Proceedings of the 39th IAHR World Congress
19–24 June 2022, Granada, Spain
doi://10.3850/IAHR-39WC2521716X20221547

Start them early and keep them involved – Examples for Outreach Activities with Children

Eva Fenrich

Esslingen University of Applied Sciences, Esslingen, Germany
eva.fenrich@hs-esslingen.de

Abstract

This paper aims at describing possibilities for bringing scientific and technical knowledge into an experiential approach for teaching children. The main focus will be on courses taught on after school programs for gifted and talented children at primary school age also detailing how these differ from similar courses taught to a broader audience at a similar age including a summer university for disadvantaged youth. A major learning in developing these courses is that methods from laboratory and fieldwork courses aimed at university level students can be adapted to younger audiences by teaching a simplified theoretical framework and focusing mainly on the experimental and by design experiential parts. To foster an understanding for science methodology the children were taught to run series of experiments using single parameter variation. Documentation of experimental results was taught in a manner that supports creativity and is age and education level adapted.

Keywords: Outreach, Youth Involvement, Science for Children

1. INTRODUCTION

Usually when we talk about youth engagement in the hydro-environment science and engineering we look into how students and young professionals can be included in our international networks. Universities and research institutions hold open days for the general public that might include some activities for younger participants but generally engaging people into the field starts at the level of undergraduate students. Even though professional opportunities are good oftentimes we face difficulties to get excellent students into water related fields. One way to mitigate this is to offer outreach activities by universities and companies as well as individual professionals bringing their knowledge to the general public and especially to children and youth.

To develop Science, Technology, Engineering, and Mathematics (STEM) talents, both researchers and policy developers recommend that educators begin early (Robinson et. al., 2014). Maltese and Tai (2010) report that for many university students and scientists their interest in scientific topics began already before middle school. This makes it necessary to spark children’s interest in general STEM topics and particularly in water related topics at a very early age if we intend to attract the brightest minds to our field.

Science education in schools often falls short of sparking an interest in STEM subjects. They often choose a traditional ‘chalk and talk’ approach with which they feel more comfortable and avoid inquiry-based methods that require them to have deeper integrated science understanding. The focus is therefore on memorizing rather than on understanding; and furthermore, heavy workloads are reported to leave little time for meaningful experiments (European Commission 2007). This is where outreach programs by scientists and engineers in the water field can bridge a gap. To reach this goal courses that bring the field of hydro-environment into the focus of both the children and their families and also foster a general understanding of scientific methodology were designed. As these after school programs have a high percentage of female participants it can also be hoped that this will bring more women into the field in the future.

2. TYPES OF OUTREACH ACTIVITIES

Single visits to a laboratory at a university open day work well to inform the general public about research and study fields and what different professions do. However it has been shown (Schiefer 2017) that a course with multiple days can foster a new understanding of scientific principles. It is therefore likely that multi day activities are also more useful to introduce children to the field of water engineering and research. Courses for gifted and talented children were therefore structured with a minimum of 6 hours of activities over two to six weeks.

The main focus of the courses was practical experimental and experiential work with theoretical input only

where it's necessary to understand the experiments. Children were shown how to document and analyze experimental results and had the opportunity to present their findings to the group.
Another outreach activity was a summer children's university mainly designed for disadvantaged children but open to all children in a region. The overarching theme of this summer children's university was sustainability with one of the pillars of the program being water related experiments and some lectures.

3. EXAMPLES OF EXPERIMENTS AND FIELD WORK FOR OUTREACH ACTIVITIES

While a general understanding of the underlying principles involved is one of the aims of teaching any applied coursework when working with a very young audience the theoretical framework needs to be taught in a quite general manner and very much adapted to the specific group of children. To engage this kind of audience, measurement accuracy needs to be held lightly against a more playful approach. Therefore each theoretical input was taught in very small portions interlinked with smaller or bigger experiments. Some real life examples were shown as videos oftentimes after the experiments were carried out, so that a creative solution wasn't influenced by trying to copy what was shown in the documentary. In the following examples some experiments used are described in more detail.

2.1 A Physical Model of the Water Cycle

Most children get an introduction to the water cycle already in school yet this is oftentimes just a theoretical concept, which doesn't spark much interest into the physical phenomena involved. For the children's courses different parts of the water cycle were simulated in a physical manner with water being heated up simulating evaporation and a cold surface being used to model condensation in a cloud. Producing artificial rainfall in this manner fosters an understanding of the processes involved. Groundwater-surface water interactions could be demonstrated in a sand box with clear sides. To demonstrate the effect of vegetation one box contained top soil with a grassy vegetation layer over a box of sand. Children were instructed to pour water onto the top layer of the different boxes. After a while they assessed how much water reaches the bottom of the box.

2.2 Rivers, Dams and a Sand Tray Experiment

Many children already have experience of building small model dams either on water playgrounds or in small creeks. With portable sand trays it is possible to let them assess prerequisites for stability, seepage, etc. The experimental design for the children course provides them with a variety of materials and the guideline to vary shapes, materials and material combination in a structured manner while documenting. In this manner they learned about the effect of sealing layers, different materials supporting stability, the effect of different designs. An overtopping experiment was also carried out.
In larger sand trays that were already prepared with a mix of different grain size sediments including some bigger rocks children learned about the formation of meanders and generally how a river cuts into the landscape. As a next layer to their experiential understanding they were instructed to find ways to stabilize the river banks with natural materials.

2.3 Model of a Pipe System for Water Supply

After a short introduction with a demonstration experiment showing communicating vessels children were given clear plastic tubes of different lengths, tubes already fitted to buckets that can be used as a model water reservoir, taps and fittings, etc. Then they were instructed to plan a water supply system for some "houses" which were set up at different heights. The participants had to find ways to supply different users and could use taps to adapt flow. This was both a technical experiment and also a group building experience. This means that potentially this experiment could be used as an introductory experiment with a new group fostering both technical understanding and communication.

2.4 Model of a Layered Water Filter

Drinking water was mixed up with some particles, colors and oils. The children were asked to clean up the water. They were provided with clear plastic columns with sieve inlays and a variety of filter materials like porous stones, sand, porous clay beads and activated charcoal. They then experimented with each material individually and then instructed to design a layered filter to clean up the water. To introduce the concept of single parameter variation children were asked to do measurement series keeping one or two layers the same and varying one layer. The group was asked to discuss why they would choose which sequence of materials. Children came up with creative solutions what kinds of filter materials could be used in addition to the materials that were provided.

2.5 Measurements and Mapping in the Field

Laboratory experiments are exciting for children as they can be very hands on. Yet going out in the field adds an additional layer of interest. This is especially true for younger children (age 6-8) as the concept of a physical model at a smaller scale is not easily understood by all participants. One important consideration for field trips and field work with children is health and safety. Therefore group sizes need to be very small (5-8 children) with only one adult supervising or additional supervision is necessary. This can be achieved by inviting some parents. Overall taking safety into consideration a body of water was chosen with easy access, relatively low water depths
As a first part of the field trip children were shown and explained different riverine structures. Then they were instructed about habitat preferences of a variety of riverine species. They received a blank map of a stretch of the body of water and then mapped out which riverine structures they could identify and where they thought that different species would have their habitats. This activity could potentially be easily adapted to a citizen science project for school classes who go on excursions anyway. After mapping the participants were introduced to kick sampling and other sampling techniques to collect macroinvertebrates. They received a simple identification key for different species and information which animals or groups of animals identify good water quality. Additionally they got the chance to measure some simple chemical parameters with a field measurement set.

4. ASESSMENT OF LEARNING OUTCOMES

To assess knowledge acquisition the participants were required to answer a quiz at the end of the course. After 6 – 12 course units of 45 min each the general concepts taught in the course had been learned by most participants. Unsurprisingly in the course groups with gifted and talented children recall of facts and the understanding was greater than in a more general audience course. Additionally the children filled in a questionnaire evaluating their course experience. This questionnaire also asked about motivation to learn more in this filed. A majority of participants was keen to learn more. Anecdotally it can be reported that children that the author met a year or two later for a different course still had a high recall of the types of experiments conducted in the course and their interest in the broader field seemed to have grown over time. After the children’s summer university participants had had a basic understanding of some water related and sustainability topics while the groups of gifted and talented children had a more technical and conceptual understanding.
Overall water and science related professions were seen as possible future careers by the children.

5. DISCUSSION AND RECOMMENDATIONS

Children’s courses were overall successful in teaching some water and sustainability related knowledge and foster a general interest in STEM related learning. It could be observed that more homogenous groups in terms of age and ability improve learning outcomes and overall satisfaction of the course participants. It is therefore recommended to design courses for a very specific age and ability group rather than keeping programs open to everyone who shows some interest. When children were asked about their interest in different professions and career paths a shift could be observed after learning outside in the field. It is therefore recommended to include filed trips or field measurements in outreach programs. Very simplified experiments give children an insight into physical principles and spark creative solutions. Including some experiments where relatively free experimentation is possible, while creating some possible frustration in the first place, seems to be both more popular with the participants and also seems to create more thorough understanding of learning outcomes. Depending on the age group and the group of participants understanding of theoretical concepts, working speed and the participants attention span can vary quite broadly even in groups that from registration seem to be quite homogenous. It is therefore necessary to plan such outreach courses with quite some flexibility factored in. With smaller children and children which haven’t had much opportunity to do practical play in their family of origin our in their school it is important to teach very small steps while older children need to be given some individual flexibility. Health and safety aspects need to be taken into consideration quite thoroughly and instruction around safety needs to be very clear and needs to be repeated as children might not have the capacity to assess dangers that well yet.

6. CONCLUSIONS

Teaching outreach activities for children at primary school age makes it possible to spark an interest in our field at a very early age. To adapt experiments and fieldwork practices from university level to a younger audience they need to be designed in a way that focuses on qualitative results and more visual outcomes. Creativity and play need to be a large part of the program. Bringing some field work or excursion into the program strongly improves children's overall motivation for the specific field of water rather than a general interest in STEM.

7. ACKNOWLEDGEMENTS

The author is grateful for the support of talentCAMPus: Forscherkids (BMBF grant) and Hector Kinderakademie to be able to develop these outreach activities and try them out "in the field".

8. REFERENCES

European Commission. (2007). Science education NOW: A renewed pedagogy for the future of Europe. Community research expert group: Vol. 22845. Brussels: Office for Official Publications of the European Communities.

Maltese, Adam V. & Robert H. Tai (2010) Eyeballs in the Fridge: Sources of early interest in science, International Journal of Science Education, 32:5, 669-685

National Association for Gifted Children, Task Force on Math and Science . (2008). The STEM promise: Recognizing and developing talent and expanding opportunities for promising students of science, technology, engineering and mathematics.

Robinson, A., Dailey, D., Hughes, G., & Cotabish, A. (2014). The Effects of a Science-Focused STEM Intervention on Gifted Elementary Students' Science Knowledge and Skills. Journal of Advanced Academics, 25(3), 189–213.

Schiefer, J., Golle, J., Tibus, M., Trautwein, U., Oschatz, K. (2017)
Elementary school children's understanding of science: The implementation of an extracurricular science intervention, Contemporary Educational Psychology, Volume 51, 447-463.

Tuijl, C. & Walma van der Molen, J. (2015). Study choice and career development in STEM fields: an overview and integration of the research. International Journal of Technology and Design Education. 26. 1-25.

