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What Could Possibly Go Wrong? About Evaluating Technology Education Projects

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Abstract

This paper discusses impact and process evaluation methodologies for the field of science and technology education with the aim to not only produce measurable outcomes, but also valuing the whole learning process. Therefore, the "Kids4Wearables" project will be presented as an empirical example, in which methods of pedagogical ethnography and further quantitative as well as qualitative instruments have been used, to evaluate this science and technology education project, and assess the interest in technology and gained competences of the 129 participating 6 to 15 year old pupils. While the quantitative instruments served the purpose of measuring the impact of the education project, pedagogical ethnography, drawings, focus group discussions and interviews have been used as additional qualitative evaluation methods. Along the example of this case study, methodological challenges and practical solutions will be presented.

1 Introduction

The theoretical background of this paper is rooted in science, technology and society studies (STS) and critical education theory. According to STS, technology is seen as a social construction, in which "certain intentions and regime interests" (Bammè 2007, p. 26) are inscribed. Therefore, technology influences people not only in their relations to nature, but moreover technology influences human bodies and their minds. As technologies pervade our everyday lives – Oskar Negt talks about a „world constituted by technology" (Negt 1999, p. 228), Nina Degele says that „technology plays a constitutional role for society" (Degele 2002, p. 162) – gaining technological competence or literacy becomes more and more important. And this is where critical educational theory comes into play.

Beside a 'general education' (in German: *Allgemeinbildung*) which is defined by Wolfgang Klafki as "[…] historical mediated awareness of main problems of the present time and the future – as far as they are foreseeable; an understanding of common participation in view of those problems and the willingness to take part in their accomplishment." (1993, p. 56;

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translation by the author) critical theory in education defines key problems, which consequently lead to certain educational demands. For instance Klafki (2005) postulated a ‘critical technological literacy’ (in German: *kritische technologische Grundbildung*), which emphasizes a level of reflection in addition to the level of use, in order to assess possible consequences of technological applications.

Negt pointed out that technological competences are “[…] in fact, not only technological qualifications in the sense of skills, but moreover knowledge about societal effects of technologies; I think that to understand those complex effects extending into societal micro-structures is a specific competence which through expansion of knowledge and training of skills leads to the perception of technology as a societal project.” (Negt 1998, p. 35, translation by the author).

These roots of an emancipatory science and technology education theory have led to the development of the ‘vehicle approach’ (based on Thaler & Zorn 2010, further developed by Thaler & Hofstätter 2012), which aims at a “technology education for everybody” (Dahmen-Adkins & Thaler 2019). By not only connecting to the learner’s living environment (Schelhowe 2006), but moreover by using kids’ interests and expertise as a vehicle (e.g. music, TV series, fashion), technology and science education is connected to a meaningful and motivational learning experience for diverse students of all genders (see Hofstätter & Thaler 2019 for more details about the practical realisation of the vehicle approach).

2 The case study

The empirical case study and methodological experiences in this paper stem from the transdisciplinary education research project “Kids4Wearables[1]” (K4W), which aimed at increasing interest in technology as well as science and technology literacy of 6 to 15 year old pupils in five Austrian primary and secondary schools.

1. Kids4Wearables (2017-2019) was a research project funded by the Austrian research funding agency FFG. The coordinator is Birgit Hofstätter from the Internationale Akademie Traunkirchen, the consortium comprised five comprehensive schools in the Salzkammergut region, two science and technology departments from Kepler University Linz, an artist specialised in fashion, and the textile company Lenzing AG. IFZ (Anita Thaler & Michaela Jahrbacher) had the task of doing the evaluation of the project.

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	Pupils	Female	Male
Total	129	60	69
With migration background	31	15	16

Table 6: *Participating pupils of the Kids4Wearables project*

The group of the 129 participating pupils (in the school year 2018/2019) comprised 46.5 % females and 53.5 % males[1], 24 % of all participating children have migration background (see table 1). However female pupils as well as children with migration background have been quite differently distributed from school to school (see Table 6).

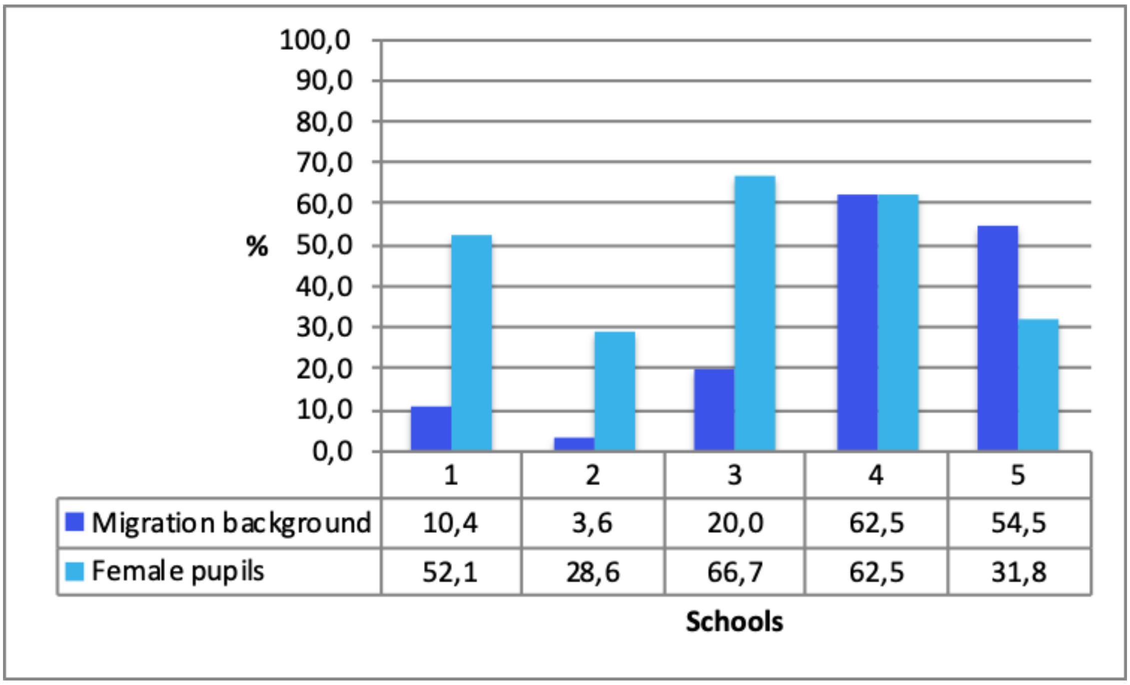

Fig. 86: *Distribution of gender and migration background of children participating in K4W*

All five schools are located in the rural area of Upper Austria. While the first two schools in Fig. 86 (school 1 and 2) are schools using 'alternative' pedagogical concepts, partly based on Montessori pedagogics, where pupils have more degrees of freedom in class und could choose to participate in K4W activities or opt out. The other schools (3, 4, 5 in graph 1) are

1. We offered also gender diverse categories for our data collection, but theye have not been used.

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‘traditionally’ organised comprehensive schools, where whole school classes took part in K4W, therefore the gender composition of these ‘natural groups’ was not influenced by K4W. The second and fifth school offer lower secondary education (“*Neue Mittelschule*”), the first school is a private (by parents organised) school offering primary and lower secondary education.

3 The methodological challenges and solutions

Research funding organisations understandably ask for proof that the (tax payer’s) money spent on research projects was successfully invested. Therefore evaluation is more and more integrated as an accompanying element in research projects.

In this paper’s case study K4W, the participating kids’ ‘interest in technology’ before and after the project was the main impact category.

While this might sound very simple, the task actually presented itself with several difficulties. It is one thing to assess interest in technology qualitatively (with interviews, drawings etc.), but a different enterprise to measure interest in technology quantitatively, to make it comparable between groups (like schools, school types, age groups, gender etc.), and between two different points of time. The biggest challenge was to find a quantitative technology-interest-instrument, which would work equally for six- as for fifteen-year olds. In other words, the challenge was to design a simply usable instrument, which can be understood and handled by kids with no or limited writing and reading competencies.

Therefore, two *Visual Analogue Scales* (VAS) have been developed for this project. VAS can be applied as alternative questionnaire formats for children. As VAS are based on the cognitive ability to bring items into relative order, it is discussed in paediatrics and children’s psychology whether young school children are able to answer VAS properly. Some studies suggest that VAS can be used only for seven- years olds and older children, others say VAS are not applicable for children under five years (Shields et al. 2003). As those studies refer to pre-school and kindergarten children, we used VAS for the quantitative part of our impact evaluation for our group of 6-year old school children.

The first VAS used in K4W assessed the individual interest in technology before and after the K4W project, posing the question of how interested the participants are in technology. This VAS contains a single line limited by “not at all” at the very left and “very much” at the very right of the line. The scale has been verbally explained to the children and they

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indicated their interest in technology with a cross on the line, the more on the right side, the higher the interest. This VAS can be evaluated by measuring the position of the respective crosses (in mm) and compare the outcomes by potential relevant categories like gender, age, schools, etc.

The second VAS measures the groups' satisfaction with K4W workshops led by external persons and consisted of five emoticons visualising very high, high, medium, low and very low satisfaction.

However, a qualitative instrument has been added to the VAS for measuring interest in technology: an adaption of the Draw a Scientist Test (DAST by Chambers 1983) respectively the Draw and Engineer Test (DAET by Thompson & Cunningham 2004). Both tests have been developed to visualise the images children have in their minds of scientists and respectively engineers.

One challenge hereby lay in the German language and the gendered word "engineer". If we would use the German word for "engineer" it would be either the female or male version ("*Ingenieurin*", "*Ingenieur*") and if we want to test also the genderedness of children's images of engineering, we cannot bring attention to gender in our test formulation. Hence, we asked all K4W children to "Draw a person, who works in engineering" – although the precise question in German ("*Zeichne eine Person, die in der Technik arbeitet*") refers to "technology" ("*Technik*") as a broader field as engineering ("*Ingenieurswesen*", which is not a commonly used term). In return, we received drawings comprising computers and generally information and communication technologies compared to the DAET.

The aim of using children's drawings is to have qualitative data about the potentially changed images of technology after K4W, which hopefully will enrich and potentially further explain the results of the quantitative data of the VAS.

When we asked the children before their very first K4W workshop to fill in the VAS "interest in technology" and to draw "a person working in technology", and after their first workshop the VAS "workshop satisfaction", all children participated actively, despite age, gender or school type. More than 1.5 years later, after the last K4W event (a "research festival", where more than 300 children and youths from various schools of the region, teachers, companies and researchers took part), all participating children were asked to fill

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in the evaluation tools a second and last time. They filled in the VAS "interest in technology" and drew "a person working in technology". However, there have been problems with this before-and-after measurement.

Due to the length of K4W with several different external persons coming to the schools, different ways of organising the K4W workshops from school to school (e.g. integrated in physics and crafts classes; regular additional project classes in the afternoon; condensed project activities in a shorter time period) some participating pupils had difficulties to comprehend the full range of the project. This had the consequence that some children – from the groups who could choose to participate (and opt out of all or some K4W activities) – could not remember taking part in (some or other) project activities, and therefore refused to participate in the after-measurement (although we recognized some of those children from K4W workshops). The principle of voluntariness in some participating schools additionally led to changing numbers of participating pupils in K4W, which additionally complicated the before-and-after measurement.

Therefore the VAS "interest in technology" delivers now three results:

1. A measurement of all pupils filling out the VAS before K4W,

2. a measurement of all pupils filling out the VAS after K4W

3. a difference between measurements before and after K4W for those pupils who filled out both VAS[1].

Only the last outcome is relevant for measuring the impact, but the other two measurements can be used as stand alone assessments to compare groups of children (e.g. age, gender, school type).

The second approach used to evaluate the process of K4W is pedagogical ethnography (Zinnecker 2000), which comprises participatory observation, interviews, analyses of documents and learning materials, and reflection workshops. With these ethnographical methods, teaching and learning can be accompanied in their making and doing. Results from pedagogical ethnography are not limited to verbally and consciously accessible

1. As the VAS „interest in technology" and the drawings (of persons working in technology) have been combined on two sides of one page of paper, indicating school, age and first name of the pupil, the drawings, and hence the VAS of the two time points can be related.

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information, nor are they censored by social desirability or 'political correctness'. In this sense the process evaluation follows the one of the core motives of action research in schools, which "lies in the will to improve the quality of teaching and learning as well as the conditions under which teachers and students work in schools." (Altrichter et al. 1993, p. 4). In the case of K4W, the action research comprised not only the evaluation but moreover the whole project, with its teacher education modules, testing of newly acquired technology related teaching units, and bilateral and group reflection meetings. Additionally the process evaluation stimulated individual reflections through interviews with teachers, and regular sent out milestone reports about the current phase of the project[1].

Additionally to the methodological challenges of developing instruments, which could measure the impact of K4W for 6 to 15 year old kids and youths with 'before-after-measurements', two other facts proved to be difficult for the pedagogical ethnography and the evaluation in general. Firstly, the education project consisted of various different sub-groups (e.g. primary and secondary schools; groups with less than 5% vs. more than 60% pupils with migrant background), which are learning/working with different teaching methods (e.g. alternative schooling based on Montessori principles vs. 'traditional' schooling). Secondly, not only the evaluation team worked four train hours apart from the education project, but also the schools were on different locations, hence school visits had to be planned well beforehand, and were very time-consuming and were therefor limited.

To enrich the results from the VAS "interest in technology", an assessment of the pupils' gained competencies during K4W has been added to the impact evaluation. This assessment was filled out from the main teachers involved in all 5 participating schools, during interviews after the end of all K4W workshops and school activities (in June 2019). These teacher interviews have been conducted as expert interviews (Bogner et al. 2005), as the position of the transdisciplinary project K4W was to include the teachers as partners and experts, and they certainly spent most of the time of K4W activities with their pupils. The expert interviews comprised the aforementioned assessment of the learned (technological) competencies of each participating group and a retrospective analysis of

1. The project and its evaluation has been divided in different phases: the first with the aim to produce customized didactical concepts for each school and group, the second about inquiry based learning, the third highlighting the kids' inventing and developing, the fourth about transferring the knowledge within and beyond the participating schools, and the fifth to evaluate the impact of the project.

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the didactical concept used for K4W in the respective school. Furthermore, four focus group discussions with 36 pupils have been conducted (in June 2019) to evaluate the groups' perceptions and attitudes (Lamnek 1998) towards specific K4W activities as well as get further validation and examples for the kids' interest in technology.

4 Conclusion

This paper introduced the framework as well as instruments for the process and impact evaluation of science and technology education. The case study of Kids4Wearables, an Austrian transdisciplinary technology education project with five schools, and various experts from textile industry, art, pervasive computing, physics and pedagogy served as an example to visualize potential challenges and the respective solutions in this very project.

It could be shown that although impact evaluation is often connected to quantitative methods, it is not limited to it (like using a visual analogue scale to measure interest in technology), and could benefit by using additional qualitative methods (like drawings, focus groups and interviews).

On the other hand, although the presented methodology of pedagogical ethnography for the evaluation of an educational process has a lot of advantages (for instance in terms of accessibility of non-verbal information), too many different locations and groups can make a regular and accompanying participation of the evaluation team very hard.

In the case of K4W the evaluation team decided to implement additional expert interviews with the main involved teachers to validate observation results as well as assess the participating kids' competencies (in addition to the interest in technology, which was the focus of the funding agency). Finally, more than a quarter of all participating pupils have been invited to focus group discussions to hear their opinion of the K4W activities and visualize their interest in technology with examples, which are otherwise missing in quantitative research.

In this sense the discussed case study showed several methodological difficulties and fixes, however the decision to complement quantitative data and research instruments with an ethnographical approach and interviews and focus groups with the participating children and teachers have surely contributed to the quality of the research.

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