Vol 8, No. 2, December 2012, pp. 45-61

Reflecting Education
http://reflectingeducation.net

Evidence of bridging the gap between formal education and informal learning through teacher education

Hannu Salmi
Research Director, Department of Teacher Education, University of Helsinki

ABSTRACT

This paper describes the developments and results of a special student teacher course used in several European countries, originally developed in Finland in close cooperation between the University of Helsinki and Heureka, the Finnish Science Centre. The integrative science education course already started in 1996. It combines formal teaching and informal learning opportunities. The main target group for this professional and personal development is student teachers although the model also suits in-service teachers. The results show how to use modern, interactive science exhibitions by combining best practices of informal learning and formal education. The objective is to use the key elements of curricula in different countries to teach the scientific research process based on learning in science centres and teaching at school. Pedagogical hands-on methods originally developed in the science centre context are adopted, converted and transferred into formal education via effective teacher education. The paper presents evidence-based results related to open learning environments as well as best practices developed in cooperation with teacher education institutes, universities, educational administrations and schools. The multidiscipline contents of modern science centre exhibitions are large and unique, forming a reliable learning source. The science centres use the pedagogical expertise of the university researchers and teacher education institutes as well as the curriculum development input by educational authorities. The "*New Educational Models and Paradigms*" theory is tested in this research. The results of the empirical part of this report show highly reliable indicators of science centre education's role supporting teacher education, of the effective use of open learning environments, and of changes in the roles and responsibilities of both teachers and students. In addition, the innovative approach helps to create a new model for teaching and teacher education. Teachers as researchers as well as practitioners who use an evidence-based approach represent a movement that is gaining momentum in several parts of the world. The future dilemma is whether it will be possible to create a stable European network linking formal and informal learning with the input of TEPE. The European Commission has shown a clear interest in supporting this type of activity.

INTRODUCTION

The role of informal learning is increasing in modern societies. This phenomenon is closely related to the growing impact of science and technology on our everyday lives. Lifelong learning needs new practical forms. Historically, the first theoretical approach for everyday science learning was created by Krieck (1922). He used the term "education by chance" ("Unreflektierte Erziehung") to describe people learning also unconsciously through work, everyday routines, art, language and culture. According to Krieck, the whole relationship among human beings is an educational one.

ISSN 1746-9082

A science centre is a learning laboratory in two senses. First of all, it is a place where visitors can learn scientific ideas by themselves using interactive exhibit units. Second, it is a place where informal education can be studied in an open learning environment.

Science centres vary greatly in their nature, size, function and content. According to most of the core ideologies of science centres, the essential role of science centres is to: advance public understanding of science, create positive attitudes to science and technology, encourage young people to learn, and maximise their opportunities to try scientific applications. How much evidence do we already have to prove that these main goals will be realised in the everyday functions of a science centre? Answering this question is not easy although we know from our everyday experiences that these pragmatic outcomes can be achieved. Because they are fairly new institutes, science centres in particular face this question more frequently than some other more traditional cultural institutes.

In the USA, the background to the expansion of modern science centres in the 1960s was the Sputnik phenomenon. The crisis in national confidence that resulted from the successful launch of Sputnik had a knock-on effect on all education in the USA. The attitude to the study and teaching of science changed dramatically. The education system in the USA was totally reformed. The Exploratorium science centre started in San Francisco 1968. In the 1970s and 1980s there was a period when nearly identical exhibitions were built by science centres simply by copying exhibit units and whole exhibitions from other science centres. The main source for this was the ‘Exploratorium Cookbooks’, which were largely published for this purpose. Many new institutes still utilise this concept for their main content. It tells us much about the international nature of science and science centres (Hein, 1990). However, the staff of science centres adapt their national and local features with their own ideas when choosing the content, design and programme ideas (Duensing, 1999).

BRIDGING THE GAP BETWEEN FORMAL EDUCATION AND INFORMAL LEARNING

The growth of science centres since the 1990s is closely related to the development of the information society. Communicating science to the public via different media is not only a matter of giving sufficient support for scientific research and academic education in society but also a process of giving citizens their basic democratic rights in relation to scientific information (Salmi, 1993; Popli, 1999; Godin & Gingras, 2000; Persson, 2000).

The continuing worldwide trend is for a broadening of the subject range of science centres and an increasingly interdisciplinary approach to exhibition themes. One non-trivial problem raised in the discussion of the role of science centres and universities relates to the meaning of the word “science”. In English, science generally means the natural and physical sciences and is often limited to physics, chemistry and biology. However, in German, Swedish or Finnish, the words “Wissenschaft”, “vetenskap” and “tiede” include the humanities, history, psychology, social science and linguistics. A modern science centre must be able to present phenomena related to all academic research. Accordingly, the content of Heureka has been planned in an interdisciplinary way. The content of Heureka’s exhibitions is supported by a broad spectrum of temporary exhibition themes. Further, the recent PISA results (Hautamäki, Laaksonen and Scheinin, 2008; Lavonen, 2008) show the importance of this relation and interaction between science and society.

Figure 1 presents the positions of a science centre in its relation to science, technology and education, and can be well used to explain and express the main goals related to the role of a modern science centre also showing science phenomena in the citizens' life, for example, according the European Commission's *Science & Society* programme. Science education is presented in Figure 1 at the point where science and education overlap. Science and technology meet in the area of research and development (R&D), within which academic research is used to develop industrial methods. Vocational education lies at the intersection of technology and education.

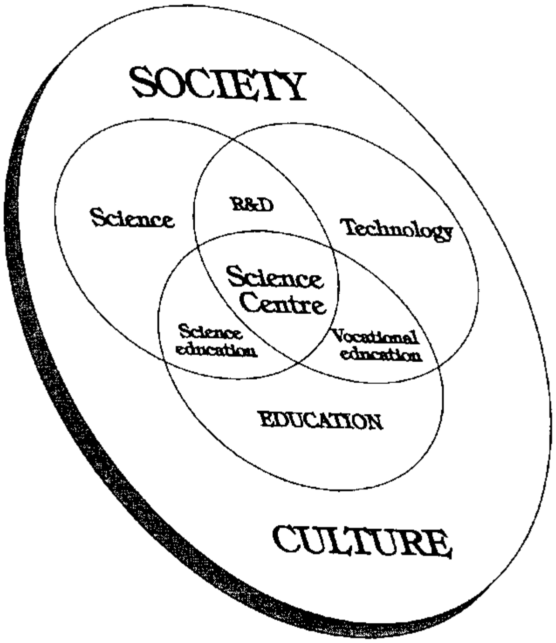

Figure 1: Education, Science and Technology in the context of Society & Culture (Source: Salmi, 1993)

In the same figure, a science centre is located where science, technology and education meet. According to this description, a science centre features all of these three fields. Any exhibition, event or educational activity like a science truck combines these three elements and adapts them to the nature of the specific content.

Positive attitudes to science and technology and the motivation for science education are created at a young age in both the field of cognitive learning but also in the more affective sides of education (Osborne, Simon and Collins, 2003).
Further, the European Commission's (2006) Rocard report underlines the importance of this phenomenon. This report and other presentations (see Osborne and Dillon, 2008)

describe the situation mostly in pre-schools, primary and secondary schools, while we also see the trends around formal education.

Informal education has often been regarded as the opposite of formal education. Even the names of the classic books – *Deschooling Society* by Ivan Illich (1971) and *The Unschooled Mind* by Howard Gardner (1991) – have been provocative. These books also contained harsh criticism of failures of schooling, which has alienated students from meaningful learning. Moreover, they argued that learning from informal sources was effective and motivating. These books have had a great effect on education and its research. The terminology of informal education is variable due to, on one hand, the slight difficulties caused by differences in school systems and, on the other, some translation problems. One main difficulty is that pure informal learning refuses to be categorised and definitions are not needed until informal learning becomes institutionalised.

The relationship between the different kinds of education is shown in Figure 2, which combines several sources (Salmi 1993, 2003). Originally, it was the scheme for educational statistics in the UNESCO report *Learning to Be* – the Faure Report (Coombs 1968, 1985). It was used then for the first time to show the forms of lifelong education.

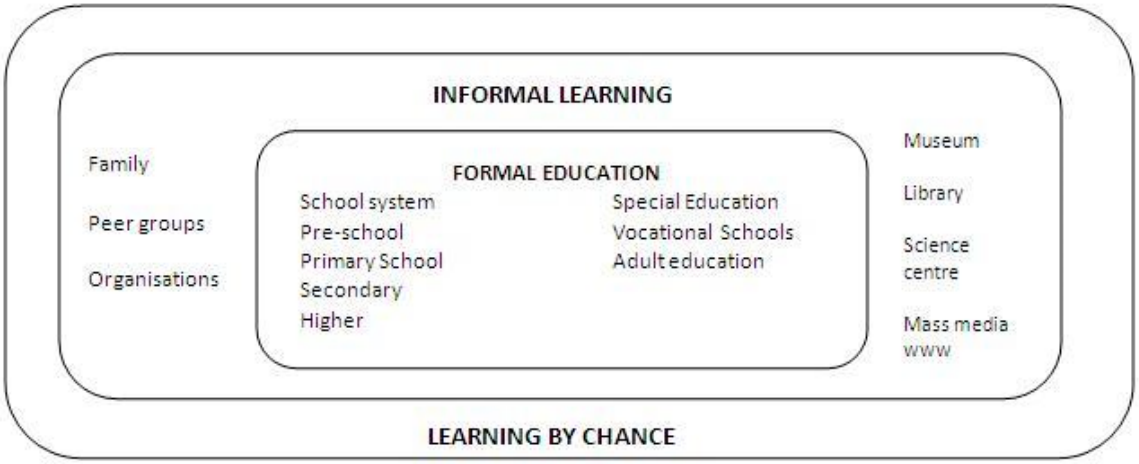

Figure 2: Formal Education – Informal Learning (Source: Salmi, 2003)

Formal education is education given by specialised organisations representing the school system from pre-school to university.
Informal education is education given by different institutes whose first function is not to educate: newspapers, television, libraries, youth free-time organisations, hobbies; peer groups and the family. Self-education is included in informal education. A personal teacher is not needed, tutorial learning sources are used by the learner.

Learning by chance is learning that occurs without any conscious education or teaching, outside organised learning situations, mostly in everyday-life situations (cf. Krieck, 1922).

It is typical of formal education to plan and form connections between different schools and courses. In informal education, the links between different studies are not consciously organised.

Non-formal education is also a frequently used term. It means any education that is organised and has clear goals but occurs outside the official school system (Lowe, 1975; Maarschalk, 1986; Bishop, 1989; Braund, 2008). Non-formal education is most often used in connection with reading campaigns in developing countries, or adult learning by non-governmental organisations, although it is often supported by the state. Here, the term non-formal education is not used because features defined under that term are included in informal education.

To advance public understanding of science, new forms of education are actively being sought. A huge amount of information especially about modern phenomena is obtained in a personal way from one's family, friends, peer groups. Further, the roles of television, libraries, magazines and newspapers are also essential. Museums and science centres have increased the number of their visitors regularly during the last decade. Most of these forms of education can be classified as informal learning either focused on young people via informal, out-of-school education programmes or as clearly informal learning occurring totally outside of any educational institutions for young people or adults. Computers and the Internet have recently reformed the whole field of education (Salmi, 2003; Braund, 2004, 2010).

Frank Oppenheimer (1968) has been called the creator of the science centre pedagogy. His criticism of the passive pedagogy of science education derives implicitly from Dewey's ideas (1938) expressed in his "learning by doing" thesis. The same approach can be seen in contemporary developments in science centre pedagogy: the famous hands-on principle articulated by Oppenheimer is a cornerstone of the principle of interaction in modern science centres. What Dewey and modern science centre pedagogy share is their accent on motivation, free will and the learner's own activity, stimulated but not forced. The results related to the role of intrinsic motivation are the most essential related to informal learning and the positive impact of Self Administrated Motivation (Salmi, 1993, 2003; see also Thuneberg, 2007; Duffy and Rimmer, 2009).

Since the 1990s informal education has become a widely accepted and integrated part of school systems. However, examples of theoretical or empirical research concerning informal education are still rare (Falk and Dierking, 1993, 2000, 2009; Salmi, 1993, 2003, 2010). The terminology of formal education and informal learning has been clearly defined in the literature for three decades now (UNESCO, 1968, Coombs, 1985, Bitgood, 1988). The recent boom in informal learning has not changed the view at the terminological level. A useful, but rarely used term is "*out-of-school education*". It means the education taking place during school hours and according to the curriculum, but using learning sources and educational environment outside the physical school buildings. The term has been defined exactly in several countries (like Finland and Netherlands) because it is part of the official school legislation.

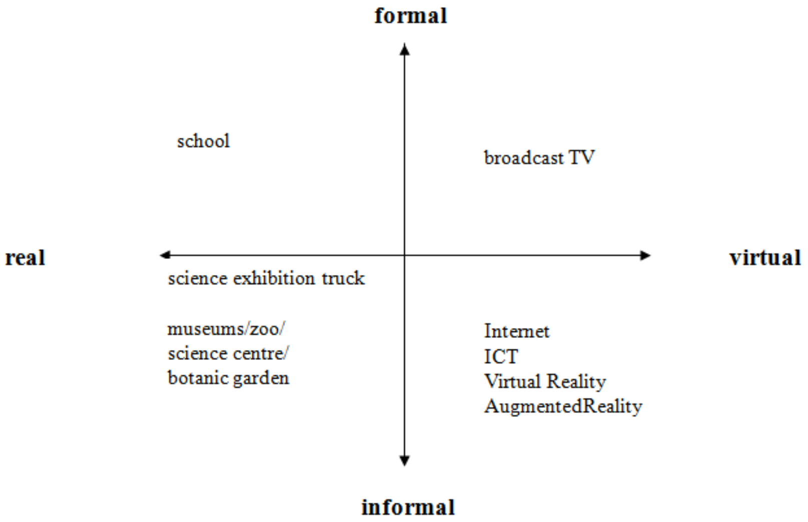

Figure 3: Persistent dichotomies or blurring boundaries? (Source: Hawkey, 2002)

Figure 3 contains a dichotomy. Several phenomena have been added to the original one by Hawkey (2002). Novel technologies (like "AR – Augmented Reality") are forming new aspects of everyday science learning options without the need for a school or physical environment. In this dichotomy, a moving science exhibition truck like a science circus is defined and located in the real environment and near the borderline between formal education and informal learning: while visiting the school the truck becomes part of formal 'out-of-school' education, but when it stops in local malls on the week-end the moving science exhibition clearly represents everyday informal science learning.

MAKING TEACHER EDUCATION WORK VIA INFORMAL LEARNING SOURCES

Research-based teacher education contains two elements: 1. teacher education must have an evidence-based scientific basis; and 2. Student teachers must learn to evaluate their own work according to the scientific research schema. In the Department of Teacher Education at the University of Helsinki, classroom teachers' education has been based on these principles since 1979.

In reality, these two principles are driven into action by two strategies:

A) *research related to didactics*. Scholars of both general and subject didactics explore such research themes as the significance of subject didactics in learning and teaching. Research focuses on subject learning and the development of teaching. Teachers' knowledge and the scientific basis of the teaching subject are an important research area in general and subject didactics, and research on didactics also explores curricula and learning material.

B) *Innovative learning environments*. Not only technological, but also social and educational innovations are closely related to this theme. The research theme entails the idea of the ubiquity of learning and involves the study of both formal and informal learning.

Included in the study of innovative learning environments is research on technology-supported teaching, studying and learning. Science centre teaching is a separate research theme, as is research on virtual planning. Research on collaborative learning and epistemic agency analyses human growth, development and learning in various contexts and age groups (University of Helsinki, Department of Teacher Education, 2011).

Model for Mobilising Professional and Personal Teacher Development

This evidence-based model (see below) was originally developed in cooperation between Heureka, the Finnish Science Centre and the Department of Teacher Education in the University of Helsinki. The two-day course has been obligatory for all student teachers of the University of Helsinki since 1996.

The model has had an impact on and wide interest in several countries. During 2005–2007 it was delivered by the European Commission DG Research *Hands-on & Brains-on: Combining formal and informal science learning* to nine European countries. More than 8,300 in-service teachers and student teachers took part in this project. The courses were administered in close cooperation with the universities and teacher education institutes of each country, and evaluated by standard methods. The evaluation and survey of the results took place by mapping the key elements of curricula, thereby helping to find new effective ways to advance learning in science centres and teaching at school.

However, the main pedagogical idea is to give enough freedom to the teacher as a pedagogical expert to use the science centre exhibitions and other settings as an open learning environment. One of the key findings while analysing the successful PISA results in Finland has been that teachers should not have only the right but also the obligation to apply the curriculum by themselves. For this, naturally, advanced teacher education skills are demanded: the idea behind all evidence-based approaches is that the methods practitioners use should be evaluated to prove whether they work, and that the results should be fed back to influence practice. It is an attempt to move from individual and personal approaches to one in which traditional ideas are tested and changed where necessary. Web-based solutions have offered new options for and solutions to this process (www.sctg.eu; www.naturaleurope.eu; www.openscienceresource.eu; www.pathway.eu; www.scientix.eu).

Every autumn in Finland more than 200 student teachers of the University of Helsinki participate in the course Integrative Science Education Course at the Finnish Science Centre Heureka. The course highlights the role of learning in informal contexts uses the Pre-visit – Visit – Post-visit –model as a pedagogical approach. The three-step model is a research-based pedagogical tool for teachers to be utilised, for example, in pursuance of planning science centre or natural museum visits. The course integrates different natural sciences in a way that promotes an active learning process and intrinsic motivation. The course consists of the following parts: introductory lecture, laboratory workshops, science theatre shows, augmented reality workshops, and Heureka Classics exhibitions. (Salmi, Kallunki and Kaasinen, 2012).

The three-step model is based on the 5E learning cycle that was first used as an inquiry lesson planning model in the Science Curriculum Improvement Study (SCIS) programme, a K-6 science programme in the early 1970s. The phases of the 5E model – engagement, exploration, explanation, elaboration and evaluation – highlight the main aspects of inquiry-based science education. The phase of engagement means getting to know the topic. In the phase of exploration, different ideas of pupils are explored through hands-on activities. Explanation is an advanced phase giving explanations and clarifying understanding. In the next phase, elaboration, the topic is deepened by applying the learnt concepts to new fields. The last phase involves an evaluation: both self-reflection and the teacher's evaluation take place (Bybee et al., 1989).

The three-step model activates learning during the science centre visit, because both the pre-visit and post-visit phases deepen the topic. The model takes into account, for instance, the following aspects of learning: orientation, motivation, focusing and preconceptions about a topic to be learned. Engagement takes place in the pre-visit phase, whereas exploration, explanation and elaboration belong to the visit phase, and evaluation is performed in the post-visit phase. (Frantz-Pittner, Grabner and Bachmann, 2011). In the table below, the exemplary details of using the three-step model in the Integrative Science Education Course at the Finnish Science Centre Heureka are presented.

Pre-visit – Visit – Post-visit – model

Pre-Visit Stage: University or teacher education institute.
As an introduction, teacher education takes place in the University through a special course, or via remote ICT-learning environments.

- The subject matter of the exhibitions is made part of the professional and personal development for all student teachers.
- Using ICT as a cost-effective pre-lecture strategy for *the orientation for the visit* itself, and for *the focus of the visit* to the centre.
- Pre-tasks for the visit stage (web-based; questionnaires; open-ended).

Visit Stage: The Science Centre Exhibition as an Open Learning Environment.
Training takes place in science centre open learning settings like workshops, demonstrations, experiments, laboratories, planetarium, exhibitions, outdoor settings etc.

- The main **impacts** of the visit to the science centre are *motivation* and *learning by doing.*
- Supplementary **impacts** of the visit to the science centre mentioned by the teachers: a) the exhibition's content as an *entity with a theme;* and b) having an opportunity to utilise varying learning methods.
- The teacher's **impact** on the visit to the science centre is well-organised especially in relation to their school rhythm, and a visit to a single exhibit unit or the children's laboratory in the science centre).
- The co-operative learning nature **as an impact** of the visit to the science centre is found to be important by the teachers.

Post-Visit Stage: Back at school.
Utilising the hands-on methods learned in the science centre in teaching as well bringing back ideas for pupils and students.

- impact on the subject matter, the teachers believe the most important is "learning by doing";
- impact of the opportunity to apply a method "to make observations";
- impact of Laboratory, Demonstrations, and Planetarium as specified IBSE personal & professional learning sources;
- impact of the entity: the pre-lectures in the school + visit + post-lectures in the school bring added value to their work (while the teachers invest a lot of their – especially mental – resources in the process!)

Teacher survey and evaluation

The recent (2006) *Rocard report* [*Science education now: A renewed pedagogy for the future of Europe*] describes the situation mostly in pre-schools, primary and secondary schools, while we also see the trends around formal education. The role of informal learning is increasing in modern societies – meaning those countries, which are developing their societies by investing and creating opportunities for research, innovations and education. The phenomenon is closely related to the growing impact of science and technology on our everyday lives. Lifelong learning needs new practical forms and formal education can learn something from informal, open learning environments like the science centres.

The Rocard report underlines the term *Inquiry-Based Science Education*. One of the weaknesses of schools' science teaching has been that studies and lessons at school are mainly deductive. There are some exceptions in some schools but, historically, the main trend in European science teaching pedagogy has applied a 'Deductive approach'. In this approach, the teacher presents the concepts, their logical – deductive – implications and gives examples of applications. This method is also referred to as 'top-down transmission". 'Hands-on learning' is the main pedagogical principle of the science centres. An opposite to 'Deductive', it represents the 'Inductive method'. This classical 'learning by doing' method is something the science centres have been pioneering in Europe over the last few decades. The multidisciplinary contents of modern science centre exhibitions form a unique and reliable learning source for inductive, inquiry-based science education.

The evaluation tool: Measuring the role of science centre pedagogy

As the pedagogical context called for the measurement of the impact of science centre pedagogy, the tool "*New Educational Model or Paradigms*" (Salmi & Sotiriou & Bogner, 2010) was utilised to receive feedback from teachers.

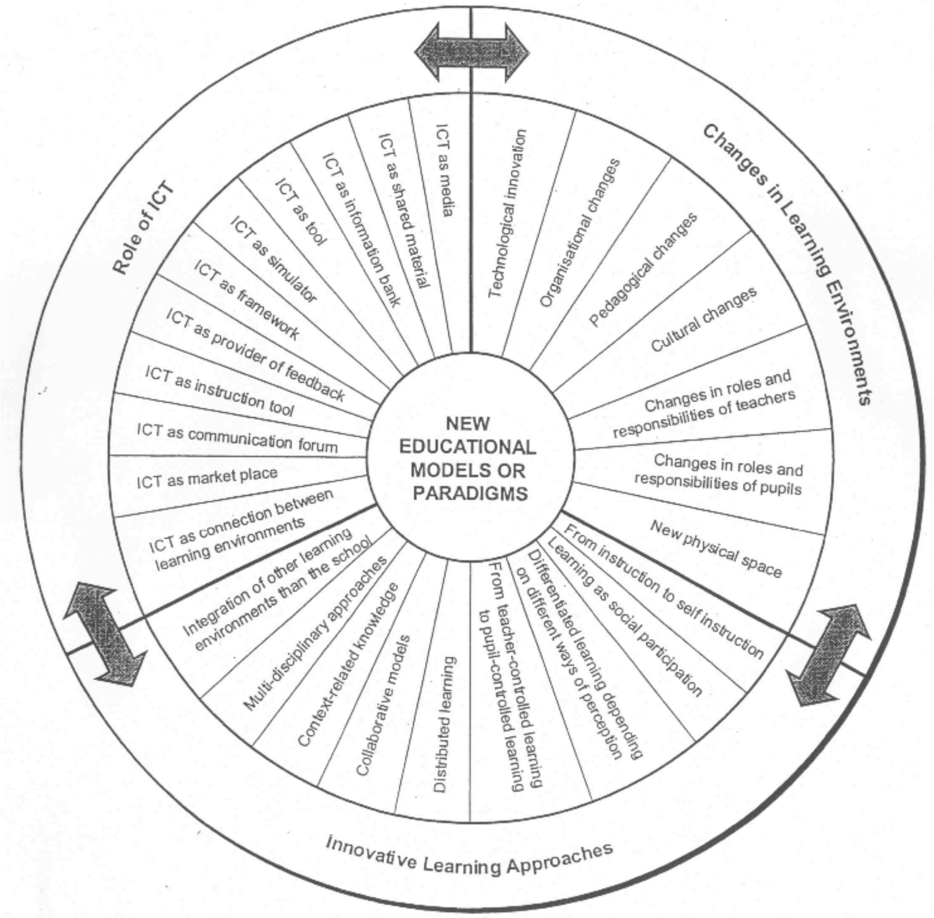

Figure 4: New Educational Model or Paradigms (Source: Salmi, Sotiriou and Bogner, 2009)

As a result of this inquiry, the pedagogical experts and teachers attending the process saw the main characteristics as including: innovative learning approaches, the integration of learning environments other than the school, and differentiated learning depending on different ways of perception. The main element was, however, moving from teacher-controlled learning to pupil-oriented learning with context-related knowledge. It is also noteworthy that the teachers were not impressed with the technology itself but with seeing ICT as a connection with the learning environment, an instruction tool. This can lead in the best case – according to the teachers' interviews – to changes in the roles and responsibilities of pupils and teachers. (Salmi & Sotiriou & Bogner, 2009). The methodological part of this research is to apply the tool originally developed for information and communication technology (ICT) use in education to other topics; in this case, to the out-of-school education in a science centre as an open learning environment.

The role of informal learning in the science centre: research-based teacher education

The data

The data were collected from trainee teachers of the University of Helsinki. The questionnaire was filled in one week after the intensive two-day course at Heureka, the Finnish science centre. (See the detailed practical and theoretical description of this course in the previous section).

The courses and tests were administrated in November 2010 and 2011. The total number of the subjects was 241 student teachers (2010 n: 131, 2011 n: 110).
The questionnaire was filled in as an e-version via the Internet. The students were experienced in using the web-based questionnaire tool in a fluent way based on their earlier studies and courses.

The questionnaire contained 27 items and was also part of the routine feedback and evaluation of the course.

The background data on the subjects included their age, gender, educational background and work experience. Many had also been working as a classroom, primary school, high school or kindergarten teacher for some period either before or during their studies.

The data were factor analysed based on the theory of New Educational Paradigms and Models (NEPM). This theory had been developed and tested earlier to describe changes in teaching and learning while moving to a new learning environment and/or method. The theory consists of three aspects: 1) a precise description of the *Role of the science centre pedagogy itself;* 2) actual *Changes in the learning environment;* and 3) the definition of the level of *Innovative learning approaches* of the method used. These three elements have a close connection to the forming of the New Educational Paradigms and Model.

Factor analysis

The main hypothesis for the factor analysis was that the answers to 21 items would load on to three clear factors named: 1) “The role of method”; 2) “Changes in the learning environments”; and 3) “Innovative approaches”. Because of the strong pre-assumptions based on the testing of the theory, model and tool, the main character of the factor analysis was *confirmative*. However, the factor analysis as a research method also contained certain explorative elements because strictly formulated hypotheses were not created before the statistical tests. Factor analysis was based on a correlation matrix.
The factor analysis was conducted using the *maximum likelihood* method. At first, attention was paid to the correlation matrices of the items. The matrix did not contain any borderline, high-valued correlations, e.g. multi-collinearity or singularity did not cause any problems for the main analysis.

The factor matrix was rotated using the Varimax method. Because according to both the NEPM theory and factor analysis practice the items correlated with each other, it would have been possible to utilise a Promax rotation. However, this method did not produce any additional value or clearer results; only the “*Role*” and “*Innovative*” factors became more blended with each other.

RESULTS

Three clear factors emerged as the results of the factor analysis from the 27 separate items (see Table 1). This main result strongly supports the theory behind the model. The main theoretical interest in this result rests on the fact that the New Educational Paradigms and Models theory was originally developed to structure computer- and technology-based education. The only element causing some initial confusion was the strong link between factors 1 and 3. The correlation between these factors showed high values ($r=0.225$, $p<0.001$). The reduction of the data by six items (see below) made the factor analysis structure even clearer. The final analysis thus contained 21 items. These items loaded exactly according to the background theory forming the three factors originally named: (1) *Role of science centre education;* (2) *Changes in the learning environment;* and (3) *Innovative Learning Approach*.

Table 1 only includes those factors that loaded with a value above 0.3. Thus, the following six items were excluded from the final analysis.

- Factor 1: Role
    - item 9: "*SCE as an information bank*"
- Factor 2: Learning Environment
    - item 12: "*SCE as a technological innovation*"
- Factor 3: Innovative Approach
    - item 21: "*Differentiated learning depending on different ways of perception*"
    - item 25: "*SCE Context-related knowledge*"
    - item 26: "*SCE Multi-disciplinary knowledge*"
    - item 27: "*SCE Integration of learning environments other than the school*"

		Factor		
		Role	Changes	Innovative
		1	2	3
THE ROLE OF THE SCIENCE CENTRE EDUCATION	1. SCE as connec. of learn. environ.	.356		.306
	2. SCE as market place	.424		
	3. SCE as communic. forum	.573		.347
	4. SCE as instructional tool	.379		
	5. SCE as provider of feedback	.589		
	6. SCE as framework	.543		
	7. SCE as simulator	.359		
	8. SCE as tool	.431		.307
	10. SCE as shared material	.409		.362
	11. SCE as media	.566		
CHANGES IN THE LEARNING ENVIRONMENT IN THE SCIENCE CENTRE EDUCATION	13. SCE Organisat. changes		.475	
	14. SCE Pedagog. Changes		.565	
	15. SCE Cultural changes		.440	
	16. SCE Changes in roles and responsibils of teachers		.604	
	17. SCE Changes in roles and responsibilities of pupils		.656	
	18. SCE New physical space		.550	

INNOVATIVENESS OF THE SCIENCE CENTRE EDUCATION	19. SCE Instruction to self-instr.			.438
	20. SCE Learning as social participation			.497
	22. SCE Teacher-controlled vs. pupil controlled learning			.415
	23. SCE Distributed learning	.407		.522
	24. SCE Collaborative models	.453		.469

Table 1: Factor analysis of the Science Centre Education (SCE) as NEWP

Factors no. 1 (Role of the science centre education) and no. 3 (Innovative approach) strongly correlated with each other, as is shown in detail in the following table.

Science centre education		Factor 1: Role	Factor 2: Change	Factor 3: Innovative
Factor 1: Role	corr	1	.071	.247
	p=		.279	.000
Factor 2:	corr	.071	1	.067
Change	p=	.279		.307
Factor 3: Innovative	corr	.247	.067	1
	p=	.000	.307	

Table 2: Interaction of the factors: correlations with each other

For the further analysis, factor points were calculated for all (n:241) subjects. Because of the design of this study, the factors may correlate with each other. This allows an opportunity to use regression as an additional research method.

VALIDITY AND RELIABILITY

The data gathering for this research succeeded very fluently. In practice, all (n:241) the student teachers of the second year course in 2010 and 2011 in the University of Helsinki attended the course and filled in the e-questionnaire as part of the evaluation and further development of the obligatory course. In practice, loss and non-response % was close to zero because the data covered the whole population.

Opinions relating to the demands of the size of a sample and the number of subjects in relation to the number of items have been varying in the research literature recently. According to Field (2009: 645-647), as metadata from several researchers the number of the subjects should be 5 to 15 times bigger than the number of items. In this study, there are approximately ten subjects for each item.

In the factor analysis method, the number of subjects is also linked to the strength of the factor loadings and the size of the communalities. These numerical values are fairly low, and the mean numeric value of the communalities included in the data after the rotation is 0.329. However, the factor loadings turned out to be reasonably strong. One-third of the items were above the numerical value of 0.5, and four items even reached the level of 0.6. The *Kaiser-Meyer-Olkin* (*KMO*) *measure of sampling adequacy* is an index used to examine the appropriateness of factor analysis and takes communalities in relation to the number of subjects into account. The *KMO* value of this study is 0.847. According to the methodology review (Fieldin, 2009) a level of .80 to .90 is considered a very good indicator that there is enough deviation and heterogeneity in the data to make the factor analysis successful.

To measure the internal reliability, Cronbach's Alpha method was utilised. Recently, there has been growing criticism of this Alpha, mainly because it only describes one-dimensional data. Thus, in this study Cronbach's Alpha was calculated, in addition to the whole data, also separately for each of the factors (see Table 3).

	Science centre education all variables	**Factor 1: The role of the science centre education**	**Factor 2: Change in the learning environment in the science centre education**	**Factor 3: Innovativeness of the science centre education**
Cronbach's Alpha	.847	.791	.731	.699
N= number of items	21	10	6	5

Table 3: Cronbach's Alpha separately for all variables and the three factors

The literature suggests that a critical value for Cronbach's Alpha is above 0.7. As the results of the previous table show, all of the items and variables turned out to be reliable in this study.

Also the correlations between the variables proved to be suitable. Nearly all the correlations among the variables within each of the three factors (1–3) remain on the continuity from 0.2. to 0.6. These values fulfil the Tabanik-Fidell criteria for valid and reliable factor analysis (Metsämuuronen, 2005: 615-616). In addition, the correlations are not so high that they create a risk of multi-collinearity.

The variables were pre-tested and measured by an existing ordinal scale. The variables and items were also divided according to a "normal distribution". The data did not contain any outliers or observations crucially distant from the rest of the data.

All research ethic rules, regulations and best practice have been carefully applied during the research process and reporting.

CONCLUSIONS

The empirical results of this study support the theoretical part of the New Educational Models or Paradigms (NEMP) presented in the paper. The factor analysis confirms the design of the study. These results give new evidence in support of the development of science centre pedagogy. Further, the items excluded from the factor analysis encourage new thoughts about further development of the NEMP theory.

The data were collected during September 2010 and September 2011. This gave an opportunity to view the data according to the split-half method. Theoretically, there was no motivation to presume the results would be different, for several reasons: a) the students were selected for the university using the same type of tests and examinations; b) the official content of the course remained the same; and c) the lecturer in charge of the outdoor education had not changed. The empirical data support the hypothesis. There was no difference in the results for the data collected in 2010 and 2011.

Meaningful learning has two components. First, the content should be meaningful and motivating for the learner. Second, the learning process should be arranged pedagogically in a meaningful way according to the learner's age, prior knowledge and skills, and according to the logical structure of the topic being taught. It is clearly more complicated to apply the latter principle to informal learning settings. However, the first principle, which involves intrinsic motivation, is often the strongest point of informal learning environments.

The role of informal learning is increasing in modern societies – meaning those countries, which are developing their societies by investing and creating opportunities for research, innovations and education. The phenomenon is closely related to the growing impact of science and technology in our everyday lives: "Science education is not only a question of advancing technology or of demands for a scientifically qualified workforce, but is also a question of social goals. The aim is not solely to produce more scientists and technologists; it is also to produce a new generation of citizens who are scientifically literate and thus better prepared to function in a world that is increasingly influenced by science and technology" (Coombs, 1985: 246). Lifelong learning needs new practical forms and formal education can learn something from the informal, open learning environments like science centres.

Similarly, the Rocard report (2006: 7) published by the European Commission also calls for new forms of teacher training: "Teachers are the key players in the renewal of science education. Among other methods, being part of the network allows them to improve the quality of their teaching and supports their motivation. – Networks can be used as an effective component of teachers' professional development, and they are complementary to more traditional forms of in-service teacher training and stimulate morale and motivation."

To summarise the main outcome of this study, the reliable results confirm the theoretical basis of the New Educational Models or Paradigms and provide evidence that it may also be used as a measurement tool for other learning environments, informal learning sources, and innovative approaches in learning and teacher education.

REFERENCES

Braund, M. and Reiss, M., 2004. *Learning Science Outside the Classroom*. London: Routledge Falmer.

Braund, M., 2008. *Starting Again*. Making Progress in Science Learning. London: Sage.

Bybee, R.W., Buchwald, E., Crissman, S., Heil, D. R., Kuerbis, P. J., Matsumoto, C. & McInerey, J. D. 1989. Science and technology education for the elementary years: Frameworks for curriculum and instruction. Washington, D.C.: The National Center for Improving Instruction.

Coombs, P., 1968. *The World Educational Crisis*. New York: Oxford University Press.

Coombs, P., 1985. *The World Crisis in Education*. The View from the Eighties. New York: Oxford University Press.

Deci, E. & Ryan, R., 2007. *SDT-theory homepage:* http://www.psych.rochester.edu/ SDT/

Duffy, T. & Russell, R., 2009. A review of the positive impact of a Self Administrated Motivational Instrument (SAMI) on deep and strategic approaches to study and on academic attainment. *Reflecting Education*, 5(2), 104-115.

Falk, J. and Dierking, L., 1992. *The Museum Experience*. Whalesbak Books: Washington DC. The Museum Experience.

Falk, J. and Dierking, L., 2002. *Lessons without Limit*. AltaMira: Walnut Creek, CA.

Falk, J., 2009. *Identity and the Museum Visitor Experience*. Left Coast Press: Walnut Creek, CA.

Fenichel, M. and Scheingruber, H., 2010. *Surrounded by Science*. Washington, D.C.: The National Academies Press.

Field, A., 2009. *Discovering Statistics Using SPSS*. Lontoo: SAGE Publications.

Fisher R., 2005. *Teaching Children to Learn*. Cheltenham: Stanley Thornes.

Frantz-Pittner A., Grabner S., Bachmann G., 2011. *Science Center Didaktik*. Hohengehren: Schneider Verlag.

Gardner, H., 1991. *The Unschooled Mind*. How Children Think and How Schools Should Teach. New York, Basic Books.

Greenfield, P., 2009. Technology and Informal Education: What is Taught, What is Learned. *Science*, Vol. 323, 69-72.

Hautamäki, J., Laaksonen, S. and Scheinin, P., 2008. Level and Balance of Achievement. In *PISA06 Finland: Analyses, Reflections, Explanations*, pp. 37-52. Ministry of Education Publications 2008: 44. Centre for Educational Assessment, University of Helsinki.

Hawkey, R., 2003. The lifelong learning game: Season ticket or free transfer? *Computers and Education*, 2(4), 5–20.

Hein, H., 1990. *The Exploratorium*. The Museum as Laboratory. The Smithsonian Institution: Washington D.C.

Hofstein, A. and Rosenfeld, S., 1996. Bridging the gap between formal and informal science
learning. *Studies in Science Education*, Vol. 28, 87-112.

Hudson, K., 1988. *The Museums of Influence*. Cambridge University Press: Bath.

Illich, I., 1971. *Deschooling Society*. New York, Harper and Row.

Krieck, E. 1922. *Philosophie der Erziehung.* Jena: Eugen Diedrichs Verlag.

Lavonen, J., 2008. Science Literacy Assessment. In *PISA06 Finland: Analyses, Reflections, Explanations*, pp. 67-109. Ministry of Education Publications 2008: 44. Centre for Educational Assessment, University of Helsinki.

Metsämuuronen, J., 2005. *Research Methodology and Statistics.* Tutkimuksen tekemisen perusteet ihmistieteissä. Helsinki: International Methelp.

Persson, P-E., 2000. Science centers are thriving and going strong, *Public Understanding of Science*, 9(4), 449-460.

Salmi, H., 1993. *Science Centre Education.* Motivation and Learning in Informal Education. Research Report 119. Department of Teacher Education, University of Helsinki.

Salmi, H., Kallunki, V. and Kaasinen, A. 2012. Pre-visit – Visit – Post-study: learning repeated in Finland. In Salmi (ed.) *Implementing Inquiry beyond the School*, pp. 32-37. Fibonacci-project: EU. ISBN 978-952-10-8519-2.

Salmi, H., Sotiriou, S. and Bogner, F., 2009. Visualising the invisible in science centres and science museums: Augmented Reality (AR) technology application and science teaching. In Karacapilidis, N. (ed.) *Web-Based Learning Solutions for Communities of Practice: Virtual Environment for Social and Pedagogical Advancement*, pp. 185-208. New York: ISR.

Salmi, H., 2010. Bridging the gap between formal education and informal learning: Towards evidence based education, pp. 35-41. In Kalogiannakis, M. et al. (eds.): Hands-on Science. Laboratory of science teaching, Rethymno: Crete. ISBN 978-989-95095-6-6.

Salmi, H. 2003. Science centres as learning laboratories. *International Journal of Technology Management, 25(5), 460-475.*

Thuneberg, H., 2007. *Is a majority enough?* Psychological well-being and its relation to academic and prosocial motivation, self-regulation and achievement at school. Research report 281. Department of Applied Sciences of Education, Faculty of Behavioural Sciences. Yliopistopaino. Helsinki.

University of Helsinki 2011. *Focus on Research.* Department of Teacher Education. http://www.helsinki.fi/teachereducation/research/focus_areas_for_research.html

Correspondence:

Dr. Hannu Salmi
Department of Teacher Education
PO Box 9 (Siltavuorenpenger 5)
FI-00014 University of Helsinki
Finland
E-mail: hannu.salmi@helsinki.fi