

An instrument for supporting teachers and teacher trainers during mathematics and science educational renewal

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This project has taken place within the Freudenthal Institute for Science and Mathematics Education, in the group taking part in the European Union Mathematics and Science for Life (*mascil*) project.

Abstract

The recently started EU mathematics and science for life (*mascil*) project offers an opportunity to find characteristics of guideline documents that are supposed to support teachers and teacher trainers in taking up intended innovations during the implementation phase of educational renewal. Gathering opinions of educational renewal experts and teacher trainers on the *mascil* guideline document improves our understanding of characteristics of guideline documents. Opinions of experts were gathered using a two cycle Delphi study. Six experts on educational renewal were sent a questionnaire on the *mascil* guideline document. Answers were summarised and sent back for verification. Opinions of teacher trainers were gathered using a questionnaire. Fifteen teacher trainers filled in the questionnaire. Answers from both experts and teacher trainers showed that guideline documents should start with examples, than give a thorough work plan on adaptation of tasks, and finally include a section on renewal theory. Usage of guideline documents should be coupled to professional development sessions and connected to experiences of daily practice. This possibly makes renewal projects more sustainable by enhancing implementation phase effectiveness.

1. Introduction

Educational renewal, being both designing new educational tasks and designing complete educational programs, is an important area for teachers, educational authorities, principals, researchers, and teacher trainers around the world. However, aspects of educational renewal still bring challenges. One of the most important of these aspects is sustainability of the renewal efforts. Showing the importance of sustainability of educational renewal, Hargreaves and Fink (2006, p. 2) argue: ‘‘If the first challenge of change is to ensure that it is desirable, and the second challenge to make it doable, then the biggest challenge of all is to make it durable and sustainable’’.

Making educational renewal durable and sustainable relies on the success of the implementation phase of educational renewal (Kuiper, 2009). The success of this implementation phase depends strongly on the affected teachers, and on the role of teacher trainers during professional development (Fullan, 2007). Involving teachers in implementing new educational ideas is crucial for educational renewal projects (Fullan, 2007; Thijs & Van den Akker, 2009). Motivating teachers who are unaware of the necessity to change their classroom practice has even been called the biggest challenge of educational renewal (Kuiper, 2009). If a new part of the curriculum needs to become part of daily practice, it is important to understand how to involve and support teachers and teacher trainers during the implementation phase of educational renewal.

The recently started EU Mathematics and Science for Life (*mascil*) project offers an opportunity to investigate how to support teachers and teacher trainers during an implementation phase of educational renewal. The aim of *mascil* is to facilitate implementation of inquiry based learning (IBL) practices in the science and mathematics classroom of primary and secondary schools, and connect those to world of work (WoW) contexts.

One of the products of the *mascil* project is a guideline document for teachers and teacher trainers. This guideline document is supposed to support teachers and teacher trainers in developing IBL-oriented classroom materials for science and mathematics using workplace contexts. Next to this, the guideline document supports teachers to use these materials for changing their classroom practices. It also provides them with information on how to adapt and implement existing tasks to make them meet *mascil*'s goals. In short, this guideline document is aimed to make the *mascil* project more sustainable. However, little information is available about characteristics of such documents.

The guideline document can be viewed as a bridging instrument, trying to bridge the gap between key players like educational authorities and teachers and between documents like curricula descriptions and textbooks. The guideline document of *mascil* can be used by all stakeholders, conferring *mascil*'s aims to different layers of people involved with educational renewal. However, it remains unclear how such a document should look like and how it should be used to bridge these gaps most effectively.

1.1 *Mascil*: IBL and WoW

Currently, the EU supports renewal projects in the area of inquiry based approaches to science teaching, like the *mascil* project (Maass & Doorman, 2013). Promoting IBL is one of the core elements of the *mascil* project (Figure 1). In IBL learning is driven by ‘‘students drawing upon their scientific knowledge to ask scientifically oriented questions, collect and analyze evidence from scientific investigations, develop explanations of scientific phenomena, and communicate those explanations with their teacher and peers’’ (Furtak, Seidel, Iverson & Briggs, 2012, p. 301; NRC, 1996). One of the widely accepted assumptions is that developing inquiry skills is needed for future lives as active, creative, and flexible citizens in the quickly changing 21st century (The Partnership for 21st century skills, 2009). For IBL to work optimally, the teacher is expected to guide and scaffold the learning process actively (Hmelo-Silver, Duncan & Chinn, 2007). It has been noted that minimal guided discovery methods might have adverse effects on student learning (Kirschner, Sweller & Clark, 2006). The *mascil* form of IBL therefore asks for guiding and supporting teachers.

The other core element of *mascil* is using world of work (WoW) contexts (Mascil, n.d.). These contexts make mathematics and science more meaningful and useful than regular textbook tasks lacking context, by giving a sense of purpose and utility to students (Ainley, Pratt, & Hansen, 2006). WoW contexts are promising for context-based science education, for they can be presented as authentic practices (Dierdorff, Bakker, Van Maanen, & Eijkelhof, 2010; Prins, 2010). Authentic practices are considered to be the most promising model for context-based science education (Gilbert, 2006). Consequently, the *mascil* project also includes attention for and development of competences related to activities from the workplace like dealing with deadlines, taking professional roles, and developing a product (Figure 1). These elements are again connected strongly to skills needed in the 21st century (The Partnership for 21st century skills, 2009).

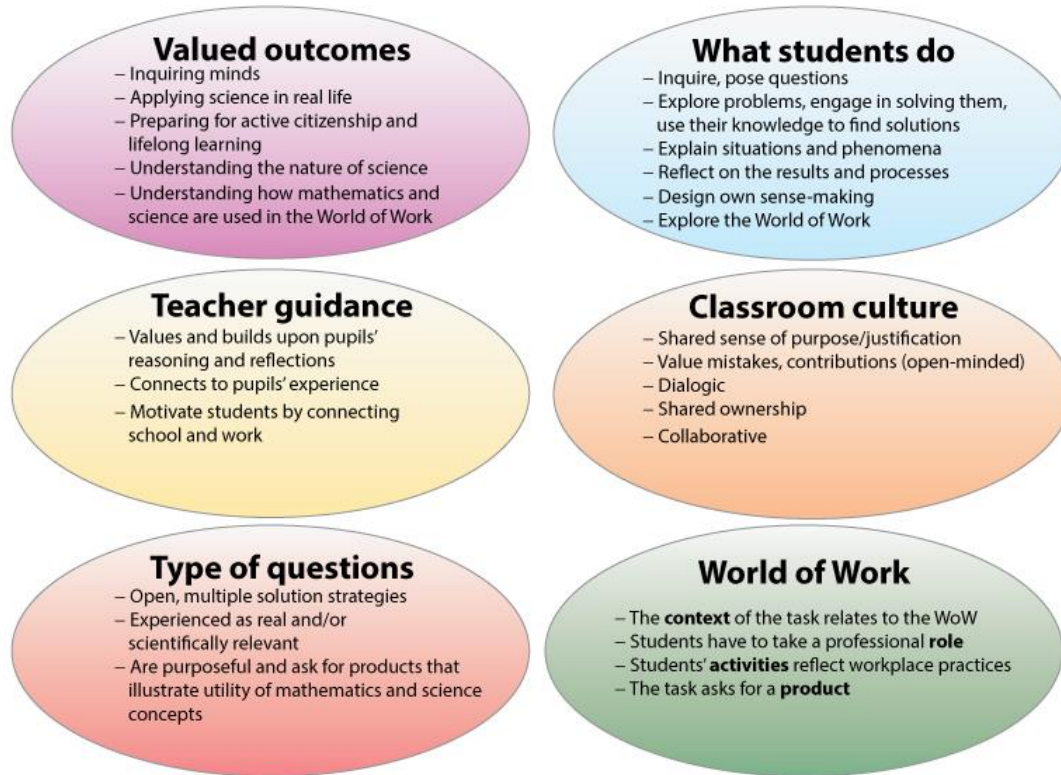


Figure 1 | *Mascil* framework as defined by the *mascil* team. Adapted from Doorman et al., 2014.

1.2 Scaling up: depth and ownership

The *mascil* team develops tasks, professional development courses, and a guideline document to implement IBL and WoW contexts. These dissemination resources play a role during scaling up of the renewal effort. Scaling up renewal efforts is one of the main challenges during the implementation phase (Coburn, 2003). Crucial elements of scaling up are (i) bringing depth to educational renewal, and (ii) creating teacher ownership of the reform effort.

Bringing depth to a renewal effort stresses the importance of giving teachers a better understanding of reform theory. This depth is crucial for creating optimal implementation conditions (Coburn, 2003; Elmore, 1996; McLaughlin & Mitra, 2001). In bringing depth to renewal efforts, teachers should gain a deepened understanding of reform theory, hereby altering their beliefs, norms of social interaction, and enacted pedagogical principles to meet the goals of the renewal project at hand (Coburn, 2003).

This enhanced understanding of reform theory is paired to the second element of scaling up: teachers becoming owners of reform efforts (Coburn, 2003; Huang, 2004; Kirk & MacDonald, 2001). Teacher ownership of reform is desired, for it makes teachers aware of the aims of reform, it makes them feel the need for renewal, and ultimately raises willingness to adapt existing curriculum materials to needs of their students, hereby making them fully implement reform in their practice (Elmore, 1996).

Teachers' willingness to change relates to Van Eekelen's (2005) five levels of preparedness teachers express during renewal (Thijs & Van den Akker, 2009). These levels are (i) *problem denial*, during which teachers are not prepared to change their practice, (ii) *tentative recognition*, where teachers do recognise the problem, but feel it is caused by someone or something else, (iii) *preparation*, during which teachers like to receive concrete information to help them change, (iv) *implementation*, during which teachers take a lot of effort to change and are likely to fall back to old practices, and (v) *maintenance*, during which teachers are completely familiar with the change and cannot imagine ever doing it otherwise.

By showing teachers how to adapt tasks, guideline documents have the potency to facilitate teacher ownership of reform during most of these levels. However, guideline documents are a lot less effective when used without (prior) professional development (Thijs & Van den Akker, 2009). Therefore, blended scenario's using both guideline documents and professional development during implementation are highly recommended, and much more effective in letting teachers become owners of reform.

1.3 Top-down and bottom-up strategies

There is a vast amount of research on continuous professional development (Armour & Duncombe, 2004). The National Partnership for Excellence and Accountability in the USA has identified several important aspects of professional development, regardless of the topic of the educational renewal (NPEAT, 1998). These include providing teachers with support for further learning, and CPD providing opportunities to gain an understanding of the theory underlying the knowledge and skills being learned.

To implement educational renewal projects like *mascil*, and to promote ownership and sustainability of these projects, top-down and bottom-up strategies can be distinguished. Top-down strategies refer to all strategies that involve external parties asking for teachers to change their teaching. Educational renewal efforts should always be stimulated top-down by governments or other institutions, because this strengthens teachers and teacher trainers in their willingness and ability to change their daily practice

(Kuiper, 2009). During top-down stimulation, clearness and consistency of a renewal effort is essential for its success (Kuiper, 2009; Kuiper, Nieveen & Berkvens, 2013). Effective top-down stimulation is achieved by involving various parties in reform projects, like policy makers, educational authorities, and school principals.

Next to top-down stimulation, bottom-up approaches are essential as well (Kuiper, 2009). In this vision, teachers are to become owners of reform projects. They should be able to adapt educational tasks to their student's needs, but leave the theoretical core of the reform intact. This process of adaptation of educational resources is another important part of the implementation phase of educational renewal (Penuel & Gallagher, 2009). Newly designed curriculum materials almost always need to be adapted to fit local needs of teachers and students (Barab & Luehmann, 2003). Here, a deeper understanding of reform theory by teachers is essential.

Renewal also has to be stimulated by teacher trainers during professional development (Kuiper, 2009). Teachers will need ongoing professional development, in the form of for instance continuous professional development, because of constantly changing curricula (Coburn, 2003). Teacher trainers play a key role during dissemination of educational renewal in supporting teachers to take up curricular renewal efforts, and are therefore of major interest. They should be able to facilitate the transition of the reform from ‘an externally understood and supported theory to an internally understood and supported theory-based practice’ (McLaughlin & Mitra, 2001, p. 21). Professional development has been proven to be successful if it combines ‘learning-off-job in courses with learning-on-job in school’ and when ‘teachers are given feedback about their teaching’ (Maass & Doorman, 2013, p. 890).

Using a combination of authorities promoting the innovation top-down, teacher trainers carrying out professional development, and teachers modifying and adapting innovation content bottom-up, might be the most effective way to implement educational renewal (Altrichter, 2005; Kuiper, Nieveen & Berkvens, 2013). However, research is needed to investigate how to support renewal efforts, assisting teachers and teacher trainers by designing guideline documents (Davis & Krajcik, 2005; Penuel & Fishman, 2012).

1.4 Research aim

The research project discussed here focuses on finding characteristics of guideline documents that are supposed to support teachers and teacher trainers in taking up intended innovations during the

implementation phase of educational renewal. In doing so, this project aims to understand which elements should be present in effective guideline documents, and how these documents can be used to support curriculum renewal most efficiently. The goal of this project is both advisory and descriptive, the questions asked will be evaluative. Conclusions are supposed to increase the sustainability of future educational renewal by improving implementation phase effectiveness. Using the *mascil* guideline document as a case-study will yield characteristics of guideline documents for other educational renewal projects as well.

The central research question for this project is: What are characteristics of effective guideline documents on science and mathematics educational renewal for teachers and teacher trainers?

Sub-questions connected to this main questions are: In which ways can the *mascil* aims be connected to current teaching practices for creating awareness and the need to change among teachers? What characteristics of guideline documents do experts on educational renewal find important, and how do they think guideline documents will be used? How would teacher trainers use the guideline document, and what do they think it should look like?

2. Methods

2.1 Research design

Different data sources and different methods of data collection were used during this project. Using opinions of *mascil* members, experts on educational renewal, and teacher trainers and using different methods of gathering characteristics will most likely result in a thorough set of characteristics of guideline documents. This research project was divided into one exploratory phase, and two research phases (Figure 2).

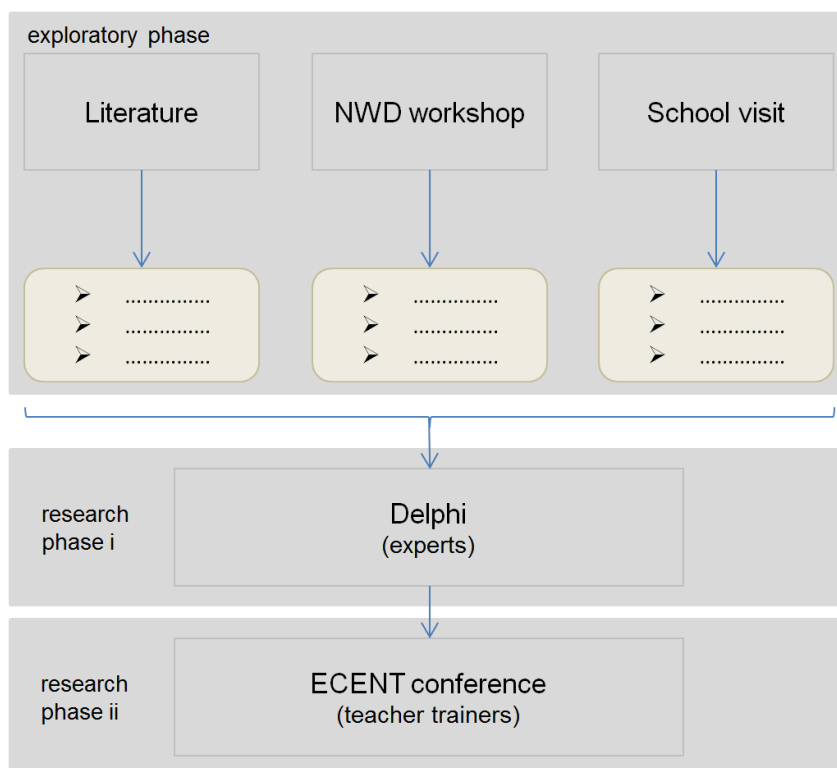


Figure 2 | Schematic representation of the research design of the project. The exploratory phase will consist of literature analysis, analysis of a recording from a *mascil* workshop at the *Nationale Wiskunde Dagen* (NWD), and analysis of a school visit of a lesson during which a *mascil* task was tested. During the first research phase, the opinion of experts on the *mascil* guideline document will be analysed by a two-cycle Delphi research. The second research phase will consist of evaluation of the *mascil* guideline document by teacher trainers during the ECENT conference of May, 2014.

2.2 The exploratory phase

The exploratory phase of the research project consisted of a theoretical part and two pilot studies. This exploratory phase was aimed at exploring possible teaching practices connected to *mascil*, hoping to find basic building blocks of guideline documents. The theoretical part included an analysis of literature connected to this research project, whereas the two pilot studies involved a *mascil* workshop and a school visit.

During the *mascil* workshop at the *Nationale Wiskunde Dagen* (NWD), teachers were informed on *mascil* theory by teacher trainers, and textbook tasks were adapted to incorporate WoW contexts and to give them an inquiry-based nature. Data collected during this workshop were looked into to gain insight in using guided (re)design of schoolbook tasks as means to bridge the gap between *mascil* theory and textbook tasks, with the aim to find possible building blocks for guideline documents and to explore potential starting points for creating awareness of *mascil* aims among teachers.

Two secondary school lessons at the *Lek and Linge College* in Culemborg, The Netherlands were attended. During these lessons, the teacher tested a (re)designed *mascil* task. Data from this pilot study were gathered to test whether the teacher experiences *mascil*'s aims in relation to her own daily practice, again with the opportunity to find possible building blocks for the guideline document.

For the exploratory phase, sampling was carried out by reading primary research, review articles, dissertations, books, and other literature on educational renewal or any other subject connected to this research project. Articles were found using three starting points: (a) the *mascil* proposal, (b) references found for a paper investigating the role of the teacher during educational renewal, which mainly incorporated articles from the course *Advanced topics: The implementation of mathematics and science curriculum efforts* given by Wilmad Kuiper at Utrecht University, and (c) suggestions of advisors during the project. Using these papers, and articles they refer to, resulted in 30 references that form the fundament of this study. These references were used to provide an entry into the field of interest as opposed to being the basis of a full literature review.

The sample from the *Nationale Wiskunde Dagen* workshop consisted of teachers who were able to choose one out of 11 parallel workshops. During this workshop, teachers adapted schoolbook tasks which were printed on sheets. There was also a group discussion and several discussions in small groups. Data were

collected by gathering all the sheets on which the teachers had written down their adapted tasks. Furthermore, the discussion of one of the small groups of teachers was recorded using an audio recorder.

The *Lek en Linge College* was chosen for the school visit because of ties to the Freudenthal Institute and Utrecht University. Notes were made during the school visit lessons at the *Lek en Linge College* in Culemborg, The Netherlands, and during the small discussions with the teacher which were held as a form of reflection afterwards. Next to these data, two videos were made during plenary discussion in the classroom.

Due to the exploratory nature of this phase, data were studied rather than analysed. The data were aimed to provide a first impression as to which basic building blocks could be present in the guideline document, and how a guideline document could possibly be used by teachers.

2.3 The first research phase

During the first research phase, opinions of educational renewal experts on the *mascil* guideline document were collected. To accomplish this, a two cycle Delphi research was used (Clayton, 1997). Since this phase revolved around opinions of experts, and a common statement on possible characteristics of the guideline document was sought, the Delphi method was suitable here. It is considered to be a relatively strong method using opinions of experts to reach a common agreement in a systematic way (Gupta & Clarke, 1996). The experts filled in a questionnaire dispersed via the internet on the nature and characteristics of the *mascil* guideline document and on their personal experience with educational renewal in general. Since using an internet questionnaire involves no face-to-face contact, the advantage of the Delphi method being anonymous was warranted. Answers of experts were summarised. To check the agreement of the experts with the summary, it was sent back to the experts with another small questionnaire.

The sample for the first research phase was hand-picked, so purposive sampling was used. This is a valid method in this case, since the research design asks for the opinion of experts, which will provide the most valuable data for this section of the project (Denscombe, 2003). However, a disadvantage of this study is the definition of the boundaries of the cases used. In this study, the experts chosen to participate were selected so they represent different groups involved with educational renewal. Some of them have experience developing textbooks, others have taught at high schools themselves, and even others directly

developed curricula in governmental institutions. Most of the experts were Dutch. The non-Dutch experts were from the *mascil* advisory board, or otherwise associated with the *mascil* project. Response rates were expected to be high since these experts have professional relationships with either the research team or the *mascil* team.

During this phase, data were collected using a questionnaire distributed via the internet (Appendix 1). This questionnaire contained evaluative questions about the *mascil* guideline document, and questions on characteristics of educational guideline documents in general. The questionnaire went through several stages during development, each being evaluated by three separate individuals. This expert validation was meant to improve the questions and structure of the questionnaire. Likert scales were added to provide an entrance point into the data, and more general questions on the history of the experts with educational renewal were placed at the beginning of the questionnaire to get the experts in the right mind-set. The final version was tested within the Freudenthal Institute as a final check and to ensure questions being interpreted correctly.

To standardize data during the first research phase, a two cycle Delphi research was used. This involved summarizing answers from the first round and sending these summaries back for evaluation. Doing this enhanced the quality and generalizability of the data (Gupta & Clarke, 1996), whilst also improving the validity of the data (Williams, 2003). Next to this, the second round provided a form of reliability check. During the second round, experts were presented with the summary, and filled in a second questionnaire on their agreement with the statements (Appendix 2). This questionnaire with open ended questions also contained Likert scales providing entry points into the data.

Qualitative data gathered with the first questionnaire were analysed by first grouping answers of all experts per question. Notes were made next to these groups, containing every core idea of each separate answer. Finally, core ideas which were shared by more than one expert were summarised. The comments made solely by one expert were considered to be inappropriate for the main summary.

2.4 The second research phase

With the input from the exploratory phase and the first research phase, a set of characteristics of the guideline document was put together during the second research phase (Figure 2). These characteristics were used to improve the original guideline document. During the 2014 ECENT conference, opinions of teacher trainers on what they want from guideline documents in general were sought using a small questionnaire with open ended questions. During the workshop, the participants were presented with the general structure of the guideline document. Several examples from the guideline document were given as well. The questionnaire aimed to gather opinions on practicality and workability of this guideline document. Two short interviews were carried out to ensure validity. Next to that, a second rater performed part of the data analysis to check for researcher influence.

The sample for the ECENT phase consisted of fifteen teacher trainers who chose to participate in the *mascil* workshop that day. The two teacher trainers for the interviews were chosen on voluntary basis out of a random selection of workshop participants. Four of the fifteen questionnaires were marked and distributed randomly amongst the teacher trainers. After the questionnaire was finished, recipients of the four marked questionnaires were asked to volunteer for a small interview. Of these, two responded positively.

The teacher trainers have voluntarily chosen to participate in the *mascil* workshop. This indicates that they are interested in the project. Whilst this will influence findings, it is also considered to be a positive effect, since enthusiastic teacher trainers will be more likely to participate, and are more likely to come up with characteristics of guideline documents. However, this bias cannot completely be kept from affecting the data, and should be kept in mind.

Data from this phase were collected by use of a small questionnaire with two open questions on guideline documents in general (Appendix 3). Also, after the workshop, two participants were interviewed to provide a form of triangulation. During these interviews the answers to the questionnaire were discussed to check for right interpretations of the data.

Data were analysed by first grouping answers of all teacher trainers per question. Notes were made next to these groups, containing every core idea of each separate answer. Finally, core ideas which were shared by more than one teacher trainer were summarised. The interviews performed after the workshop were

analysed in the same way. These data provided a form of triangulation, by using another data source to check validity of the questionnaire data.

Next to these small interviews, the data analysis was also partially performed by a second interpreter. This was done by providing the second interpreter with two sheets of raw data and a stack of core ideas which the primary researcher had used to label these data with during analysis beforehand. The second interpreter had to match the data with the core ideas according to his interpretation. To make this task more genuine, several superfluous core ideas were added.

3. Results

3.1 The exploratory phase

The articles used during this study covered many issues in the field of educational renewal which might be connected to the use and development of guideline documents. However, no papers were found that made explicit mention of guideline documents.

During the NWD workshop, teachers used a *mascil* tasks to find characteristics of IBL and WoW contexts. During both small group and plenary discussion, they were able to come up with a list of IBL and WoW characteristics. Next, they were able to redesign textbook tasks to make them meet *mascil*'s aims. During a final discussion, they came up with a work plan for adapting tasks.

The school visit showed the benefits of using *mascil* tasks to the teacher, who thought it was a new and useful way to involve students with a topic. Although some of the aspects of the *mascil* task were still underdeveloped, the teacher was content with the lesson.

3.2 The first research phase

The following statements are summarized from the answers from the six experts gathered using questionnaires. Quantity of these statements is displayed as (-/6), showing the number of individual experts that made a similar statement. Four out of six experts indicated that they agreed or agreed strongly with the summary as displayed here, the other two did not respond to the final summary.

General problems with teachers understanding reform theory and teachers becoming owners of change are acknowledged (6/6). Possible strategies to solve these problems include involving teachers in educational renewal from the start (2/6). However, teachers need to have support and extra time to be involved in developing educational renewal (2/6). They also should follow professional development (PD) courses (3/6), and they should be able to link the renewal to their own experiences (3/6).

The guideline document is considered to be clear (3/6), but much too theoretical (2/6). The coverage of topics is good (3/6), with IBL examples being very well explained (3/6). Educational change is not explicitly mentioned in the document (2/6).

It is stressed that teachers will not read the guideline document (5/6), partially because it is too theoretical (2/6). Only some experienced teachers or some teachers who attended professional development courses from the *mascil* project might use the current document as a summary (2/6). It is stated that teachers will rely more on the PD courses themselves (2/6). However, it is said that the way this document is introduced to teachers, with an explanation on how to use it, might make them use it (2/6).

Teacher trainers will use this guideline document when designing professional development sessions (3/6). It contains useful elements for reflection during PD sessions (2/6).

Ideas that were not shared by more than one expert are presented in appendix 4. They are considered not to be part of the general consensus among experts, so they are displayed separately. 17 out of 28 core ideas made it into the final summary.

3.3 The second research phase

The following summaries are made from the forms handed in by 15 teacher trainers after the ECENT conference. Quantity of these statements is displayed as (-/15), showing the number of individual teacher trainers that made a similar statement.

The guideline document should make extensive use of examples (6/15). There should be examples with different stages of openness (2/15). Good practice examples are desired as well (2/15).

Next to these examples, the document should contain a list of steps indicating how to redesign existing tasks into IBL tasks and connecting them with WoW contexts (5/15). There should also be a section on how to find workable WoW contexts (3/15). An indication of how to keep these contexts up to date is desired (3/15). The document should also contain theory behind IBL and WoW (4/15).

Teacher trainers would use the guideline document (11/15). They would let the teachers or students design lessons or redesign tasks to make them more IBL-oriented and add WoW contexts (6/15).

The second interpreter who analysed part of the data gathered during this phase connected the core ideas in an identical fashion to the teacher trainer's statements as the primary researcher. 9 out of 24 of these core ideas made it into the final summary. The two interviews provided further reason to believe the data were interpreted correctly.

3.4 Overview and quotes

To summarize the data, both experts and teacher trainers agreed that the guideline document should make extensive use of examples. It was found that the document should start with several examples, and work its way into theory from there. In the following sections, examples should be present as well. One of the experts voiced this in the following statement, saying the guideline document:

“... should not start with a lot of theory and tips but with a short introduction followed by some examples and some experiences of real teachers. After that one may go more in depth.”

Next to examples, teacher trainers want a list of steps on the opening of textbook tasks and make them meet *mascil*'s aims. The section after the introductory example should thus contain a concise work plan enabling the target group, in this case teachers or teacher trainers, to carry out the desired change. One of the experts commented on this work plan as well. In her statement, several sections of guideline documents were mentioned:

“The document seems to be very useful for preparing PD sessions on the themes of IBL and the connection to the world of work. It gives (1) a theoretical basis, (2) good examples to work with and (3) all important keywords for characterising tasks and a structure and criteria for reflecting on tasks and their use in classrooms. Last but not least (4) teacher trainers may use these guidelines when accompanying teachers in the process of (re)designing tasks during PD sessions.”

The document should also contain a thorough but concise theoretical section. Both experts and teacher trainers consider this of importance. Opening with the theoretical section is believed to repel teachers, so if teachers are among the audience of the guideline document, it is advised to place the theoretical section at the end of the document. The theoretical section can be longer if the document is aimed at teacher trainers alone. If teachers are the sole target audience, make the theoretical section short and use accessible language.

It is also considered to be important to combine usage of guideline documents with other tactics, like professional development. When teachers are able to link reform theory to their own experiences during professional development or real in classroom testing of materials, experts believe it is more likely for teachers to feel the need for the renewal.

4. Discussion

4.1 Significance of the results

During this study, several characteristics of guideline documents on science and mathematics educational renewal for teachers and teacher trainers were found. These characteristics connect to what is already known about the implementation phase of educational renewal.

The pilot study during the NWD showed several building blocks which could be present in guideline documents. Teachers are able to find characteristics of IBL and WoW from a *mascil* task, and use these characteristics during subsequent (re)design. This indicates that a section on reform theory might be needed in the guideline document. Then, teachers were able to construct a set of guidelines for (re)design of tasks, using the many examples given to them during the workshop. Guideline documents seem to need different examples of textbook tasks and new tasks, and a sound work plan for (re)designing old tasks to make them meet reform aims.

During the school visit the teacher seemed to become more interested in *mascil*. This evokes the thought that making teachers experience tasks raises their enthusiasm for the project. Therefore, it might be effective to promote teachers testing the renewal in the classroom.

These basic building blocks were also found during the two research phases. Teacher trainers stress the importance of a section showing how to adapt tasks, making them meet the aims of the renewal project. The importance of this work plan mirrors theory about teacher ownership of renewal. The guideline document could serve as a tool for teachers, facilitating teacher ownership of the renewal project. Teachers are usually restricted by the availability of classroom materials (Kirk & MacDonald, 2001). In showing them how to adapt tasks, guideline documents improve implementation conditions of educational renewal, for more classroom materials can be designed.

For effective bottom-up teacher ownership of educational renewal, guideline documents should incorporate a systemic and logical work plan showing teachers how to act in the light of the educational renewal at hand. In the *mascil* guideline document, this means a sound work plan on how to adapt existing tasks and how to design new tasks which meet *mascil*'s aims. With this work plan, teachers become owners of the renewal, which is essential for increasing implementation phase effectiveness (Kuiper, 2009).

Both experts and teacher trainers want a section on reform theory to be incorporated in the guideline document. In doing so, the guideline document retains its ability to enhance reform depth. This will lead to teachers adjusting their daily classroom practices to meet renewal aims. One of the issues reformers face when scaling up educational renewal is building reform-centred knowledge and materials within schools, in such a way that informed decisions can be made in relation to the educational renewal project (McLaughlin & Mitra, 2001). Providing a guideline document with a strong theoretical section is a sound way to solve this problem, for it enables teachers to understand the theory behind the renewal and supports them in further learning (NPEAT, 1998).

Guideline documents should be coupled to professional development sessions, creating blended scenario's (Thijs & Van den Akker, 2009). Furthermore, teacher education should provide teachers with the necessary skills and consciousness needed for local curriculum development, or adaptation of tasks, making them owners of the renewal (Huang, 2004). Thus, again, a strong work plan showing step by step adaptation of tasks using appropriate examples should be essential in the *mascil* guideline document and possibly other guideline documents as well.

The experts state that teachers should be able to link the renewal to their own experiences. This is thought to raise their willingness to commit to the renewal project, making them feel the need for change. These statements are tightly linked to Van Eekelen's (2005) five levels of preparedness teachers express during renewal. Linking the renewal to their own experiences might result in teachers occupying higher levels in Van Eekelen's scale, indicating that they are more willing to implement the renewal and even feel the need to do so. If the guideline document is coupled with effective professional development, teachers have the incentive to change and the means to do so on their own. So guideline documents, when used correctly, have the potential to both involve teachers in educational renewal and support them during the process.

It has been noted that the lay-out of the guideline document also plays an important role in making it more effective to reach teachers. However, since this statement was only made by one of the six experts and none of the teacher trainers, further research is needed to look into this subject. This research should focus on finding the most effective medium for guideline documents to be presented to teachers.

4.2 Limitations

Several limitations are present in the design of this study. These limitations are mostly linked to the case-based nature of the study, caused by this study only using one guideline document from one educational renewal project. Since case-studies tend to face difficulty in credibility of generalizations, it must be made clear how conclusions from this study can be generalised. During this study, questionnaires were designed to make them find general characteristics, using *mascil* as an example instead of the target project.

However, one might question generalizability of the findings. Further research in this area is needed, to find out whether using guideline documents of educational renewal projects other than *mascil* would lead to the same conclusions as the present study.

However, the fact that this study is case-based offers advantages. One of the advantages is that using a case-study allows usage of different methods and data sources (Denscombe, 2003). Using all these different data sources provides a form of triangulation, reducing bias of individual sources (Denscombe, 2003; Denscombe, 2008), and it frequently produces high quality data (Johnson & Onwuegbuzie, 2004). Next to this, since using a case-study is suitable for theory building research like this project, results from this study are likely to be complete and meaningful (Denscombe, 2003).

To avoid pitfalls of mixed methods research, it should be made clear how to connect data from all different sources. Information from the exploratory phase was combined to create the questionnaire used during the first research phase (Figure 2). Data gathered during the first research phase guided the interviews conducted during the second research phase. Together, these data resulted in a set of characteristics of guideline documents.

A well-known problem with the Delphi method is the choice of experts, or the sample selection (Clayton, 1997). A method based on the opinions of a group of people depends strongly on the selection of those people for its success. For this study, experts were chosen with emphasis on their diverse background, to cover the biggest possible range of expertise on educational renewal. As stated in the methods section, these experts were from different countries. This might have influenced findings since differences between school systems and work ethic between the countries might lead to experts having different opinions on characteristics of guideline documents. Since these experts were all part of the *mascil* team, these differences are thought to have minor influence on the data.

During analysis of qualitative data, validity and reliability issues are a common problem (Denscombe, 2003). During the first research phase of this project, validity issues are minimized by making use of a two-cycle Delphi research, feeding summaries back to the experts for evaluation. In doing so, conclusions are double checked and validity is ensured. During the second research phase of the project, these issues are tackled by performing interviews with teacher trainers to enhance validity of the data. As with all qualitative research, the researcher's self influences the data to some extent (Denscombe, 2003). This reliability issue was accounted for by use of the two cycle Delphi method during the first research phase, and by using a second interpreter of the data during the second research phase.

A last limitation of this study is the fact that no teachers were consulted during the main research phases. Since so little information was available on characteristics of guideline documents, this study can be seen as an introduction into this particular field. Findings from this study should be supplemented with subsequent research involving teacher opinions on guideline documents. This will further increase our understanding of guideline documents, resulting in a thorough overview of guideline document characteristics.

4.3 Conclusion

This study aimed to find characteristics of effective guideline documents on science and mathematics educational renewal for teachers and teacher trainers. The experts on educational renewal and the teacher trainers which participated in this study came up with three sections for the guideline document which seem to be essential. An effective guideline document should start with different examples, then offer a working plan for adaptation of existing curriculum material, and finally offer a concise theoretical section, underpinning the adaptations and bringing depth to the renewal. Using guideline documents during professional development sessions linking the renewal to teachers own experiences further improves their willingness to change and makes them feel the need for the renewal effort.

If these sections are present in a guideline document and if the document is presented connected to professional development sessions and daily practice, the guideline document can be a powerful instrument supporting implementation of educational renewal. With this, we are one step closer to tackling the biggest challenge of making educational renewal durable and sustainable (Hargreaves & Fink, 2006).

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Questionnaire on the mascil guideline document

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This questionnaire, belonging to my Master research project at the Universiteit Utrecht, is about the guideline document belonging to the *mascil* project which was sent to you by mail. Please have a look at this document before answering the questions.

Upon receiving the answers to this questionnaire, a general statement containing opinion of all experts will be formulated. This statement will be sent back to you with the goal to check its validity. After this second round, the statement will be used to improve the *mascil* guideline document.

The *mascil* (*mathematics and science for life*) project aims to promote a widespread implementation of *inquiry-based learning* (IBL) in primary and secondary schools across Europe. The major innovation of *mascil* is to connect IBL in school with the *world of work* (WoW), making science more meaningful for young students and motivating their interest in careers in science and technology¹.

To achieve these aims, the *mascil* team, amongst many other activities, designs example tasks and a guideline document for (re)designing tasks that support IBL in connection with the WoW.

Among the many theories on educational change, there are two points of big importance for teachers for the success of the *mascil* project:

1. teachers and teacher trainers should understand **why** *mascil* tasks might help to complement IBL and a connection to the WoW, and
2. teachers and teacher trainers should be able to **select** and **adapt** parts of the *mascil* tasks and of their own task (textbook, projects, etc.) to their needs and those of their students for addressing IBL and using WoW contexts.

Please answer in English and explain your answers concisely. Answers given will be dealt with anonymously in research publications and activities and will be kept strictly confidential.

¹ For more information, see <http://www.mascil-project.eu/about-the-project.html>

Questions addressing educational change in general

1. What experience with educational change comes first to mind (e.g. a project, etc.)?

2. Problems with teachers understanding the theory behind reform efforts and teachers becoming owners of change are recognisable for me.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

What suggestions do you have related to these problems?

The questionnaire continues on the following page.

Questions addressing the mascil guideline document

3. The relationship between text and visualisations in the guideline document is suitable for its purpose (guidelines for teachers for developing IBL-oriented classroom materials for science and mathematics using workplace contexts).

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

Why?

4. The format (e.g. length, structure, etc.) of the guideline document is suitable for its purpose (guidelines for teachers for developing IBL-oriented classroom materials for science and mathematics using workplace contexts).

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

Why?

The questionnaire continues on the following page.

5. The examples at the end of the *mascil* guideline document cover the key issues related to (re)designing tasks for IBL and WoW (key issues being addition of IBL and WoW elements to existing tasks).

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

Why?

6. Theoretical notions that are (or could be) addressed in the guideline document relate to IBL, WoW, and educational change. Are these the key notions and are they sufficiently elaborated upon?

The questionnaire continues on the following page.

7. Teachers use guideline documents like this one.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If yes: how?

If not: why?

8. Teacher trainers use guideline documents like this one.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If yes: how?

If not: why?

The questionnaire continues on the following page.

9. Do you feel any information is missing or is superfluous in the *mascil* guideline document?

10. Please fill in any other comments you have on the guideline document here.

Thank you very much for your time.

Summary of answers from experts

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Data gathered with the *questionnaire for experts on the mascil guideline document* were analysed by first grouping answers of all six experts per question. Notes were made next to these groups, containing every core idea of each separate answer. Finally, ideas which were shared by more than one expert were summarised. Quantity of these statements is displayed as (-/6), showing the number of individual experts that made a similar statement. Would you please be so kind to read the summary and answer the five questions on the following pages.

Summary

General problems with teachers understanding reform theory and teachers becoming owners of change are acknowledged (6/6). Possible strategies to solve these problems include involving teachers in educational renewal from the start (2/6). However, teachers need to have support and extra time to be involved in developing educational renewal (2/6). They also should follow professional development (PD) courses (3/6), and they should be able to link the renewal to their own experiences (3/6).

The guideline document is considered to be clear (3/6), but much too theoretical (2/6). The coverage of topics is good (3/6), with IBL examples being very well explained (3/6). Educational change is not explicitly mentioned in the document (2/6).

It is stressed that teachers will not read the guideline document (5/6), partially because it is too theoretical (2/6). Only some experienced teachers or some teachers who attended professional development courses from the *mascil* project might use the current document as a summary (2/6). It is stated that teachers will rely more on the PD courses themselves (2/6). However, it is said that the way this document is introduced to teachers, with an explanation on how to use it, might make them use it (2/6).

Teacher trainers will use this guideline document when designing professional development sessions (3/6). It contains useful elements for reflection during PD sessions (2/6).

Questions

1. The summary includes my opinions on the *mascil* guideline document.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If you have any commentary on this statement, please write it down here.

2. All my main comments on the guideline document are present in the summary.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If you have any commentary on this statement, please write it down here.

The questionnaire continues on the following page.

3. I agree with the statements made in the summary.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If you have any commentary on this statement, please write it down here.

4. To make the guideline document more accessible to teachers, it could start with examples and an explanation on how to use it, with theory in the end or in an annex.

Strongly agree

Agree

Disagree

Strongly disagree

No opinion

If you have any commentary on this statement, please write it down here.

The questionnaire continues on the following page.

5. Please fill in any other comments you have on the summary, the guideline document, or the project in general here.

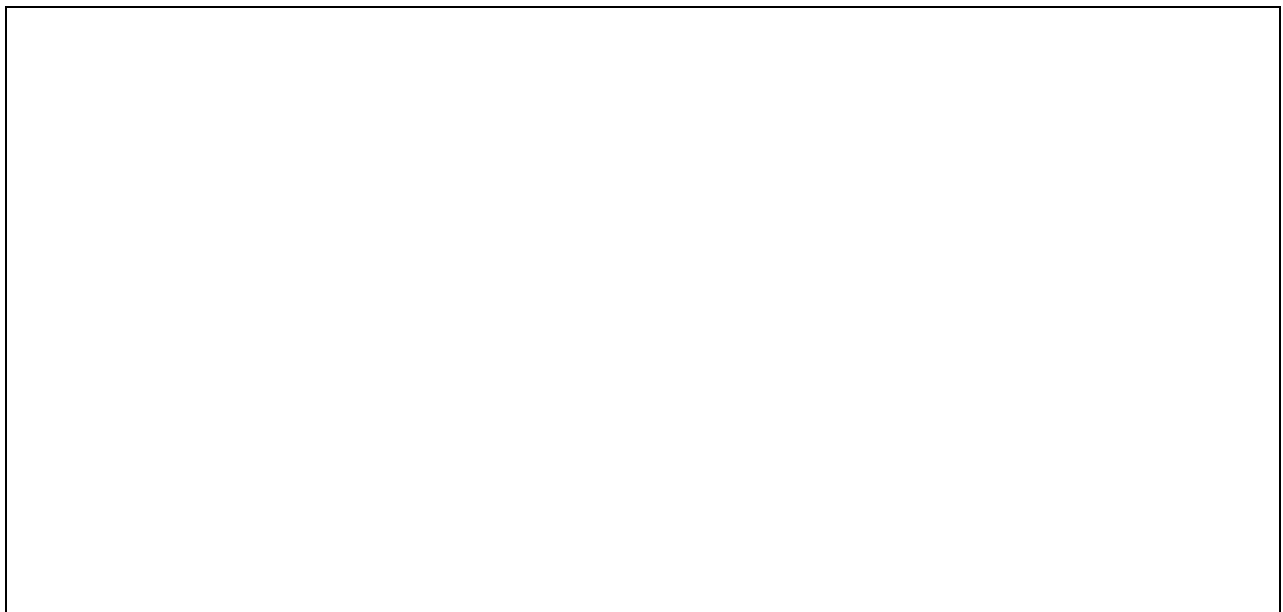
Thank you very much for your time.

Appendix 3: Second research phase questionnaire [English version, a Dutch version was used during the experiment]

How should the guideline document look like for it to be effective during designing a professional development session?



Can you give an example of how you would use the guideline document during your daily practice?



Appendix 4: Statements made by separate experts, data from phase 2.

A possible strategy for solving problems regarding educational renewal is making teachers co-designers of the reform effort.

Teachers should become aware of the need for change.

Teachers are already heavily burdened, and prefer classroom materials that are ready to use.

The document is much too long.

To make the document more accessible for teachers, maybe the main document could be very short, only offer some information on IBL and WoW, with one example for mathematics and science for each of these issues. The rest of the document can be placed in the appendix.

To make the document more useful to teachers, it might also help to have a section on how teachers should approach professionals from industry.

Examples for the WoW might focus more on the four dimensions mentioned in the text (context, activities, professional role, product).

Information on the nature of educational change is not needed in the document.

Providing several versions of the same task is very good.

When this document is presented in a different way, for instance in a teacher journal, with a nice layout and more practical advice, its usefulness and accessibility for teachers might increase.

There seems to be an inherent contradiction or tension ‘‘between authenticity in respect to the WoW and the inquiry based character of the task. Actions, processes or procedures used in workplaces often strictly follow rules or recipes. It might be interesting to discuss this issue with contacts from the WoW, especially with vocational teachers or instructors in firms when collaborating on formulating tasks related to the respective field of work’’.