

Collaborative curriculum design to increase science teaching self-efficacy: observation of teacher interactions

Chantal Velthuis^a, Petra Fisser^b, Jules Pieters^b

^aEdith Stein University for Teacher Education, PO Box 568, 7550 AN Hengelo, the Netherlands

^bDepartment of Curriculum Design & Educational Innovation, Faculty of Behavioral Sciences, University of Twente, PO Box 217, 7500 AE Enschede, the Netherlands

Corresponding author:

Chantal Velthuis

Edith Stein University for Teacher Education

PO Box 568, 7550 AN Hengelo, the Netherlands

E-mail: chantal.velthuis@edith.nl

Telephone: +31 74 851 6247

Fax: : +31 74 851 6161

Abstract

Teachers' sense of self-efficacy is a predictor of their behavior in the classroom, because self-efficacy affects the effort they invest in teaching. In this paper we describe how a Teacher Design Team (TDT) contributes to the increase of science teaching self-efficacy of primary teachers. Interactions of teachers are observed during curriculum design, to determine the value of different design stages for increasing self-efficacy. The results show that the stages Analysis, Design and Development provide the most valuable interactions. It is also confirmed that success, by performing activities in the classroom, is still an important means to stimulate science teaching self-efficacy.

Science teaching self-efficacy, curriculum design, team collaboration, interactions

1. Introduction

Primary teachers should be able to create a learning environment that challenges children to ask questions about Science & Technology (S&T) and to discover their own answers. This inquiry based way of learning stimulates better understanding of science concepts and it motivates children to learn science (Mantzicopoulos, Patrick & Samarapungavan, 2008). To further improve S&T education in this direction, teachers in the Netherlands are encouraged by the government by an innovation initiative called VTB-pro to participate in a professional development program. Those programs for teaching S&T in primary schools concentrate mainly on subject matter knowledge, pedagogical content knowledge (PCK), and partly on attitudes towards S&T. However, such a regular professional training program seems not enough to result in a change in S&T education (Author et al., 2010). 90% of the schools, who participated in this program still judge the subject S&T as not important enough to search for time in the overloaded curriculum (Warps, Wartenbergh, Hogeling & Pass, 2010). A more promising way to really improve S&T education is increasing self-confidence of teachers in teaching science. More self-confident teachers in science teaching do more inquiry-based science activities with their students (Harlen & Holroyd, 1997; Plonczak, 2008) and spend more time teaching science in their classrooms (Harlen & Holroyd, 1997). Also, according to theory about self-efficacy, teachers with a high sense of teaching self-efficacy will invest more in teaching (Bandura, 1986; Tschannen-Moran & Woolfolk Hoy, 2007). Therefore, the key to improve S&T education and to invite teachers in primary schools could be by increasing teachers' self-confidence in science teaching or their science teaching self-efficacy, instead of focusing on subject matter knowledge and PCK. In this study an alternative way of professional development, a Teacher Design Team (TDT), is introduced to increase self-efficacy in teachers. A TDT is a collaboration between teachers and a researcher working together to renew their own curriculum (Handelzalts, 2009). Participating in a TDT is expected to increase self-efficacy, because it is shown to contribute to more self-confident teachers (Handelzalts, 2009) and a TDT does take into account the four sources of influence to increase self-efficacy as defined by Bandura (1986): mastery experiences, vicarious experiences, social persuasions and reducing stress reactions. In this study we test whether the use of TDT indeed results in an increase in self-efficacy and explore to what degree stages of curriculum design contribute to improved self-efficacy of the participating teachers. The aim of the present study is to further extend TDT as a professional development program to improve science teaching self-efficacy of the participating teachers. To be able to gain more insight in the efficiency and the degree of effectiveness to improve science teaching self-efficacy during the different stages of curriculum design, interactions between team members in a TDT are observed in this study. The focus is on interactions, because interactions and exchanges of ideas among the participants in a team are considered as most important for the learning process in a TDT (Voogt, Westbroek, Handelsaltz, Walraven, McKenney, Pieters & de Vries, 2011). To be able to determine the likelihood of increasing science teaching self-efficacy of those interactions during the different stages of curriculum design, an observation instrument is developed based

on both concepts of instructional relevance (Henry, 2010) and collaboration level (Little, 1990), and data are collected.

2. Theoretical framework

Self-efficacy is defined by Bandura (1977) as one's perceived ability to perform an action that will successfully lead towards a specific goal. Teachers with a high sense of self-efficacy will set higher goals, be less afraid of failure, and find new strategies when old ones fail (Tschannen-Moran & Woolfolk Hoy, 2007). Teachers' self-efficacy beliefs may vary from subject to subject, because self-efficacy is highly context dependent (Bandura, 1977). To improve S&T education it is important to increase teachers' self-efficacy in science teaching or the science teaching self-efficacy (Andersen, Dragsted, Evans & Sørensen, 2004).

People's belief about their efficacy can be developed by four main sources of influence: mastery experiences, vicarious experiences provided by social models, people's beliefs that they have what it takes to succeed and reducing people's stress reactions (Bandura, 1986; Tschannen-Moran & Woolfolk Hoy, 2007). Mastery experiences are the most effective way of creating a high feeling of self-efficacy and the more successful the experience, the more likely one will repeat or extent their behaviour. Vicarious experiences, which are examples or experiences from others, similar to oneself, are also increasing the sense of efficacy: "if they can do it, I can too". The third source, people's beliefs that they have what it takes to succeed, is also influenced by what Bandura calls "social persuasion", to be persuaded verbally by others that they possess the capabilities to master given activities. Unrealistic boosts in efficacy are proven to be immediately challenged by disappointing results of one's efforts. Reducing people's stress reactions has to do with physical and psychological aspects and how these aspects are perceived and interpreted. Someone's mood affects his or her judgements of their personal efficacy.

A training for professional development like a teacher design team does take into account the four sources of influence to increase the self-efficacy. First, the teachers have to design science lessons and materials especially for their own students and they will experience science successes in their classroom by themselves. Secondly, in the team, the teachers exchange classroom experiences (vicarious experiences), but also ideas about the aims of their curriculum, including specific concepts, skills and attitudes that their *own* students have to learn and ideas for methods and materials as well. Especially the confrontation with the aims of their curriculum might contribute to a change in the view of teachers with regard to the importance of the subject science in primary schools. Thirdly, the teachers involved are responsible for the science curriculum innovation in their own classroom, but moreover they together are responsible for the school curriculum. This joint responsibility makes social persuasion by team members when needed very likely. The last source of influence to increase the self-efficacy is to reduce people's stress reactions. The small group of well-known colleague teachers (3 – 5) provides a safe environment to adequately acquire science knowledge, pedagogy and didactics. Such a collegial supporting learning environment is assumed to increase self-efficacy of teachers (Tschannen-Moran & Woolfolk Hoy, 2007).

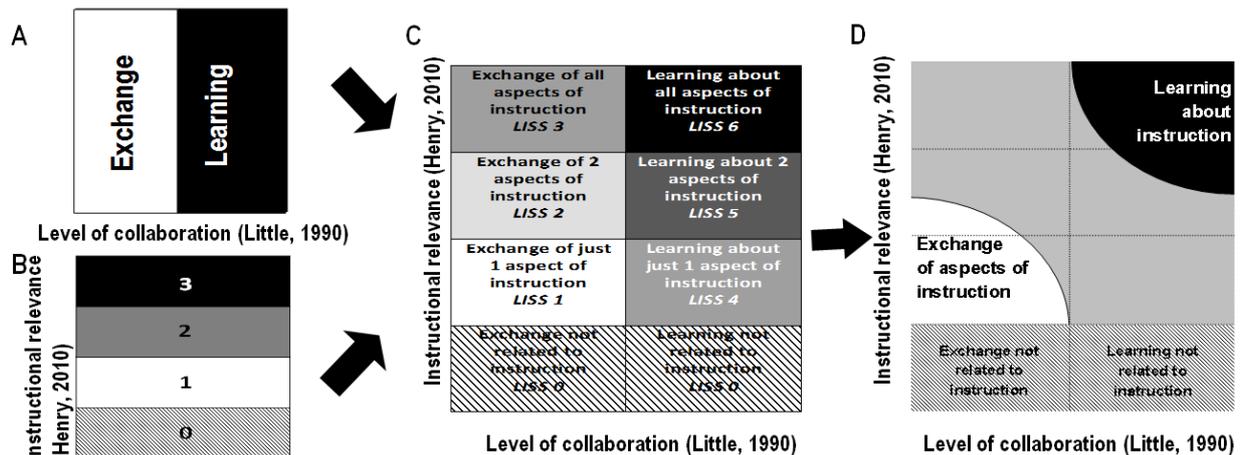
Apart from the sources of influence to increase self-efficacy as described by Bandura, it is known that the amount of 'science' content knowledge and the *self-assessed* level of 'science' content knowledge are important predictors for the science teaching self-efficacy (Author et al., submitted). Loucks-Horsley (2003) demonstrated in her study the value of TDTs in this area. Participating teachers improved their awareness of diverse pedagogical approaches and their content knowledge of science as well.

Learning in a TDT takes place individually, mainly with cognitive outcomes, and collaboratively, through interactions and exchanges of ideas between the participants (Voogt, Westbroek, Handelsaltz, Walraven, McKenney, Pieters & de Vries, 2011). In order to determine collaborative learning processes and learning outcomes, observations of interactions can give insight in valuable stages in the process of curriculum design by the team for increasing the self-efficacy. Hence, two concepts seems to be important to determine the likelihood of increasing science teaching self-efficacy of interactions during curriculum design: (1) the collaboration level or the learning potential (Little, 1990) and (2) the instructional relevance (Little, 1990; Cohen & Ball, 1999; Henry, 2010). The focus on both the level of collaboration and the extent of instructional relevance reflects our view that observing teachers' interaction is a way to measure a group's collective capacity to support professional learning with respect to science teaching, resulting in instructional improvement and thus more science teaching self-efficacy.

Collaboration has proven to be a successful learning method in groups asking each other questions, explaining and justifying opinions, articulating their reasoning and elaborating and reflecting their knowledge (Soller, 2001; Meirink, Imants, Meijer, & Verloop, 2010). Little (1990) describes four levels of collaboration with an increasing level of interdependence: (1) storytelling, (2) help and assistance, (3) sharing and (4) joint work. The more dependent the teachers are on each other, the more potential the collaboration has for learning, therefore, storytelling and help are considered as exchange, and sharing and joint work as learning (Figure 1A). Little's classification is originally based on how interaction takes place in everyday school practice, this classification is already used in several studies in more formal settings, where it has proved to be useful (Meirink, 2007; Sjoer, Meirink, & Platteel, 2010).

Besides the potential for learning of teacher interactions, it is important *what* teachers learn. To increase the science teaching self-efficacy it is important to focus on the classroom practice. For this, the key aspects of teaching and learning (content, teachers and students) are used (Cohen & Ball, 1999). Henry (2010) showed that teams, that are exploring the relations among all these aspects, are the most successful teams, those associated with high student learning gains. Successes in the classroom are important for the teachers' self-efficacy (Bandura, 1986) and therefore interaction about all three aspects of learning has a higher probability to increase self-efficacy than interaction about one or two aspects of instruction. Interaction about subjects not related to teachers, students or content will not contribute at all to the science teaching and thus will not influence science teaching self-efficacy of the teachers (Figure 1B).

Combining the level of collaboration and the amount of aspects of learning during interaction, provides us important information about the effectiveness of the teacher interaction during the process of curriculum development to improve the science teaching self-efficacy. In this study, the two levels of collaboration (exchange or learning) and the four levels of instructional relevance are combined to eight different levels of team interaction with different 'Likelihoods for Increasing the Science teaching Self-efficacy', which we call LISS levels (Figure 1C) Figure 1C is simplified to a 'LISS' diagram in Figure 1D



LISS level 0, exchange and learning of subjects with no relation to instruction will not contribute to the science teaching self-efficacy of the teachers. To LISS level 1 the conversations belong, where teachers exchange one aspect of instruction. These conversations are expected, without taken into account level 0, to contribute least to the increase of science teaching self-efficacy of the respective teachers (white). The conversations, in which teachers learn about instruction, LISS level 6, are most valuable for the teachers for their classroom practice and therefore their science teaching self-efficacy (black). The darker, the part in the figure is, the bigger is the probability that the interaction of the teachers contribute to an improvement of science teaching self-efficacy.

3. The Study

The meetings of one TDT were observed to see which interactions during the process of curriculum design led to an increase of teachers' self-efficacy. The research questions addressed in this study are:

1. Does participating in a TDT as professional development program result in an increase in science teaching self-efficacy?
2. Which stage(s) of curriculum design result(s) in interactions between teachers with a high likelihood to increase the science teaching self-efficacy?

3.1 Participants

This study was carried out in a medium sized primary school in the Netherlands, with about 190 students. The school can be characterized by being a school with many students with language deficiencies, especially related to reading texts. The five participants in the

TDT were two teachers, a pre-service teacher, the school's principal and the researcher who guided the TDT. All members participated voluntarily. Together they are responsible for the whole school-curriculum, but they also have their own specialism and their own age group (see Table I).

Table I: Participants TDT and age groups of students

Participant TDT	Responsible for age
In-service teacher 1	11-12 (group 8)
In-service teacher 2	8-9 (group 5)
Pre service teacher	6-7 (group 3)
Principal	
Researcher	

3.2 Research design

The whole design process was carried out in eight meetings of approximately two hours each. All meetings were video-taped for observation.

The assignment of the team was to redesign their S&T curriculum for students from age 4 till 12. They decided to adapt their science method, the 'Science Towers' (in Dutch: www.techniektorens.nl as well). The 'Science Towers' are cabinets shaped as towers with 80 lesson boxes inside. Each lesson box within the towers is focused on a specific topic within a domain, for example building a bridge, making soap, etc. Each box has a manual for the children, which guides them through the activity in the box. The team wanted to redesign those boxes in a way that (1) children can work more independently with those boxes, and (2) children can learn more by inquiry.

The activities associated with the ADDIE model, Analysis, Design, Development, Implementation, and Evaluation, (Dick & Carey, 1996) were used as a process guide for the design process. The team followed activities belonging to the different design stages. After analyzing the needs and opportunities for a new curriculum, alternative solutions for the curriculum were explored and a prototype for a science box was designed. From completion of this activity the team could repeat design or even analysis activities; the process guide allowed non-linear processes. Throughout the whole design process, activities were planned to pay attention to the upcoming implementation and evaluation. This way of working fits more the practice of an educational designer (Visscher-Voerman & Gustafson, 2004).

The researcher provided the structure for the design activities by the team, gave information in response to questions from the team, and stimulated the design process.

3.3 Instruments

Several data collection instruments were adapted and developed in this study to further extend TDT as a professional development program to improve science teaching self-efficacy of the participating teachers. The STEBI-NL was used to measure the science teaching self-efficacy to address the first research question (Author et al., submitted). An observation instrument was developed to gain more insight in the efficiency of the different stages of curriculum design and the degree of effectiveness of the design stages to improve science teaching self-efficacy (research questions 2 and 3). Furthermore, a teacher focus group

interview was performed to get more in-depth information about the TDT as a professional development strategy to improve science teaching self-efficacy. These instruments are explained in the next sections.

3.3.1 Teacher questionnaire: STEBI-NL

The STEBI-NL (Author et al., submitted) was used to measure science teaching self-efficacy of the teachers. STEBI-NL was translated from an existing English instrument: the STEBI-B (Science Teaching Efficacy Belief Instrument), a commonly used questionnaire to measure science teaching self-efficacy (Riggs & Enochs, 1990, Bleicher, 2004, Bursal, 2010). The STEBI-NL is a 23-item instrument, containing items such as, “I will typically be able to answer students' science questions” and “Increased effort in science teaching produces little change in some students' science”. The teachers used a 5-point Likert scale, ranging from strongly agree to strongly disagree, to indicate their opinion on the statements.

3.3.2 Observation instrument

The main goal of the observation instrument was to determine the LISS-levels of the design activities and to classify the design-activities as analysis, design, development, implementation or evaluation, based on the ADDIE-model. An observation instrument was developed based on the level of collaboration and the instructional relevance. Four levels of collaboration and four levels of instructional relevance were distinguished, based on the classifications of Little (1990) for the levels of collaboration, and the classification of Henry (2010) for the instructional relevance. The content validity of the original levels of collaboration (Little, 1990) and the instructional relevance were explored and discussed in an expert meeting, with two teacher educators and two educational scientists and one primary school employee responsible for educational research. Point of discussion was the validity of the level of collaboration and the gradation of instructional relevance. The experts concluded that the levels of collaboration and the grades of instructional relevance were not specific enough. More specific definitions were formulated and these definitions are shown in Table II and III.

Table II: Observation guide: the different levels of collaboration

Level of collaboration	How to recognize?
Story telling	Teachers exchange class experiences, without a direct connection with the curriculum design appointment.
Help and assistance	Exchange of materials, methods, ideas and opinions with team members to answer questions, to brainstorm or to solve a problem without having a discussion.
Sharing	Materials, methods, ideas and opinions were compared and analyzed. By reasoning, the team will create together 'new' ideas or opinions about what is important in science education.
Joint work	The teachers solving together a problem in their school practice. They are working on content specific materials for the curriculum and are jointly responsible for the final result. They investigate different alternatives.

Table III: Observation guide: the different levels of instructional relevance

Gradation of relevance	How to recognize?
0	Conversation has no direct relationship with teacher, pupils or content
1	Conversation focus on: teachers in isolation, pupils in isolation or content in isolation
2	Conversation explores two elements of instruction and is missing the third.
3	Conversations explores/draws connections among all three elements of instruction: teachers, pupils and content

Afterwards the instrument is tested for reliability in a second expert meeting. For this meeting, seven video fragments from different meetings and activities, in total half an hour, were shown to two science teacher educators. They were asked to score the level of collaboration and the instructional relevance from the different design activities and they also noted observed changes. The intersubjective reliability (Cohen's kappa) of the observation-instrument is .71 for both the level of collaboration and the instructional relevance, which is good (Cohen, 1960).

3.3.3 *Teacher focus group interview*

A focus group discussion interview is used in addition to the observations and the STEBI-questionnaire to get more in-depth information. Topics of the interview were: the value of a TDT as mean of professional development for teachers, the curriculum design as process guide, the collaboration process, and the corresponding role of the teachers, the principal and the researcher. To obtain as much information as possible, all teachers were invited for the interview, except the pre-service teacher who was not able to come.

3.4 *Data Collection and Analysis*

3.4.1 *Teacher questionnaire: STEBI-NL*

The teacher questionnaire was administered three times to the teachers during the development process in the TDT (pre-intervention, just before starting the development, post-intervention). Because there are only three teachers available to fill in the STEBI-NL questionnaire, only averages of individuals can be compared and no significance levels can be adjusted.

3.4.2 *Observation instrument*

First, the design activities in the team were classified as analysis, design, development, implementation or evaluation, based on the ADDIE-model (Dick & Carey, 1996). Subsequently, the level of collaboration and the instructional relevance of the activities are

determined based on the levels described in Table II and III, during the meetings by the researcher, while participating in the team. By observing the video-tapes after the meetings, the time and the changes in the level of collaboration and instructional relevance were observed in more detail. When it was not clear when a shift took place, the fragment was observed again. The result is that one activity consists of more fragments. All those fragments are divided in the seven different LISS levels (exchange and learning about subjects not related to instruction are considered both as level 0) based on both level of collaboration and instructional relevance, as mentioned before and shown in Figure 1C. Besides the LISS-levels of the interactions during the design activities, also determining the rate of time spent on the specific levels is important to improve the efficiency of the different design stages to increase the science teaching self-efficacy of the participating teachers. The more time spent on the highest levels, the more efficient the design stage is for improving science teaching self-efficacy. Therefore, the total time spent on the different levels for each stage of curriculum design is determined with the corresponding rate of the total time spent on this stage.

4. Results

First the results of the teacher questionnaire, STEBI-NL are provided to answer the question whether participating in a TDT results in an increase in science teaching self-efficacy. Subsequently the results of the observation instrument are presented to gain insight in which stage(s) of curriculum design result(s) in interactions between teachers with a high likelihood to increase the science teaching self-efficacy. The results of STEBI, the observation instrument and the focus interview are used in combination to gain insight in important components of curriculum design to extend TDT as professional development program to improve the teachers' science teaching self-efficacy.

4.1 Teacher questionnaire: STEBI-NL

The STEBI-NL is completed by the three teachers in the team, before, during (after development of materials) and after participating in the TDT. The results of STEBI-NL are presented in Table IV and indicate that the first part of the curriculum design process, till development, was most valuable for the increase self-efficacy of teacher 1 and the pre service teacher. Due to technical problems no results could be administered with teacher 2 before the TDT participation.

Table IV: STEBI-NL results of team members, before , during and after the design process in the team.

STEBI	pre	during	post
Teacher 1	3.96	4,22	4,35
Teacher 2	*	3,29	3,63
Preservice teacher	3,58	3,79	3,46

* data is missing

The science teaching self-efficacy from the teacher and the pre-service teacher is improved respectively with .26 and .21 on a 5 point Likert scale, during the first half of the design process, from the 'analysis' till 'development'. In the second half of the design process the science teaching self-efficacy of teacher 1 is increased with another.13, while the self-efficacy of the pre-service teacher is reduced with -.33. The self-efficacy of teacher 2 is improved in the second half with .34.

4.2 Observation instrument

The observation instrument was used to determine the likelihood that science teaching self-efficacy will increase during the design activities. The time (minutes) spent on the different LISS levels during the stages of curriculum design(Analysis, Development, Design, Implementation and Evaluation) of one team are displayed in Table V and Figure 2.

Table V: Number of minutes spent on the different LISS level during the stages of curriculum design of one team (minutes spent on a specific LISS-level/ total time spent on the corresponding design stage* 100%)

	level 0	level 1	level 2	level 3	level 4	level 5	level 6	Total time
Analysis	0 (0%)	12(20%)	0 (0%)	0 (0%)	8 (14%)	25 (40%)	16 (26%)	62(10%)
Design	17 (6%)	12 (4%)	8 (3%)	35 (12%)	45 (14%)	43 (15%)	129 (45%)	289(48%)
Development	13(13%)	6(6%)	8 (8%)	5 (5%)	7 (7%)	46 (48%)	12(13%)	95(16%)
Implementati on	94 (71%)	4(3%)	3 (3%)	7 (5%)	9 (7%)	7 (5%)	7 (6%)	132(22%)
Evaluation	4 (17%)	1(2%)	2(6%)	18(75%)	0 (0%)	0 (0%)	0 (0%)	24 (4%)
Curriculum- design (total)	124(21%)	32(6%)	21(3%)	63(11%)	71(12%)	120(20%)	170(27%)	602 (100%)

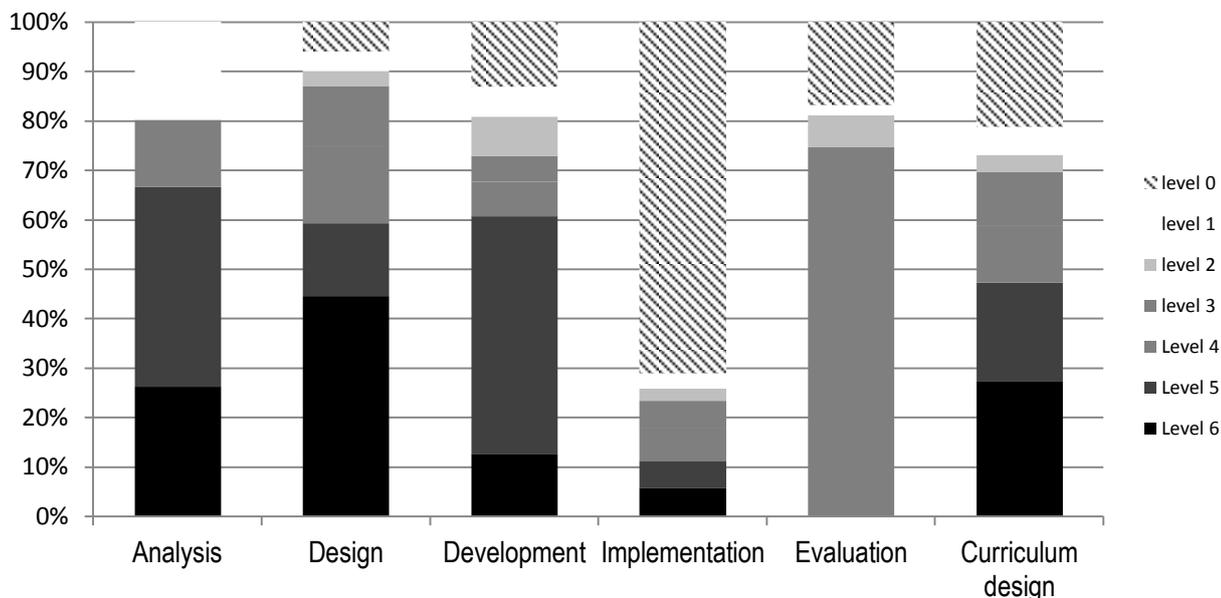


Figure 2: Bar chart with the rate of time spent on a specific LISS-level from the total time spent on the corresponding design stage

The design stage in TDT took 129 minutes of interactions on level 6 (45%), which means a high likelihood to increase the self-efficacy of the teachers during this stage. To illustrate how a discussion on LISS-level 6 proceeds, a part of the design discussion is transcribed in Textbox 1. During this part of the discussion, the team is answering the question ‘Which learning experiences are most suitable in order to obtain the objective that children get a broad view of technology learning experiences be selected to help attain these?’. The team talked about learning by playing, learning by experiencing, visual learning instead of learning by text and excursions as mean to stimulate the senses. This part of the discussion resulted in a team interaction on LISS level 6 during 28 minutes.

Textbox 1: Discussion on LISS-level 6 during the stage of design

Researcher: How do you accomplish that children get a broad view of technology?

Teacher 1: to offer and do

Teacher 2: to start close to the ideas of the child and then expand

Teacher 3: Making connections

Teacher 1: this was a nice example with Knex and Lego during crafts classes. For children, this activity felt like playing. We are playing! This while they had the idea that they have to create something, but it was ok that they were playing with Lego and Knex. They have no idea how much they are learning with this activity.

Principal: Do you mind?

Teacher 1: No, it is just nice..

Teacher 2: Yes, for children, it is fun to play

Teacher 3: but what we want is that what they experience during playing and what they learned in the game to be naturally and their knowledge of how this play works can be applied in other situations. Actually, adults do nothing but playing. And when young animals are playing, they do it for learning. So playing is learning and learning is playing.

Teacher 1: but that is....

Teacher 3: but they need you for the transfer to a bit further than their own little world. Some children will do this by themselves, especially the cognitive stronger children, those with understanding, will be faster to make those connections.

Researcher: What does this mean for learning?

Teacher 3: that everything can be learned

Principal: but do you say that after doing something you have to provide a theoretical foundation or theoretical explanation or background..

Teacher 2: I think that it should

Teacher 3: it need not to be theoretical, you can also take the practical part to a higher level. For example, how will that be with.... Something still visible and practical, to expand the previous experience. So, the children understand that both experiences are actually the same, which you can subsequently underpin with theory.

Teacher 2: and a lot of movies

Teacher 3: that is also a good opportunity

During the discussion as transcribed in Textbox 1, the team is talking about play as a means to teach children technology and about the supposed role of the teacher. All three elements of instruction (teachers, pupils and content) are explored, which is instructional relevance level 3. Moreover, opinions of the different team members are compared and analyzed, which is determined as collaboration level 3. Combining collaboration-level 3 with the instructional relevance level 3, declared LISS-level 6 in this fragment.

The time spent on development of student activities was divided over two meetings. During meeting 4 the team was working jointly on the development of science boxes, while during meeting 6 the teachers were developing science boxing for their own students. Development activities during meeting 4 resulted in 48 minutes discussion time on LISS level

5 and 6 of in total of 63 minutes(76%) compared to 9 minutes of the total discussion time of 32 minutes during development activities in meeting 6 (28%), see Table VI.

Table VI: Number of minutes spent on the different LISS level during development activities in meeting 4 and 6 of one team

	level 0	level 1	level 2	level 3	level 4	level 5	level 6	Total time
Development	13	6	8	5	7	46	12	95
Meeting 4	2	3	3	3	4	42	6	63
Meeting 6	11	2	4	2	3	3	6	32

Table V shows that during Analysis (66%), Design (60%) and partially Development (61%) most discussions are on level 5 or 6, but during Implementation and Evaluation only a small part of the discussion time was spent on level 5 and 6, respectively, 11 and 0%. Especially during the implementation the discussions focused on organizational matters, on level 0 (71%), because the team was searching for possibilities in the organization to involve other team members in the design process. During implementation activities it became clear how difficult it is to ask support by the rest of the team in the hectic days in school. The verbal protocol of the discussion in Textbox 2 illustrates this difficulty for the team. While the researcher asks to let the lesson be presented by somebody else in the team, the reactions are very cautious and the question is shifted to a pre-service teacher and at the end they do not even ask a teacher or a pre service teacher.

Textbox 2: Discussion during implementation activities

Researcher: And is it possible to execute the lesson by the teacher of group 4? That is even more valuable...

Teacher 2: She has got pre service teachers in her group. ...

Pre-service teacher: Those pre service teachers are on Friday morning in the group. I think we have to ask them to do the Science lesson instead of asking the teacher.

Teacher 1: Well, you have to ask the teacher, if it is ok, that the pre service teachers will execute the Science box in her group.

Finally, the team concluded that testing the science box in another class was complicated and that they could achieve the same result by presenting the revised boxes and their own experiences during the school break. In the focus interview the teachers explained that they experienced asking colleague teachers to do something for you as difficult, because they know that all the teachers in the team have too many things to do.

The time spent on level 0 during the other stages was 0% during the Analysis, 6% during Design, 13% during Development and 17% during Evaluation. During evaluation activities, teachers told each other what adjustments they had made in the instruction for their students, but they never compared or analyzed the developed materials to reach collaboration level, sharing (LISS level 4 till 6). Only clarifying questions were asked like: 'Did your children perform the activity?' or 'You did the activity with your whole group at once?' Despite encouragements of the researcher to evaluate the 'real' instruction materials from each other, the materials were not collected. This lack of sharing was expressed by the 24 minutes spent on evaluation, with a maximum LISS level of 3 in their discussions. Later, during the focus interview, the team explained that it is very difficult to listen to each other, because they are convinced about their own ideas.

5. Conclusion and Discussion

This study aimed to further extend TDT as a professional development program to improve science teaching self-efficacy of the participating teachers. During TDT meetings interactions between team members are observed to gain more insight in the efficiency and the degree of effectiveness of activities corresponding to the different stages of curriculum design to improve science teaching self-efficacy. The results of the STEBI-NL indicate that the science teaching self-efficacy is improved most during the first half of the design process, from the 'analysis' till the 'development'. This improvement of self-efficacy during analysis and design, as depicted by the STEBI-NL, corresponds with the result of the observations, which showed the most valuable discussions to increase science teaching self-efficacy during activities belonging to the stages of analysis, design and development, especially when the teachers jointly develop materials. During analysis and design activities, teachers had to discuss what they exactly wanted to achieve with their science curriculum in their school, how

they organised these activities and how the materials have to be made; the participating teachers were really dependent on each other. As expected, analysis and design resulted most of the time in discussions with a high level collaboration and a high instructional relevance. On the other hand, the results of the observations indicate that the discussions in the TDT about implementation and evaluation are far less valuable to increase the science teaching self-efficacy. In the sections below we discuss the value of the implementation and evaluation for increasing science teaching self-efficacy.

The stage of implementation is considered as less value for increasing science teaching self-efficacy according to the observations. Implementation was expected to be valuable for increasing science teaching self-efficacy, because implementation will result in more successes in the classrooms, which is the most important source of influence of self-efficacy (Bandura, 1986; Tschannen-Moran & Woolfolk Hoy, 2007). The reason why implementation activities in a TDT seem to be less valuable to increase science teaching self-efficacy probably is because in this study the discussions about implementation are observed and not the implementation itself. These discussions during implementation were most of the time about organizational matters and not about science teaching, which means that this discussion will not influence the science teaching self-efficacy in a direct way. On the other hand, an implementation plan is very important to secure the implementation itself. Therefore, it seems to be important to make this stage more efficient by achieving the same result, S&T successes in the classroom, in less time. The principal could improve this by planning more time before starting this training to share results of the team and to make clear on beforehand that the team can ask teachers beyond the TDT as critical friend for new ideas and to test products. Probably, this will result in less discussions on LISS level 0 and more on level 5, because the focus will be more on science education and less on how and when to inform and inspire your colleagues. Another problem in this team was the experienced difficulty to ask colleague teachers to do something for you because the teachers have many things to do. A clear focus in the school team could avoid the feeling of teachers to be busy and stimulate teachers to take opportunities to achieve a real instructional improvement in S&T education for their school. Several studies confirmed indeed that it is essential for a principal to have a clear focus and specific goals for the school, which are shared with the team members (Verschuren, 2010; Meirink, Imants, Meijer, & Verloop, 2010). In conclusion, if the principal has both a clear focus on science education and a corresponding strategy on the level of organization and people, this will firstly result in more valuable interaction during implementation and, secondly, a sustainable change can be realized in science education.

Just like the implementation stage, from the observations it could be concluded that the evaluation stage was less valuable to increase science teaching self-efficacy of the teachers in the team. The goal of evaluation activities was to be critical to each other's developed materials or to the experiences. This should result in exchanging ideas among the participants in a team, which is considered important for the learning process in a TDT and therefore to improve science teaching self-efficacy. Remarkably, during evaluation activities teachers just shared what adjustments make the box more suitable for their children, but they

never compared or analyzed the developed materials to reach the collaboration level where teachers are learning, LISS level 4 till 6. Later during the focus interview the team explained that it was very difficult to listen to each other, because they were convinced about their own ideas. Moreover, because of the experienced time problem, it was a very practical solution to divide the amount of work, each teacher developed for their own specialism, instead of collaborating on a common assignment. Because interactions and exchanges of ideas among the participants in a team are considered as most important for the learning process in a TDT (Voogt, Westbroek, Handelsaltz, Walraven, McKenney, Pieters & de Vries, 2011; Veen, Zwart, Meirink, & Verloop, 2010), it seems to be important to stimulate collaboration to a higher level. Therefore, to make discussions during the evaluation more valuable to increase self-efficacy it might be better that all participants are working on the same task, with a clear common goal, and with the same responsibility. This would stimulate collaboration among teachers. It would also be valuable when teachers want to learn from each other's experiences. Vicarious experiences are very important to increase the self-efficacy of teachers (Bandura, 1986; Tschannen-Moran & Woolfolk Hoy, 2007). To stimulate the process of learning from each other, the researcher has to encourage teachers to ask critical questions to their colleagues and to ask by himself critical questions as well, as is confirmed by a study of Sjoer, Meirink and Platteel (2010).

Another notable result was the impressive increase in science teaching self-efficacy during the second part of the curriculum development of teacher 2, compared to the minimal increase of teacher 1 and even a decrease of the pre-service teacher. The high increase in science teaching self-efficacy of teacher 2 can be explained by the performed classroom experiences. Teacher 2 was the only participant of the TDT who performed classroom activities only in the second part of curriculum design. Classroom successes are known to be a major source to increase self-efficacy and could therefore explain this impressive increase (Bandura, 1986; Tschannen-Moran & Woolfolk Hoy, 2007). So, determining the LISS levels during interaction seems to provide information about the value for increasing the self-efficacy of the teachers. However, we have to keep in mind that classroom success still is an important means to stimulate teaching self-efficacy. Consequently, it is very important to encourage teachers to do activities with students during professional development programs.

A limitation of this study is that the interactions of just one TDT were observed during development of a science curriculum. The group was composed of committed, thoughtful teachers and a pre-service teacher, who seriously took this appointment, and all with their own knowledge, skills, experiences and attitude towards science. We acknowledge that those individual differences positively affect the human resources available in the team. Variations of teams by individual differences in a team may influence the LISS level of the interactions during the design process. Analysis of those variations is interesting for further research. In this study, we argue that the differences in team discussions should be seen as a result from the group's assignment and its contextual resources and constraints.

In this study we have demonstrated that determining the LISS levels by observing the instructional relevance and the level of collaboration during interaction provides information about the value for increasing the science teaching self-efficacy of the teachers. The

observation instrument is therefore a first step towards an efficient program in a TDT to improve science teaching self-efficacy of participating teachers. This study was an extensive exploration of the discussion in one team. Further research is needed in more teams to optimize the TDT as professional development program for increasing the science teaching self-efficacy.

6. References

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