

# Open science and research leads to surprising discoveries and creative insights

**Open science and research roadmap 2014–2017**

Reports of the Ministry of Education and Culture, Finland 2014:21



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## OPEN SCIENCE AND RESEARCH

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## Summary

This roadmap is based on the work of the Open Science and Research Initiative (ATT), a cross-administrative initiative established by the Ministry of Education and Culture, whose goal is to promote open science and the availability of information. Open science means the promotion of an open operating model in scientific research. The key objective is, subject to the restrictions of research ethics and the juridical environment, to publish research results, research data and the methods used, so that they can be examined and used by any interested party. Open science includes practices such as promoting open access publishing, openly publishing research materials, harnessing open-source software and open standards, and the public documentation of the research process through 'memoing'.

Open science and research can significantly increase the quality and competitiveness of Finland's research and innovation system. By increasing openness in research, we will simultaneously be improving reliability, transparency, and the impact of research. Openness also creates opportunities to participate in scientific advancement, and enables easier and more effective utilisation of research results. Promoting open science and research requires not only extensive involvement from the research community, but also cooperation and coordination, internalising new ways of working, and developments in research environments, researcher services and research infrastructures.

Our vision for 2017 is: Open research leads to surprising discoveries and creative insights. This means a situation in which research data and materials move freely throughout society; from one researcher or research team to another, between disciplines, to innovative businesses, and to decision-makers and citizens. Information flow is facilitated by clear policies and best practices, and by providing services to safeguard the availability of scientific and research results. Openness is a joint operating model. Openness has given Finnish research an international competitive edge.

Research results (publications, data, methods and the tools required to publish) will be openly and permanently available in data networks via standardised interfaces in accordance with ethical principles and respecting legal operating environments. Openness within research infrastructures will always be pursued when it is legally and contractually possible. Further use of research results is not unnecessarily restricted, and the terms and conditions of their use are clearly defined.

The objectives of the Open Science and Research Initiative (ATT) are to make Finland the leading country for openness in science and research by 2017, and for the opportunities afforded by open science to be extensively harnessed in Finnish society.

Dialogue in science and research will be promoted on many levels, both nationally and internationally. The roadmap will be implemented via four sub-objectives, which are:

- reinforcing the intrinsic nature of science and research, so that openness and repeatability increase the reliability and quality of science and research.
- strengthening openness-related expertise, so that those working in the Finnish research system know how to harness the opportunities afforded by openness to boost Finland's competitive edge.
- ensuring a stable foundation for the research process, so that good, clear basic structures and services enable new opportunities to be harnessed at the right time and ensure a stable basis for research.
- increasing the societal impact of research, so that open science creates new opportunities for researchers, decision-makers, business, public bodies and citizens.

A set of measures has been defined to achieve these sub-objectives. To realise our vision, all parties must engage in extensive cooperation to implement these measures. Using the measures in this roadmap, various parties will take responsibility for putting policies into practice. We will gauge our success in achieving targets by monitoring the progress and impact of individual measures. Monitoring will also be promoted by increasing visibility, by analysing shared sets of basic information, with impact assessments, and through the required support functions and analyses.

## Tiivistelmä

Tämä tiekartta perustuu opetus- ja kulttuuriministeriön asettaman poikkihallinnollisen Avoin tiede ja tutkimus -hankkeen (ATT) työhön tiedon saatavuuden ja avoimen tieteen edistämiseksi. Avoin tiede ja tutkimus tarkoittaa pyrkimyksiä edistää avoimia toimintamalleja tieteellisessä tutkimuksessa. Keskeinen tavoite on tutkimusetiikan ja juridisen toimintaympäristön asettamissa rajoissa tutkimustulosten, tutkimusdatan ja tutkimuksessa käytettyjen menetelmien julkaiseminen siten, että ne ovat kaikkien halukkaiden tarkasteltavissa sekä käytettävissä. Avoin tiede ja tutkimus sisältää käytäntöjä, kuten tutkimusjulkaisujen avoimen saatavuuden (open access) edistäminen, tutkimusaineistojen avoin julkaiseminen, avoimen lähdekoodin ja avoimien standardien hyödyntäminen, sekä tutkimusprosessin julkinen dokumentointi niin kutsutun avoimen muistikirjan menetelmällä.

Avoin tiede ja tutkimus voi merkittävästi kohentaa Suomen tutkimus- ja innovaatiojärjestelmän kilpailukykyä ja laatua. Lisäämällä tutkimuksen avoimuutta parannamme samalla tieteen luotettavuutta, läpinäkyvyyttä ja vaikuttavuutta. Avoimuus myös lisää mahdollisuuksia olla osallisena tieteen edistämisessä ja se mahdollistaa tutkimustulosten tehokkaamman ja helpomman hyödyntämisen. Avoimen tieteen ja tutkimuksen edistämiseen tarvitaan paitsi tutkijayhteisön laajaa osallistumista, myös tutkimusympäristöjen, tutkijapalveluiden ja tutkimusinfrastruktuurien kehittämistä, yhteistyötä ja koordinaatiota sekä uusien toimintatapojen omaksumista.

Visio vuodelle 2017 on: Tutkimuksen avoimuudella yllättäviä löytöjä ja luovaa oivaltamista. Tämä tarkoittaa tilannetta, jossa tutkimuksen tulokset liikkuvat sujuvasti koko yhteiskunnassa; tutkijalta ja tutkimusryhmiltä toiselle, tutkimusalojen välillä, innovaatiotoimintaan sekä päättäjille ja kansalaisille. Tiedon kulkua autetaan selkeiden linjausten ja hyvien käytäntöjen avulla sekä tarjoamalla palveluita tieteen ja tutkimuksen tulosten saatavuuden turvaamiseen. Avoimuus on yhteinen toimintamalli. Avoimuus on tuonut suomalaiselle tutkimukselle kansainvälistä kilpailuetua.

Tutkimuksen tulokset (tutkimusjulkaisut, tutkimusdata, tutkimusmenetelmät ja tutkimusjulkaisujen tuottamiseen tarvittavat työkalut) ovat avoimesti ja pysyvästi saatavilla ja käytettävissä tietoverkoissa standardoitujen rajapintojen kautta tutkimuseettisiä periaatteita noudattaen ja oikeudellista toimintaympäristöä kunnioittaen. Tutkimusympäristön avoimuuteen pyritään aina, kun se on lainsäädännön ja sopimusten puolesta mahdollista. Tutkimustulosten jatkokäyttöä ei rajoiteta tarpeettomasti, ja niiden käyttöehdot tuodaan selkeästi esille.

Avoin tiede ja tutkimus -hankkeen tavoitteena on, että vuoteen 2017 mennessä Suomi nousee johtavaksi maaksi tieteen ja tutkimuksen avoimuudessa ja että avoimen tieteen

mahdollisuudet hyödynnetään laajasti yhteiskunnassamme. Tieteessä ja tutkimuksessa vuorovaikutusta edistetään monella eri tasolla, niin kansallisesti kuin kansainvälisesti. Tiekartta toteutetaan neljän osatavoitteen kautta, jotka ovat:

- tieteen ja tutkimuksen perusolemuksen vahvistaminen, jolloin avoimuus ja toistettavuus kasvattavat tieteen ja tutkimuksen luotettavuutta ja laatua.
- avoimuuteen liittyvän osaamisen vahvistaminen, jolloin suomalaisessa tutkimusjärjestelmässä toimijat osaavat hyödyntää avoimuuden mahdollisuudet niin että kilpailukyky kasvaa.
- tutkimusprosessin kestävä perustan vahvistaminen niin, että hyvien ja selkeiden perusrakenteiden ja palveluiden avulla saadaan hyödynnettyä oikea-aikaisesti avaamisen mahdollisuudet ja huolehdittua kestävästi tutkimuksen perustasta.
- tutkimuksen yhteiskunnallisen vaikuttavuuden kasvattaminen niin, että Avoin tiede ja tutkimus luo uusia mahdollisuuksia tutkijoille, päätöksentekijöille, elinkeinoelämälle, julkisyhteisöille ja kansalaisille.

Kunkin osatavoitteen saavuttamiseksi on määritelty joukko toimenpiteitä. Toimijoiden laaja osallistuminen toimenpiteisiin on edellytys vision saavuttamiseen. Tiekartan toimenpiteiden avulla yleiset toimintaperiaatteet viedään käytännön toimenpiteiksi eri toimijoiden vastuulle. Tavoitteiden toteutumista arvioidaan seuraamalla yksittäisten toimenpiteiden etenemistä ja vaikutusta. Seuranta edistetään myös kasvattamalla näkyvyyttä, analysoimalla yhteistä tietopohjaa, vaikuttavuusseurannalla sekä tarvittavien tukitoimien ja selvitysten kautta.



# Prologue

Open science and research seeks to promote science through openness, and to increase the societal impact of science by improving the management and utilisation of information generated by research. Finland's goal is to be the leading country for openness in science and research by 2017, and for Finnish society to extensively harness the opportunities that open science affords.

This roadmap provides a plan for Finnish researchers, research groups, research organisations, decision-makers, funders and citizens to promote the preconditions, utilisation and practical adoption of open science and research from 2014–2017. It is a strategic-level plan for Finnish open science and research that describes the activities required to achieve the desired changes, advancements and developments. Its measures will be supplemented and updated by, for example, working groups. It will also be amended when necessary, so not all activity will be tightly bound to initial plans.

As the current state of national and international efforts is clarified through a variety of analyses, the roadmap's measures will be updated and certain areas will be highlighted. The roadmap is based on existing analyses and publications.

Open science and research will increase the quality and competitiveness of Finland's research and innovation systems in particular. By increasing openness in research, we will also be improving reliability and transparency. Openness creates opportunities for everyone to participate in scientific advancement and enables more effective utilisation of research results. We will achieve this by putting the principles of openness into practice, thereby facilitating and accelerating the utilisation of research results, and increasing the impact of research. To achieve this, we require extensive involvement from the research community, and development across the system: in research environments, researcher services and research infrastructures. This in turn will require new working methods to be internalised, and extensive cooperation and coordination between research organisations, research infrastructures and support services.

This roadmap is supplemented by the Open Science and Research Manual, which is a key tool in achieving the roadmap's objectives. The manual provides guidance on the practical implementation of open science and research. Additions will be made to the manual by working groups from the Open Science and Research Initiative (ATT), from open comments, and from this roadmap. Detailed guidelines and model processes will be inserted into Chapters 2 and 3 in particular. The first comprehensive version of the manual is scheduled for publication at the end of 2014. The manual will be updated when necessary, and we intend for this work to continue after the end of the initiative.

The following have participated in writing and commenting on this roadmap: Pirjo-Leena Forsström (CSC); Jessica Parland-von Essen (CSC); Anssi Neuvonen (VTT); Juha Hakala (National Library of Finland); Pekka Olsbo (University of Jyväskylä); Jyrki Hakapää (Academy of Finland); Miika Alonen (CSC); Suvi Remes (CSC); Johanna Lilja (Federation of Finnish Learned Societies); Riitta Maijala, Juha Haataja and Sami Niinimäki (Ministry of Education and Culture); ATT expert team members; Aila Louhelainen (University of Oulu); ATT strategy team members; ATT working group members; Seppo Kangaspunta (Ministry of Employment and the Economy); Kristiina Hormia-Poutanen (National Library of Finland); Pirjo Kontkanen (University of Helsinki); Maria Rehbinder (Aalto University); Viveca Still (Ministry of Education and Culture); the Council for Finnish University Libraries; Antti Auer (University of Jyväskylä); Soile Ollila (TEKES); Tuija Pulkkinen (Aalto University); Johanna Moisio (Ministry of Education and Culture); and those who have left comments on the [avointiede.fi](http://avointiede.fi) website.

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# 1 Introduction

To resolve today's major societal challenges, we need interdisciplinary dialogue and a new kind of openness.

The kind of open science enabled by the digitalisation of the research process has become a globally significant way to promote both science itself and its societal impact. Although openness has always been and always will be a fundamental principle of science and research, these new open operating models will make science more democratic than ever before. Open science is a human rights issue, and this is beautifully encapsulated in Article 27 of the 1948 Universal Declaration of Human Rights: "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits."

In recent years, the increase in subscription fees to scientific journals – and researchers' and libraries' resistance to this phenomenon – has boosted interest in open science methods. At the same time, digitalisation and the Internet have enabled the global dissemination of scientific results. Open science<sup>1</sup> creates tremendous opportunities, and its benefits extend to all branches of society. For researchers and research groups, openness conserves resources, improves the quality of research, and potentially offers increased credits and opportunities for cooperation.

Finland's future economy will rely on research, innovation and expertise. Open science and research play a decisive role in all of these. For decision-makers, the availability of scientific and research results provides additional background material and is a prerequisite for rational decision-making. Citizens can benefit from increased transparency and increasing trust in science: they can even participate in science and research themselves.

Many international organisations are campaigning for open science. OECD reports<sup>2,3</sup> and reviews focus on harnessing open science in industry and innovation. UNESCO's focal point is, in addition to the civil rights of open science, its use in education. In the EU, open science has also been recognised as a key for change. In addition to the EU's four freedoms - free movement of people, goods, services and capital – a fifth has arisen: free movement of information. The European Commission believes in open information and the exchange of

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1 The Royal Society, (2012), Science as an open enterprise, The Royal Society Science Policy Centre report 02/12

2 OECD (2009), Access to Research Data: Progress on Implementation of the Council Recommendation. Unpublished document. DSTI/STP(2009)3.

3 OECD (2007), OECD Principles and guidelines for access to research data from public funding, OECD Publishing

expertise to improve economic performance and enhance the EU's ability to compete using information. From now on, the European Commission's funding mechanisms for science and research will also require the widest possible availability of information.

The broadest definition of the concept of open science covers a range of activities geared towards promoting the availability of research results, including research publications, materials and activities. The OECD's Open Science<sup>4,5</sup> initiative defines the concept as follows: "Open science commonly refers to efforts to make the outputs of publicly funded research results more widely accessible in digital format to the scientific community, the business sector or society more generally. Open science is the encounter between the age-old tradition of openness in modern science and the tools of information and communications technologies (ICTs) that have reshaped the scientific enterprise and require a critical look from policy-makers seeking to promote long-term research as well as innovation." Open science and research is intertwined with the digital research process, which is changing how research is carried out and enabling a new approach, yet also requires investments in, for example, interoperability.

*Open science and research refers to efforts to promote open procedures in scientific research activities. The key objective is, in the context set by research ethics and legal frameworks, to publish research outputs (research publications, research data, research methods) so they can be examined and used by any interested party. Open science and research involves practices, such as promoting open access to research publications, open availability of research data, harnessing open source software and open standards, and open documentation of the research process.*

The establishment of openness can be supported by, for example:

- a Promoting cooperation and interoperability at a national and international level, including efforts to promote joint operating models for research organisations, link information, develop science support processes, and build shared or compatible services. The coordination should be easy and seamless from the local level to global level.
- b Supporting the acquisition of expertise in open science and research through, for example, training, guidelines, best practises and enhancing general information management expertise throughout the research system.
- c Providing incentives to promote cultural change by rewarding openness. Clear descriptions must be provided when rewarding or requiring openness (indicators, metrics, career impacts).
- d Furthering legislation that supports and encourages openness.
- e Promoting, enabling and rewarding cooperation and interoperability by, for example, building cooperation platforms and enabling and rewarding cooperation.

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4 OECD (2013d) **Background and Progress Report [DSTI/STP/TIP(2013)5]. Working Party on Innovation and Technology Policy (TIP).** Unpublished working paper.

5 OECD (2013e), **Background Paper for the TIP Workshop on Open Science and Open Data [DSTI/STP/TIP(2013)13]. Working Party on Innovation and Technology Policy (TIP).** Unpublished working paper.

- f Sustainably developing research services and infrastructures. These should be planned with interoperability in mind (both nationally and internationally) and using open-source software, open interfaces and standards whenever possible.
- g Drawing up clear policies and guidelines for openness for every party involved.

### Finland's strengths will facilitate the implementation of the Open Science and Research Roadmap.

- Finland is one of the leading countries with regards to investments in R&D as a percentage of GDP.
- According to many indicators, Finland's infrastructures for science and research are of high quality.
- Indicators point to excellent innovative skills in Finland.
- Finland aims for equality in its researchers' working environments.
- The Finnish population is highly educated.
- Finland has an extensive library network and is the world number-one in library usage and the societal appreciation of libraries.
- Finland's scientific libraries are proactive in organising events and exhibitions, and are continually ramping up their own publishing activities.
- People in Finland respect science and research and are interested in the results of research.
- Second to Iceland, Finland has the most researchers per capita.
- Research institutions and universities are linked by a comprehensive network and are engaging in closer cooperation.
- Finland is launching many initiatives that support our objectives on many fronts (such as furthering open government, and initiatives targeting the availability of mass data and public administration information).
- Finland's national structures are advanced and include those inherited from previous initiatives (RAKETTI, KDK<sup>6</sup>, TUTA<sup>7</sup>, TTA<sup>8</sup>).

Finland can make the jump to open science and research through national cooperation – something that is not possible in all countries.

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<sup>6</sup> National Digital Library, [www.kdk.fi](http://www.kdk.fi)

<sup>7</sup> Research Data Materials Survey Initiative, [http://www.minedu.fi/OPM/Julkaisut/2011/Tiekartta\\_tutkimuksen\\_sahkoisten\\_tietoaineistojen\\_hyodyntamiseksi.html](http://www.minedu.fi/OPM/Julkaisut/2011/Tiekartta_tutkimuksen_sahkoisten_tietoaineistojen_hyodyntamiseksi.html)

<sup>8</sup> Finnish Research Data Initiative, <https://www.tdata.fi>

## 2 Vision and basic policies

### **Vision 2017**

*Open research leads to surprising discoveries and creative insights*

Research data and materials move freely throughout society: from one researcher or research group to another, between disciplines, to innovative businesses, and to decision-makers and citizens. Information flow is facilitated by clear policies and best practices, and by providing services to safeguard the availability of scientific and research results. Openness is a joint operating model. Openness has given Finnish research an international competitive edge.

### **The basic policy for open science and research in the Finnish research system**

Research results (publications, data, methods and the tools required to publish) will be openly and permanently available in data networks via standardised interfaces in accordance with ethical principles and respecting legal operating environments. Openness within research infrastructures will always be pursued when it is legally and contractually possible. The further use of research results will not be unnecessarily restricted, and the terms and conditions of their use are clearly defined.

To ensure shared intent with regard to openness, policies and principles must be clarified and verified from 2014–2017. It is essential to have parallel principles throughout the research and innovation system. Organisations must introduce and mobilise a policy of openness in routine activities.

## 3 Objectives

The objectives of the Open Science and Research Initiative (ATT) are to make Finland a leading country for openness in science and research by 2017, and for the opportunities afforded by open science and research to be extensively harnessed in society. Dialogue in science and research will be promoted on many levels, both national and internationally. This will be achieved through four sub-objectives: reinforcing the intrinsic nature of science and research, increasing openness-related expertise, ensuring a stable foundation for the research process and increasing the societal impact of research.

Progress will be monitored during 2014–2017 using the assigned indicators.

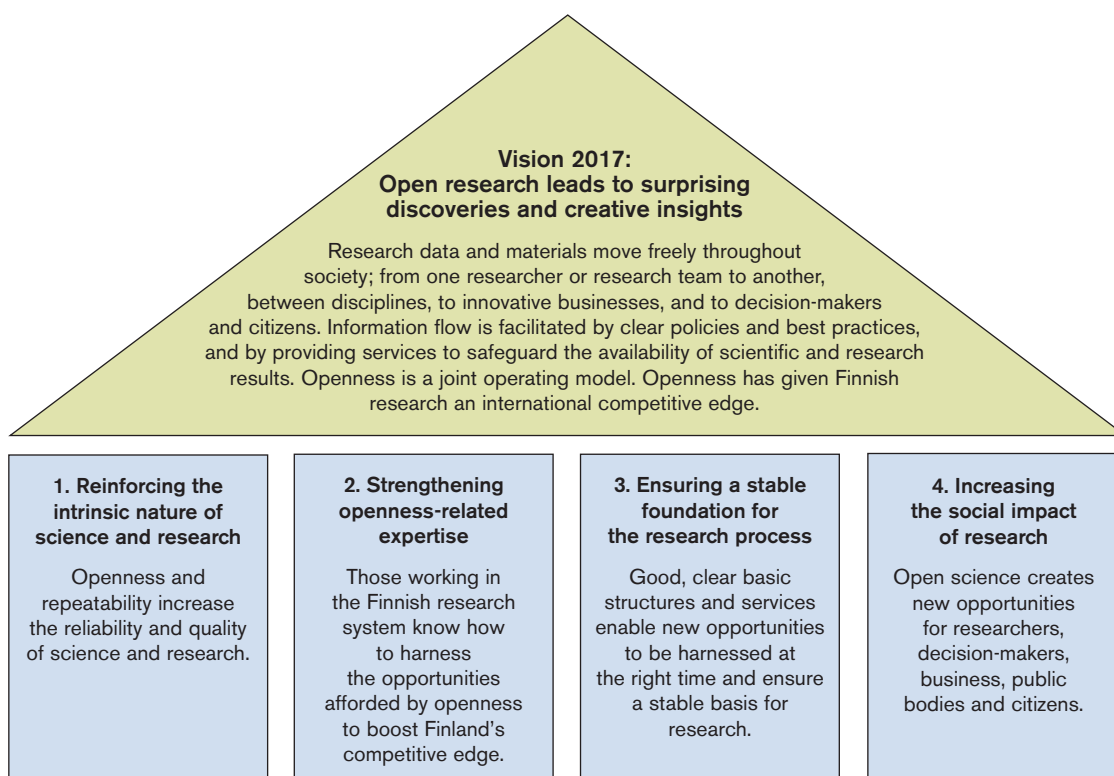


Figure 1. Vision and objectives



### 3.1 Reinforcing the intrinsic nature of science and research

#### Goal

Openness and repeatability increase the reliability and quality of science and research.

Openness is a fundamental principle of science and research. It enables the generation of new information on the basis of existing data. Science has always sought to promote high-quality research and best practices, and to prevent bad research and falsification. Openness is both a prerequisite and a means of promoting science and research. However, the research system still needs structures and working methods for openness to be extensively harnessed. Open science and research are a long-term continuum that consists of openness in both the research process and working culture. Models for openness can be used to create opportunities for rich dialogue, and increase diversity in scientific activities. Further, we are now presented with brand-new opportunities for achieving openness and replicability.

When this objective has been achieved:

- The availability of research results will be self-evident, and no separate solutions for openness will be required, only development of science and research as a whole.
- Openness will promote transparency, more extensive assessment and verification of research results, and new work on the basis of existing data.
- Openness will make the research process more effective and improve quality through, for example, greater utilisation of research infrastructures.
- Openness will have made it easier for scientists to grapple with complex, multidisciplinary research questions.

### 3.2 Strengthening openness-related expertise

#### Goal

Those working in the Finnish research system know how to harness the opportunities afforded by openness to boost Finland's competitive edge.

Knowledge and expertise are the basis for, and a key factor in, civilisation. The development of openness-related expertise and its tools is an investment in the research system, in individual researchers, and in the competitiveness of Finland's research system as a whole. By revamping working methods, we can pave the way for increased expertise. Competence must be developed strategically, systematically, and with an eye to the long term. Sufficient expertise for implementing openness must be found in all sectors of the research system. Participatory training will support education tailored to the needs of different parties.

When this objective has been achieved:

- Researchers will have access to user-friendly tools and services for successfully documenting and linking data.
- The lifecycle management of research data will be improved, and the importance of openness and availability will be internalised in the Finnish research system.
- Those who produce research data will know how to plan the lifecycle management of their results. Information will be available and can be reused.
- Research groups and researchers are able to choose the suitable level of openness, depending on data sensitivity, research ethics, legal constraints, age and other factors.
- Open science and research will not simply be a collection of methods and recommendations, it will be an approach that networked parties in the research system will be motivated by and trained to realise.
- Research organisations will develop competence and related services for stakeholders such as researchers and research groups, but will also provide expertise that serves society in a broader sense.
- Target groups will be informed about research data in an interesting manner, and taking their needs into account.

### 3.3 Ensuring a stable foundation for the research process

Goal

Good, clear basic structures and services enable new opportunities to be harnessed at the right time and ensure a stable basis for research.

The research process will be based on skilled people, in their ability to successfully design and manage the lifecycle, and quality of research results. Science and research will be on a firm footing when results are widely available and reliably preserved. To enable validation, verification and replicability, the following must be systematically available in the long term and in compatible formats:

- research publications
- research data
- research methods (including research plans)
- metadata for publications, data and methods; quality information
- references and links between publications, data and methods
- user rights (such as licences)

Establishing a foundation for this requires the careful planning of integrated management (tools for this include system architecture, SA). Openness must be made easy for researchers, who must be supported and encouraged in all possible ways.

<sup>9</sup> A more detailed description of the research system can be read here:  
<http://www.research.fi/fi/tutkimusymp%C3%A4rist%C3%B6t>

When this objective has been achieved:

- The research system will promote the circulation of scientific information, and open, linked data will form a natural part of this. Plenty of information about research will be available on many different levels, and will be presented through a variety of approaches. Data can, for example, be visualised for the general public. Scientific journalism will be supported by releasing information and providing expertise for popularising science. This will also promote interdisciplinary information flow and the birth of new insights.
- Correctly implemented openness will be an easy and motivating way of working, and one for which researchers can also find the required services.
- Research data, publications and methods will be easily discoverable and accessible.
- Open data architecture will enable the development of interoperable research data infrastructures. Archives, libraries and museums will form a natural part of this package.
- There will be a solid foundation from which to meet major challenges, and research data and methods will be in active use.

### 3.4 Increasing the societal impact of research

Goal

Open science creates new opportunities for researchers, decision-makers, business, public bodies and citizens.

The societal impact of research may mean the birth of new innovations and their commercialisation, but it can also refer to the use of research data in community decision-making and passing information on to citizens and professionals in other fields.

High-quality research is closely linked to expertise and innovation, which have a great impact on economic growth. Economic growth may be influenced through product recipes, that is, by increasing the number of ideas that are realised. It is important for information and new ideas to move rapidly, and to be adopted in new and insightful ways. The greatest economic opportunities, and likewise the greatest risks, are to be found in radical new products, services and markets. Through a more open approach, ideas will not grow singly, but multiply, as they can be combined with existing ideas. Immaterial rights fundamentally support the free movement of information. Copyright should give authors the incentive to create and publish new works for the joy and benefit of society and its citizens. Open science and research will not prevent commercial benefit via contractual research, as that also has a favourable impact on Finnish society and well-being. Inventions can be protected with patents and utility models before the open publication of results.

In addition to these other dimensions, the technologies associated with openness (such as open, linked data) are also general-use technologies. Effective information flow promotes all-round education and acts as a counterpoint to strong specialisations, thereby creating new approaches and insights. Circulating and popularising research data outside academic scientific circles plays an important role in increasing its societal impact.

### When this objective has been achieved:

- Openness will have made ideas easier to combine.
- Research results will be more rapidly utilised, and open data will genuinely be raw material for innovation.
- Openness will be considered in the organisational methods of science, technology, business models, and service solutions. For example, research results will be public to enable the further development of data.
- Scientific literacy will have increased among citizens, decision-makers and officials.
- There will be better ways for producing and collating data for decision-making.
- Citizen science will have progressed. Circulating and announcing research results outside the academic community will have become standard practice.
- It will be easier for researchers to answer the public's questions.
- Transparency will have increased the credibility of science from the citizen's perspective.
- Open science and research and open government will progress with mutual support for each other.

## 4 Measures

### Key measures

- 1 We will be opening up the information we produce (research publications, data and methods), subject to the restrictions of research ethics and the juridical environment, with the aid of open publication, open peer review, and parallel archiving. We will be publishing research results under open licences (recommendation: CC4.0 BY) and harnessing support services that facilitate openness.
- 2 We will be taking full advantage of openly available research results. We will be ensuring that we have the required expertise in open standards, interfaces, and source code. In addition to availability, we will also be ensuring the quality, discoverability and usability of research results.

Measures can be divided up according to objectives. The designated coordinator is not the only party involved, but rather the party responsible for taking the initiative. To achieve our vision, all parties must engage in extensive cooperation to implement these measures.

### 4.1 Reinforcing the intrinsic nature of science and research

To ensure replicability and openness, jointly funded research environments, support services and results will be made widely and equally available to research communities that are guided by agreed policies, principles and contracts of openness. The principle of openness (taking into account, for example, contractual limitations) will also cover research environments on a broad scale (including research infrastructures and research services administered by different organisations, consortiums and other parties), because only then will research be sufficiently transparent for others to evaluate and utilise. Open research environments will be promoted with clear openness policies and fair agreements on copyrights and other rights. Architecture will also be developed to clarify the research process as a whole. The nationwide status of openness in research environments will be evaluated in early 2015 as part of these measures.

Agreed openness procedures will help those working in research environments to handle different types of requests for information, and will have a favourable impact on how parties adhere to shared principles for creating, releasing and using materials. Agreed procedures for managing and distributing materials will also indirectly improve the quality of these materials.

## Openness policies comprise:

- Principles for licensing the publications, data and methods administered by a research environment
- Principles for scientific publishing activities and the use of publications
- Principles for the creation, maintenance, availability and use of digital collections administered by a research environment
- User rights and principles of use for services and resources
- Principles for promoting collective data production
- Guiding principles for system architecture

Year	Measures	Primary parties responsible
2015	Holding an open science and research forum	Open Science and Research Initiative (ATT initiative) and networks
	Publically recognising efforts to promote openness (announcements in the above forum).	ATT initiative
	Analysing the development and current status of working culture in research environments (for example, research infrastructures), including the funding of appropriate, permanent solutions.	ATT initiative/openness policies working group
	Drawing up openness policies and principles to support research organisations' activities. The focus will be on ensuring systematic and efficient operations.	ATT initiative/openness policies working group
	Suggesting incentives for openness in peer reviews, accreditation, and financing instruments.	ATT initiative/impact working group
	Assessing the maturity level of the openness of working culture in research institutes and institutions of higher education. This assessment will be used as the basis for promoting openness through extensive participation and by, for example, seeking synergies and identifying agents for change.	ATT initiative, institutions of higher education, research institutes
	Promoting societal impact during cooperation using agreed measures and through extensive participation and discussion. Debate and experts' input will be encouraged at all levels.	Institutions of higher education, research institutes, networks, decision-makers, officials, citizens
2016	Holding an open science and research forum	ATT initiative and networks
	Reviewing progress	ATT initiative and networks
	Developing an evaluation model for citizen science	ATT initiative, Ministry of Finance, Open Knowledge Finland
2017	Holding an open science and research forum	ATT initiative and networks
	Monitoring the maturity level of Finnish working culture	ATT initiative, institutions of higher education, research institutes
	Assessing decision-makers' and officials' scientific literacy and the openness of preparatory information	ATT initiative and networks
	Reviewing progress	ATT initiative and networks

## 4.2 Measures for increasing openness-related expertise

Our goal is to harness the opportunities afforded by openness as extensively as possible. Increased awareness is an important motivational factor for all parties involved in science and research, but the change driven by new generations in particular plays a key role in generating the required motivation. To accelerate this change, older researchers should also be made more aware of the importance of openness. The majority of training programmes can be organised by institutions of higher education, for example, as part of training targeted at doctoral candidates. An open research certificate could be used to help

evaluate a researcher's openness-related expertise. The education of instructors and the drawing up of educational materials and guidelines should be organised centrally between institutions of higher education and, for example, libraries. It would be worthwhile for this training to make extensive use of, for example, libraries' metadata expertise. Improvements are needed in the expertise required to use open data and materials in decision-making and societal development.

Year	Measures	Primary parties responsible
2015	Updating and adding to the manual	Open Science and Research Initiative (ATT Initiative) and all parties
	Analysing current competency levels and any required training, creating a training package, and identifying critical expertise. Extensive participation and support for networking as part of educational activities.	Libraries, institutions of higher education, research institutes
	Developing a certificate for open research. Writing a description of the areas of openness expertise relating to researchers, and creating a self-evaluation tool.	Libraries, institutions of higher education, research institutes
	Openness-related training and guidance on, for example, open science and research methodology and how to use open data and open teaching materials.	Libraries, institutions of higher education, research institutes
2016	Establishing professorships focused on openness	Universities
	Piloting a Certificate of Open Research	Training organisations
	Providing openness training and guidance	Libraries, institutions of higher education, research institutes
2017	Introducing a Certificate of Open Research	Training organisations
	Providing openness training and guidance	Libraries, institutions of higher education, research institutes

### 4.3 Measures for ensuring a stable foundation for the research process

Our goal is for publications, materials and methods generated and utilised by research to be easily available in a usable format throughout their entire lifecycles, and with preservation guaranteed. With regard to open publication, the 2017 target is for all publications produced by the Finnish research system to be openly available (gold or green Open Access) with preservation guaranteed. The majority of research data and methods should also be openly available by 2017, and there should be links between publications and the data they have used. All materials should be described in a sufficiently standardised manner, and metadata should also be freely available.

Metadata describe the context, content and structure of research results, as well as their management and processing. This metadata can be used, for example, in data searches, localisation and authentication. There must be extensive and successful cooperation between Finnish research organisations and other parties that manage national and international research services, so that information is shared and linked. Finnish research will thereby also obtain international visibility and achieve global impact. Through cooperation, we seek to create and integrate structures (services, networks, training systems and materials), so the resulting research data will be of the highest and most usable quality. Support services for openness will facilitate the research process and make it easier to assess. Common support services will promote interoperability and shared use during the research process. Services that guarantee data permanence will in turn help to ensure long-term replicability.

Year	Measures	Primary parties responsible
2015	Working on interoperability and the introduction of the architecture to further architectural policy and shared practices for the storage, distribution and publication of results. This will ensure that both national and international perspectives are considered.	Open Science and Research Initiative (ATT initiative)/system architecture working group, and data model working group
	Drawing up a service map and promoting service design and usability via bottom-up workshops. Identifying users' special requirements.	ATT initiative/system architecture working group, and data model working group
	Drafting a report on the current general status of publications, complete with suggested policies	ATT initiative/publication working group
	Piloting open publication in Finnish publishing	ATT initiative/publication working group
	Developing metadata definitions for describing research data and research tools	ATT initiative/data model working group
	Developing search and utilisation services for research results (also covers methods)	ATT initiative/system architecture working group, and data model working group
	Developing the long-term preservation of research results	ATT initiative/long-term preservation working group
	Piloting a management model for open products with the National Digital Library (KDK)	National Digital Library/ATT initiative
2016	Working further on architecture	ATT initiative/system architecture working group, and data model working group
	Creating a permanent operating model for open publication on the basis of the pilots	ATT initiative/publication working group
	Developing the required support services	ATT initiative/service providers
	Developing the long-term preservation of research results	ATT initiative/long-term preservation working group
	Introducing support and encouragement for accreditation	Funders
	Opening up new major national research data	Research institutes, institutions of higher education, archives, museums, etc., ATT initiative
2017	Putting into practice the long-term preservation of research results	ATT initiative/long-term preservation working group

#### 4.4 Measures for increasing the societal impact of research

These measures seek to create new opportunities for obtaining and harnessing data, both for researchers and society as a whole. They can be used to boost Finland's competitive edge and strengthen business. This will require, for example, training, improvements in interoperability, drawing up principles, and contractual services. Making research results comprehensible promotes citizens' scientific literacy and supports open preparatory procedures in decision-making.

Year	Measures	Primary parties responsible
2015	Motivating companies and research organisations using a variety of events and discussions to consider, brainstorm and develop business opportunities around forthcoming research services.	TEKES
	Promoting a clearer division of responsibilities in service production (such as the role of companies and opening up bidding on the provision of infrastructure services).	ATT initiative/architecture working group
	Suggesting indicators to measure openness and open availability, and the use of services and incentives to promote them.	ATT initiative/impact working group
2016	Introducing openness as a criterion for receiving research funding.	Funders
	Promoting peer reviews of openness during national and international cooperation	Funders/ATT initiative/impact working group
	Meeting with openness networks	ATT initiative/Open Knowledge Finland
2017	Reviewing progress	ATT initiative/Open Knowledge Finland



## 5 Monitoring and responsibilities

Using the measures in this roadmap, various parties will take responsibility for putting policies into practice. We will gauge our success in achieving targets by monitoring the progress and impact of individual measures. Monitoring will also be promoted by increasing visibility, analysing shared sets of basic information, using impact assessments, and via any required support functions and analyses.

### 5.1 Science policy-makers' responsibilities

Science policy-makers' responsibilities	Monitoring
Establishing a system that collects data describing openness.	Published guidelines
Highlighting openness in organisational strategies.	Published strategies
Clarifying the role played by research funders (including foundations) in promoting open science and research in accordance with funding objectives. Also, so-called free researchers need to be considered, as they seldom have access to, for example, publication archives.	Descriptions of funding opportunities
Setting mandates and assigning roles in the early stages. Openness will later become a normal part of the research process and its support activities.	Published roles
Rewarding openness (for example, rewarding an institution of higher education for promoting open science and research, or a highly visible individual award for openness)	Notification of awards received
Promoting openness in accreditation. Safeguarding accreditation practices and drawing up best practices.	There is already a description of accreditation that considers openness
Rewarding openness policies and best practices, and their associated contract management.	A maturity-level test of openness culture
Paying particular attention to the open description of methods and materials, as well as their general comprehensibility, in project assessments.	Publication of assessments
Promoting international cooperation relating to open science and research.	Published descriptions of cooperation

## 5.2 Research funders' responsibilities

Research funders' responsibilities	Monitoring
<b>Research funding decisions should require:</b> <ul style="list-style-type: none"> <li>- the rapid and widest possible publication of research results</li> <li>- good availability and comprehensibility of results</li> <li>- clear contracts on copyrights and proprietary rights for research results</li> <li>- the open licensing of results (the Open Science and Research Initiative ATT recommends a CC4.0 BY licence)</li> <li>- the planning of data management and prediction of further use (including the documentation and description of materials, the standards used in production and distribution, data collection design, services used, and links to other materials)</li> <li>- a working method that safeguards the long-term preservation of research results, as well as the use of any associated services</li> <li>- an open use policy for funded research infrastructures.</li> </ul>	Funding guidelines available in the information network
<b>Research funders should support:</b> <ul style="list-style-type: none"> <li>- open publication (publications, materials, methods); that is, the costs of open publication should be accepted as project expenses and thus supported financially</li> <li>- the preparation of materials for publication (including anonymisation and documentation)</li> <li>- researchers' efforts towards openness, through, for example, awards for researchers</li> <li>- open cooperation and making research results generally comprehensible</li> <li>- the building of a common service infrastructure.</li> </ul>	Descriptions of funding formats
<b>Research funders should state:</b> <ul style="list-style-type: none"> <li>- their recommendations concerning open access publication alternatives</li> <li>- how openness will be rewarded in career development</li> <li>- how the funder would like copyrights and proprietary rights to be managed</li> <li>- what quality criteria they stipulate for research</li> <li>- the methods and indicators to be used in evaluations.</li> </ul>	Funding terms and conditions
<b>Research funders should reward:</b> <ul style="list-style-type: none"> <li>- clear contracts, open licensing, policies that support openness and their associated plans.</li> </ul>	Funding terms and conditions
<b>Research funders should promote:</b> <ul style="list-style-type: none"> <li>- the establishment of an open accreditation model</li> <li>- expertise in openness and good data management</li> <li>- peer reviews of data and methods alongside peer reviews of publications, in both national and international frameworks</li> <li>- the assessment of openness and the most transparent measurement possible</li> <li>- the creation and maintenance of the expertise required to harness the opportunities afforded by openness</li> <li>- the clarification of financing instruments that support openness.</li> </ul>	Participation in efforts to promote openness

## 5.3 Research organisations and research groups' responsibilities

Research organisations and research groups' responsibilities	Monitoring
Introducing openness into organisations' strategies.	Published strategies
Creating a participatory atmosphere that considers personnel's practical requirements and their concerns over resources.	Maturity-level assessments and questionnaires
Developing clear policies for drawing up contracts for publication, licensing, and copyright and proprietary rights.	Published policies
Clearly describing researchers' rights and obligations with regard to openness.	Published policies
Increasing and maintaining competence by, for example, establishing professorships to promote openness.	Training programmes and new professorships
Encouraging the use of a common service infrastructure, and providing the infrastructure and tools required for compatibility with shared local infrastructure services.	The network's user guidelines
Providing and locally using quality systems	Network guidelines
Promoting interoperability (for example, using open-source software, open standards and interfaces; architectural work; investing in the production of sufficient metadata).	Participating in the promotion of interoperability by, for example, drawing up an overall picture of shared research activities
Improving the replicability of research.	The metadata stored in metadata services (such as Etsin, Juuli, etc)
Promoting openness, availability, visibility and usability, and introducing support services for their measurement.	

## 5.4 Researchers' responsibilities

Researchers' responsibilities	Monitoring
Planning related to the quality and lifecycle of results (publications, data, methods) and participation in implementation of such plans.	Maturity-level assessments
Allocating resources to the publication of research data and finding ways to enable its further use.	Details of items stored in metadata services
Agreeing on copyrights and proprietary rights in accordance with guidelines.	Copyright and proprietary right information stored in metadata services
Licensing research results in accordance with guidelines.	License details stored in metadata services
Using references and citations.	Metadata services
Choosing a publishing channel.	Growth in the parallel archiving of publications
Taking advantage of peer review whenever possible.	Usage statistics
Promoting research replicability and open publication (includes publications, materials and methods) whenever possible.	Information about openness stored in metadata services
Producing sufficient, error-free metadata.	Descriptive details stored in metadata services
Ensuring sufficient expertise in openness.	Participation in training; open research certificate

## 5.5 Trade and commerce's responsibilities

Trade and commerce's responsibilities	Monitoring
Understanding the benefits of openness and developing associated expertise in the strategic and practical implementation of openness.	Participation in training; open research certificate
Harnessing the materials and methods now available under open licences and encouraging the strategic availability of companies' own materials.	Success stories

## 6 Threats to the roadmap's vision and how to prevent them

The following examines threats that could obstruct the realisation of our vision of open science and research. It also outlines the possible impact of these threats, and suggests ways in which they might be prevented.

Threat	Impact	Prevention
The opinions and needs of those using data are not sufficiently considered.	Services are not developed with a sufficiently customer-oriented approach, meaning that openness is not promoted in practice. Openness is considered a burden or a threat.	Users' special needs must be identified, and they must be involved and encouraged. Services must be sufficiently flexible and customer-oriented.
An open working culture does not form within an organisation, or openness does not feature in an organisation's strategies.	There is no progress in cooperation and coordination within the research system, and system architecture is left incomplete. Silos remain and continue to form where they could be removed.	Benefits must be concrete. Ensure shared intent through participation and competency development. Seek synergies within and between organisations. Identify agents for change and empowerment within the organisation.
When designing services and choosing indicators, the differences between research disciplines and organisations cannot be sufficiently considered.	Polarisation and a lack of diversity in science. Organisations and researchers begin to mistrust openness.	Openness and extensive participation. Avoid overly black-and-white guidelines on performance. This is a clear message from funders and, in particular, the ministry.
No effort is made to encourage openness.	No progress in openness through soft methods.	Identify and use the most important incentives at an early stage.
Investments in increasing competence are not made at the right time, or they cannot be channelled to the critical targets within the research system. Information is offered in the wrong format at the wrong time.	No progress in openness, no improvement in data management, and Finnish research suffers.	Identify critical targets and develop user-oriented services. Extensive participation, so that requirements can be charted. Rapid reactions (flexible operations) to support networking and the spread of tacit knowledge through concrete cooperation. Profound expertise in communications, and wide-ranging, multidisciplinary operations.
Newly available resources and materials are not harnessed.	Wasted resources and opportunities. A potential weakening in the level of research. Finland will fall behind within the EU and globally.	Sufficiently high-quality and reliable services that provide both good discoverability and sufficient documentation. Data and metadata should be extensively linked. Adhere to standards, such as guidelines, and make sure they are developed and updated.
Insufficient or poorly organised resources for development and training, with no eye to the long-term.	No one dares to invest in projects, and organisations' operating models remained unchanged. Research results cannot be accessed, or there have been deficiencies in their storage.	Move away from project-based funding to appropriate, permanent solutions. Focus on training and systematic operations. At the same time, changes in working culture yield more effective coordination and greater efficiency.

Cooperation cannot be implemented on a practical level.	No progress in openness; inefficient use of resources.	Extensive discussion and participation. Openness must be adhered to in practice and discussion must be actively encouraged. Crowdsourcing must be used extensively at work. Engage in supportive discussions, request feedback, and harness the input of experts and research communities at all levels.
The needs and opinions of research organisations are not given sufficient consideration.	Openness principles, guidelines and operating models are not created at an organisational level.	The differences between organisations must be identified, and organisations must be involved in and encouraged to engage in cooperation and openness.
Overall management becomes too difficult, as there is so much non-standardised information. The selected technologies and solutions don't stand the test of time.	Discoverability and actual availability suffer. Benefits go unreaped. The visibility of Finnish science suffers.	Strongly promote linked data technologies and their use. Use good services to ensure sufficient documentation, and the preservation of links and context. Successful monitoring of the operating environment coupled with long-term planning and funding.
A human or technical error occurs in some data protection system or service promise, with unfortunate consequences.	A lack of confidence in services and the management and administration of the system as a whole. Progress in openness grinds to a halt, and the overall data management of research suffers.	Extremely accurate operations from service providers (such as auditing) and very clear instructions for users. Provide the clearest and most standardised guidelines possible at all levels.
Openness will collapse when funding ceases in 2017; services will be forgotten and become obsolete.	Work will be lost; a return to zero. Finland will lose its head start and international influence, and won't be able to provide the infrastructure services required by the EU.	Identify the functions and services that require permanent funding. The working culture and methods of organisations and administrations should be shaped to support and prioritise openness and good data management in general. Try to boost the efficient use of resources through cooperation and expertise, and by establishing structures and working methods to support this.
Finnish science becomes a silo that is not properly linked to international research.	Researchers lose confidence and materials are moved abroad, where they are no longer necessarily even linked back to Finland. Data management gets more difficult in international projects. Research becomes less competitive.	Service descriptions and websites should be published in both Finnish and English. For example, national glossaries and data models should primarily be produced in Finnish and Swedish with other language versions as required. The opportunities afforded by linked data should be harnessed. Close cooperation with essential international players and research communities.
The agents for open science and research cannot be made an active part of operations.	The expertise and activity of experienced Open Knowledge and Open Science groups is not harnessed.	Maintain an open and participatory working process throughout a project. Remain open to external initiatives. Extensive participation in public events and discussions, from Facebook groups to as wide an audience as possible.
The quality of research materials and metadata is insufficient for long-term preservation or reuse; resources are insufficient for making new openings.	Wasted resources; the quality of research may suffer.	Materials must be under control before they are even created. Make developments in data management and its design by providing support, training and services. Policies and different parties' responsibilities must be clarified throughout the research system.

The probability and consequences of these threats have been evaluated in Figure 2.

Consequences Probability	Minor 1	Detrimental 2	Serious 3
Unlikely 1	<b>Negligible risk</b> The system is too difficult to manage as a whole. The agents for open science cannot be introduced.	<b>Low risk</b> Openness will collapse when the initiative ends. The silofication of Finnish science.	<b>Moderate risk</b>
Possible 2	<b>Low risk</b>	<b>Moderate risk</b> An open working culture will not form within organisations. Not taking differences into account. Not encouraging openness. Cooperation cannot be implemented on a practical level. Research organisations' opinions will not be considered. An error in data protection.	<b>Significant risk</b> Data users' opinions will not be considered. Newly available resources will not be fully harnessed. No eye to the long term in development work.
Probable 3	<b>Moderate risk</b> Insufficient investment in know-how.	<b>Significant risk</b> The quality of materials will be insufficient for long-term preservation.	<b>Intolerable risk</b>

**Figure 2.** An evaluation of the probability and consequences of the aforementioned threats.

- 1 Suomalaisen koulutusjärjestelmän kehitys 1970–2030
- 2 Oppimisen ja hyvinvoinnin tuki. Selvitys kolmiportaisen tuen toimeenpanosta
- 3 Toiminta- ja taloussuunnitelma 2015–2018
- 4 Osallisuus, palaute, seuranta; Kuntien liikuntatoimien nykykäytännöt
- 5 Drop-out vai throw-out?; Tutkimus lasten ja nuorten liikuntaharrastusten kustannuksista
- 6 Tutkimus- ja innovaationeuvoston toiminnan ja vaikuttavuuden arviointi
- 7 Cultural Cooperation in the Barents Region; Strategy 2014–2018
- 8 Taikalamput näkyvät ja vaikuttavat; Lastenkulttuurin taikalamppuverkoston keskusten vuosien 2009–2013 toiminnan vaikuttavuuden arviointi
- 9 Miesten ja naisten tasa-arvon edistäminen liikuntapolitiikassa; Hyviä käytäntöjä Suomessa, Ruotsissa ja Norjassa
- 10 Opiskelijatutkimus 2014. Korkeakouluopiskelijoiden toimeentulo ja opiskelu
- 11 Osallistumista ja aktivointia; KUULTO-toimintakokeilun matkassa
- 12 Korkeasti koulutetun väestön kehitys
- 13 Koulutus, työllisyys ja työttömyys
- 14 Kansainvälisen tutkimusrahoituksen vastinrahoitus Suomessa
- 15 Opetuksen ja oppimisen kansainvälinen tutkimus TALIS 2013. Yläkoulun ensituloksia
- 16 Suomalaisnuorten ongelmanratkaisutaidot
- 17 Suomalaisen koulutusjärjestelmän kehittyminen kansainvälisessä vertailussa
- 18 Osaamisella ja luovuudella hyvinvointia. Opetus- ja kulttuuriministeriön tulevaisuuskuva 2014
- 19 Kansallisen osaamisperustan vahvistaminen. Johtopäätöksiä
- 20 Tutkimuksen avoimuudella yllättäviä löytöjä ja luovaa oivaltamista. Avoimen tieteen ja tutkimuksen tiekartta 2014–2017



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