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Bildungslandschaft or the inter-organizational cooperation network approach (ICNA) as a new approach to attracting pupils to science and technical education

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Abstract

The paper presents a short review of the literature on attractiveness and argues for the need to consider an inter-organizational cooperation network (ICNA), which organizes out-of-school learning as a necessary and new perspective to promote attractiveness in technical education. The paper offers a case of cooperation: a Pupils' University, for 5th and 6th grade pupils in primary schools within Northern Jutland, Denmark with a discription of the network and a discussion about how learning structures influensces the learning proces. The paper highlights the contribution of the new concept of a network approach to attractiveness compared to other approaches.

Keywords: case study research, attractiveness, networked learning, inter-organizational learning, inter-disciplinarity, out-of-school learning

1. Introduction

Attractiveness means "the quality of arousing interest" (thefreedictionary.com). There is a major research interest in the interest-concept, which is central in science education (Krapp & Prenzel, 2011, p. 44). Lindahl points out that research on interest in science and technology is very complex and "difficult to get a grip on" (2003, p. 50), and Krapp & Prenzel write that the construction of interest is "a multidimensional construct" with both cognitive and emotional categories "((2011, p. 30, referring to Gardner, 1996; Hidi, Renninger & Krapp, 2004; Schiefele, 2009).

A brief overview below of causes and issues that relevant research has uncovered, will illustrate the complexity of the issue and identify where there is need for further research.

In general Lindahl (2003) summarizes, on the basis of research by Gardner (1975) and Schibecis (1984), three categories of importance to science interest: the **individual students**, **factors in schools** and **factors outside schools**.

For the **individual students** the factors of gender, age and, personality are mentioned as important to science interest.

Factors in schools that influence science interest are manifold. They are, among others the course content, topics covered, pupils influence, pedagogical methods, language interaction in the classroom and the science teacher (Lindahl, 2003). Aikenhead (1996) in his research draws attention to a cultural barrier. Science is perceived as an alien culture to many students. The difference between the context of learning science in school and the context of implementing this knowledge in daily life and student experience is vast. Stocklmeyer, Rennie & Gilbert (2010) point out that "the nature of the curriculum" is a "major reason for the lack of interest". The science curriculum is "looking inwards to the canon of orthodox natural science, that is, at the products and processes of science itself". The traditional formal science education has too many problems of deficient attractiveness, as briefly outlined above. Many efforts have been made to "increase the meaningfulness of student learning" and "change the way in which science is taught" in the formal system (Stocklmayer Rennie & Gilbert, 2010, p. 4). However, their conclusion is: "None of these efforts have so far been effective in initiating sustained change on a wide scale."

As for **factors outside school** Lindahl brings up "home" and "society"(2003, p. 46-48). Learning environments outside of school have likewise received much attention in recent years (see eg Eshach, 2007; Rennie et.al, 2003). The idea is that out-of school learning can solve some of the problems identified earlier in this article, especially the relevance of learning, the nature of the curriculum and the cultural barrier. Besides "home" and "society" out-of-school learning are outreach activities from individual companies (eg Danfoss Universe), museums (Waltner & Wiesner, 2009), zoos (Scott & Matthews, 2011), NGOs or others (Technologiestiftung Berlin, 2009), and educational institutions such as university colleges and universities etc. (Guedens & Reynders, 2011; Grunwald a, b, 2012). Still, Eshach´s point should be highlighted: "It seems as if there is a gap between the feeling that great potential may lie in school field trips, and some of the recent research results indicating that this potential is not fully achieved (2007, p. 175)." Thus, the question is whether greater involvement from institutions outside school can help to provide specifically designed learning opportunities that can help create more meaning, relevance, and authenticity to students than schools alone can? And what will it take in order to make a better use of the potential? The starting point of this article is that while it is important to look at learning outcomes, there seems to be a blind spot caused by not adequately looking at cooperation networks organizing out-of-school learning.

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2. Cooperation between non-formal and formal education

The research on "Bildungslandschaften", which is a relatively new concept (Mack, 2009, p. 62) in the German debate on education, may be able to provide a perspective that can be used here. The concept of Bildungslandschaften seeks to combine in-school and out-of-school education and learning. In the current theoretical discussions regarding German education policy and education, a systematic and broad cooperation between different actors is described in order to address specific identified issues that may lie at the local, regional or even national level. The purpose is to create "experience space" for children to create ideas/conceptions about their personal future (Bollweg & Hahn 2011: 13).

We will emphasize one point from the discussion of "Bildungslandschaften", which may be useful in the discussion of supporting young people's interest in science and technical education. The point is that education and cultural formation (Bildung) is to be understood in a more wide holistic sense as learning and education landscapes. The term "Bildungslandschaft" includes both education, up-bringing and childcare as a complete educational and support program. For this very reason it is used in this article. Embedded in this holistic perspective is the desire to overcome segmented thinking and acting and discrimination within the educational system, in order to understand the learning process from birth to young adults. This thought process takes its point of departure from the biography of the individual child (Weiss, 2009, p. 31).

3. Problem Formulation

As mentioned previously, there is a gap between the expected potential of non-formal out-of-school learning activities for students and actual increased interest and motivation in science learning.

The assumption in this article is that cooperation between formal and non-formal education can help to exploit the potential of non-formal out-of school learning for primary school pupils.

The problem statement is:

How can a network approach and the knowledge of the players and the players' conditions in the network help to exploit the potential of non-formal out-of school science learning for primary school pupils?

This article will contribute to the discussion on what a network approach can provide compared to other approaches that, despite many efforts, have not been shown to operate satisfactorily with regard to supporting interest in science and technical education. By looking at a specific network- the organizing cooperation network around the Pupils' University SKUB - and following the development of this network over a four year period, there is a unique opportunity to draw some conclusions on the contribution of an interdisciplinary cooperation network in attracting pupils to science and technical education.

4. The case: a cooperation network at a PUPIL´S UNIVERSITY program on climate and energy for 5th and 6th graders in primary schools

The Pupil's University SKUB on climate and energy at Aalborg University (www.skub.aau.dk) targets fifth and sixth grade primary school students in Northern Jutland, Denmark. The project application and coordination was done by Freie Universität Berlin through the EU project SAUCE-"Schools at University for Climate and Energy" (www.schools-at-university.eu), and supported by the EU program "Intelligent Energy-Europe: For a sustainable future." The Pupil's University SKUB at Aalborg University was initiated by the Energy Planning Group at the Department of Development and Planning. The project aim was, inter alia, (1) to develop cooperation between European universities to establish the pupils' university on campus as a new teaching method in energy and climate teaching, (2) to increase pupils' understanding of renewable energy and intelligent use of energy as the basis for the sustainable development of society and to make them aware of different options, (3) to support students' interest in green technology and science.

The Pupil's University SKUB held its first program in 2009 with the participation of 640 students, 400 in 2010 and 710 in 2011. The author of this paper was the manager of this project in the three-year period. After the EU project was finished in 2012, the Center for Teaching in Nature, Technology and Health in Northern Jutland (NTS) at Aalborg University took over the management of the project and completed a program. The research discussed in this paper covers this four - year period from 2009-2012 with the involvement of a total of 108 classes consisting of 2260 students and their teachers.

Each annual program lasted for one week. A school class participated for one day at the university with students enrolled at the university, in the opening event in the auditorium and in two different workshops. This structure was chosen to show the peculiarity of the Aalborg model of teaching in small groups with the opportunity for hands-on work. Examples of workshops are: "When the waves are high" on the use of wave energy in the laboratory; "How can you save electricity?" as well as "Architect for a day" on eco-friendly construction.

The success of the project can be read as follows: The project team has, in collaboration with university teachers, developed workshops that have become increasingly practical and problem oriented and thus more relevant to students. More than 80% of the children would like to come again. The participating teachers gave SKUB an average score of 4.1 on a scale of 1-5 where 5 is the best. Some schools and teachers attended all four years and have made participation in the program an integral component of the school year science education.

5. Research method

The research method is anchored in a case study method. It is an action research / participatory research where the researcher was the project manager for the first three years of its start-up and development. Data material includes summaries, observations, semi-structured interviews with steering committee members, mail correspondence and evaluations in the form of questionnaires to students, school teachers and university lecturers done after each of the four completed programs from 2009-2012.

The theoretical framework for the analysis is based on the relationship between actors, their learning processes and learning structures that are addressed from a theoretical perspective of "organizing learning systems", or so-called "learning networks" in work-based learning (Van der Krogt, 1995, 1998, Poell et.al., 2000). From this theoretical perspective the three dimensions of "learning networks" meet in a kind of cycle, where learning structures influence actors, that then implement learning processes, which in turn affect learning structure, etc.

Learning structures are defined here as content and organizational structures, and expanded in this project to include resource structures as well (See Table 2). Learning structures are the framework for, and thereby the context for, the learning of the inter-organizational cooperation network. The analysis is carried out and discussed in the following section.

6. Analysis and discussion

A. ***A brief description of the cooperation network***

"To start something totally new ... I think it has been a very exciting process" (Member 5, Table 1). As this statement shows, the project had to develop a new partnership between Aalborg University and Danish primary schools that did not exist in this form before. Therefore, it was necessary to involve partners with knowledge of primary schools right from the start. That was the reason for the establishment of the steering committee, which *"... was one of the best ways to gain some knowledge regarding elementary school conditions into our planning because none of us had sufficient knowledge regarding daily life in public schools"* (Member 3, Table 1). The overall composition of the steering committee was agreed upon in the internal project group at Aalborg University just after the establishment of the project (see Table 1).

It is important to mention that the other participants in the European SAUCE project had not established this type of steering committee. The reason behind the need for a steering committee was that we in the Aalborg project had decided to develop a training program mainly undertaken by university teachers. The other European partners in the project involved environmental educators from outside the university to a much higher degree. These educators had experience in teaching children and were, because of the incentive structure at the university, easier to recruit than university lecturers. Table 1 shows the individual members of the steering group, their organizational association and their diverse professional backgrounds.

Steering committee member	**Place of employment**	**Education and work experience**
1	AAU	Energy expert, researcher, multidisciplinary experience in technology and social sciences, educational background in economics and anthropology
2	AAU‡	German engineering background; long experience in private enterprise, environmental NGO, and as a school teacher; supplementary education as an environmental adviser, holds a master's degree in learning processes
3	AAU§	Physicist, former teacher and college lecturer in physics, project participant at the University, background in the folk high school world
4	AAU§	Background in IT at teacher college and knowledgeable in the folk high school world
5	A Primary School in Municipality X	Teacher of mathematics, nature and technology, carpentry, and music
6	B Primary School in Municipality X**	Teacher of physics, mathematics, and nature and technology

‡ Employed part-time by the project (around half-time).
§ Employed hourly as needed for the tasks of the project.
** Participated from Autumn 2008 to Summer 2010.

7	C Private Primary School in Municipality X	Teacher of social studies, biology and geography, and nature and technology in the project period
8	School administration in Municipality X	School consultant, educated schoolteacher, holds a master's degree in didactics of natural science, head of the "natural" school in the municipality
9	Municipality Y, the job market department and D Primary School in Municipality Y [††]	Teacher, experience in human relations, now supervises education for young people (75%-time) and establishes school learning for the Primary and Secondary School D (25%-time)

Table 1. Composition of the steering committee for the project Pupil's University, SKUB, Oct. 2008-Aug. 2011.

As Table 1 shows, the members of the steering group have very diverse backgrounds. As a member of the steering committee expresses it, it was *"... the diversity that gave decent results ..."* (Member 3). It is particularly noteworthy that the teachers have very different educational and professional backgrounds, reflecting the composition of a normal Danish primary school.

During the project period it emerged very quickly that there was a greater need for networking. It was necessary to establish contacts and cooperation within Aalborg University both to identify committed teachers and to get connect with different levels of management to get the project embedded in the organization. Local and regional networking was also needed to include schools and school administrators (Grunwald, 2012, p. 115). This article focuses only on the learning process of the steering committee, as described in Table 1. For this reason, the evaluation results from university teachers, primary school teachers, and pupils are not included in the analysis here, as more in-depth discussion of these other actors would be necessary.

B. Framework conditions as the context for a network learning process

To answer the question of how ICNA can help to promote the attractiveness of science education, it is necessary to know something about the framework conditions of the different actors in the network and how these influence the network learning process. Partly inspired by Poell et al.'s theoretical perspective of "organizing learning systems" in work-based learning, we have modified and further developed this perspective in order to include a concrete inter-organizational context. Brief descriptions of three learning structures that have decisive influences on learning in the steering group (the arranging network) are given in Table 2. They include content, organizational, and resource learning structures. In this article we focus on the importance of the content structure.

Learning structure	**Explanation**
Content structure	The content learning structure and framework from the members of the steering committee. This is what has to be learned by the members to implement the project and meet the project objectives. "What is learned … may take the form of knowledge, expertise, skills, understanding, insight, opinion, attitudes" (Illeris, 2007, p. 37).
Organizational structure	Division of tasks, responsibilities, roles "in organizing the learning activities" (Poell et al., p. 34). Organizational learning structure from players that can influence the learning in the steering group and the organizational structures inherent in the whole project.
Resource structure	Not a part of Poell et al.'s perspective. Based on the evaluation of the analysis material, it is especially temporal and economic factors that affect the learning process in the steering committee.

Table 2: Learning structures

The steering committee met ten times, each time for three hours. The meeting structure was determined by the internal AAU group's proposal for the agenda. These could be ideas, suggestions, or problems that the AAU group found important to confront with the other members of the steering group in order to hear their opinions and suggestions. The non-AAU external members of the steering committee supplemented with their knowledge, evaluations and proposals. The subjects discussed included development of program structure, the pedagogical design of the workshops, further development of the teacher group, how to co-finance the project, evaluation of the program, how it could be continued, etc.

1. Different worlds are brought into contact

"One could, for a moment, think that university and secondary schools and primary schools, each have something to do with teaching and something with learning ... so they are quite similar to one another. They do perhaps up to a point but there are, well, also many ... different worlds ..." (Member 9).

[††] Participated from Summer 2010 to Summer 2011.

Another member of the group, referring to the learning process through the project, explains how to understand the "different worlds" as follows:

"It was ... a challenging process. Because I could feel when I walked away that I had very much been focused on trying just to get the dialogue launched in any way possible... from the angles you yourself saw it from" (Member 8).

How can the different worlds that were brought into contact and the different "angles" each member brought to the process be described?

An indication of these different perspectives is given in the Table 1 overview of the professional backgrounds of the members. A closer look at the individual members reveals that the public school teachers are especially focused upon meeting the requirements in the law set out in the Ministry of Education's so-called "common goals" , containing aims and content descriptions for each curriculum and grade in the Danish school (Members 5 and 6). This means that it is a must for out-of-school activities to be in accordance with these common goals.

In addition to this, the municipality has a *"... school policy that is agreed upon by politicians for all schools in Aalborg ... with focus areas as important goals for the teaching activities …*" (Member 8). Schooling is to a high degree politically determined and a changing area where, for example, *"...the political system at the national level sometimes overrules and sometimes adds teaching tasks that should be implemented in addition to the declared focus areas of the municipality"* (Member 8).

The municipality school consultant here serves to connect the administration, primary and secondary schools, politicians in the municipality, and the public. *"I have 12 part-time lecturers who teach at various historical and science out-of-school workshops at different locations in the municipality and receive pupils every day throughout the school year. This work I am trying to implement in the strategy of administration and municipality management"* (add attribution). In the work of the consultant it is also important *"to be aware of what is going on with regard to the political level and the development in education, and try to transfer this information to schools ... in dialogue"* (Member 8).

The education supervisor is a part of the steering group through his 25% employment at a school that focuses on establishing, developing, and maintaining out-of-school learning for pupils of the school in companies, secondary education, and the wider community. In this context, the school was interested in establishing cooperation with Aalborg University *"because for several years we actually have talked about ... if we could be able to get an ... open door into the university ..."* (Member 9).

For the four University-affiliated members see Table 1. The first priority was to implement the project in a satisfactory manner. (See the purpose of the project in the case description.).

2. How to integrate school and university pedagogically

As described above, the primary school teachers need to fulfill the common goal of science education. Therefore a large part of the discussions during the meetings were about *"... bridging the gap between the teaching pupils will participate in [at the university] with what is actually happening in the schools. This is probably the biggest problem"* (Member 8).

"I was well aware that at the university the lecturers would not have the knowledge regarding the challenges the schools are facing and the framework in which the teaching is embedded, or what you must achieve in school, the educational goal you have and how you find the best way to coordinate it with what scientists are at present researching in and have interest in. This is really, really difficult, but I think it's good that it was articulated ... It is very difficult. But I also feel that teachers from the university environment were willing to listening to the challenges" (Member 8).

During the meetings there was much talk about the proposed solution of developing teaching materials to be used in schools in preparation for the Pupil's University. The first ideas for teaching materials were discussed in with the whole group. This development work stopped, however, because there were no resources in the EU project for this work, and because the project failed to find additional financing.

The meetings were filled with discussions of the pedagogical design of the workshops at the University. One of the points made is that students should have the opportunity to explore and experiment by themselves. One member concludes, *"... much of the teaching carried out at Aalborg University is also much of what we recommend in science didactics ... that really ought to be formed in such a way that it plays together"* (Member 8).

This refers to problem-based learning that is student-centered and in which a "problem is the starting point directing the students' learning process and places the learning in a context" (Barge, 2010). There is still a long way to go toward achieving this goal, as this research project shows. To make it "play together," i.e., to develop problem-based learning in collaboration between school and university, where students may themselves identify problems they are interested in working on, would require a considerable amount of inter-organizational cooperation between school and university.

Another, perhaps competing, goal comes from the primary school teachers, who wish to show their students something *"great"*. By "great," Member 7 means that *"... the university has some things that you do not see in school"*. Another teacher

expresses this need in a different way: *"We want to see something gear"* (Member 5). "Gear" could refer, for example, to the university's ocean wave laboratory. It is clear from the empirical evidence that this statement should also be seen in light of lack of resources for equipment in schools (Grunwald a, 2012).

It is clear that it would have been possible to make a program at the University without putting together a steering committee. It might also have been possible to gain permission to attend some classes (although the cooperation network with schoolteachers was a great help at the beginning of the project). But if the goal is to get beyond the stage called "soft drink visits" or just a fascinating "excursion" then collaboration among the different actors is necessary. In the case of the Pupil's University, the experience of sharing and knowledge building through learning about each other's daily lives, frame conditions, professionalism, and work environments have been of great value: *"I think the cooperation with the teachers was invaluable! And it saved us from many pitfalls"* (Member 4).

C. A brief remark regarding resource structures

The meetings were organized in such a way that there was time for discussions. This was possible because the schoolteachers' participation and work hours were funded by the EU project.

The importance of time as a resource in establishing and developing a new type of cooperation is evident from the following statements:

"In such a steering committee, it is important that there is some time ... If we had met several times but with less time per meeting, I think it would have been hopeless ... Exactly because it [the project] started up from zero and had to be developed from the bottom, it became of course necessary to talk a lot and develop many ideas."
"When you look at how much comes out of it ... Obviously, if you spent the same time discussing things when making a course as a teacher, then you would have to work 80 hours a week. If it took you so long to find solutions…. even so, I do not see it as a problem (in this project). It is probably necessary" (Member 7).

This statement is in accordance with the general opinion in the group that it was necessary to invest time in learning to understand each other's working conditions (final evaluation of the steering committee, August 2011). Only on this basis is it possible to build a real bridge between primary school education and out-of-school education.

7. Conclusions

Out-of-school teaching in itself does not necessarily result in more pupils becoming interested in natural science and technical fields. This article and the underlying research indicate that it is necessary to focus on the organizations that organize out-of-school teaching and their learning processes. A better bridge between formal (primary schools) and informal (in this case, Aalborg University) learning is necessary if the out-of-school activities are to give the pupils more than a single, disconnected experience. Without this bridge, the organizing institution is more or less "fumbling in the dark" in developing educational offerings based solely on its own understanding and assumptions. Unfortunately this disconnect happens in many cases because there is a lack of research on the organization of the learning process in a cooperation network. As our literature study on attractiveness and science interest shows, the focus is largely directed at out-of-school learning outcomes, i.e., what the students got out of the class. In this study of a cooperation network in a concrete case, the Pupil's University SKUB at Aalborg University was followed throughout the project process, providing a unique opportunity to study the learning process in such an organizational network, which was strongly influenced by the conditions of the involved organizations.

The European project SAUCE gave the economic opportunity to gather an inter-organizational network and to spend the time needed to understand each other's working conditions, such as regulatory requirements, incentives, work environments, and pupils' technical qualifications. Though it required a major time investment, the cooperation network led to successful collaboration with interesting educational programs for fifth and sixth grade pupils. In addition to the steering committee, a large network of teachers, school consultants, and University employees was established. With the conclusion of the EU project, this continuity was broken. It is possible to ensure the continuation of the Pupil's University at Aalborg University according to the established format, but the experiences and knowledge that have been built up through the cooperation of the steering group and larger cooperation network during the course of the three-year project cannot be further developed. The steering committee no longer exists. This creates difficulties for the new project manager; in fact, the project manager has already changed twice since the end of the SAUCE project. In this way, much valuable experience has been lost. This development reflects some basic conditions regarding the project-borne learning landscape.

Preventing such loss of knowledge, experience, insight into other partner's working conditions, and pedagogical

considerations requires a more continuous and formalized type of cooperation between the involved organizations. One proposed solution is an inter-organizational cooperation network approach in the form of a "Bildungslandschaft."

As the findings in this research show, the primary school teachers and the school consultant consider the biggest problem to be that there is not a close enough connection between school education and the program at the University. The steering committee has made considerable efforts to create a better link between science education in school and pupils' experiences at the University. As discussed in this article, it is especially due to lack of allocation of the needed resources in this case. It should also be mentioned that the Pupil's University project at Aalborg University went beyond the efforts of project partners in the other EU countries in establishing this systematic collaboration between the university and the primary schools.

This article shows that it is necessary to focus on the framework conditions of the organizations involved and also to look at the framework conditions that a concrete collaborative project (here the SAUCE project) creates for the learning process and how these shape out-of-school learning for pupils. Other approaches, such as looking at science didactics, teachers' professional backgrounds, or pupils' motivation give the inter-organizational network a more holistic view of both the learning process in the network and the conditions of the learning process. Knowledge of pupils' science abilities and interests are represented through primary school teachers and the municipality school consultant. Continuing this way of thinking and involving students in a cooperation network of this kind will further enhance the collaborative development of a motivating out-of-school science learning process.

If we take the recommendations for science didactics seriously by instituting a problem-based approach in which students study problems or, ideally, work on self-defined problems, it will require closer cooperation between schools and the university. It will require much more cooperation, coordination, and mutual understanding of each other's work and framework conditions. It will also require that the "Bildungslandschaft" approach establish a binding collaboration with sufficient allocation of resources and a comprehensive educational approach that increases the attractiveness of technical programs by means of building a bridge between primary and secondary schools and technical/engineering education.

ICNA is considered to be an indispensable way to support the interest in and attractiveness of technical programs. There is a further need for research into how cooperation between formal and non-formal education in the form of a holistic "Bildungslandschaft" approach can be facilitated and organized.

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