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# D 5.4 – Paper on Future Research Issues

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| RE | Restricted to a group specified by the consortium (including the Commission Services) | |
| CO | Confidential, only for members of the consortium (including the Commission Services) | |

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The Form-it project consortium:

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Universität Zürich - Institut für Gymnasial- und Berufspädagogik

Jozef Stefan Institute

National Institute for Curriculum Development

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Leibniz-Institut für die Pädagogik der Naturwissenschaften an der Universität Kiel

# Table of Content

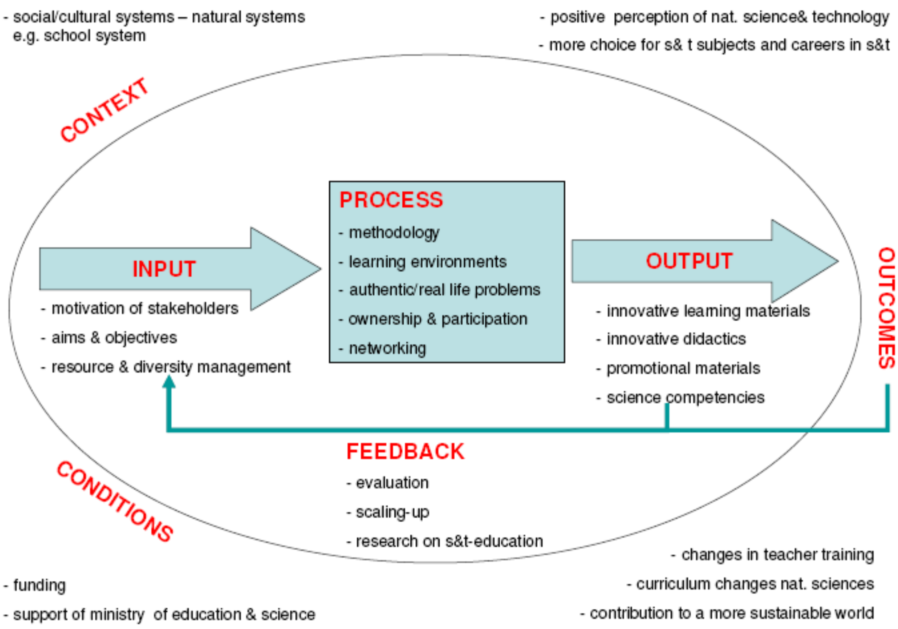
# 1. Background

In recent years, the state and the improvement of science education have globally become important issues: The World Conference on Science and Technology Education in Perth, Australia, 2007, issued a declaration in which it “expresses strong concern about the state of science and technology education worldwide […] In many countries the supply [of those students who will go on to further studies for careers in all those professional fields that directly involve science and technology] is now falling seriously short and urgently needs to be addressed” (Fensham 2008, p. 4). Europe, too, faces this alarming decline in young people’s interest in scientific studies. The shortage of scientists and engineers is expected to affect economic prosperity. Equally grave, the acquisition of relevant skills in a knowledge society is “under increasing threat”. […] The origins of the declining interest among young people for science studies are found largely in the way science is taught in schools” (European Commission 2007, p. 2).

Against this background, the project Form-it “Take Part in Research”[1] was looking to support and promote Research and Education Cooperation activities (REC) in science and technology. This innovative form of science education is assumed to get more young people interested in science and technology (GRID 2006) and thereby to increase scientific literacy and have more students take up a career in these fields.

During the course of Form-it, European experts working with and on innovative didactic models and new learning arrangements for science teaching carried out a survey on REC within all participating countries (Austria, Germany, Italy, Lithuania, the Netherlands, Slovenia, Switzerland, and the UK), documented Good Practice examples, set up guidelines for teachers and researchers, and formulated recommendations for policy-makers (for more information, the project results, and publications, see http://www.form-it.eu/ ).

In the European project *Form-it*, experts from eight different countries belonging to different faculties in natural science and educational research, with different backgrounds, and different perspectives on research education collaborations (RECs) came up with a diverse list of interesting and challenging research issues (see Annex). Theses Issues are related to the proposed ‘quality areas’ and the framework for a successful REC in Science and Technology (see also the Good Practice Catalogue).




[1] 2006-2008, funded by the Sixth Framework Programme of the European Union

The work of the *Form- it* consortium illustrates that projects like ours provide the opportunity to develop comprehensive ideas about innovative research issues which could give guidance to others. If these ideas become reality, the results of the research could significantly contribute practical knowledge for science education.

Giving orientation and advice is one major purpose of the list in this deliverable. Amongst others you will find research questions regarding diverse and even controversial issues:

- The role of images of science, scientists, and technology and their impact on science education.
- RECS and their potential for education for sustainable development in a broad sense.
- Science education on the level of a society level: Single mothers' children and the likelihood of admission to the Technical University – An example from Lithuania.
- Question of teaching authentic science and learning science in an authentic environment (e.g. RECs): Theoretical and practical opportunities and boundaries.
- RECs as element of science education in schools. Integration of successful approaches into formal education.
- RECs and their impact on teaching methods, and teacher training as well as their potential to promote inquiry based learning (and teaching) as a method of choice.

The following pages go into detail introducing these topics. Some of the issues have already been discussed at the *Form-it* Conference in March 2008 in Vienna, others were generated during recent project meetings. Therefore, the compilation of topics reflects the developments of the *Form-it* project in its second year.

It is our aim that the research issues stimulate a fruitful discussion not only in the science community but also amongst politicians and other people responsible for science education.

# 2. Research Issues related to REC and the 7th Framework Programme

## 2.1. How to connect school experiments with high-level science experiments?[2]

Špela Stres (IJS)

as the main title, but it includes all of the below mentioned topics:

v) How to involve experts for secondary and primary schools? (Diversity management)
vi) Do science teachers meet PISA requirements? Do they stimulate/facilitate students to ask open scientific questions, explain phenomena scientifically, and present scientific evidence (not opinion)?
vii) What are characteristics of scientists which are interested in RECs?
viii) How to reward a scientist, collaborating in REC?
ix) How can RECs make science 'cool' for 'kids'?
x) How children can participate in day to day research – more suitable and less suitable research topics

The first question is of direct interest of IJS. Our goal is to set up a number of experiments, which can be conducted in school environment and can then be upgraded, as the children/students come to the research institute environment, into the labs. At school they learn, do and participate, in the lab, they think and connect what they see with what they have been doing at school.

We have an example of such an experiment already developed. Our goal would be to explore how different scientific fields can be covered in this same way.

During the course of work also other questions about how science teachers can manage science and teaching connection, how much PISA requirements can be valuable (or not) within this task.

Also the question of which scientist is suitable to deal with children/students in the more didactic way and how this scientist can incorporate this didactic line of work into his or her scientific mission (and how he or she should be rewarded for doing so), is important and needs to be answered as a side effect of the main product.

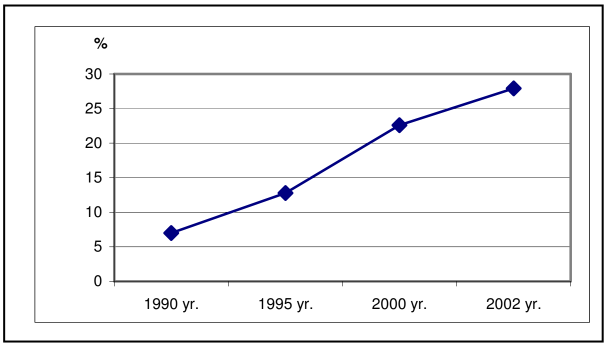
As final on this quest to connect school and basic & applicative laboratory science, we need to know what the categories are through which we can distinguish between more or less suitable RECs.

Research topics are not all similarly suitable for such a connection with the every day school study process and some need to be dealt with in a more careful way. To do so, a differentiation between more and less suitable scientific topics should be made as well as a classification of different topics.

[2] Research question according Annex no.4 and also mentioned: no. 11 – 23 -24 – 25 – 26 - 27

## 2.2. Single mothers in higher education: Relations between mothers and their children[3]

Lena Anceviciene (KTU), Saulius Raila (KTU)




Although partnership without marriage in Lithuania is still less spread compared to other countries it has become more and more frequent in recent years. According to the data of the International Institute "Family and Fertility" even 78% of Swedish women at the age of 25-29 have had the experience of the first partnership as an unregistered marriage at 25. This indicator amounts to 71% in Finland, 64% in France, 61% in Norway, 63% in Estonia, 55% in Switzerland, 42% in Latvia and 16% in Lithuania, bet the number of extra-marital children is growing (Fig.1).

Fig.1. Number of extra-marital children in percent (live births delivered by unmarried mothers)

So, in our work we decided to analyze the family influence on the success of studies of children living in a full family and in a single mother's family. We gave the questionnaire to those, who filled the application form entering 13 Lithuanian universities. There we had also some questions concerning the parents of applicators. We gave the questionnaire to all the applicants and 3905 were returned. Nowadays women have realized that participation in social, economic and political activities and education helps them with family planning, health care and nutrition, and the better they are educated the more they contribute to their families' welfare in contrast to women with little education. But mothers want their children to have a better future and they understand that only a university degree offers this possibility. Living alone they understand, how difficult life is and this encourages to struggle for a better life for their children. We wanted to know, what the study achievements of children being raised by a single mother are. In Lithuania we have the 10 score system and children have to study 12 years in order to obtain high education and then they have the right to enter the university. We have no entrance exams, but the applicants are selected according to the final marks. Positive score at school is 4, while at the university it is 5. All students entering university filled in the application and we compared them to single mothers' children (Fig. 2). We can see that single mothers' children did poorer at school (they had lower marks).

[3] Research question according Annex no.7

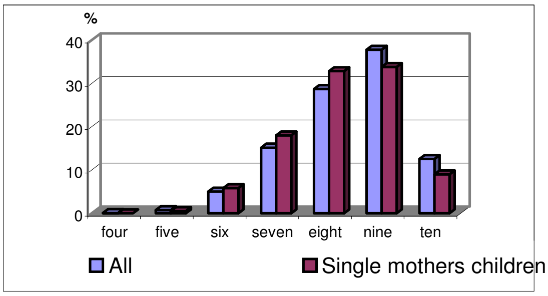



Fig. 2. Comparison of graduation scores of all applicants and those with single mothers

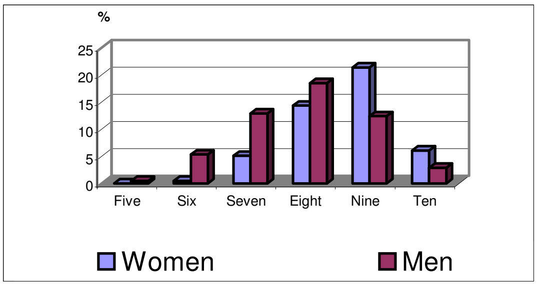



Fig. 3. The average mark of single mothers' children who filled the admission forms (women and men separately)

We can see (Fig 3) that women have more high marks than men. Many instructors favor the hypothesis that women are more diligent.

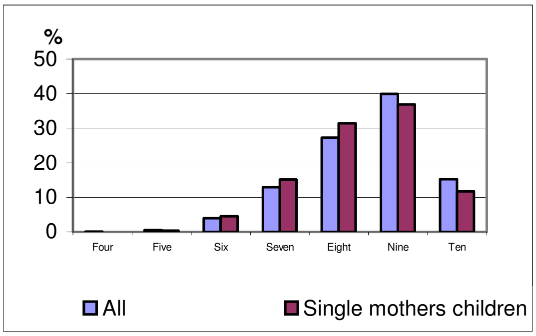



Fig. 4. Scores of those who were admitted to KTU

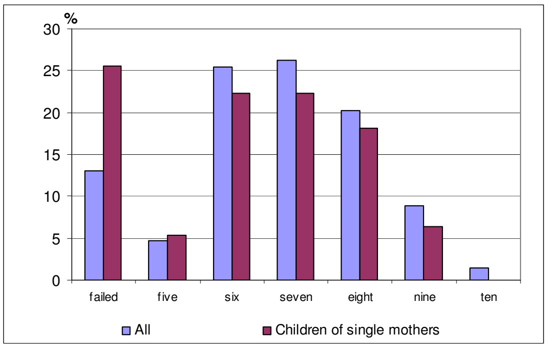



Fig. 5. 1st semester scores at KTU

It can also be seen that those single mothers children who were admitted to Kaunas university of technology (KTU) had lower scores (Fig. 4) and the comparison in histogram of 1st semester scores of all students and of single mothers children (Fig. 5) shows that single mothers children have lower study achievements at the university also.

The positions held by women as compared to that of men are less, especially in economically strong fields. In banks, factories, parliament and other decision-making positions there are very few women in responsible positions. In our new generation of students, of which many are children of single mothers, women are doing better that men. We expect them to become our future woman leaders in a changing world.

## 2.3. Image of science: pupils who are not interested in studying science or technology[4]

Lena Anceviciene (KTU), Christine Gerloff-Gasser (UZH), Friederike Gienke (IPN), Stefan Hesske (UZH), Dirk Hillebrandt (IPN), John Meadows (LSBU), Tomaz Ogrin (IJS), Saulius Raila (KTU)

**Keywords:** Image of science, Interest in Science and Technology (S&T), Qualitative methods

**Importance:**

A majority of young people chooses an area different from science and technology (S&T) for their career. In Lithuania, e.g., 60 % of all high school graduates take up studies in social sciences, in contrast to 16 % that take up studies in S&T (S. Raila, pers. communication). Amongst others, the way science is taught at school has been put forward as a reason for the low interest in scientific careers (European Commission 2007). Connected to this is the image of science and scientists, of technology and engineers pupils and students have.

The image of science has received much interest lately by global and European initiatives (e.g., TIMMS and PISA studies (correlative data with student performance), European Researchers' Nights (contest "Draw a scientist"), FP7 (Area 5.1.1.4 The role and image of scientists)).

**Connection to REC:**

Research and Education Cooperation (REC) contains an outstanding potential to adding important facets to pupils' and students' images of S&T, such as authenticity of working surroundings and methods, giving an integral face to S&T by personal contact, experiencing the creativeness and challenges in the quest for scientific knowledge or a solution to a problem. These aspects are likely to enhance pupils' and students' knowledge about S&T and their interest in pursuing a career in S&T.

Up to now, we know little about the influence of REC on the image of S&T, apart from mostly anecdotal reports.

**Main research questions:**

1. What are the images of science and scientists/technology and engineers pupils have who are and who are not interested in studying S&T?
2. What shapes these images? Family, school (teachers, science classes, peers), society (media, societal status of scientists/engineers), individual interests and attitudes, individual experiences with S&T, etc. How do the images and the factors shaping the images differ among cultures/countries?
3. Is the image of science and scientists/technology and engineers the reason or the consequence of being or not being interested in S&T? (causal relationship between the image and the individual interest might be difficult to prove, the interaction could be described by qualitative methods)
4. How to influence certain elements of these images in a specific direction? How to build a positive image to raise interest in studying S&T? (design of an intervention, including e.g. modeling science, popular role models, online materials, authentic out-of-school sites, role play)
5. How does the involvement in REC activities change the image of S&T? (qualitative study, also looking at the images of the teachers and scientists/engineers)

**Expertise needed:**

Area Image of Science, qualitative methods, quantitative data on career choices

[4] Research question according Annex no.12

## 2.4. What is the level of understanding of basic principles we can reach/we want to reach in a REC? It is ‘authentic science’ or a Troyan horse for teaching ‘school science’?[5]

Michela Mayer (RM3-SSIS), Eugenio Torracca (RM3-SSIS)

In many European countries the science core curriculum is still very rigid, and follows determinate sequences of contents, mainly dealing with what is considered ‘basic’ and prerequisite for further scientific or technological studies.

Very often RECs subvert this sequence and ask students to deal with topics, concepts, instruments that are considered, by the teachers, too difficult or ‘advanced’. The Form-it Survey and the catalogue of Good Practice show that the interest of the students to Science and Technology rise a lot during their participation to RECs, but what about their basic understanding of Science? Are RECs also useful for a deeper, more extensive, understanding of basic science, or their function is only to rise the interest in order to motivate students to go back to ‘dulling but useful’ school science?

In what sense RECs are dealing with ‘authentic science’, and in what ways this attitude to deal with science could be imitated and adapted to normal science classes?

A first step of a research plan could be a reflection, based on national case studies, on what is considered a ‘normal science class’ (what core curriculum, what educational methodologies, what basic competences) and what examples we have of ‘authentic science’ classes in different countries. The definition of ‘basic science’ and ‘authentic science’ should be challenged and illustrated with different examples. What means basic? Basic from the point of view of key competences, of disciplinary concepts, of real life? What means authentic? Authentic to whom? To scientists or to teachers or to students who don’t know the answers to the questions raised?

Once clarified the concepts, one focus of the research could be the collection of evidences that RECs improve not only the interest of students but also their key competences (PISA key competences in science will offer a possibility of comparison in performances for 15 years old; TIMSS for the lower levels).

Another focus could be a closer examination, through case studies, on what we consider ‘authentic science’, not only during RECs but during ‘normal’ science classes. A operational definition of authentic science and a set of guidelines could be one outcome of such a study.

As a final outcome, evidences should be collected that RECs have high probability to be implemented as ‘authentic science’ and a reflection on its characteristics and quality criteria could help teachers to design ‘authentic science’ classes, in normal school life also.

[5] Research question according Annex no.35

## 2.5. Research Issue: Influence of RECs on ESD[6]

Patrzizia Jankovic (BMUKK), Jana Huck, Robert Lorenz (FUB), Michela Mayer (SSIS - RM3)

**Argument of inclusion**

- research / surveys within the Form-it project have shown links between RECs and ESD
- demands: sustainability as an approach towards RECs
- science is an essential part of the curriculum, but interest of young people is rather low
- RECs offer a possibility to lead young people towards science, to show that science is linked with everyday life and important for the future
- interest of pupils can be increased by problem-based and inquiry-based learning
- generally ESD does not play a major role in education, but themes and methods of ESD are useful to create interest among pupils
- a link between RECs and ESD would lead to synergetic effects, pupils have the possibility to learn by hands-on and minds-on activities and to experience science in a different way
- to deal with the topic of sustainability results in a different way of learning for pupils: science is experienced as having major influence on the pupils environment, relevance for society and giving the opportunity to solve problems successfully

**Key Words**

ESD, sustainability, typology of RECs, quality criteria, recommendations

**Research Questions**

1) How many RECs are related to ESD?
2) What kind of science is proposed in RECs regarding ESD?
3) Does the scientific aspect in RECs explicitly / implicitly consider ESD?
4) Do RECs improve the general acceptance of ESD in schools?

Activities to consider:

- reuse of the database of Form-it
- typology of RECs and of ESD initiatives
- Quality criteria: adapt to ESD criteria? (ESD is already looking for many of the QC Form-it has proposed)
- New collection of GP: RECs in ESD at formal level/non-formal level
- Look at: changes in organisation, role of teachers, student/people activities and interest
- Look for ESD initiatives that deal with science subjects

**Ideal Consortium**

institutes with REC experience, educational institutes, RECs active in ESD or with a close link towards ESD

**Connection to REC**

- RECs with a scientific background are the main focus, research about RECs already active in the field of sustainability / ESD
- one possible aim: recommendations to REC in general on how to adapt themes and methods to the aspect of sustainability

[6] Research question according Annex no.38

## 2.6. How to build a long term benefit into the life of a school?[7]

John Meadows (LSBU)

The way in which British schools embed change into their lives is often through the development of a written policy document, which is prepared by the staff of the school, and perhaps by pupils, parents and governors too, with some input from the local community. Such a policy document would then be part of the school's action plan and improvement planning and would be monitored and evaluated annually. In this way, the benefits and costs would be explored and reported.

In a European context, research would need to focus on school development and change at a number of levels (not necessarily in order of importance), which, depending on context might include: -

National government
Local government
Community
School and governors
Head teacher
Department
Teacher
Pupils and parents
And others…..

In the context of RECs, other partners would also need to be involved in the research, especially scientists working in industry and university.

The main focus of research would need to be on the National and local contexts of ling term changes in scools and how these are different or similar across Europe and between different types of school systems, for example, primary or kindergarten, l;ower and upper secondary, post – 16 education systems.

Another major focus would need to explore examination systems across Europe and how REC activities might be embedded in statutory curriculum practice.

The question itself – how to build a long term benefit – implies that RECs do benefit schools in the short term. One of the outcomes of future research should be to show how this happens at a school, rather than individual pupils level. What is the benefit of a REC to a school? How do schools measure the changes which lead to improvement? In Britain, there is already a large amount of data on school improvement – this would need to be compared with school improvement data from other European countries. How is improvement estimated?

What criteria exist to quantify school improvement?

[7] Research question according Annex no.50

## 2.7. How to make REC an element of regular science education[8]

Patrizia Jankovic, Günther Pfaffenwimmer, (BMUKK)

The future of success of the European Research Area is mainly depending on young people developing skills and competencies to tackle the future challenges. The key competencies needed today are self motivated and self directed learning strategies, team-working and communication skills and above all the capacity to differentiate, select, apply and replace information from the immense and daily growing global knowledge base.

Therefore science education in school is confronted with a high pressure to replace / develop further outdated teaching approaches by modern concepts.

Research and Education Cooperation (REC) is an effort of a new learning design, integrating actors of different fields - pupils, teachers and scientists work side by side together.

Integrating REC in school teaching demands broad changes in teaching and learning approaches to develop subject and methodological competencies. Participatory learning strategies are recommended and can produce attitudinal and value changes in respect of science learning (backstage-science; enculturation in communities of experts).

REC involvement offers researchers the stimulus of intense teaching and learning experience as well as new aspects and questions evolving from concrete collaboration.

In order to further develop and to mainstream REC, it should be part of core curricula at all school levels.

Curricula should progress in complexity in terms of integrating the different subjects and methodologies addressed.

Developing subject competencies should be accompanied by practical experiences in real life contexts to also develop social and personal competencies.

REC needs to be integrated into teacher initial as well as in-service teacher training.

**Main research questions**

- How to mainstream a concept like REC from pilot phases to the broad group?
- How to keep the momentum of development at the single (REC partner) school?
- How can school and research co-operation be strengthened in a longer perspective?
- What are characteristics and factors for the successful development of committed schools and research partners?
- What is the role of the different partners within REC and how can it be supported?
- How can inter- and transdisciplinary co-operation be stimulated, acknowledged and structurally supported?
- How must teacher education be transformed to enable teacher (students) to work and collaborate in a REC?
- What can be learned in REC in a longer perspective?

[8] Research question according Annex no.50a

*The following comments and questions were raised during a reflecting workshop on the Power point presentation of www.sustain.no at the University of Klagenfurt in June 2006 and are provided by Prof. Peter Posch. We think that these are helpful aspects to be considered when developing a follow up to Form it.*

***Comments:***

- An important advantage of REC is: On can participate and does not need to do all the work of thinking oneself.
- School could be seen only as „recipients“, the school external institutions being seen as “setters of the tasks”. There seems to be a contradiction between the recipient role of schools and the pedagogical aims: („Learning by doing, to develop responsibility, Educating for citizenry, Participation, Action competence“).
- How to clarify and communicate the roles, functions and responsibilities of all partners involved, including the teachers?
- How to avoid that students are only providers of data and have only little possibilities to „leave traces“? If they only can provide data their interest will decrease soon and the learning outcomes would be limited.
- How to keep the students´ interest and participation alive? How to provide space for creativity?
- How can students recognize success of their work? Are there concrete outcomes which show that their work helped to better the / a Situation?
- To what extent can such projects become routine and an integrated part of teaching and learning at school? Or are these additional activities only? To what extent are these activities part of assessment? Which organisational flexibility can schools get, who are involved in such co-operations and networks?
- To what extent can the interests of schools be taken into account? How can an impression of misuse of schools be avoided?
- Which significance has interpersonal communication? A limitation of the interaction to an „electronic meeting place“ might not function on longer terms.
- What are reliable and successful model of financing REC?
- Are there any examples of international co-operations and how do they work and what are their results?
- Is systematic evaluation available? If not, how to implement, perform and communicate such evaluation?

**Ideal consortium**

Teacher training institutions

Ministries of Education and of Science

Science Research partners

Educational researchers

Schools with all their stakeholders (principal, teacher, etc.)

School authorities

Sponsoring partners from Economy

Trade Unions of teachers as well as of researchers

School partners (e. g. parent and student representatives)

## 2.8. Inquiry learning and learner autonomy: implications for designing learning materials and teachers roles[9]

Henk Ankoné (SLO)

Doing research is a complex task, which must be built up with care throughout the curriculum. It is of vital importance to realise a transfer of learning tasks from the teacher to the student: the student will have to learn how to do independent research. The methodology expounded below can serve as a handle to support teachers in their educational activities, such as:

- Variation in coaching the students in their work on research assignments;
- Analysis and screening of research assignments for a target group;
- Adaptation of existing assignments to the level of a target group;
- Design of new research assignments for a target group;
- Design of a programme to ensure a consecutive learning process with respect to research skills.

When designing such a programme the teacher or the school can use interim objectives, for instance learning standards. The methodology described below makes it possible to combine (interim) objectives for general skills with (interim) objectives for acquiring subject kills and subject content. When talking about general skills we mean learning to handle the different steps in a research assignment. When talking about subject skills we think of the different approaches in the social subjects, such as geographical or historical working methods. As for the content, we think of a certain subject content in an assignment: for instance, living in a historical part of the town or public transport in the country.

### 2.8.1. Independence and coaching in research assignments

Students generally find research assignments difficult. But some steps, for instance phrasing questions, are more difficult than others. It is helpful to students to work on research assignments at different levels of complexity and steering. By doing the assignments in the right order, they learn to do independent research step by step.

A possible sequence of activities could be the following:

1. orientation on the topic
2. phrasing research questions
3. formulating a research approach
4. elaborating an activity plan
5. gathering information
6. processing information
7. answering research questions
8. passing on results
9. evaluation

[9] Research question according Annex no.22a

### 2.8.2. The level of complexity

Research assignments can vary in complexity and the degree of steering. The degree of difficulty depends on the extent and the complexity of the research assignment.

*The extent*

In the beginning you can adapt the extent of the research assignment by skipping a number of steps. At the first time you can, for instance give them the research question, the subquestions and the sources of information.

*Complexity*

The complexity can pertain to the topic, the research question or the working method. Some topics are less complex than others, because there are fewer factors that play a role. Realistic topics with sufficient practical relevance can easily get more complex.

The presentation of the question allows variation. In the arts and humanities, for instance, a research assignment can be descriptive, explanatory, predictive, assessing or problem solving. The degree of complexity increases on the scale from descriptive to problem solving.

Variation can also be created in the research method. There are simple methods of observation and registration, but there are also technically difficult methods of measurement.

*Coaching*

Teachers are used to vary with respect to the extent and the complexity of assignments. It is more difficult, though, to offer the right amount of variety with respect to coaching. Indeed, in schools the intensity of steering decreases as the students move on to higher grades, but a more intense steering is resumed, as soon as the subject matter becomes more complex. The following figure can serve as a convenient aid.

*Figure 1. Level of complexity and steering in assignments*

| level of complexity → <br> ↓ intensity of coaching | Easy: 1 | Reasonable: 2 | Difficult: 3 |
|---|---|---|---|
| Little coaching: C | C1 | C2 | C3 |
| More coaching: B | B1 | B2 | B3 |
| Ample coaching: A | A1 | A2 | A3 |

(adapted from: Donkers & Gerritsen (1998))

The ultimate aim is that students accomplish a difficult assignment with little steering. The way towards this aim can start at A1 and follow any route to C3. A horizontal step means that the intensity of coaching remains about the same, while the level of complexity is rising. In lower secondary teachers will feel inclined to make their students follow the route A1→B1→C1, whereas in upper secondary the route A2→B2→C3 will perhaps be more obvious.

### 2.8.3. Learning to make decisions

Common methodological models of transfer of more autonomy from the teacher to the student are very generally outlined , for instance on a scale from teacher steering via shared steering toward student steering. As it is not clear how shared steering can be realised, such models do not give the teacher any support. Below we give a survey of how the teacher can gradually diminish his/her coaching activities. The scale of six positions the teacher can adopt has been derived from the so-called POCOB-method (a Dutch acronym for design and coaching of practical assignments), developed by the Netherlands Institute for Curriculum Development, SLO, together with the Institute for Teacher and School, ILS, of the University of Nijmegen

*1. The teacher stipulates*
The teacher stipulates what happens, without revealing the considerations that have led to this decision. The teacher determines the research topic, phrases the research question, offers suitable sources of information, gives a mark etc. The students carry out the assignments, but in this way, they do not learn how they can do such a task themselves. Assignments presented in this way are not process-oriented.

*2. The teacher gives examples*
The teacher shows how a research task must be carried out. He/she explains what (s)he is doing and what strategy (s)he is using. The teacher gives an example to illustrate why a certain research question is good and another is not. Students must indicate what they are successively going to do and why they choose this approach for the research steps.

*3.The teacher gives options*
The teacher coaches by stepping back and offering support. For example, the teacher offers several topics, from which the student can make a choice. In the same way the teacher can offer research questions and forms of presentation. Students give account of their choice to each other and to the teacher. The teacher determines the 'possible' alternatives, and from these the students make a reasoned selection.

*4. The teacher makes suggestions*
The teacher steps back further and supports the students only where necessary. The teacher makes suggestions and lets the students consider alternatives. The teacher suggests aspects that need to be taken into account in formulating a research question and invites the students to think of other relevant aspects. Alternatively, the teacher gives types of information sources (internet, newspaper, TV etc.), within which the students themselves must search for their information. Thus, the teacher decides on part of the alternatives, or (s)he partly decides on the alternatives.

*5. The teacher gives criteria*
In this case, the students devise the alternatives and the teacher gives the criteria. The teacher defines the requirements with respect to carrying out the learning task. (S)he tells them, for instance, the requirements a research report has to meet. Students work this out and indicate why they think they meet the set of criteria.

*6. The teacher gives advice*
The teacher lets the students carry out the learning task independently, and is available as an interlocutor to discuss each step in the execution of the task. The students make the decisions. They account for their decisions to the teacher.

### 2.8.4. A matrix of research steps and teacher positions

Below you find a matrix for the gradual development of skills for research assignments derived from the POCOB-model (Designing and coaching practical assignments).

| Research steps: | Changing teacher position in successive assignments: | | | | | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th |
| | Lower Secondary | | | Upper Secondary | | |
| 1. orientation on the topic | 1 | 1 | 2 | 3 | 4 | 5 |
| 2. research questions | 1 | 1 | 2 | 3 | 4 | 5 |
| 3. research approach | 1 | 2 | 3 | 3 | 4 | 5 |
| 4. activity plan | 1 | 3 | 4 | 4 | 5 | 6 |
| 5. gathering information | 5 | 5 | 5 | 5 | 6 | 6 |
| 6. processing information | 5 | 5 | 5 | 5 | 6 | 6 |
| 7. answering questions | 1 | 3 | 4 | 5 | 6 | 6 |
| 8. passing on results | 1 | 1 | 2 | 4 | 5 | 6 |
| 9. evaluation | 1 | 1 | 2 | 3 | 4 | 5 |

The changing position of the teacher in successive research assignments represents one of the several strands to be drawn together to ensure a consecutive learning process for research assignments. In this way the scope for students to make decisions grows with each assignment. In each subsequent assignment students practice one or more research steps, in which they will have to make more and more decisions on their own.

In upper secondary education the ideal situation is that students take responsibility for their own learning process. Within the context of the examination programmes position 5 is the highest feasible one for a number of research steps. Also in the most advanced variant the topic to be selected must be relevant for the examination programme (position 5), and the teacher remains responsible for the final assessment (position 5).

The POCOB-model offers support to teachers in several aspects of their task. It can be helpful in the realisation of professional coaching in practical assignments, but also for screening and adapting existing practical assignments for a certain target group, as well as in the design of new practical assignments for a target group. If assignments for different subjects are developed according to this method within a school, a consecutive learning process for research assignments can be enhanced across the curriculum, which will also comprise subject skills and subject content.

## 2.8.5. Levels and the consecutive learning process

The method described above allows us to formulate interim objectives for the different research steps at different levels: for the step 'selection of a research topic' the objectives leading to an increasing degree of student autonomy could be the following:

The student can:

- select a research topic by imitating the selection process the teacher presented (position 2)
- make a well-reasoned selection of a research topic from a given list of topics (position 3)
-

For the step 'processing information' the interim objectives could be the following:

The student can:

- process gathered information in the way the teacher had demonstrated it (position 2);
- select and apply a suitable manner of processing information from a list of different manners (position 3);
- process gathered information with the help of instructions (by the teacher or in the learning materials) (position 4);
- process gathered information using a set of given criteria (position 5);
- process gathered information on the basis of criteria of his/her own (position 6).

The levels are determined by the degree of the students' autonomy in performing the task in combination with the typology of questions. We distinguish four types of questions: descriptive, explanatory, evaluating, and problem solving questions with a rising degree of difficulty. A descriptive question on a certain topic is easier than an explanatory question on the same topic. Evaluating and problem solving questions on the same topic are more complex than explanatory questions.

If we combine the degree of difficulty of the questions with the degree of students' autonomy as represented in the five positions of the POCOB-scale, this will result in a matrix with twenty combinations. That is too many, so for lower secondary education we reduced it to four levels, A to D. A descriptive question where the student gets options to choose from (box a3) is at the same level as an explanatory question where the student is offered an example (box b2)

| | | | | | |
|---|---|---|---|---|---|
| d. problemsolving | B | B | C | D | D |
| c. evaluating | A | B | B | C | D |
| b. explanatory | A | A | B | B | C |
| a. descriptive | A | A | A | B | B |
| ↑ questions<br>autonomy → | Given<br>1 | Example<br>2 | Options<br>3 | Suggestions<br>4 | Criteria<br>5 |

With the help of this matrix you can choose a number of levels of reference and then formulate the corresponding learning objectives. Let's take the example of a learning objective pertaining to the level indicated in box b3:

"The student can make a well-reasoned selection for an evaluative research choosing from a list of possible topics."

The descriptions above are formulated as general research skills. You can also combine them with subject skills by embedding them in a relevant subject context. For selecting a topic the formulation can be as follows: "the student can select a *historical* research topic". For processing information the following formulation would be adequate: "the student can apply *geographical* working methods for processing gathered information". The combination with subject skills is important, because doing a subject research assignment implies the development of general research skills at the same time, whereas the other way round this will only hap

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# 4. Annex: List of interesting and challenging research issues

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **CONDITIONS** | | |
| 1 | Implementation | How flexible are (national) educational systems to incorporate RECs? | Educational system |
| 2 | Implementation | How to use REC projects to move the system, particularly the curriculum? | Educational system |
| 3 | Implementation | How to make RECs an element of science education? | Educational system |
| 4 | | How to connect school experiments with high-level science experiments? | |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **CONTEXT** | | |
| 5 | Gender | What motivated women scientists to choose a science career? | Scientific career |
| 6 | Gender | Gender problems in the spheres of science | |
| 7 | Social/Cultural context | Single mothers and their child achievement | |
| 8 | Social/Cultural context | Are there REC programs in the USA, Japan, China, India? | Distribution of RECs |
| 9 | | How RECs changed over the past 100 years? | |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **INPUT** | | |
| 10 | Conditions | Preconditions for successful RECs | Context |
| 11 | Educational expertise | How to involve experts for secondary and primary schools? | Partners: education, Diversity Management |
| 12 | Image of science | What are the images of science and scientists those pupils have who are not interested in studying science? | Science for all |
| 13 | Infrastructure | How to involve research institutes' equipment? | Partners: research(er) |
| 14 | Science communication | Do researchers/scientists and non-scientists have the same language? Do they find a 'common ground'? | Diversity Management |
| 15 | Transfer science into school | High technology & the school | Process, Output |
| 16 | | Which institutions are most suitable to develop RECs systematically – how to optimize researchers involvement | |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **PROCESS** | | |
| 17 | Competency deve-lopment | Model of competency development | |
| 18 | ESD | Education for Sustainable Development (ESD) might increase the interest in RECs | Participation |
| 19 | Image of science | What is the meaning of 'authentic science' at different age levels? | Authenticity |
| 20 | Inquiry-based learning | Dissemination and use of inquiry based teaching meth-ods on a large scale in Europe | Methods |
| 21 | Inquiry-based learning | Inquiry-based learning in specific areas, e.g. health | Methods |
| 22 | Inquiry-based learning | How to bring cutting edge science to school 'wrapped' in inquiry-based learning? | Methods |
| 22a | nquiry-based learning and teaching | Inquiry learning and learner autonomy: implications for designing learning materials and teachers roles | Methods |
| 23 | Motivation of pu-pils/students | How can RECs make science 'cool' for 'kids'? | |
| 24 | Teaching & lear-ning methods | Do science teachers meet PISA requirements? Do they stimulate/facilitate students to ask open scientific ques-tions, explain phenomena scientifically, present scien-tific evidence (not opinion)? | Partners: teachers, methodology |
| 25 | | What are characteristics of scientists which are inter-ested in RECs? | |
| 26 | | How to reward a scientist, collaborating in REC? | |
| 27 | | How children can participate in day to day research – more suitable and less suitable research topics | |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **OUTPUT** | | |
| 28 | Curriculum development | Developing curriculum models in RECs | |
| 29 | Impact | Learning processes and changes in attitudes with all partners involved in a REC (pupils/teachers/researchers) | Evaluation |
| 30 | Impact | What influence do RECs have on researchers' attitudes to education? | Partners: Research(ers) |
| 31 | Impact | What change do the researchers in a REC undergo when interacting with educational partners (pupils, students, teachers, educational research)? | Partners: Research(ers) |
| 32 | Impact | 'Mutual gain hypothesis': What have teachers and researchers learned from the REC? Has it brought any changes in local curriculum? | Partners: Research(ers)/ Teachers, School |
| 33 | Inquiry-based learning | Inquiry-based learning in out-of-school learning centers: research -> development of examples/programs | Learning material |
| 34 | Scientific knowledge/ competencies | Are transactive RECs increasing science competencies/scientific literacy of the pupils/students? | Evaluation |
| 35 | Scientific knowledge/ competencies | What is the level of understanding of basic principles we can reach/we want to reach in a REC? Is it 'real science' or a Troyan horse for teaching 'school science' ? | Input, Process |
| 36 | Scientific literacy | Can RECs contribute to an informed debate on ethics and science, and how? | Evaluation |
| 37 | Teaching & learning materials | Developing teaching & learning materials in RECs | Learning material |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **OUTCOMES** | | |
| 38 | ESD | Influence of RECs on Education for Sustainable Development (ESD) | More sustainable world |
| 39 | Image of science | What influence do RECs have on the perception of science by girls and boys? | Gender |
| 40 | Impact | Vocational choices: How to get people (pupils/students) to choose a scientific career? Are RECs a possibility? | Career building |
| 41 | Impact | Do RECs influence the perception of science of the broader public? | Science communication |
| 42 | Science communication | What is the exact role of RECs in science communication? | |
| 43 | Scientific excellence | How to keep/build up scientific leadership in a changing world? | |
| 44 | Visions | RECs and the future: Delphi study about possible scenarios | |

| | Area | Question/Subject | Categories |
|---|---|---|---|
| | **FEEDBACK** | | |
| 45 | Teaching & lear-ning methods | Is the impression of many RECs being transmissive correct? | Evaluation methodo-logy |
| 46 | Longterm impact | Does the impact of RECs in terms of changes in atti-tude/motivation/ competencies persist over time? | Evaluation |
| 47 | Longterm impact | What do adults think of RECs they experienced 10-15 years ago? (longterm) | Evaluation |
| 48 | Networks | Added value of REC networks | Evaluation, Scaling up |
| 49 | Output | Are the 'desirable RECs' put forward in the Survey on RECs really leading to transaction? | Evaluation methodo-logy |
| 50 | REC sustainability | How to build a long-term benefit into the life of the school? | Partners: education |
| 50a | REC sustainability | How to make REC an element of regular science edu-cation | |
| 51 | Teacher education | Can systematic teacher in-service training improve sci-entific literacy of the pupils/students? | Evaluation |
| 52 | Teacher education | How can teachers be taught how to realize RECs? | Partners: teachers |
| 53 | Teacher education | Role/contribution of RECs in/to the professional development of teachers | |
| 54 | | Definition/types of RECs | |