CURRICULUM DEVELOPMENT AND PROJECTS

Claas Wegner is a senior teacher for biology and PE at a secondary school and lecturer at Bielefeld University in the Department for Didactics of Biology.

Friederike Strehlke is a trainee teacher for the subjects philosophy and English at a secondary school and also staff member in the project 'Kolumbus-Kids' at Bielefeld University.

CLAAS WEGNER

Department for Didactics of Biology, Universität Bielefeld, Germany
Claas.Wegner@Uni-Bielefeld.de

FRIEDERIKE STREHLKE

Universität Bielefeld, Germany
Friederike.Strehlke@Uni-Bielefeld.de

The Benefits of the German Science Project 'Biology Up Close'

Abstract

Science and technology have a huge impact on all areas of today's society. Also, industrialised countries' economies are highly dependent on scientific progress which in turn makes them rely on trained people. However, recent PISA studies show poor results for German students' scientific literacy. Due to many pupils' lack of interest in the field of science and the need for scientific knowledge in today's society, it is crucial to find ways to motivate pupils to become scientists and increase their interest in this field. In order to achieve this, Claas Wegner initiated the project 'Biology Up Close' in 2009. During workshops at university, participating pupils aged between 10 and 18 years have the opportunity to 'grasp' scientific phenomena through conducting experiments in a motivating way. This article describes the project and also its beneficial aspects enabling pupils from regional schools to experience biology in a vivid way at university laboratories. The workshops are planned, organized and held by teacher students, which in turn helps them to improve and reflect on their teaching skills. Finally, the article presents how the project promotes the pupils' interest in science in a conclusion.

BACKGROUND

Natural sciences and technology have a huge impact on all areas of today's society and have become indispensable for our cultural identity. Consequently, schooling young people in the subjects of science, technology, engineering, and mathematics is essential for every country striving after long-term economic success. Especially the industrialised countries' economies are highly dependent on the development of new technologies, scientific progress and also future engineers who have to be well-educated and well-trained. Yet, there is a lack of pupils' interest in science subjects to be on view in many European countries as well as a shortage of young researchers which is problematic (Merzyn, 2008).

Since 2000, the Programme for International Student Assessment (PISA) study has been conducted regularly by the OECD, the Organization for Economic Co-Operation and Development. It is a worldwide study of 15-year-old students' performance on mathematics, science and reading skills

that takes place every three years in about 60 countries. Generally, PISA is meant to provide results to be used in the shaping of future educational policies and the results provide media and the public with images and perceptions about the quality of the school system (Sjøberg, 2007). Unfortunately, all PISA studies show relatively poor results for the German students' scientific literacy and hence, the development of methods to enhance student performance is demanded by the German education system as well as by education systems in other countries with similar results (Prenzel, Rost, Senkbeil, Häußler & Klopp, 2001; Rönnebeck, Schöps, Prenzel, Mildner & Hochweber, 2010). Although the number of German university graduates in natural sciences and technology has risen over the last years, scientists state that there are still a lot less university graduates than the German economy necessitates. Companies are constantly seeking graduates in mathematics, informatics, sciences and technology. This is why the Federal Ministry of Education and Research in Germany has established a variety of measurements and programs to support the young people's interest and motivation for sciences (Bundesministerium für Bildung und Forschung, 2014; Hetze, 2011; Koppel & Plünnecke, 2009; Prenzel, Reiss & Hasselhorn, 2009).

In general, a learner's motivation is regarded as the central condition for successful learning and it is driven by and highly dependent on an individual's interests and attitudes (Krapp, 2001). Rheinberg describes motivation as an activating orientation to a target status that is regarded as positive. He states that the strength of this orientation influences the action's duration and intensity. In an educational context this means that the extent of learning motivation affects whether a student learns at all and if so, for how long and with how much effort. Intrinsically motivated actions, on the one hand, are considered as interesting, exciting or challenging by learners and show positive aspects of experience. In contrast, extrinsically motivated actions pursue an instrumental goal, usually associated with positive consequences, for instance praise of the parents or good grades (Rheinberg, 2000). Consequently, Sjøberg and Schreiner (2010) state that positive attitudes towards sciences are important learning goals for schools in most countries. As a matter of fact, part of the reason for having science subjects in the obligatory school is not just to convey the established science knowledge, but also to teach pupils some respect and appreciation for science as part of their culture. Moreover, values and interest are important determinants for future educational and professional choices. To sum it up, negative experiences with science have a lasting detrimental effect on people while positive experiences are likely to have a lasting positive effect (Sjøberg & Schreiner, 2010).

The Need for Innovative Concepts and Projects

PISA results show that pupils from many countries score very low concerning their interest for and attitudes towards science. These negative attitudes may be long-lasting and harmful to how people later in life relate to science and technology. Hence, from a life-long educational and societal perspective, the affective dimensions of science education should be seen as just as important as test scores at the end of compulsory school (Sjøberg & Schreiner, 2010). Because of the high need for people that are well-trained in science and technology, experts constantly discuss new concepts on how to support interest from an early age and several extracurricular educational opportunities have been developed during the last years in Germany and many other international educational systems, such as the ROSE research project and the PROFILES project (Engeln & Euler, 2004; PROFILES, 2014; ROSE, 2014; Schreiner & Sjøberg, 2004; Sjøberg & Schreiner, 2010). The study's relevance for today has not decreased since it was just recently that Anders Jidesjö defended a dissertation based on ROSE and similar results regarding affective aspects are also found in newer data from PISA and TIMSS (Jidesjö, 2012).

ROSE is short for 'The Relevance of Science Education' and is a comparative, cooperative research project involving about 40 countries. It originated at the University of Oslo in Norway under the leadership of Professor Svein Sjøberg who, by now, is retired. The project was further supported by The Research Council of Norway, The Ministry of Education in Norway, The University of Oslo and the Norwegian Centre for Science Education and is mostly locally funded. The project's main purpose is

to shed light on affective dimensions of importance to how young learners relate to science and technology and to gather and analyse information from learners about crucial factors having a bearing on their attitudes and their motivation to learn sciences. For instance, the students are asked what they think of their science classes at school and what they would like to learn in school science education. The target population of this project is students towards the end of secondary school (age of about 15 years). The project's research instrument is a standardised questionnaire mainly consisting of closed questions with four-point scales. Following the data from the project as well as other recent educational statistics, the science and technology sector in Europe is facing a crucial problem when it comes to recruiting young people to the science and technology sector. This is why the University of Oslo conducted the follow-up project Lily (Norwegian: Vilje-con-valg). It focused on the issue of promoting young people to pursue careers in the areas of STEM (science, technology, engineering and mathematics) subjects. Recruiting conditions, retention and the equal gender representation in STEM related education and careers was in the centre of research (Project Lily, 2011). Lily, again, served as a pilot study for the IRIS project, which is short for Interest and Recruitment in Science. The IRIS project sought to find out important factors influencing the recruitment, retention and gender equity in science, mathematics and technology education. In this project, which was a collaborative research project supported by the European Commission and involved six partner institutions, the target population was first-year students at the tertiary level. Additionally, both qualitative and quantitative studies with students of the upper secondary school level or from advanced university courses were conducted (IRIS, 2014a).

An "IRIS Associated" group (also called "IRIS international") was formed of different partners, but many of those who had already participated in the ROSE project. The newly arranged group under the leadership of Dr. Anders Jidesjö at Linköping University intended to use the questionnaire locally, and collected data from STEM students eight months into their first year of university or college education. Up to September 2013, the data sets comprised findings from an additional 20 countries. For instance, the project addresses questions like 'How important was each of the following school experiences in choosing your course?', 'How important were the following persons in choosing your course?', 'Please describe how you came to choose this course', 'To what extent do you agree with the following statements about your experiences as a student so far?' or 'Do you attend a course where one gender is over-represented?' as these are crucial factors for young people when it comes to choosing a future profession. The project period ran from 2009 to 2012, however, the results from the study are still being disseminated (IRIS, 2014a; IRIS, 2014b).

PROFILES, on the other hand, stands for 'Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science'. It is a project funded by the European Commission, consists of 21 partner institutions from 19 different countries and is coordinated by Berlin University's Division of Chemistry Education. It aims at supporting Inquiry-Based Science Education and therefore conducts innovative learning environments and programmes for the enhancement of teachers' professional development. Supportive action strategies are supposed to raise science teacher's self-efficacy and enable them to take ownership in more effective ways in teaching, so as much students as possible should benefit from the PROFILES teaching modules and approaches (The PROFILES Project, 2014).

To conclude, in order for pupils to make an effort in science lessons and consider becoming scientists, intrinsic motivation and a positive attitude towards the learning content is a prerequisite. This can be best achieved, for example, by conducting experiments and exploring real life scientific phenomena in a direct way. One way of raising interest is to implement scientific subject matters into lessons as appealing, varied and entertaining as possible and to provide pupils with unexpected questions and contents (Schiefele & Streblow, 2006). Unfortunately, due to a lack of time and material, school teachers do not have the possibility to create every single lesson as interesting and appealing as possible for the wide range of students a class consists of. In the light of this evidence and after doing research on

other international projects supporting young people's interest in science, secondary school biology teacher and university lecturer Claas Wegner initiated the extracurricular project 'Biology Up Close' (German: 'Biologie-hautnah') in 2009. The project aims at getting children and young adults between ten and 18 years into science and to make them interested in becoming scientists. Therefore, the project enables pupils from cooperating, regional schools to experience biology in a vivid and direct way during science workshops at Bielefeld University's premises. This article is to present the project as well as a study concerning its beneficial aspects for both university students and participating pupils.

THE PROJECT

In 2009, 'Biology Up Close' was initiated by Claas Wegner from Bielefeld University's Department for Didactics of Biology. Its objective is to let student teachers of biology develop a one-day workshop which is related to science as well as the pupils' emotional interest. The theoretical and didactical approaches employed during these workshops are developed by student groups in two obligatory seminars. There, the student teachers are able to test and discuss their ideas with each other. After that, they are to put this workshop into practice with pupils from cooperating regional primary and secondary schools. During the preliminary seminars, the university students receive critical feedback and support by qualified academic tutors.

The topic of the workshops can be chosen by the student teachers themselves as long as they fit the regional curriculum of biology and the project's scope to enable pupils to experience science in a vivid way. This can be achieved, for example, by taking pupils to the extracurricular learning environment 'university' and letting them conduct and evaluate experiments on their own. All of the workshops are designed in order to be of direct relevance to the pupils' lives so that they motivate them intrinsically and raise their interest for science. At the moment, the project comprises a total of seven workshops for about 30 participants each. The different topics range from human biology over marine biology to dealing with the production and effects of painkillers on the human body. The action- and motivation-oriented workshops can be attended by pupils from year four to year twelve depending on the subject-matter. Normally, one workshop takes one day of between four to six hours. If biology teachers from cooperating schools wish to participate in one of the workshops with their class, they have to arrange an appointment with the university in advance. University students will then conduct the workshop together with the pupils.

During their visit at university, the pupils gain inside into the institution as well as the numerous possibilities of education and research this authentic learning environment offers. This supports them in exploring new interests for different work fields and studies, especially the branch of science which might be a future career choice after getting to know it better. Further, as children need to be motivated in order to work on challenging tasks successfully, the workshops are designed to motivate the participants and give them a high level of autonomy. By providing pupils with autonomy, their self-determination is fostered and through group work phases their feeling of social integration is increased. This in turn enables concentration and successful learning (Wegner, Minnaert & Strehlke 2013). Moreover, the workshops enhance the pupils' social skills since they cooperate with their team members, need to help each other and benefit from the cooperation to achieve their common goal, namely finding the solution to natural scientific problems. Some of the activities dealt with during a workshop will be outlined further in the following. Even if they are not realisable in the context of regular school teaching, they may function as ideas or inspiration for extracurricular study groups or projects at your school.

Another important aspect to consider in the workshop is the choice of appropriate teaching methods. They are to support the children's motivation and interest in science, such as watching short film clips, conducting biological experiments and working in the laboratory or modern course rooms on everyday life phenomena. It is worth to mention that extracurricular learning environments have developed positively during the last years and are nowadays used more frequently. Especially courses

in laboratories have proven to both motivate and stimulate pupils well (Euler, 2005). Working and conducting experiments independently in authentic laboratories raises the pupils' interest and receptiveness towards science as well as it enables them to confront scientific questions in activating learning forms. Also, experiencing this learning environment first-hand helps pupils to think about future career choices (Euler, 2005). Meanwhile, the student teachers planning the sessions improve and foster their teaching skills for they autonomously plan, organise and conduct workshops for pupils. Since the workshops' contents are selected to fit the regional biological curriculum, the student teachers will be able to use their self-developed teaching material later in their professional life as well. Hence, the project is beneficial for both the university students planning the workshops as well as the pupils participating in them.

One Example of the Project's Workshops

As mentioned before, the project comprises workshops dealing with relevant science topics. This paragraph is to explain the Cosmetics Workshop in more detail, functioning as one example of the various workshops the project offers. During this course which is designed for pupils from year seven to nine (ages twelve/thirteen to about fifteen/sixteen), participants deal with different kinds of skin creams and their ingredients. As a matter of fact, pupils and adults of both sexes use cosmetics on a daily basis, such as different creams, gels, shampoos, deodorants or body lotions. The field of body care products is of direct relevance to the participants since they might be in puberty and thus their appearance and hygiene is very important to them (Niekrenz & Witte, 2011). Additionally, pupils are confronted with the omnipresence of advertising in their everyday life. Countless commercials praise the different cosmetics' ingredients and their 'miraculous effects' on the human body. Thus, cosmetics are integrated in our lives to that high an extent that many young people do not realise or question how many products they actually use every day and if this usage is really necessary.

Because of the vast product variety young people tend to select the 'right' product by the random principle, influenced by the brand, advertising and the product's design. Hence, although cosmetics are of direct relevance to the pupils' lives and everyone has experienced using them before, pupils have seldom dealt with this topic in a scientific way or analysed the products' ingredients. What effects do those substances have on our skin? Do we need those cosmetics? And is it necessary to invest a lot of money in cosmetics in the first place? These questions are to be answered by the pupils in this very workshop where they have the opportunity to experience this phenomenon through experiments. Since advertising has a huge influence on young people, this workshop also combines science with social elements. Through dealing with cosmetics in a scientific way, the pupils are encouraged to develop a critical attitude towards advertising claims and are supported to form their own views on a scientifically basis.

As an introduction, the pupils are presented with two promo clips for products of a popular cosmetics manufacturer announcing certain ingredients. Further, they are provided with some theoretical background knowledge concerning the fields of skin build-up, biomembranes and emulsion. After having encountered the theoretical input in a group work phase, the pupils create a cream in the university's laboratories all by themselves (see Figure 1). This process makes obvious that all skin creams they can buy in shops are composed on the basis of the same formula, namely water, oil, emulsifier and added ingredients.

During several post-experiments with their self-made creams, they find out what effects the ingredients they add to the basic cream have on their skin (see Figure 2). For instance, pupils conduct experiments to test how essential oils as well as different sun protection factors affect and protect the human body. In order to examine different sun protection factors, pupils employ plastic balls which are sensitive to ultraviolet (UV) light. When exposed to UV-light and not protected by the self-made sun-cream anymore, the plastic balls discolor. By testing creams with different protection factors, the

Figure 1. Pupils producing cream.

Figure 2. Participants doing post-experiments.

participants question how much extra time can be spent in UV-light when the protection factor is increased to a certain extent. Since there is no exact scientific result to this phenomenon, they learn that sun protection factors do not equal a precise time frame that can be spent in the sun and that different skin types react differently to UV-light and thus require another form of protection. This can be tested by the pupils with their own skin type.

At the end of the workshop, the pupils find out whether the advertised and highly praised ingredients actually have 'miraculous effects' on the human body or if they do not. In fact, countless creams promising to smoothen and nourish the skin consist of ingredients which cannot be absorbed by human skin in the first place. Through the workshop the participants are introduced to an interesting, relevant branch of science by providing them with the opportunity to conduct experiments themselves and question the items they use every day.

Is the Project able to Promote the Pupils' Interest in Science?

In order to find out whether our workshops are able to raise the pupils' general interest in science, university students carried out a survey among 28 participating pupils (16 females, 12 males) aged between 15 and 19 years in 2013. These 28 participants did not attend the same workshop but each four students were selected by the random principle as representatives of the seven different workshops the project offers. This empirical study used a pre-post measurement which in this case asked pupils to fill out a standardised questionnaire both directly before and after the workshops. In this way, it was to find out to what extent the workshop influences the participants' dispositional and career interest. The second questionnaire also surveyed their current interest, the laboratory characteristics they noticed, how they evaluated the workshop's efficiency and if they were interested in participating in a project workshop again.

RESULTS AND CONCLUSION

The results of this study reveal that the participation raised the pupils' overall interest in science by having a positive influence on the emotional and intrinsic components of their current interests. Those components, in turn, have shown to be positively influenced by the workshop's characteristics 'authenticity', 'reference to everyday life', 'challenge', 'cooperation' as well as 'understandability'. Those characteristics were standardized items in the questionnaire the pupils were able to tick off. Following the study's results, the pupils experience the university's laboratories as an authentic extra-curricular learning environment and they feel that the interdisciplinary, relevant contents and the understandable but challenging tasks of the workshop support their general scientific literacy. Further, the answers of the questionnaires show that a waste majority of the pupils has enjoyed the workshop and would like to participate in a similar workshop in the future. This is a surprisingly positive result since the pre-test (first questionnaire) reveals that the majority of the pupils had a lack of interest in science and a rather reluctant attitude towards science subjects at school.

Further, the study reveals a connection between the pupils' interest in science and experiments and their interest to work in the scientific field. As expected, the participation in only one workshop does not change the pupils' overall career choice. However, their interest affects their professional wish and since the workshop supports their current interest in science, it makes them more open to consider doing an internship or even studies in this sector in the future. To conclude, the extra-curricular workshop proves to be an efficient learning environment that successfully promotes the participants' current interest in science.

School is often called to be the primary place of learning. Necessarily, school also has to be the place where pupils get motivated and enthusiastic to learn in the first place. However, motivating pupils and getting them into science needs to be optimized, especially when considering the fact that industrialised countries' economies are that dependent on trained people developing new technologies and in order to ensure scientific progress. Thus, it is important that innovative and efficient science projects like 'Biology Up Close' fight the general lack of pupils' interest in science subjects and the shortage of young researchers. Although it has to be admitted that one single workshop does not change the pupils' overall attitude towards science, it might lay the foundation for further projects promoting their interest in sciences. It is important to mention that the maintenance and intensification of the pupils' interest has to be the goal of further workshops, projects or science lessons in order to fight the

lack of interest. After all, an initial enthusiasm for the field of science has to be maintained constantly and might lead pupils to consider working in that particular sector. This could be the beginning of progressively minimising the lack of required, skilled personnel. The project supports both the course members in their direct and vivid experience of science and the university students in practicing to design lessons plans and conduct practical workshops with young people. We hope that the presentation of this project can serve as an inspiration for future-projects in schools or at universities. For further information please visit our homepage www.biologie-hautnah.de.

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