne, 2012). Most recently research has been motivated by a declining number of students studying science, technology, engineering and mathematics (STEM) at post-compulsory level (Reid, 2006), as students' attitudes towards these subjects are likely to influence whether to study them (e.g. Tytler and Osborne, 2012). Many interventions, such as trips, summer camps and projects, have been developed across Europe to improve students' attitudes towards science and to encourage more students to consider a career in STEM (e.g. Jensen and Sjaastad, 2013; Lykkegaard and Ulriksen, 2016; Schutte and Koller, 2015). The extent of the engagement of students in classroom science activities, as active and involved participants, has an effect on their attitudes towards the subject (Sesen and Tarhan, 2010; Tytler, 2014). University students who consistently choose to participate actively during class have been shown to make significantly greater learning gains than students who rarely or never participate in class (Obenland, Munson, and Hutchinson, 2013). For example, when a teacher asks a class a challenging question or during class discussions, only a subset of students may be willing to volunteer an answer in front of the class on a regular basis. Acknowledging that students' participation may vary over time, with different teachers and subjects, we call these students vocal students. However, many students, from both university and school, tend to choose to remain silent. Again, although this may vary with time, subject and teacher, there is often a general pattern of students not being willing to participate in class, and these we call the quiet students. This could be because they are shy, they lack confidence in their own abilities, they are afraid to speak up for fear of giving the wrong answer or of fear to appear unintelligent to their peers and/or teacher (Fassinger, 1995; Gibson and Chase, 2002). Facilitating quiet students' participation in class discussions, encouraging them to ask questions and offer comments in class is likely to enhance their attitudes towards school science. However, there appears to have been little research into possible differences in attitudes towards school science of vocal and quiet secondary students, and how to improve them.

In this study, an intervention programme (*The Young Researcher Intervention*), combining in-class biology and biotechnology teaching and learning with out-of-school biology and biotechnology experiences, was developed in an attempt to improve vocal and quiet upper secondary science students' attitudes towards school biology and biotechnology and to encourage them to pursue a career in science.

Conceptual framework

The construct of attitude can be described in three closely linked components; cognitive, affective and behavioural (Reid, 2006). The cognitive component consists of the beliefs a person holds about the attitude object, for example that science is hard to understand. The affective component consists of the feelings a person holds towards an object. This could be a feeling of excitement when solving a physics problem. The third component is the behavioural response or action that is taken towards the object, for example pursuing a career in science. The three components refer to an evaluative judgement of the attitude object, e.g. attitude towards school science or attitudes towards scientists (Lemon, 1973). It is important to notice that there is a basic distinction between attitudes towards science (for example school science) and scientific attitudes (working and thinking in a scientific way) (Gardner, 1975). Attitude towards school science, more specific biology and biotechnology, is the focus of this paper.

Attitude towards science is not a single unitary concept as it consists of a large number of sub-constructs that contribute in varying degree towards an individual's attitude towards science. The sub-constructs that should be included in a study depend on the context in which attitude is investigated (Osborne, Simon and Collins, 2003). This study looked at the attitudinal sub-constructs of enjoyment of biology and biotechnology experiences, self-belief and plans for future participation in science. The feeling of enjoyment of biology or biotechnology a student derives when engaging in a task. Self-belief is regarded as being a student's conception of their competence in relation to school science, which are believed to form attitudes towards the subject. Students' future plans for participation in science (e.g. a job in STEM) are considered to be the students' attitudes towards engaging more with science in the future. These three sub-constructs of attitude were relevant in this context as it was considered that they would be affected by the intervention. In addition, the study included the support by and influence of others, e.g. teachers and peers, as they are known to have an effect on both self-belief and future participation in science (e.g. Nugent et al., 2015). Until recently, most studies on attitudes towards science have focused on quantitative methods, mainly surveys (Tytler, 2014). Qualitative studies have smaller sample sizes and therefore tend not to be used to make generalisations, but they offer insight into the influential factors underlying the students' attitudes towards school science (Osborne, Simon and Collins, 2003). This study is conducted using a qualitative approach, consisting of in-depth interviews with students to capture their enjoyment of biology and biotechnology, self-belief, plans for future participation in science and any additional influences that developed during and after the intervention, to investigate how they talk about their attitudes towards school biology and biotechnology and beyond. This means the data will be rich and will help us to give reasons for attitude changes.

The most widely studied self-belief constructs are self-concept and self-efficacy because of their influence on students' academic functioning (Pajares and Schunk, 2002). The things we believe we are capable of, how we compare others to ourselves, the judgement we make of how others view us, what characteristics we think we possess and what roles we take on, all have an influence on the way we behave and what actions we take in learning situations (Bong and Skaalvik, 2003). The two constructs share a common core in that they are concerned with an individual's self-belief of competence (Lee, 2009) and they are sometimes used interchangeably. Self-concept and self-efficacy both influence the tendency to engage in some tasks and avoid others, they also affect how much effort people will expend on an activity, how long they will persevere when confronting obstacles and challenges and how resilient they will be in face of failures (Bandura, 1977). However, the two constructs are theoretically and conceptually different: Self-concept is an evaluation of the skills and abilities one possesses and focuses on past-oriented conceptions, whereas self-efficacy focuses on performance capabilities to fulfil given tasks and is future oriented (Zimmerman, 2000). Nevertheless, when using a qualitative methodology it is sometimes difficult to make a clear distinction between the two sub-constructs, because respondents' replies might not fall into specific categories.

Self-concept describes a person's general perception of the self in given fields of functioning. Here, self-concept is based on beliefs about one's own ability to master school science, which in turn is believed to form attitudes towards the subject (Kind, Jones, and Barmby, 2007). Self-concept perceptions are past oriented because relevant experiences need to be processed, based on the type of experiences and achievements in the past (Bong and Skaalvik, 2003). Self-concept is influenced by social comparison, causal attributions, reflected appraisals from significant others, past experiences and psychological centrality. It is suggested that students compare their own academic performance with that of other students in their class and use the resulting social comparison information to form their own self-concept (Nagengast and Marsh, 2012).

Self-efficacy refers to one's perceived confidence to be able to do things or gain particular outcomes in given situations (Bandura, 1977). Self-efficacy is future oriented because it represents an individual's confidence in his/her successful accomplishment of a task. Self-efficacy focuses on performance capabilities rather than personal qualities (Zimmerman, 2000). Enactive mastery and vicarious experiences, verbal persuasion and physiological reactions play a role in shaping one's self-efficacy (Bandura, 1997).

There is a concern about students opting out of the STEM pipeline, which is often explained by a lack of interest in pursuing a STEM education or career (e.g. Regan and DeWitt, 2015). The broadening of curriculum offerings in new subjects and the perceived difficulty of school science subjects are elements that influence students' decisions about taking further science courses (Archer and Tomei, 2013; Lyons, 2006). Also a number of studies have shown that students and their parents have very little idea about subject usefulness and the range of careers and jobs to which science can lead (Archer and Tomei, 2013; Blenkinsop et al., 2006).

Engaging students in hands-on activities corresponding to those carried out by professionals and providing them with information about the variety of careers in science may have a positive effect on them to pursue a science-related career (Schutte and Koller, 2015). Archer, DeWitt, and Dillon (2014) have reported how a careers-focused intervention may have a positive effect on broadening students understanding about the possibilities within science.

A large variety of out-of-class science activities exist, such as field-trips, visits to museums and science centres as well as intervention programmes offered by organisations such as universities and companies (e.g. Innes et al., 2012; Jensen and Sjaastad, 2013; Luehmann, 2009). These activities and intervention programmes are developed as a way to give students supported access and enhance their achievement in science, understanding of the nature of science and attitudes towards science (Gibson and Chase, 2002). Interventions held at university research facilities can offer students an actual and first-hand insight into laboratory and field equipment and scientific research in the making that is not available on most upper secondary science courses. Also, students meet and talk to professional scientists and university students, which contribute to their knowledge about STEM opportunities and careers (King and Glackin, 2010).

However, the effect of interventions depends on a number of factors. The content of the intervention should complement the science curriculum at school. A meaningful engagement in curriculum-based learning activities before, during and after the intervention is necessary (Jarvis and Pell, 2005) and both in-school and out-of-school teachers have to make student learning objectives clear and be able to relate the content of the intervention to the students' interests (McLoughlin, 2004).

This study investigates the impact of an out-of-school intervention with in-school biology and biotechnology teaching on vocal and quiet students' attitudes towards school biology and biotechnology. Specifically, this looks into their enjoyment of biology and biotechnology, self-belief, plans for future participation in science and additional influences. The research questions were:

- What are vocal and quiet students' self-evaluated outcomes of the intervention?
- How did the intervention influence vocal and quiet students' attitudes towards school biology and biotechnology, indicated by their enjoyment, self-belief and future career plans?

Further, the study intends to identify any useful information about the design of intervention programmes that can be used to inform developers and practitioners who wish to improve students' attitudes towards school science.

Method

The Intervention in the Current Study

The *Young Researcher* intervention was developed with the aim of improving attitudes towards school biology and biotechnology among science students, and inspiring them to pursue a career in science. The topics of the intervention were the nature of science, intestinal nutrient uptake and intestinal cancer which were closely linked with the in-school curriculum. The intervention was developed in collaboration with upper secondary science teachers, one from each of eight participating schools, and five science researchers. The intervention was integrated into biology and biotechnology lessons over a period of three months. It consisted of whole class teaching combined with a whole class research visit to Aarhus University (AU), Foulum, Denmark, then the selection of 16 students to participate further, followed by two six-hour *Young Researcher* days for these selected students, working in a cell biology laboratory at university, two weeks apart. The *Young Researchers* were responsible for sharing what they had learned with their class, who depended on their input in order to progress with the class curriculum.

The two *Young Researcher* days consisted of short introductions then hands-on practical exercises in the cell laboratory and group work in co-operation with the research team. The *Young Researchers* were encouraged to ask questions and discuss their findings with each other and the research team.

Selection of Participants

The present study is based on 16 upper secondary science students selected to be *Young Researchers* in the intervention programme during spring 2015. All students (aged 16-18 years) had biology or biotechnology as their specialised study programme (A-level subject).

After each whole class visit to AU Foulum, each of the upper secondary science students in the eight schools (in total 116 female and 73 male students) chose two students to participate in the intervention. All students were involved in the selection, in order for them to take ownership of the project and because students have known each other for 18 months, in a variety of topics and subjects. Students were encouraged to choose a vocal and a quiet student on the basis of a vocal student being a student who participated or attempted to participate in class discussions and who was willing to answer questions on a regular basis whereas a quiet student rarely participated or attempted to participate vocally in class.

The selection of students was based on a class discussion about the abilities that would be needed for a student to participate as a *Young Researcher*. Abilities were listed as items on a schema and all students had to rate themselves on a scale from 1 (very poor) to 10 (very good) on each of the items, and inform whether they were interested in participating in the intervention or not (98% response rate). Schemas varied slightly between schools, but common features were that students had to be knowledgeable, committed, creative and have an ability to collaborate and an ability to communicate.

Students were also asked to write the names of two other students on each item that they thought would score highly on that particular item, with one student being characterised as vocal during class and the other as a quiet student. Out of the 189 students from the eight participating schools, 61 students were interested in participating as *Young Researchers*. The decision of who should participate was based on the schemas with the highest average rating of items, followed by a class vote in most schools and in a few the teacher had the final say. In total 16 students were selected to participate (two from each school), eight students characterised by students from their class as vocal and eight as quiet students.

Thirteen female and three male students were selected. Although females in this group are over-represented, it was important for the research that students chose which peers would be selected. Possible reasons for the over representation of female students may be because the subject of the intervention was cancer, which may have meant that more female students were willing to participate in the scheme. Also there were more quiet female students as boys consistently show more positive attitudes towards school science than girls and they are more confident (Reagan and DeWitt, 2015) and thus vocal during class.

Data Collection

Data for the present study consisted of individual semi-structured interviews with the *Young Researchers*. Interviews were used to enable students to share their thoughts, feelings and understandings that had developed during the intervention (Brinkmann and Kvale, 2015). The interview schedule focused on components of measures of attitude towards school biology and biotechnology, such as the students' incentives to participate in the intervention, enjoyment of biology or biotechnology, their self-belief, the people who had supported and influenced them during the intervention programme, their self-evaluated outcomes of the intervention and specifically whether the intervention had affected or changed their future career plans. The interviews lasted about 30 minutes, they were carried out in Danish and recorded and transcribed verbatim. Excerpts in the paper have been translated into English by one of the authors.

Data Analysis

An exploratory thematic approach consisting of six-steps was performed to analyse and structure the interview data (Braun and Clarke, 2006). In the first step we became familiarised with the data, reading through the transcripts and identifying interesting and recurrent passages. The second step consisted of the construction of an initial thematic framework. In the third step data were indexed and in the fourth step, similarly indexed data were sorted into themes and subthemes. Step 5 involved reviewing the data extracts to see how well the thematic framework fit the data and finally, step 6 of the data analysis consisted of making an interpretation of the data. The interpretation moves across the data but also looks more deeply into specific interviews and uses quotes that illustrate points and patterns in the themes.

A fellow researcher not involved in the project was involved in the data analysis and differences were compared and discussed until an agreement was reached, with the initial inter-coder reliability being more than 80 %. The agreed codes were used in the final coding of the interview transcripts using NVIVO 10. In the present paper, three key themes have been identified, coded and analysed. The key themes are; students' self-beliefs, students' future career plans and additional influences. Student names are pseudonyms and the letter in parenthesis after student quotes represent whether a student was perceived as vocal (V) or quiet (Q).

Findings

First, we consider the overarching theme of students self-evaluated attitudes and then move on to how the three themes serve to capture the vocal and quiet students' attitudes towards school biology and biotechnology.

Attitudes

When asked about impacts of the intervention on them, some students explicitly expressed a strengthened appreciation for biology and biotechnology after the intervention and said that it had improved their attitudes towards school, biology and biotechnology:

> "I actually think it has changed my attitude towards school. Especially biotechnology, I am not quite sure what it was about that day [at AU Foulum] but I thought it was really good. And then lately I think that I have had an even bigger enthusiasm for biotechnology, than I had before" (Jasper, Q).

The students' feelings and emotions towards the intervention reflect the affective component of their attitude towards school science. All *Young Researcher* students felt enthusiastic about the intervention and captivated by the design and the topics included in it. The students expressed having achieved "a better understanding of the topics and content" (Nancy, Q) by "linking theory and practice" (Sheila, V). They felt that "the content had a moderate level of difficulty" (Andrew, V) and that it was properly linked to the in-class curriculum.

Students' self-belief. Self-belief was one of the sub-constructs of attitude used in this study, i.e. a student's evaluation of their own competence in relation to school science, looking into self-concept and self-efficacy.

Vocal students characterised themselves as highly participatory in class discussions and they "talk a lot during class" (Alice, V) and "if there is something I do not understand, I just ask about it" (Rosemary, V). In relation to being a quiet student, one of the vocal students says: "… [quiet students are] not that active, which of course has nothing to do with not being clever and such, but perhaps it is more about how active you are [during class] or how shy you are or something" (Charles, V).

The quiet students said about themselves that they were not very willing to ask questions or offer comments during class discussions unless they understood the material and were absolutely certain of the correct answer to a question in class as they worried about the other students' and their teachers' perception of them. "If I say something during class, I don't say it unless I am 100% sure, because you are always afraid of what others might think and so on" (Tina, Q). And as Jasper (Q) says "I often have a tendency to, how shall I put it, to kind of think that if it [the answer and/or comment] is wrong, then it is stupid to have said it and so I don't say as much during class".

Most of the quiet students expressed that they had not anticipated being chosen for the intervention. They were generally modest about their own abilities and did not consider themselves as high achievers compared to the vocal students: "Well, I was a bit surprised when I was chosen, personally, when I compare myself to others, then there are others who are better than me" (Nancy, Q). "…it depends on who you compare yourself to because I think our class generally has a pretty high level. And then I think, well, I think that I am pretty normal" (Joanna, Q).

Social comparison is also a source of information for self-concept and hence this suggests that quiet students have a lower self-concept when making an external comparison, comparing themselves to the students in their class before the intervention. Some of the quiet students expressed an appreciation that the selection of students "did not necessarily have to be the two best [in attainment] in class and it was kind of more open to everyone" (Donna, Q) which gave them incentive to opt in.

All students were very pleased that they had been selected for the intervention. For the majority of all students this was the first time they had been selected to participate in a science intervention. The acknowledgement from the class and teachers, in thinking they possessed the abilities acquired to participate, made the students feel able to do it and thus affected both their self-concept and self-efficacy positively. There were more examples of quiet students talking about this than vocal students: "It shows that they [the other students in the class] want you to participate in things like this and want you to represent the class, which was nice" (Jasper, Q). "Well, I have just got some more faith in my own abilities. Also because others kind of had to select me… It was nice to know that others think that I can do it" (Linda, Q).

For some students it was the content of the intervention itself that was important in leading them to increase their self-efficacy. "… I think [it gave me] affirmation that you can do this sort of thing and you had the impression that they [the research team] expected something from you and I think we fulfilled that which is reassuring" (Jasper, Q).

Additionally, multiple visits to the research laboratory seemed to have enhanced students' self-efficacy. Most students mentioned that the second *Young Researcher* day was less intimidating as "you kind of knew what it was all about" (Joanne, Q) and "you knew the agenda, how things would run and you knew the laboratory" (Donna, Q) and students thus felt much more relaxed and able to participate. Students' evaluations of the research laboratory as a friendly learning environment seemed to have affected their achievement positively, increasing their self-efficacy.

Despite this, one of the quiet students still expressed doubt in her potential; "I would like to study medicine, but I am not confident that I will get the grades to be able to do it" (Nancy, Q). This still may represent an increase in Nancy's self-efficacy, and maybe an honest and realistic judgement of herself.

Being part of the intervention also affected the quiet students' willingness to engage vocally and ask questions in class. A few quiet students explicitly mentioned that they would make more effort and "step on it" (Joanna, Q) in relation to participating in class.

The quiet students seemed to have realised the value in participating and asking questions by getting instant feedback on their own understanding as well as the benefit of having to explain concepts aloud, in groups or when teaching their fellow students in class:

> "… well I feel like it [something in me] has changed because previously I didn't ask [questions] as much. If there were something I didn't understand, for example, I thought that she [the teacher] might tell more about it later or that maybe it didn't matter. Whereas at Foulum, by just asking about little things, I really got a lot of knowledge and then you got a lot of extra knowledge and [I got] so much more out of it [by asking about things]. And that kind of made me think, okay, if it is like that, if I ask questions during biology lessons, then I will get so much more from it and that would be great. So I think that I have become much more inquiring when learning new things, because I have realized that if you want to know stuff , you get so much more out of it [by asking]" (Joanna, Q).

This self-evaluated change in quiet students' behaviour from being reluctant to talk to being more vocal in class is a noticeable and important difference in their attitude in school biology and biotechnology lessons.

Overall, students' perceptions of themselves seemed to have been positively affected by the intervention especially the self-efficacy sub-construct of self-belief. Self-concept differed between vocal and quiet students when making an external comparison, with vocal students very likely having a higher self-concept because of their certainty in their own abilities.

Students' future career plans. The intervention aimed to inspire science students to pursue a career in science by making them aware of STEM careers and broadening their views of where science may lead. We wanted to explore whether students expressed STEM-related aspirations and whether they were interested in studying and working within a science or science-related field in the future.

Students were asked about their aspirations for future education and careers. All students aspired to a career in a STEM or STEM-related field. They all had good knowledge of the Danish educational system and they knew what options lay before them and how to proceed to further or higher education when finishing upper secondary school.

All but one vocal student said they wanted to continue on to higher education. For example, one student said that participating in the intervention "whetted my appetite [for continuing on to university]" (Rosemary, V), and increased their "will to go to university" (Andrew, V). Knowing that they wanted to go on to study science in higher education encouraged students to work hard in school in order that they would get the necessary grades to be able to do this. Other students also wanted to do something in the STEM field e.g. a molecular biologist (Gloria, V), a veterinarian (Rosemary, V) or a doctor (Andrew, V). One vocal student wanted to continue on to further education to become a physiotherapist (Mary, V).

Among the quiet students, half wanted to continue on to higher education and half wanted to continue on to further education. Between the quiet students who wanted to go on to higher education, only one student knew what she wanted as her future career, namely to be a veterinarian (Donna, Q). The three others were undecided, but they knew that they wanted to study science, as

Jasper (Q) says "generally all aspects of science interests me… computer science, biology, technology and physics". The quiet students who wanted to go on to further education aspired to have jobs in a STEM-related field e.g. a dietitian (Linda, Q) and a physiotherapist (Tina, Q).

The intervention appeared to have had a positive influence on students in broadening their views of where science can lead and how science qualifications are transferable. As Charles (V) says "you know that it [science qualifications] can keep options open". Students generally said that they valued having been presented with various career options. Working with the research team and experiencing their different contributing roles made students more aware so "being a researcher…is an option, which is something I have taken with me from there [the research laboratory at AU Foulum]" (Donna, Q). In fact, after participating in the intervention, all but one of the students who wanted to continue on to higher education also considered being a researcher as a possible future career. For instance, one of the vocal students explained how her aspirations had changed as a result of the intervention:

> "Well, when I opted in for the project, I thought I was going to be a veterinarian… but now I have moved a little away from that... I might study to become a researcher, after having been out there [in the research laboratory at AU Foulum] within the field of biology" (Sheila, V).

Two presentations about career paths made students consider a broader spectrum of career opportunities in science and it showed them that choosing a particular career in science would not mean that they were fixed to only that one career path. As one of the students put it:

> " I think, the part about hearing how people got to where they are today was one of the things I found really cool about being at Foulum. You might have an idea of what to do, but then you might realise along the way that there is something else you would rather do instead…" (Rosemary, V).

In other words, the intervention seemed to have positively added to students' aspirations in science and it had effectively broadened their knowledge of where science can lead.

*Additional influences***.** In this study, several different additional elements were found to have an influence on the *Young Researchers* in relation to their participation and their self-evaluated outcomes of the intervention. Being in a working research laboratory and having the support of family, the research team, the other *Young Researchers*, their class and their teachers all had a positive influence on the students, to varying degrees.

About two thirds of the students came from families where either one or both parents had further or higher education backgrounds and about one third of the students (3 V and 3 Q students) came from families where both parents had a vocational education background. Generally, family encouragement and support were perceived as high and students explained that their parents were happy for them and "they thought it was really great that I was given the opportunity to participate" (Sheila, V). One of the quiet students was immediately "asked if he wanted to borrow his parents' car" (Jasper, Q), so that he would be able to participate in the two *Young Researcher* days. In addition, most students said that their parents had asked and talked to them about their experiences following the intervention.

Working in the research laboratory with the research team at AU Foulum had a positive influence on all students. The students felt very welcome by the research team who managed to create "a pleasant atmosphere" (Alice, V), where "things were explained very well" (Jasper, Q). The students expressed a feeling of inclusion and acceptance that promoted their interaction with the research team and they felt safe asking questions and engaging in discussions: "...I got to ask the questions that I wanted to ask and I think they were really good at explaining the things too, in a good pedagogic way... and they were just really good at answering questions" (Rosemary, V).

The intervention gave the students a new perspective on how science is carried out in working scientific environments, outside of school. The students developed an understanding of the complexity of scientific research, the need for persistence, accuracy and precision, e.g. “How many times you really have to do an experiment, in order to be able to use the data” (Mary, V) and “how much preparation you have to do before you can do your experiments” (Holly, V). Students focused on and really enjoyed doing things they could not do, or were different from the things they normally experienced, at school, e.g. because of equipment and resources: ”Well, the thing is, that when it says sterile water, then it actually is sterile water, and not just school tap water, I think it’s really nice experiencing what it is like” (Mary, V).

> “I thought it was pretty fascinating to try, how shall I put it, to stand with it [research equipment] in your hands and being in the place where it happens… it was not just something you were told, but you had to do it yourself” (Charles, V).

Also, more than half the students mentioned that the intervention had improved or changed their perceptions of researchers and laboratory technicians positively, e.g. “I have realised that not all research have to be really boring, where you work in a dark room doing scary experiments” (Tina, Q). Also one of the quiet students was particularly affected by the female post-doctoral researcher and said:

> ”One of the researchers, I just think that… she was just mega cool and very pleasant. And I think that it was really great to kind of like see a young and sparky woman like her being able to do something that might seem a bit nerdy. I think that was really nice. It is not like I think I am prejudiced or whatever but it was still nice to see, that I can mirror myself a little in her and think that if someone like her can do it, that I can imagine myself doing it” (Joanna, Q).

The *Young Researchers* appreciated that there were two students from each school participating in the intervention as they valued working with their fellow school student as *Young Researchers*. At the same time, they also appreciated being mixed in groups with students from other schools in the laboratory. They felt part of a group of people who had a shared interest in biology or biotechnology, who had been selected on more or less the same abilities and who had opted in, “which made it easy to talk to everybody” (Sheila, V), and created a safe environment where “everyone was prepared to work and learn something” (Joanna, Q). The opportunity to work with other *Young Researchers* may have affected their frame of reference for evaluating their own science abilities and helped the students realise that they could do well.

Support from the students not having been selected as *Young Researchers* seemed to have had a positive influence on the *Young Researchers* too. Nancy (Q) said: “The class participated in the project together”, which seemed to make the class more willing to participate in whole group discussions, when the *Young Researchers* shared their findings and experiences, compared to normal lessons. This feeling was strengthened by these non-selected students showing an interest in learning more about their experiences and asking questions about it once the *Young Researchers* returned to school. One of the students mentioned that she thought the students from her class appreciated that the *Young Researchers* “told [them] what we were doing, so it was not something secretive, that no one really knew anything about” (Donna, Q) and continues by saying how “it was nice for us being able to share our experience with the class”. The *Young Researchers*’ own enthusiasm and commitment to the intervention programme seemed to add to this:

> “I really think it [being committed] had an influence on people, because people were like, ‘wow that was pretty cool’ and ‘that was really great’ and such and ‘wow where do you know this stuff from?’… But I generally think it [commitment] is contagious… it helps the class a lot if someone is committed” (Gloria, V).

The majority of the students felt supported by their teachers and mentioned how their teacher had thoroughly planned classes, so that the intervention content linked to the in-class curriculum and they included the *Young Researchers*' findings and experiences at the right time:

> ”Our teacher had put a lot of thought into it, so that we wouldn't lag behind… But I thought it was really nice, well, I think it would be an advantage if you kind of urge the teachers to teach these topics, you know at the same time as the project. I think that was part of what really made me learn from it, but my class also gained a lot from my presentation and teaching" (Donna, Q).

All students had met with their teacher before the two *Young Researcher* days and some students reported that the preparation consisted of "we went through the laboratory journal and she sat with us and asked if there was something we didn't understand" (Charles, V). Other students experienced that "…well, we got the lab journal and then that was that" (Tess, Q). This seemed to affect these students' experiences, as they did not appreciate "what it [the whole first *Young Researcher* day] was all about" (Tess, Q). It affected students understanding of the content positively when they had to teach their class: "I could feel, that when I got back to class, and we had to like go through it [teach] in class and such, then I could feel that I had a much better understanding of it" (Nancy, Q). Unfortunately students from two schools had not had the chance to teach their class at the time of the interview and they were not too optimistic "I'm not sure whether it will actually happen" (Holly, V).

Overall, being in a friendly learning environment and the support from various others had a positive effect in making the students more relaxed and active in their learning.

Discussion

The aim of the intervention programme was to improve attitudes towards school science, specifically biology and biotechnology, among vocal and quiet science students and inspire them to pursue a career in science. All students in the present study had biology or biotechnology as their specialised study programme (A-level subject) and thus represent students who (probably) already had a positive attitude towards school science and who might realistically pursue a STEM career. High attaining students and students believing in their own abilities are more likely to continue in science post-16 (Archer and Tomei, 2013). Overall, participating in the intervention programme positively affected all of the students' attitudes towards school science. Students' self-belief was affected positively shown by their views on future career opportunities that were broadened and in many cases included doing research as an option following their participation in the intervention. However, differences were found in how the intervention affected vocal and quiet students' self-belief and future career plans.

Vocal students talked more about going into research and how to get there by ensuring they worked hard and achieved the necessary grades. Quiet students showed a more obvious change in their attitudes to science lessons by becoming more vocal and being more willing to participate in class. Quiet students talked about wanting to offer answers to questions, as well as asking them, without the same fear, as before the intervention, of being wrong in front of their class. This demonstrates a clear change in the behavioural component of attitude (Reid, 2006) and indicates enough strength of feeling (affective component of attitude) in order to influence this change in behaviour (Lemon, 1973).

That the quiet students became more vocal might have further affected their attitudes towards school science and future participation in science. We know from research that children with more positive attitudes towards science show increased attention to classroom instruction and participate more in science activities (Germann, 1988). More active participation during class has also been shown to have a positive effect on students' attitudes towards the subject (Sesen and Tarhan, 2010) and university students who participate more in class sessions make more gains in their learning (Obenland, Munson and Hutchinson, 2013). It seems likely that this might be the case with the quiet students in the present study. So quiet students started to believe in their own abilities and potential, they realised the value of asking questions, as it led them to learn and understand more, and they changed their behaviour and became more willing to participate vocally in class.

A number of elements could have influenced the students' positive change in self-belief. Self-belief is a difficult area with many overlaps between self-concept and self-efficacy. Overall, it seems like vocal students' self-belief was higher compared to quiet students who at the same time experienced a greater positive influence on their self-belief than vocal students.

Self-concept is formed in relation to both internal and external comparisons. Internal comparisons refer to students comparing their self-perceived ability in one subject with their abilities in another subject, whereas when making an external comparison, they compare their own abilities in subjects with the perceived abilities of other students (Marsh, 1986). The quiet students did not perceive themselves to be high achievers in biology/biotechnology compared to vocal and other students in their class (external comparison). External comparison with peers in the immediate social context can to some extent change self-concept (Stake and Mares, 2005) and the *Young Researcher* experience seemed to have particularly affected the quiet students' frame of reference positively. At AU Foulum, students compared themselves to their fellow *Young Researcher*s, who had been selected to participate under the same circumstances. Thus quiet students probably considered themselves as level with the other *Young Researcher*s, whereas compared to their class, they did not consider themselves to be high achievers or at the same level as some of the other students. When returning to class and presenting their experiences and findings, the *Young Researcher*s came to realise how the experience had increased their competence and knowledge in science. They compared themselves favourably to others in their class, who had not participated as *Young Researcher*s, which probably helped increase their self-concept. A more positive self-concept may result in higher achievement, which again leads to a more positive self-concept (Marsh and Section, 2006). Vocal students probably experienced the same, but were affected to a lesser degree, as they already perceived themselves as high achievers.

The *Young Researcher* experience was a successful experience for all students, influencing their self-efficacy positively, as they were able to undertake the actions required to complete the intervention. When students understand that they can progress in their learning, their self-efficacy increases (Palmer, 2002).Vocal and quiet students differ in their level of self-efficacy, with vocal students having higher levels of self-efficacy, as they knew themselves to be high-achievers and opted in to the intervention without much consideration. However, being selected to participate in the intervention by the students from their class, especially had a positive influence on quiet students and they came to believe that they could do the work given to them, influencing their self-efficacy positively. In addition, a friendly environment, created by instructors, has been shown to have an influence on students who start to ask questions and be open about their skills (Jensen and Sjaastad, 2013). Thus being in a friendly environment with the research team and fellow *Young Researchers*, where it was safe to ask questions and share information with one another seemed to have been important for the quiet students. Moreover, the students in the present study experienced successes with the skills and abilities they had, both at AU Foulum and back in class, strengthening their self-efficacy.

Both self-concept and self-efficacy are related to assessments, by students, of their capacity to enter higher education and do well (Parker et al., 2014). Self-efficacy plays a part in educational progression and the decision as to whether or not to go into higher education. Students' external and internal comparison processes (self-concept) have a significant influence on STEM degree selection

(Parker et al., 2014). In our study, all vocal students but one wanted to go into STEM higher education, while only half of the quiet students considered STEM higher education. By increasing the quiet students' self-belief, they may be more likely to choose higher education in STEM. It would be interesting to conduct a long-term longitudinal study to follow the actual educational and career outcomes of students that participated in the intervention.

Archer, DeWitt and Dillon (2014) suggests that considering interventions suitable for a wide range of students is inappropriate, as whole-class interventions will have to address a heterogeneous group of students in different ways. For example, in a study by Klop (2008), a whole class intervention designed to change students' attitudes towards modern biotechnology showed a positive change in some students whereas others appreciated the intervention to a point but then they lost their interest and concentration. Thus, providing interventions for selected groups of students may have a more pronounced impact as the content and academic level of the intervention can be targeted. Our findings raise an interesting question regarding the impact on attitudes towards school science of two different types of students: Should interventions be open to a few (vocal/high achieving) students, and provide activities and experiences that reinforce their pre-existing positive attitudes towards science to try to keep them in the scientific pipeline, or, should interventions serve as a mechanism to improve the attitudes of quiet and/or *potentially* high achieving students towards science, and encourage them to consider higher education and a career in STEM, thus possibly increasing the size of the pipeline?

Gibson and Chase (2002) found that students who applied for an intervention programme, aimed at stimulating a greater interest in science, maintained a positive attitude towards science. In another study by Schutte and Koller (2015) students self-selected to participate in an intervention programme, designed to motivate more upper secondary school students to pursue a science career. The students in their study were highly motivated in science at the onset of the intervention programme and participating in the intervention did not change or develop their future career plans in science. Taken together these along with our findings suggest that students who apply or self-select for science intervention programmes already have high levels of self-belief and future career plans in science or a science-related field, and that the effect of the intervention, on this type of student, is relatively low. Moreover, Archer, DeWitt and Dillon (2014) suggest that girls participating in a STEM career intervention from high attaining groups were confirmed in their aspirations towards science or a science-related field whereas the intervention may have been more influential on girls from the middle attainment group, changing their views on science.

The students in our study were all interested in science and in participating in the intervention but the data imply that the quiet students would not have self-selected or applied for participation due to their lower level of self-belief compared to the vocal students. Our findings suggest that promoting interventions aimed at building quiet and/or potentially high achieving students' self-belief in science while enjoying the experience could be a way to increase their self-belief and thus the size of the scientific pipeline.

Conclusion and implications

Interventions appear to be effective if they are carefully developed, planned and "performed". The intervention in our study made a difference to all students and in particular quiet students, as not only were their self-belief and future career plans positively affected, but also their behaviour changed towards being more vocal during class.

Therefore our study has some implications for designers and teachers planning interventions who wish to improve quiet students' attitudes towards science:

- Make the aim and prerequisites for participation very clear to all students.

- Involve all students in the intervention programme and let students participate in the selection of their classmates for specific parts of the intervention, as being selected by their peers had a pronounced impact on the selected students.
- Make sure to include multiple visits so that students' self-belief is strengthened.
- Create a friendly environment out-of-school where researchers can influence student participation and learning. Researchers should create an environment where it is safe to ask questions and make mistakes, without students' contributions being assessed.
- Students' should actively participate and work with peers from other schools and investigate real-life problems or questions and engage in activities corresponding to those carried out by professionals.
- Students should be responsible for sharing their experiences and be encouraged to acquire additional information from the intervention, which they then teach to their class.

The findings in this paper point to the value of interventions in increasing selected students' attitudes towards school science. The findings show that an intervention of the type presented in this paper have a large impact on quiet students, their self-belief and future career plans compared to vocal students. Targeting interventions on this type of students, suggest a likelihood for increasing the size of the STEM pipeline.

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