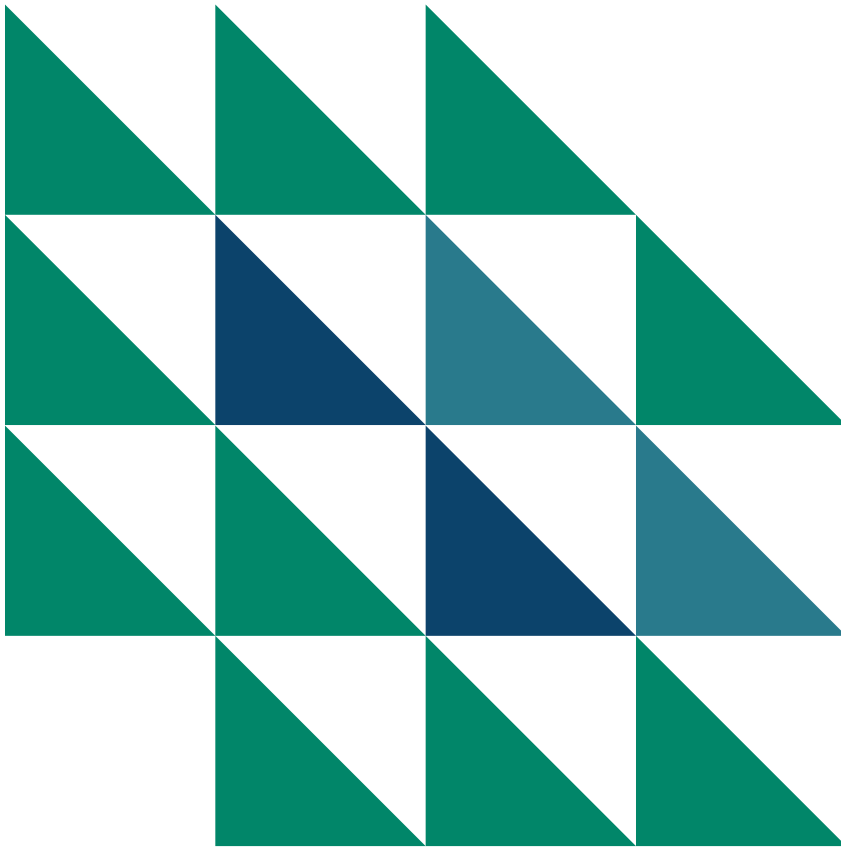


**RESPONSIBLE
RESEARCH SERIES
4/2021**



**SCIENTIFIC LITERACY CHANGES THE
WORLD. SCIENCE EDUCATION
RECOMMENDATIONS**

RESPONSIBLE RESEARCH SERIES

Responsible Research Series publishes declarations, policies, studies, recommendations and other documents relating to the openness, responsibility and accessibility of science and research. Publications also cover science communication and science-society interactions. The publication series is not a scientific peer-reviewed publication. The series is published by the Committee for Public Information (TJNK) and the Federation of Finnish Learned Societies (TSV).

Scientific literacy changes the world. Science education recommendations

Available also in other languages:

Tiedeosaaminen muuttaa maailmaa. Tiedekasvatuksen suositukset

Vetenskapligt kunnande ändrar världen.

Rekommendationer om vetenskapsfostran

Responsible Research Series 4:2021

3rd volume

Publisher: The Committee for Public Information (TJNK) and Federation of Finnish Learned Societies (TSV)

Helsinki, 2021

ISSN: 2670-062X

ISBN: 978-952-5995-45-9

DOI: <https://doi.org/10.23847/isbn.9789525995459>



**SCIENTIFIC LITERACY CHANGES THE
WORLD. SCIENCE EDUCATION
RECOMMENDATIONS**



SCIENCE EDUCATION RECOMMENDATIONS

Contents

Foreword	5
What is science education?	6
Science communication is science education	7
Science education is accessible	8
Science education is broad-based	11
Science education and responsible research	13
Science education enables participation	13
Citizen science as a springboard to science	15
Science education is collective	16
Science education involves comprehensive and broad-based activities	17
Science education is inspiring and rewarding	18

FOREWORD

Information processing skills are becoming all the more significant as traditional authorities of knowledge are challenged by media hubbub and false and misleading information. Critical thinking and the ability to interpret information flows and distinguish between relevant and irrelevant information are increasingly important civic competences.

Competent, critically thinking citizens build their lives and the society around them on reliable information. In addition to media literacy, we need scientific literacy.

Scientific literacy relies on science education. In Finland, science education is carried out by various actors from early childhood education to higher education, from nationwide networks to rural school science clubs, and from scientific societies to science journalists and non-fiction writers. Science education involves diverse activities and audiences, but they all share the same goal: to offer high-quality, lifelong science education.

The purpose of these science education recommendations is to provide a shared starting point and source of inspiration for all those engaged in science, learning and education. They can be summarised in five principles:

- Science education is accessible
- Science education is broad-based
- Science education enables participation
- Science education is collective
- Science education is inspiring and rewarding.

We also offer tips and ideas to provoke thought to support the implementation of these recommendations.

These science education recommendations have been drawn up by actors in the field and are meant for other actors in the field. The recommendations are the result of a project titled 'An inquiry and recommendations to support scientific education' (Selvitystyö ja suosituksia tiedekasvatuksen tueksi) jointly conducted by the Federation of Finnish Learned Societies and the Committee for Public Information and funded by the Ministry of Education

SCIENCE EDUCATION RECOMMENDATIONS

and Culture. The project involved dozens of experts from the fields of education, training, research, arts and museums, scientific societies and liberal adult education.

Due to the coronavirus pandemic, our collaborative activities mainly took place online in 2020. Inevitably, the transfer into the virtual world and other changes in practices will also be manifested in the ways in which we carry out science education and science communication. We would like to warmly thank all the actors in the field of science education and the representatives of scientific societies who participated in our online workshops and contributed to the writing of these recommendations!

WHAT IS SCIENCE EDUCATION?

Science education refers to systematic and goal-oriented activities that aim to improve people's and society's scientific literacy and scientific capital through education and communication. The purpose of science education is to raise interest in science and offer joy of learning.

Science education relies on research-based, scientific knowledge, which is what it also teaches. The best science education practices are developed based on research in the field.

Scientific literacy means basic skills in processing research-based knowledge, obtaining reliable information, critical thinking and learning. Scientific literacy also includes an understanding of the results, tasks and meaning of different branches of science.

Scientific capital, on the other hand, refers to people's and society's ideas, experiences, attitudes and resources that are related to science and change over time.

Formal science education forms part of early childhood education, basic education and continuing education. Various informal and non-formal forms of science education such as science centre and museum activities, science clubs and science communication are an important part of scientific learning.

In addition to these more systematic efforts of science education, people also engage in voluntary learning through their personal interests and various activities. Lifelong learning, which can also be viewed as continuous scientific learning, can be thought of as a way of improving scientific literacy with the help of science communication.

But how do you know whether your work is related to science education? Science education is linked to research and science communication. It often combines the everyday environment with research-based knowledge creatively and systematically. Science education is about participating in research, learning research skills and familiarising yourself with different fields of science. It develops your curiosity and learning skills. If your work involves any of these activities, it means that you are one of those people who participate in science education!

Science communication is science education

Science communication means sharing information about science. It means scientific communities' internal and external communication and interaction. The aim of science communication is to share information obtained from research, shed light on scientific methods and ways of thinking, and describe the theoretical basis of scientific disciplines.

Science education forms part of science communication.

Science communication takes place within branches of science (intra-specialist communication), between different branches of science and their experts (inter-specialist communication), in the pedagogical communication included in teaching and continuing training, as well as in popular communication. A society's scientific capital can be increased by providing researchers with basic communication skills as part of their training: knowledge can only be put to use if it reaches those who need it.

SCIENCE EDUCATION RECOMMENDATIONS

Non-fiction plays a central role in continuous scientific learning. Science journalism and non-fiction represent more traditional forms of non-fiction writing, which are characterised by slowly produced, lengthy publications. In online media environments, on the other hand, non-fiction is short and fast-paced. Non-fiction also includes textbooks and scientific literature. When people can read world literature in their native language, it builds up their scientific capital and also develops the language in question as a language of science.

Besides non-fiction, any fiction that draws on research-based knowledge also shapes the reader's intellectual capital and world view.

SCIENCE EDUCATION IS ACCESSIBLE

Science education explains scientific principles clearly and in a way that takes the audience into account. Accessible science education promotes equality, reduces inequality and is available to anyone regardless of the circumstances.

Openness and publicity are central principles in scientific research. Science education plays an important role in realising the openness of science. Communication about science should be clear, accessible, multilingual and targeted to people from different backgrounds. The more people know about, understand and have an interest in science, the easier it will be to use the information available and critically evaluate it.

To promote the publicity of science, science education should be easily accessible. This means that people's individual circumstances, needs and limitations should be taken into account when planning, implementing and evaluating science education. The accessibility of science can be improved by making scientific information openly available and scientific methods and practices understandable.

There is no universal solution to accessibility. Physical accessibility can be improved by removing barriers related to location and environment, for example. Social accessibility is related to encounters between people. In the virtual world, accessibility means, above all, that digital material is accessible for all.

It is important to identify barriers to accessible participation. They may be personal, contextual or structural, and include different types of physical barriers, a lack of digital skills, a poor financial situation, language barriers, illiteracy and a remote place of residence. To ensure that science education is accessible, science educators must actively interact with different audiences and communities, as well as evaluate and develop their own activities.

Tips and ideas:

- Accessibility is a question of values. Digital technology offers many possibilities for action, but not everyone can participate in virtual events or even want to use digital material. Virtual activities can also exclude people. When you plan an event, you should consider what kinds of technical skills your target audience needs in order to participate.
- Evolving communication technologies and virtual environments enable new types of science education activities and help to reach various audiences. Podcasts and audio books enable science communication through listening, social media discussion threads may attract a lot of attention and scientific debating clubs can be organised online with minor resources. You can use the technological solutions available on your desktop, keeping in mind their limitations and possibilities.
- Accessibility is a question of language. Using clear and understandable language helps everyone, including those who create content. Multilingual events and material offer more people the chance to get acquainted with science in their own native language. If the target audience is migrant families, for example, it is possible to combine science education with language teaching.

SCIENCE EDUCATION RECOMMENDATIONS

- Collaboration enables often better accessibility and may help to reach the target audience. Could minority language speakers be possible collaboration partners for your science education activities? Any collaboration must benefit both parties.
- It is important to organise smaller and bigger events in different parts of Finland. This promotes regional equality. In general, it is a good idea to arrange activities in places where people move and gather: schools, shopping centres, public transport and sports clubs. Public libraries are open to all, and their personnel are skilled in searching for and evaluating information. Random encounters with scientists may spark an interest in people to engage in scientific learning more thoroughly.
- It is easiest to reach people who are already interested in science. To raise the curiosity of those who are perhaps not so interested in science, it is a good idea to find out in detail who the target audience is, what kinds of needs they have and what may hinder interaction with them. Once such issues of accessibility have been identified, it will be easier to solve them.
- Science education meant for adults can shed light on the characteristics of science and the reliability of research-based knowledge in particular. Evening events for adults in science centres have become very popular. It is also possible to organise science camps for adults, or include content for adults in children's science events. When people of different ages come together, they may learn from each other and adopt new points of view.
- Multisensory content offers diverse and interesting possibilities for action and participation. Science education can well be implemented through dance, physical exercise, music or gamification. Collaboration with artists helps to create richer experiences in science education.

SCIENCE EDUCATION IS BROAD-BASED

A broad approach to science education helps to demonstrate the diversity of science. This kind of science education sheds light on the basic characteristics of science, highlights the significance of multidisciplinary and shows the wide variety of people who are involved in science.

One of the aims of science education is to improve scientific literacy with respect to different branches of science. This can only be achieved through broad-based science education, by promoting interaction between different branches of science and involving various kinds of scientists.

The basic characteristics of science are one of the topics of broad-based science education. As a central goal, science education should answer the following question: **how does science work?** Disagreement and criticism are also part of science. Science does not always find straightforward answers to everything. Above all, science education can improve people's understanding of the fundamental but complex issues in science.

Global problems and broad phenomena such as climate change cannot be fully grasped without a multidisciplinary approach and collaboration between different scientific disciplines. Science education shows the importance of collaboration.

Science education should also offer role models with whom people can identify, as well as provide encounters with scientists. By demonstrating the diversity of science and introducing different kinds of disciplines and researchers, it is possible to make science more easily approachable. Introducing a wide variety of perspectives makes it more likely that people will find something meaningful to them in science – every person is interested in something!

SCIENCE EDUCATION RECOMMENDATIONS

Tips and ideas:

- A good idea for science educators is to address current issues that require a multidisciplinary perspective. Environmental education and sustainable development are issues that demand a broad approach. For example, a smile, the sun and water are all phenomena that can be studied by applying various approaches from the fields of natural science, medicine or the humanities, for example.
- Museums and science centres are a natural forum for the collaboration between different branches of science. For example, the activities of natural history museums may include themes from the humanities, social sciences or technical sciences.
- A phenomenon-based and multidisciplinary approach is a suitable starting point for an online article, exhibition or workshop. Workshops can be organised by implementing learning by doing and experiential learning, and they suit all branches of science. Easily accessible science blogs and videos broaden the channels of scientific discussion.
- In communication and interaction, images play an increasingly important role. Image banks should include more diverse selections of images, particularly in relation to the humanities and social sciences. Science is not only about laboratories and white coats! The need for more diverse imagery does not only apply to scientific disciplines but also to scientists.
- It is important to highlight the wide variety of scientists from different fields as well as of career possibilities. Libraries, archives and science administration, for example, are partners in research. All those who work in science and research can think about their work from the point of view of science education and society's science literacy.
- For researchers and scientific societies, participation in science research offers a possibility to increase the visibility and attractiveness of their own branch of science. The publications of scientific societies may be distributed further to reach new kinds of audiences. It is possible to publish popularised versions of scientific articles and adapt research theses into engaging shorter content for different audiences.

Science education and responsible research

Finnish people trust in science and research. This trust can be preserved by practising research responsibly. Science education should clarify ethical and social questions related to research and the use of research-based data.

Good research practices should also be followed when the general audience participates in research. This kind of action, also called citizen science, helps to understand ethical principles related to science and research and thus improves scientific literacy. At the same time, those who participate in research gain knowledge of researchers' professional ethics and research legislation.

The publication of research data includes the process of peer review, the purpose of which is to ensure the quality of research and critical evaluation of information. The responsible use of data also requires an understanding of the limits of using research-based data. Science communication as part of science education helps to understand the responsibility involved in communication: to what extent is it possible to generalise, simplify or highlight the significance of research results? This also offers a chance to get acquainted with the media's modes of operation and good practices.

SCIENCE EDUCATION ENABLES PARTICIPATION

By emphasising active and voluntary participation, science education attracts people to science and sparks an interest in deeper scientific learning.

Learning is very much an interactive and social activity. High-quality science education invites people to participate on their own terms and takes them into account. It puts emphasis on people's active and independent participation and also offers the educators themselves the chance to learn something new.

SCIENCE EDUCATION RECOMMENDATIONS

Especially in children's and young people's science education, experiential learning often plays an important role, and this type of education is implemented through workshops and science camps and clubs. For adults too, science education should offer experiences, participation and agency.

Citizen science, i.e. research in which ordinary people participate, offers the general public the chance to generate scientific knowledge. Citizens are thus able to take part in scientific discussion and deepen their understanding of a certain topic. At best, such research projects are designed in collaboration with the participants.

Tips and ideas:

- To make science education meaningful, motivating and accessible, the participants should be involved already in the planning phase. Research activities can be planned based on children's and young people's questions, for example. What topics and phenomena are the target audience interested in? In what ways could they participate? To whom are the activities designed and what is their main idea? How can the participants be involved in the planning of activities?
- Learning by doing can be used in many ways to offer people possibilities to actively participate in science education. Learning environments that include play and games, and enable a joy of doing and participating, promote people's learning regardless of their age. Clubs, camps, workshops and games help people understand science through independent learning and new ideas. Digital environments enable many forms of independent learning.
- In science centres and museums, it is possible to organise experiential exhibitions that invite people of all ages to experiment and learn, either alone or together. Offering people the chance to demonstrate their skills encourages them to experiment, investigate and produce knowledge.
- Open doors days in research institutes, libraries and archives also invite people to engage in seeking information. Pop-up science kiosks offer easily accessible science education. General-knowledge science publications may serve as an introduction to scientific literature.

- Universities can make their premises available for use as meeting places and for open science events. This also makes it easier for researchers to participate in science education and develop their science communication skills.
- It is a good idea to make use of the interactive and entertaining possibilities of social media. Using visuality and stories, it is possible to create content that is easy to approach and that makes an impact.
- You should ensure that you do not exclude anyone accidentally or deliberately by using gender-biased expressions or imagery, for example. If you create the impression that your activities are restricted to a certain audience only, they appear less meaningful and accessible.

Citizen science as a springboard to science

People can participate in scientific research without being qualified researchers. In citizen science projects, the general public can participate in research by contributing to data collection, for example. Citizen science may even spark a career in science. For researchers, citizen science serves as an instance of societal interaction.

Genealogy, local history and observation of natural phenomena present old forms of citizen science. Long-time enthusiasts are often experts in their field. Citizen science brings research into ordinary people's everyday life and environment.

In citizen science too, it is important to ensure responsibility in the production and use of information.

SCIENCE EDUCATION IS COLLECTIVE

Doing science and research is a collective activity. Successful science education is based on collectivity, collaboration and networks.

Participation, collaboration and the chance to make an impact create a sense of community, which in turn creates possibilities for various types of cooperation. Active players of all kinds are an important resource in science education.

Finland has a strong tradition and effective practices in natural science education. This type of expertise is also needed in other branches of science. The LUMA network, which focuses on natural sciences, mathematics and technology, serves as an example of how to build nationwide cooperation and combine science education and research in Finland.

Regional and nationwide networks of science education enable a coordinated and multidisciplinary collaboration between science education actors. One solution would be an open science education database, which could be used to accumulate information and expertise available to everyone. Strong networks also make it possible to improve the quality of activities as part of a responsible culture of science and research.

Tips and ideas:

- You should keep an open mind and a broad scope when looking for collaborative partners. The most important thing is to begin a discussion and see whether there might be common goals and mutual benefits. Sometimes spontaneous social media networking may result in a long-term partnership. Other times, short-term collaboration is exactly what is needed.
- By working together, science education activities can be made more accessible, broad-based and meaningful. Communication is also more effective when there are more links to the target audience. Moreover, by joining up forces, there is less need to compete over the attention of the audience. It is a good idea to share good practices of science education actively and openly.

- Traditionally, early childhood education, the school system, universities and science centres have played a central role in science education. Funding and support should also be directed to informal learning and small-scale activities such as science clubs run by pupils themselves.
- Schools may appoint science education officers who are in charge of developing teachers' science education skills and networks. This task should not be assigned to teachers on top of their full-time jobs: instead, they should be provided with the necessary resources. Education and teaching professionals may also be offered continuous training in science education.
- Scientific societies build bridges between researchers and the general public through their virtual and physical events. They could also collaborate with teacher training and schools to find new possibilities of organising science education. These societies could also participate in the development of general education in their field.

Science education involves comprehensive and broad-based activities

Among others, the following actors offer science education content and activities:

- Open universities, adult education centres and other actors of liberal adult education
- Libraries and archives
- The education system from early childhood to higher education
- Dedicated science educators such as the Finnish LUMA network
- Social media influencers
- Scientific and cultural institutes and international societies
- Science centres and museums
- Journalists, non-fiction writers and other communication professionals
- Researchers, scientists and scientific societies.

SCIENCE EDUCATION IS INSPIRING AND REWARDING

Science education offers experiences and joy of learning. Professional recognition is rewarding and motivating for science educators. Sufficient resources ensure high-quality and meaningful science education.

Science education is not only about distributing knowledge – science is also enjoyable! Science and research offer fascinating information, interesting problems and ways to make the world a better place. Good science education offers experiences of success, encourages people to educate themselves and also enables researchers to learn new things.

Science education is part of science communication, which is part of researchers' work. However, the amount of unpaid work in science should not be increased. Those who practise science education should be provided with good conditions for their activities and should receive proper remuneration. High-quality and diverse activities as well as nationwide networking require resources. Science education can also be promoted by allocating funding for science communication.

Organisations may include science education and science communication in their strategy and develop their remuneration practices in this way. The creation of a nationwide science education network that covers all branches of science would strengthen the field of science education and enable continuous activities.

We encourage all actors to network and develop the field together!

Tips and ideas:

- It is a good idea to plan activities that are exciting and inviting. What especially interesting and wonderful is happening in science at the moment? What kind of engaging scientific content would the audience like? What inspires researchers?
- Creative work is rewarding. Scientific and artistic methods can be combined in science education in many ways. Science theatre, artistic science workshops or artistic experiences inspired by scientific

phenomena can be used to create richer experiences and broaden the scope of science education.

- Science education needs visibility, and communicating good practices is one form of sharing expertise. It is a good idea to draw up a communication plan already when planning science education activities.
- A nationwide science education network would make it possible to plan joint projects, prepare broader funding applications and implement diverse partnership programmes in Finland and abroad.
- In universities, science education could be better included in work plans, for example, and its role in societal interaction could be acknowledged more clearly. If science education and science communication are taken into account in researchers' evaluation and merits, researchers will be more motivated to participate in science education activities. The more science education is incorporated in basic activities, the less there is need for allocating separate resources to it.