

MAKING SCIENCE UNDERSTANDABLE AND MEANINGFUL: BRIDGING THE GAP BETWEEN FORMAL EDUCATION AND INFORMAL LEARNING

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INTRODUCTION

”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” [1].

Learning and education can be defined both narrowly and broadly: they can occur either unconsciously or formally. One of the first to present this broader definition was in 1922 the German philosopher Krieck [2] who used the term "unreflektierte Erziehung" – “education by chance”. According to him, people also learn unconsciously through work, art, language and culture. The whole relationship between human beings is an educational one. Philosophically, informal education represents the ideas of freedom, in the spirit of Rousseau's tradition as manifested, for example, in the work of A.S. Neill.

Learning in informal contexts has often been regarded as the opposite of formal education. Even the names of the classic books – *Deschooling Society* by Ivan Illich [3] and *The Unschooling Mind* by Howard Gardner [4] – 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 educational research.

Until the 1990s, informal learning solutions were often considered as unreachable ideals, or informal education was used only as a tool for criticising school or school reforms. To advance public understanding of science, new forms of education were actively sought. Learning does not take place only in the actual world of school but in the presented world of nature, parks, yards, science centres, gardens, and the media, as well as through the virtual worlds of the internet and social media.

Since the 1990s, however, informal education has become a widely accepted and integrated part of school systems. Despite this development, there has been less theoretical or empirical research in the informal sector. Recently, learning in informal contexts has become a more accepted part of science education.

A huge amount of information, especially about modern phenomena, is obtained in a personal way from family, friends, and peer groups. Furthermore, the roles of television, libraries, magazines, and newspapers are also essential. Museums and science centres have regularly had increased numbers of visitors during the last decades. Despite this development,

there has been less theoretical or empirical research in the informal sector [5]. ICT- and web-based learning has totally changed the vision of formal education [6, 7].

The terminology of informal education is variable, due to, on the one hand, to the slight difficulties caused by differences in school systems and, on the other, some translation problems. One of the main difficulties is that pure informal learning refuses to be categorised, and the definitions are not needed until informal learning becomes institutionalised. Learning in informal contexts and open learning environments are the latest terminology in the field.

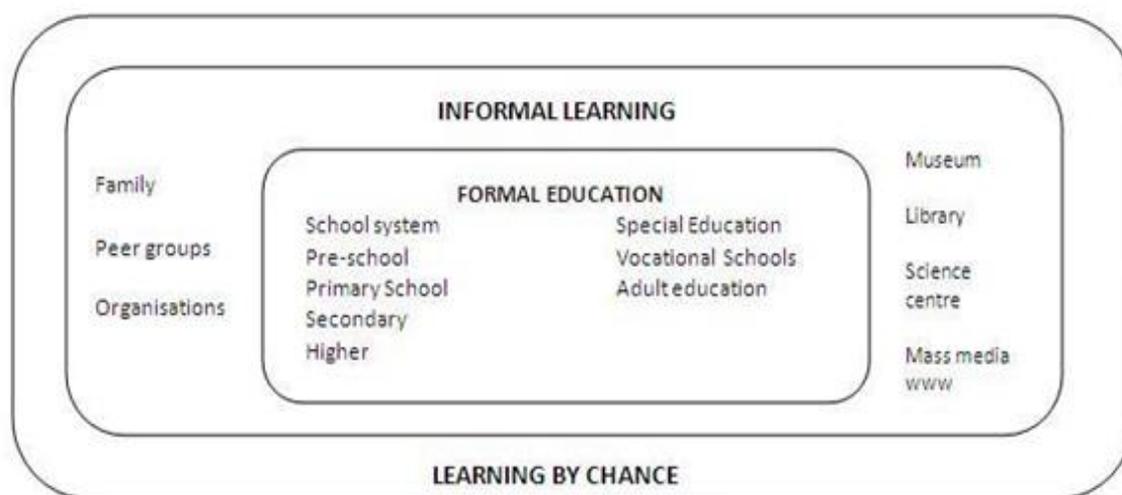


Fig.1. The relationship between the different kinds of education [8]

The relationship between the different kinds of education is shown in Fig.1, which is a combination from several sources. Originally it was the scheme for educational statistics in the UNESCO report *Learning to Be – The Faure Report* in 1968. It was used then for first time to show the forms of life-long education.

To promote 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 family, friends and peer groups. Furthermore, the roles of television, libraries, magazines and newspapers, and of course by ICT and web-based reality are essential. Informal learning has often been regarded as the opposite and criticism of formal education. However, since 2000s, informal education has become a widely accepted and integral part of school system.

The terminology of formal education and informal learning has been clearly defined in the literature for three decades now. The recent boom in informal learning has not changed the view on the terminological level. However, out-of-school education is yet another essential term. It means education that happens during school time and according to the curriculum, but uses settings and institutes outside the physical school building.

SCIENCE CENTRE PEDAGOGY

The numbers science centres – and their visitors – have increased 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 any educational institutes for young people or adults. We have to head towards the evidence based education via teacher training. There is all too much anecdotes and every-day-experiences related to science education and informal

learning. There has to be more reliable link between research communities and teacher training.

The role of informal learning is increasing in the modern societies – meaning the 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. Lifelong learning needs new practical forms, and the formal education can learn something from the informal, open learning environments like the science centres.

Hands-on learning is the main pedagogical principle of the science centres. This classical “learning by doing” method is something that the science centres have been pioneering in Europe during the last decades. The multidiscipline contents of modern science centre exhibitions form a unique and reliable learning source. The most important results related to informal learning underline the role of intrinsic motivation and the learner's own activity, stimulated but not forced.

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. Secondly, it is a place where informal education can be studied in an open learning environment.

In the USA, the background to the expansion of modern science centres in 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 towards the study and teaching of science dramatically changed. The educational system in the USA was totally reformed.

Exploratorium Science Centre started in San Francisco in 1968. In the 1970s and 1980s there was a period when nearly identical exhibitions were built by science centres just by copying exhibit units and whole exhibitions from other science centres. The main source for this was the ‘Exploratorium Cookbooks’, which were to a large extent published for this purpose. Many new institutes still utilise this concept for their main content which says much about the international nature of science and science centres.

However, the staff of science centres adapts their national and local features with their own ideas when choosing the content, design and programme ideas.

Frank Oppenheimer has been quoted as the creator of the science centre pedagogy. His criticism of the passive pedagogy of science education derives implicitly from John Dewey's ideas (1938) expressed in his thesis ‘learning by doing’. The same approach can be seen in contemporary developments in science centre pedagogy: The famous hands-on principle articulated by Oppenheimer is a corner-stone of the principle of interaction in modern science centres. What Dewey and modern science centre pedagogy share is the accent on motivation, free will and the learner's own activity, stimulated but not forced.

The growth of science centres since the 1990s is closely related to the developments 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.

The continuing world-wide trend is for a broadening of the subject range of science centres and an increasingly interdisciplinary approach to exhibition themes. One non-trivial problem that has been raised in the discussion of the role of science centres and universities is related 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, Hungarian, or Finnish, the words ‘Wissenschaft’, ‘vetenskap’, tudomány, and ‘tiede’ include the humanities, history, psychology, social science and linguistics. The modern science centre must be able to present phenomena related to all academic research. Accordingly, the content of the leading science centres in Europe has been planned in an interdisciplinary way. The content of exhibitions is supported by a broad spectrum of temporary exhibition themes. Also the recent PISA-results are showing the importance of this relation and interaction between science and society.

Figure 2 presents the positions of a science centre in its relation to science, technology and education. It can be well used in order to explain and express the main goals of the European Commission Science with and for Society 2020 programme. It shows how these objectives are met through the cooperation between universities, science centres, schools, teacher education and school authorities. Science education is presented in 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 is at the intersection of technology and education. Science education is at the intersection of science and education. A Science Centre is located where science, technology and education meet.

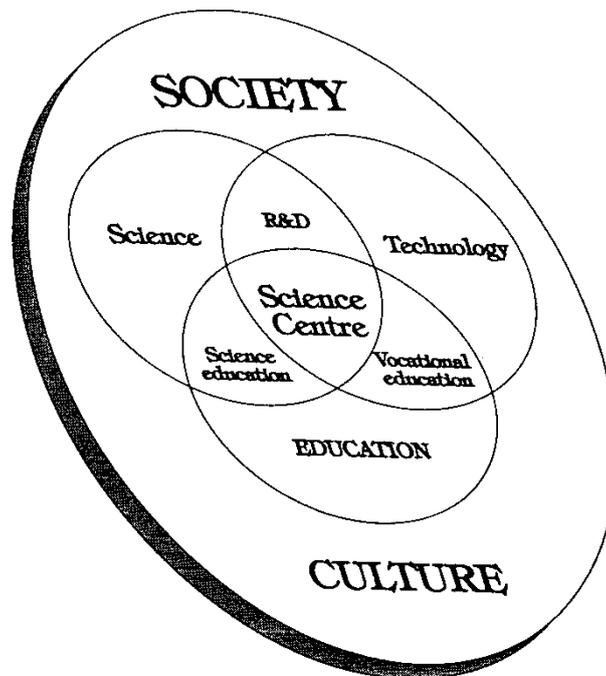


Fig.2. Education, Science and Technology in the context of Society & Culture [9, 7]

In the same figure, 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 the science truck, combine these three elements and adapt them to the nature of the specific content.

Out-of school education often uses informal education sources for formal education. It forms a pedagogical link between formal education and informal learning. Science centre education is one form of out-of-school education [10].

The methods of informal learning have traditionally been used in, for example, the teaching of biology, geography learning, science education, museology solutions, and art education. To advance public understanding of science, new forms of education were actively sought [11]. Learning does not take place only in the actual world of school, but in the presented world of nature, parks, yards, science centres, gardens, and the media, as well as through the virtual worlds of the internet and social media [12]. There has been few activities related to mathematics education and learning in informal learning settings including science centre exhibitions [13,14]. The international mathematics happening BRIDGES arranged every second year is one of the few role models for this type of public understanding of mathematics exhibition and activities. Such results have been multiplied in the literature [10, 6]. However; science, technology and engineering have traditionally been tactile and become more and more visual, and many of the skills trained and taught are definitively not textual. Therefore, “here might be a mismatch between the structure of the knowledge and the structure of the print and language media traditionally used both impart and test that knowledge” [15].

Positive attitudes towards the science and technology and the motivation for science education are created at a young age both in the field of cognitive learning but also in the more affective sides of education. “Feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science of on society or scientists themselves” [16]. Attitudes have shown to be formed early, hard to change after elementary school. Because of this phenomenon, it is important to analyze and influence them before transition to middle school. The change of these false pre-concepts are especially difficult, if the attitudes have been formed more intuitively, automatically and on emotional basis than more consciously in process of time [17].

The big challenge is the fact, that the attitudes of girls already early ages become more negative towards science. Overall, students often tend to lose their interest by time. Therefore, analysing motivation, attitudes toward science and science education are essential in order to make predictions about whether and how the pupils will engage with science later in life and their career. It is essential not just for the individuals but also for society and the economy.

Recently some promising results have been reached in this area. How do science, technology, engineering, and mathematics attitudes vary by gender and motivation? Attractiveness of science exhibitions were carefully studied in six countries: Belgium, Estonia, Sweden, Latvia, Estonia, and Finland [18]. Science centres tend to give opportunities to hands-on experiences in an attractive learning environment. The study analysed attitudes, motivation and learning during a science exhibition visit, their relations to gender and future educational plans (N=1800 sixth-graders). Pupils’ performance in a knowledge test improved after the visit. Autonomous motivation and attitudes towards science predicted situation motivation awakened in the science exhibition. Interestingly, the *scientist* attitude and the *societal* attitude were clearly separate dimensions. The third dimension was manifested in the *engineering* attitude typical for boys, who were keener on working with appliances, designing computer games and animations. *Scientist* and *societal* attitudes correlated positively and *engineering* attitude correlated negatively with the future educational plans of choosing the academic track in secondary education. The *societal* perspective on science was connected to above average achievement. In the follow-up test, these attitudes showed to be quite stable.

CONCLUSIONS

The main results of the science centre pedagogy can be stated as follows [19]:

1. Science centre education is still too much based on anecdotes and everyday knowledge.
2. Motivation is the main outcome of science centre pedagogy: how to move from situation motivation into intrinsic motivation!
3. Quality knowledge learning results can be achieved – but only by pre-lesson and/or post-materials in context of science centre visit.
4. The teachers must have courses related to science centre pedagogy to receive” cost-effective” learning results.

Also the European Commission’s Rocard Report [20] has underlined the importance of this phenomenon. This report and other presentations describe the situation mostly in the pre-schools, primary and secondary schools while we also see the trends around the formal education. The role of learning in informal contexts is increasing in the modern societies – meaning the countries which are developing their societies by investing and creating opportunities for research, innovations, and education.

The digital technology and increasing computational complexity of daily practices are reorganizing our society. The quality of science education in primary and secondary schools is so rooted in the bright scientific history of Europe and so critical for its future that every effort should be made to remedy a far from optimal situation, such as that which we observe at the beginning of this 21st century. The European Union has all the necessary talents and tools to rebuild a strong educational system in science, able to communicate to every young person a taste for science, an understanding of its place in culture, and a vision of professional careers.

Science affects everyone’s life. Thus, being scientifically literate is a civil right, and science education should promote accessibility to science by an attractive, inviting and not a too difficult pathway. However, both age and gender have to be taken into account. The modern movement for public understanding of science started from the Sputnik-phenomenon in late 1950s. Unfortunately, it seems that the humankind and the societies do react only after crises already have happened like the Tsernobyl accident, or are clearly treating like the Climate crisis. Scientific literate learners is one solution in the process of Science with and for Societies in 2020s.

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