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A Mixed Methods Study Into the Development of Teacher-Researchers' Research Knowledge

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Abstract

This article reports on a mixed methods study into the development of research knowledge of secondary education teachers conducting research in the context of a professional development program. 26 teachers of 12 schools in the Netherlands participated in the study. Data were collected by using questionnaires, interviews, concept maps, oral tests and logbooks. Findings show a positive research knowledge development in teacher-researchers after following a one-year course in teacher research. This development was not only found in teachers' self-reports, but was also measured by tests. In the process of research knowledge development, teacher-researchers mainly have difficulties with formulating research questions, developing research instruments, and reporting about their research.

Keywords: teacher learning, professional development, teacher research, research knowledge, mixed methods

1. Introduction

Teacher research has been increasingly initiated at secondary schools (Oolbekkink-Marchand, van der Steen, & Nijveldt, 2013; Ponte, 2005) for the purpose of improving educational practice. It is considered a promising activity for teachers' professional development (OECD, 2009; Ponte, Ax, Beijaard, & Wubbels, 2004; Rust & Meyers, 2007; Vrijnsen-de Corte, 2012). It is found to be an effective strategy for teachers to generate knowledge about their educational practice (Lunenberg, Ponte, & van de Ven, 2007; van der Linden, 2012) by which teachers are better capable of improving their practice (Lunenberg et al., 2007).

The aim of the present study was to gain a deeper insight into the professional development of teachers, focusing on the development of research knowledge in teachers who are conducting teacher research. Although in an extensive body of literature teacher research is indicated as a promising activity for teachers' professional development, an in-depth investigation of what teachers actually learn seems to be lacking. Participating in a course in teacher research (or other forms of teacher professional communities) 'seems to be a promising way to trigger teacher learning' (Admiraal, Lockhorst, & van der Pol, 2012, p. 360).

In educational literature, we could not find much research reporting on the development in research knowledge of teachers. In their study conducted in the setting of a University of Applied Sciences, Geerdink, Boei, Willemse, Kools, and Van Vlokhoven (2016) found that teacher educators reported to have increased their research knowledge after participating in research related professional development activities. Similarily, Reis-Jorge (2005) and van der Linden (2012) found that student teachers reported that a course in research contributed to their research knowledge. Van der Linden (2012) also found an increase in research knowledge as measured by a knowledge test. As far as in-service teachers are concerned, Vrijnsen-de Corte (2012) found that teachers reported having positively developed research knowledge after having conducted research. Altogether, relatively little attention has been paid to teachers' research knowledge development (Reis-Jorge, 2005). However, further investigation of teachers' development of research knowledge is relevant for multiple reasons.

Firstly, it is relevant as research knowledge is essential for conducting research which in turn leads to professional and school development. Secondly, it is relevant for educationalists and teacher-educators who want to determine to what extent conducting teacher research fosters research knowledge. With this study, insight is gained into the aspects of research knowledge that are most difficult for teacher-researchers (i.e., a teacher who, in addition to performing teaching activities, conducts research into his/her educational setting). These findings are valuable for setting up courses in teacher research. Thirdly, it is relevant to study the development of research knowledge now that research related activities are becoming part of the curriculum in secondary schools in the Netherlands (*Besluit bekwaamheidseisen onderwijspersoneel*, 2017, August 8th; Onderwijsraad, 2014) and other countries (OECD, 2017). Secondary education teachers should therefore acquire research knowledge in order to be able to supervise students who perform these activities.

1.1 Teacher Research

Within the educational research field terms as 'practitioner research', 'action research', 'action inquiry', and 'teacher research' are used interchangeably. They all have in common that in this kind of research both theory and practice are involved. Piggot-Irvine, Rowe, and Ferkins (2015) noted that the term chosen is dependent on the situation in which the research takes place. In this study, the term 'teacher research' is used as all research central to this study is conducted by secondary education teachers. The term 'teacher-researcher' will be used for teachers who, next to performing regular teaching tasks, conduct teacher research in the context of the TR-course.

Teacher research is defined by Lytle and Cochran-Smith (1994) as a 'systematic and intentional inquiry carried out by teachers in their own schools and classrooms' (p. 24). Lunenberg et al. (2007) defined teacher research as "a method of obtaining critical insight into a problem experienced in the real world and of solving that problem, in order to learn from the experience for future action' (p. 15). For defining teacher research in this study, we adhered to the definition in the handbook we used in the teacher research course: 'Teacher research is the systematic and interactive inquiry by teachers into their own practice for the purpose of improving this practice' (van der Donk & van Lanen, 2012, p. 17, my translation from Dutch).

In educational literature, six characteristics are formulated constituting the central notions of teacher research. In sum, these characteristics are the following (presented in arbitrary order). A characteristic of teacher research is the *collaborative* nature which entails the involvement of stakeholders (colleagues, students, parents) in the research process (Admiraal, Ben, & Zwart, 2013). Teacher research is *context specific* (Admiraal et al., 2013). This characteristic refers to the practice-oriented base of teacher research. The educational practice in which teacher research is conducted is *dynamic* with its many participants in a continuous changing setting (Piggot-Irvine et al., 2015). Two other characteristics are that teacher research must be carried out *systematically* in order to contribute to *the primary aim of improving practice* (Piggot-Irvine & Zornes, 2016; Somekh & Zeichner, 2009). Another characteristic of teacher research is the involvement of a *teacher-as-researcher* (Stenhouse, 1975). This characteristic entails that practitioners (teachers) are engaging in the research process (Carr & Kemmis, 2005). In order to be able to engage in this process (i.e. to conduct teacher research), teachers should acquire research knowledge.

1.2 Research Knowledge

Research knowledge entails knowledge of the process of conducting teacher research (van der Linden, Bakx, Ros, Beijaard, & van den Bergh, 2015). Next to this, teacher-researchers need to have insight into quality criteria for teacher research in order to conduct successful research (van der Linden, 2012). In the course in teacher research (henceforth referred to as the TR-course), the five quality criteria as described by Anderson and Herr (1999) – outcome, process, democratic, catalytic, and dialogic validity – were used to establish the quality of teacher research.

In handbooks for teacher research (Berg, 2004; Campbell, McNamara, & Gilroy, 2010;

Lankshear, & Knobel, 2004) the process of conducting teacher research is presented in a research cycle. In the handbook (van der Donk & van Lanen, 2012) used in the TR-course this cycle consists of six phases that focus on ten aspects of research knowledge:

1) Getting oriented: research themes (1) and research questions (2)
2) Finding focus: literature study (3)
3) Making a plan: research methods (4)
4) Collecting data: research sample (5) and research instruments (6)
5) Analyzing and concluding: data analysis (7), concluding and discussing (8)
6) Reporting and presenting: referencing (9) and writing the research report (10)

This research cycle is used in multiple studies on teacher research in both the Netherlands and elsewhere (e.g. Dana, Pape, Griffin, & Prosser, 2016; van der Linden, 2012; Vrijnsen-de Corte, 2012). By using it in our study, we align with these other studies on teacher research.

If teachers conduct research by passing through the phases of the research cycle, this will enable them to evaluate and adjust their teaching practice (Smeets & Ponte, 2009). To be able to do so, teachers should have knowledge of the six phases and the corresponding ten aspects. In our study, the development of teacher-researchers' research knowledge was therefore characterized by knowledge of the ten aspects of research knowledge. When talking about development in research knowledge, we mean a positive development (i.e., more elaborate and/or deep knowledge) unless stated otherwise. For good understanding of the development of research knowledge, a detailed process description of the TR-course is given below.

2. Context

2.1 Background of the Course in Teacher Research

This study was conducted in the context of a Professional Development School (PDS) project in the Netherlands. Two PDS – in which secondary schools and Tilburg University are partners - have developed a course in teacher research in which teachers are learning to conduct teacher research: the TR-course. The learning process takes place by being trained in doing research while at the same time conducting a research project. The supervisors of the TR-course support teachers in conducting research, thereby aiming at enhancing their professional development (here defined as the growth of individual teachers' research ability) and school development (here defined as the improvement of educational practice and the research culture in the school).

Within each PDS one group with teacher-researchers was formed. The content of the TR-course was the same for both groups, but the groups worked autonomously (since they worked in different regions). All teacher-researchers participated on a voluntary basis. They were exempted from regular school work half a day per week for participating in the TR-course. Successful completion of the TR-course resulted in receiving a certificate. No pre-service teachers participated in the TR-course.

During the data collection for the present study, the TR-course was being carried out for the fifth year. The TR-course covers one school year which is the timeline of the present study. Most teacher-researchers attend the TR-course for one year, some enter in a second year in which they participate in parts of the course.

2.2 Program of the Course

The TR-course consisted of thirteen group meetings in which two supervisors (among which the author of this study) provided a research skills training covering all six phases of the research cycle of teacher research (see under 1.2). There were two kinds of group meetings: training meetings – which were obligatory for first year teacher-researchers only - and peer review meetings – which were attended by all teacher-researchers. During training meetings, theoretical background was given concerning each separate research phase and practical assignments were made. In the joint peer review meetings, the teacher-researchers provided each other with feedback on their research. The first and last group meetings also were joint meetings in which they respectively introduced themselves and their ideas on their research, and reflected on the TR-course. The twelfth meeting was a public presentation meeting in which teacher-researchers presented their research findings to colleagues. Table 1 gives an overview of the research phases covered in the group meetings.

Table 1.Overview of TR-course: group meetings and research phases

meeting number and type	research phase
1. peer review	introduction
2. training	getting oriented
3. training	finding focus
4. peer review	finding focus
5. training	making a plan
6. peer review	making a plan
7. training	collecting data
8. peer review	collecting data
9. training	analyzing and concluding
10. peer review	analyzing and concluding
11. training	reporting and presenting
12. peer review	presentations
13. peer review	evaluation

Every year, the participating teacher-researchers were asked to reflect on the TR-course. Based on their comments, improvements were made to the TR-course (e.g., more authentic

educational situations were used in the training, a larger amount of time was spent on peer review). Box 1 presents the agenda of a typical training meeting.

Box 1 A typical training meeting

14:00 Group meeting starts with information on program and goals
14:10 Teacher-researchers ask and answer questions
14:20 Supervisor gives theoretical background on a specific research aspect
14:50 Break
15:00 In pairs, the teacher-researchers make several assignments to practice
15:30 Teacher-researchers work on their research individually or in pairs
16:00 Group meeting ends with short evaluation and preview of next meeting

In addition to the group meetings, individual consultation moments of half an hour were held in which a teacher-researcher discussed the research (process) with the supervisor. The supervisor was at all times available for questions via email. Both the group meetings and the individual consultation moments took place at a secondary school.

2.3 Research Themes

At the start of the course, most teacher-researchers had already thought of a research theme and objective. Some teachers came up with their own theme and objective, others had responded to a call from their school leader to conduct research into a specific theme. For example, a teacher-researcher (female, age 27, teacher of arts) conducted research into pupils' participation in extracurricular activities. Another teacher-researcher (male, age 41, teacher of philosophy) conducted research to find common ground between colleagues about the curriculum. A teacher-researcher (female, age 52, teacher of Dutch language) examined how to support vocabulary development in all school subjects. A teacher-researcher (female, age 43, teacher of geography) conducted research into a new examination plan for the development of schoolwide testing criteria. Teacher-researchers conducted their research individually or in pairs. During the school year in which this study was conducted, 14 teacher-researchers worked individually and 12 teacher-researchers worked in pairs.

3. Methodology

3.1 A Mixed Methods Study

A mixed methods study was conducted to examine the development of teacher-researchers' research knowledge. As suggested by van Driel, Beijaard, and Verloop (2001) and Kagan (1990), qualitative and quantitative research approaches were combined in the design (triangulation by method). Next to self-reported learning outcomes, learning outcomes as measured by tests were included, as what teachers report to do may differ from what they actually do (Geerdink et al., 2016). Moreover, this study intended to make the learning process explicit by monitoring it throughout the TR-course, as recommended by van Driel et al. (2001).

3.2 Research Questions

The research question central to this study was: *How does research knowledge of secondary education teachers develop while conducting teacher research in the setting of a course in teacher research?* This question was divided into three sub questions:

1) *What is the self-reported research knowledge development of teacher-researchers?*
2) *What is the research knowledge development of teacher-researchers as measured by tests?*
3) *What difficulties do teacher-researchers encounter during the process of conducting teacher research?*

3.3 Participants

A total of 35 teachers of thirteen schools were involved at the start of the TR-course. Nine teachers dropped out because of a lack in facilitation (2x), unforeseen extra workload (4x) or personal circumstances (3x). The remaining 26 teachers of twelve schools are the participants in this study. There were two groups (one per PDS) of respectively eight and eighteen teachers. In Table 2 information on the participating teacher-researchers in this study is provided. The average age and male-female ratio is representative for Dutch secondary education teachers (www.stamos.nl). Relatively many first-degree teachers (73%) are participating in the TR-course compared to the overall percentage (24%) of first-degree teachers in Dutch secondary education (www.stamos.nl). (Note 1)

Table 2. Background information on the participants (N=26)

		teacher-researchers
age (mean)		41.12
sex	male	52%
	female	48%
subject taught	alpha	46%
	beta	4%
	gamma	31%
	other	19%
teaching grade	first degree	73%
	second degree	27%

* alpha: languages (e.g., Dutch, English), beta: natural science (e.g., mathematics, biology), gamma: social sciences (e.g., economy, history), other: physical education, arts, dramatic arts, nursing

3.4 Data Collection and Analysis

Five instruments were used to collect data on the development of research knowledge in

teacher-researchers. Table 3 presents an overview of the instruments, providing information on which research question is being answered by using it and what kind of data are yielded.

Table 3. Overview of instruments and kind of data being collected

Instrument	Research Question	Data
questionnaire	1	self-reported knowledge development
interview	1	self-reported knowledge development
concept map	2	knowledge development as measured by tests
oral test	2	knowledge development as measured by tests
logbooks	3	process of conducting teacher research

We have a full data set including data from all five instruments of six teacher-researchers. Of seven teacher-researchers we have collected all the data, expect the interviews and oral tests. Five teacher-researchers provided only questionnaire and logbook data, while two teacher-researchers provided only concept map and logbook data. Six teacher-researchers provided only logbook data.

In all the instruments, the development of research knowledge was investigated by examining the ten aspects (see above), except for the concept maps in which a specific coding schema was used. In the following, the instruments, procedures and analyses are described in more detail.

3.4.1 Questionnaire

The questionnaire consisted of twelve statements that were rated on a three-point scale (*no / a little / yes*). Statements were formulated according to the ten aspects of research knowledge as described above, complemented with one statement about the research cycle and one statement about quality criteria. Teachers were asked to rate the degree to which they felt they had knowledge about the aspects prior to participating in the TR-course and how this knowledge had developed after participating. An example:

- *Before participating in the course, I knew how to formulate research questions.*
- *After participating in the course, I know better how to formulate research questions.*

The questionnaire was completed online prior to the last group meeting. All teacher-researchers were approached via email. Out of the 26 teacher-researchers, 18 responded (69%). Questionnaire data were analyzed by calculating average scores and standard deviations.

3.4.2 Interview

The interview consisted of an evaluative question that was added to the oral research knowledge test (see below) at the end of the school year. Teacher-researchers were explicitly

asked about any perceived changes in their research knowledge.

3.4.3 Concept Map

Knowledge development can be assessed with concept maps by using a pretest-posttest design (Novak, 2002). In this study, the teacher-researchers drew a concept map during the first group meeting and once again during the last group meeting of the TR-course. Prior to the task, they received instructions on how to make a concept map. Both times their task was to construct a concept map of all their knowledge about the core concept 'teacher research'. No more predefined concepts were listed because predefined concepts could restrict teachers in the expression of their knowledge (Meijer, Verloop, & Beijaard, 1999). Following Koopman, Teune, and Beijaard (2011) and van der Linden (2012), the task was divided into three steps: 1. think of 20-40 concepts related to 'teacher research', 2. cluster concepts that are related, 3. draw the concept map (write down clusters in order of importance and connect related concepts with lines). Subsequently, participants were asked to write down how well the map reflected their research knowledge and whether they enjoyed making the concept map (Meijer et al., 1999). After finishing their second concept map, teacher-researchers were handed-out their first concept map and were instructed to indicate the differences between both maps. They were given 30 minutes to construct the concept map. Fifteen teacher-researchers drew both a concept map at the beginning and at the end of the TR-course.

For concept map analysis, a coding schema by Koopman et al. (2011) was used. This coding schema entails a three-phase procedure in which the concept maps were analyzed by hand by the first author of this study. In the first phase, research knowledge was evaluated on seven characteristics:

1) total number of concepts (counting the number of concepts)
2) total number of links between concepts (counting the lines drawn between the concept)
3) ratio between concepts and links (calculating the ratio by dividing the number of concepts by the number of links)
4) ratio between relevant and irrelevant concepts (calculating the ratio by dividing the relevant concepts by the irrelevant concepts in which the relevance is determined by the concepts as used in the TR-course)
5) position of concepts to the core (analyze the position of a concept relative to the core concept and evaluate this arrangement on a three-point scale)
6) depth (determine the maximum number of layers counting from the core concept)
7) total number of clusters of concepts (counting the number of clusters of concepts)

In the second phase, the quality of the concept maps was determined on a five-point Likert scale (*very poor to very good organization of knowledge*) based on findings in the first phase. In the third phase, knowledge development was determined by comparing the quality of the concept maps (drawn before and after participating in the TR-course) on a five-point Likert scale (*strong decrease of knowledge to strong increase of knowledge*). In addition to this

three-phase procedure, we conducted a content analysis in which all items on the concept maps were categorized (by the first author of this article) according to the ten aspects of research knowledge (as described above).

3.4.4 Oral Research Knowledge Test

Eight teacher-researchers (four from each PDS) participated in the oral research knowledge test at the beginning of the TR-course. During the school year, two of those teachers dropped out the TR-course because of personal circumstances. Therefore, only six teachers participated again at the end of the TR-course.

The oral research knowledge test was pre-structured and consisted of questions covering ten aspects of research knowledge as described above. These questions formed a knowledge test by which the knowledge development was measured.

The oral research knowledge test was conducted face-to-face at the schools of the teacher-researchers or by telephone. All oral tests were conducted by the author and audio recorded with the teachers' consent. The average duration of the oral test was fifteen minutes. All recordings were transcribed verbatim and analyzed per question. Answers were scored by the first author of the study on their correctness and completeness using the handbook of the TR-course as reference point. Furthermore, answers at the beginning and end of the TR-course were compared with each other.

3.4.5 Logbooks

Throughout the TR-course, a logbook was kept by one supervisor in order to document the consultation hours and the questions received via email. Immediately following a consultation hour, the supervisor made notes of the consultation hour. Each email question was documented. All logbook entries were coded according to the ten aspects of research knowledge as described above. When a logbook entry included more than one aspect, it was given multiple codes.

4. Findings

In this section, the findings on the teacher-researchers' research knowledge development are presented. First, a description of the self-reported knowledge development is given (sub question 1) and next the research development as measured by tests (sub question 2) is described. In the last section, the process of the research knowledge development is described (sub question 3).

4.1 Self-Reported Research Knowledge

The teacher-researchers' self-reported research knowledge development was assessed with questionnaire (statements that were rated on a three-point scale) and interview (an evaluative question) data. The questionnaire data showed that on average, the teacher-researchers reported relatively high scores about their research knowledge before attending the TR-course ($M = 2.38$, $SE = .15$). Despite these high scores, they on average did also report an increase in their research knowledge ($M = 2.33$, $SE = .15$). The increase in research knowledge was

reported on all aspects (score of 2 or more), see Table 4. Of all 180 responses (18 teacher-researchers x 10 responses), 52 percent presented a substantial increase (scores of 3), 30 percent a modest increase (score of 2) and 18 percent no increase (score of 1) in research knowledge.

Table 4. Self-reported initial research knowledge and self-reported growth in research knowledge (average scores on a three-point scale and SE

Aspects of Research Knowledge (Per Research Phase)	Initial	Growth
research theme (getting oriented)	2.17 (.22)	2.33 (.18)
research question (getting oriented)	2.44 (.17)	2.39 (.18)
literature study (finding focus)	2.50 (.19)	2.11 (.20)
research methods (making a plan)	2.44 (.17)	2.44 (.19)
research sample (collecting data)	2.44 (.17)	2.22 (.21)
research instruments (collecting data)	2.22 (.17)	2.56 (.17)
data analysis (analyzing and concluding)	2.22 (.17)	2.28 (.18)
concluding (analyzing and concluding)	2.28 (.14)	2.39 (.16)
referencing (reporting and presenting)	2.50 (.19)	2.28 (.21)
writing the research report (reporting and presenting)	2.44 (.15)	2.33 (.16)

In addition, teacher-researchers reported that their initial knowledge of the quality criteria (M = 2.44, SE = .15) increased by conducting teacher research (M = 2.33, SE = .16). Their initial knowledge of the different phases of conducting research (M = 2.39, SE = .20) also increased (M = 2.33, SE = .20).

To get a more complete picture of the self-reported development in research knowledge, six teacher-researchers were interviewed. In one open-ended interview question, they were asked to comment on their development in research knowledge. Overall, a development in research knowledge was indicated by all six teacher-researchers. Two of them specifically indicated that they knew more of the process of conducting research after having participated in the TR-course. Three teacher-researchers indicated a development in their knowledge of research methods. A perceived increase in knowledge of research instruments was indicated twice. Teacher-researchers also explicitly reported on increased knowledge about formulating research questions, conducting data analysis and the literature study (all three aspects were mentioned once).

4.2 Research Knowledge Development as Measured by Tests

The research knowledge development of the participants was measured by means of concept maps and oral tests. First, the analysis of the concept maps is presented, starting with an

example of the concept maps drawn by the same teacher-researcher (who we will call Teacher A) before and after the TR-course (see Figures 1 and 2). For readability, both concept maps were digitalized and translated to English.

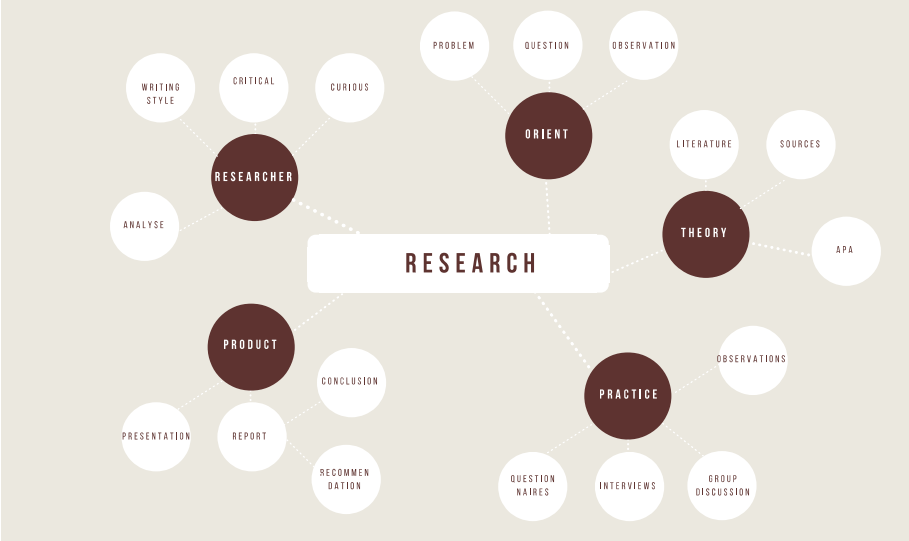

Figure 1. Concept map drawn by Teacher A before participating in the TR-course

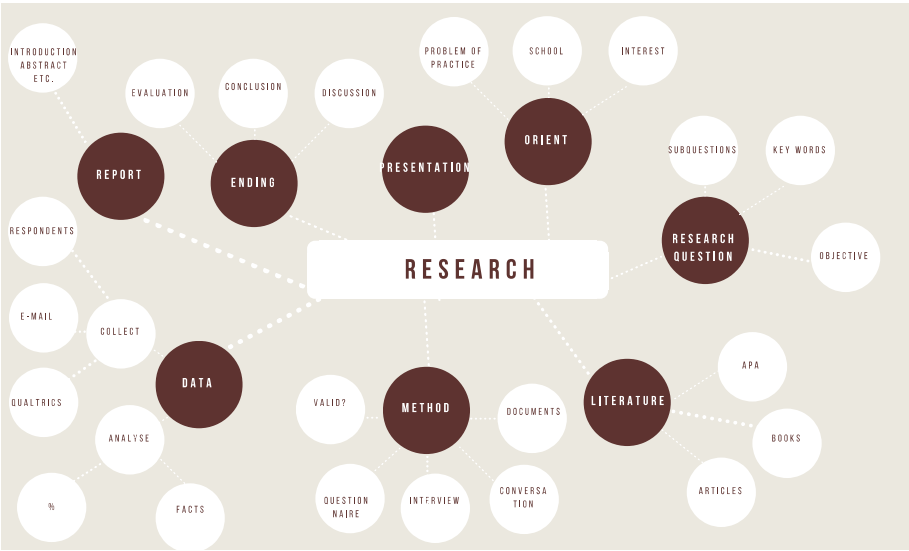

Figure 2. Concept map drawn by Teacher A after participating in the TR-course

Next, the data of the analysis of the concept maps of 15 participants are given (see Table 5). For each characteristic of the concept maps the difference between the maps drawn before and after the TR-course is tested for significance. Furthermore, these differences are illustrated using the

concept maps of Teacher A as an example.

Table 5. Mean scores on seven characteristics of the concept maps (N=15)

	mean score pretest	mean score posttest
total number of concepts	26.40	26.20
total number of links	28.40	24.93
ratio between concepts and links	0.94	1.11
ratio between relevant and irrelevant concepts	1.02	0.98
position of concepts to the core	1.93	2.13
depth (number of layers)	2.87	2.47
number of clusters of concepts	4.73	3.40

The first analysis phase, examination of the concept maps on seven characteristics (see Table 4.5 for an overview), showed that the total number of concepts increased in the concept maps of eight teacher-researchers and decreased in the concept maps of seven teacher-researchers. On average, the number of concepts before the TR-course (M = 26.40, SE = 2.20) was statistically not significantly different than the number of concept after the TR-course (M = 26.20, SE = 2.18), t(14) = 0.20, p = 0.92. In Teacher A's concepts maps, 23 concepts could be identified in the concept map drawn before the TR-course and 33 concepts in concept map drawn after the TR-course (see Figure 4.2 and 4.3). The total number of links increased in six and decreased in nine concept maps. On this aspect, no statistically significant difference was found between the concept map drawn before (M = 28.40, SE = 2.58) and after (M = 24.93, SE = 1.90) the TR-course, t(14) = 3.47, p = 0.25. In Teacher A's concept map, we identified 23 (before) respectively 33 (after) links between concepts. The ratio between concept and links varied with a lower ratio in three, an equal ratio in four and a higher ratio in eight concept maps. Also on this aspect, no statistically significant difference was found between the concept map drawn before (M = 0.94, SE = 0.03) and after (M = 1.11, SE = 0.13) the TR-course, t(14) = -0.17, p = 0.19. The ratio in the concept maps of Teacher A was both times 1.

Hardly any difference was found in the concept map drawn before (M = 1.02, SE = 0.05) and after (M = 0.98, SE = 0.02) the TR-course in ratio between relevant and irrelevant concepts and no statistically significant difference was found t(14) = 0.04, p = 0.51. All concepts of Teacher A's concept maps were judged as relevant. The position of concepts to the core remained approximately the same in before the TR-course (M = 1.93, SE = 0.12) and after the TR-course (M = 2.13, SE = 0.13) and no statistically significant difference was found t(14) = -0.20, p = 0.08. We found that the concepts in Teacher A's concept maps drawn before the TR-course were more logically positioned than in her concept map drawn after the TR-course. Furthermore, the depth was the same in most concept maps; an increase in two and a decrease in five in the number of layers was found. No statistically significant difference was found on

this aspect between the concept map drawn before (M = 2.87, SE = 0.13) and after (M = 2.47, SE = 0.22) the TR-course, t(14) = 0.40, p = 0.14. In both of Teacher A's concept maps, the maximum number of layers was three. The average number of clusters of concepts was higher in the concept maps drawn before the TR-course (M = 4.73, SE = 0.67) compared to the concept maps drawn after the TR-course (M = 3.40, SE = 0.62), but not statistically significantly different t(14) = 1.33, p = 0.15. In Teacher A's concept map drawn before the TR-course, we identified five clusters of concepts, in her concept map drawn after the TR-course we identified seven clusters of concepts.

Phase two of the analysis showed that the overall quality of the concept maps that were drawn after participating in the TR-course (M = 2.87, SE = 0.19), was on average not different from the quality of the concept maps drawn before participating in the TR-course (M = 2.80, SE = 0.18), t(14) = -0.07, p = 0.72. We judged the quality of the concept maps drawn before the TR-course as poor (5x), neutral (8x) or good (2x) and the quality of the concept maps drawn after the TR-course as poor (5x), neutral (7x) or good (3x). The concept map drawn by Teacher A before the TR-course was judged as neutral and the concept map drawn after the TR-course as good.

During phase three of the analysis, the teacher-researchers' knowledge development was determined by comparing the quality of both concept maps of each participant. In the concept maps of three teacher-researchers a slight decrease of knowledge was found, while those of four teacher-researchers showed a slight increase in knowledge. In the concept maps of eight teacher-researchers no difference in knowledge between was found between the maps drawn before and after the TR-course. This indicates that the research knowledge of teacher-researchers remained approximately the same during the school year. In Teacher A's concept maps, we found a slight improvement in knowledge (the quality of her concept maps increased from neutral to good).

Further examination of the concept maps indicated that all concept maps clearly showed aspects of research knowledge. Of all concepts that were noted in the concept maps, 73 percent (before TR-course) and 79 percent (after TR-course) could be categorized as pertaining to the aspects of research knowledge. Most concepts in the concept maps drawn both before and after the TR-course were related to the phase of analyzing and concluding (20% and 21% respectively). In the concept maps drawn before the TR-course, a great number of concepts concerned the phases of getting oriented, finding focus and collecting data (17%, 19% and 17% respectively). The same holds for the concept maps drawn after the TR-course (getting oriented 19%, finding focus 13%, collecting data 16%). Hence, also with regard to the content of the concept maps, no positive development in teacher-researchers' research knowledge was detected.

However, teacher-researchers themselves did report differences between their concept maps. Teacher A for example stated that her concept map drawn after the TR-course contained more content and that the research cycle was better represented in that concept map. Overall, six teacher-researchers indicated that their concept map drawn after the TR-course was better structured. Four teacher-researchers indicated that this map was drawn from experience more

than from knowledge only. Three teacher-researchers observed that the last phases of the research cycle were overrepresented in their concept map (as that was what they had recently been working on). Overall, the teacher-researchers (12 out of 15), including Teacher A, reported that the concept maps represented their knowledge of teacher research. Furthermore, most teacher-researchers (12 out of 15), including Teacher A, enjoyed making the concept maps.

Data from the oral research knowledge test were analyzed to further measure the research knowledge development in teacher-researchers. Six teacher-researchers were tested before and after participating in the TR-course. From the analysis, it became apparent that teacher-researchers did positively develop their knowledge of research, as is shown in Table 6.

Table 6. Number of participants that improved (+), stayed the same (=) and declined (-) per aspect of research knowledge, after following the TR-course, as established in the oral research knowledge test (N=6)

aspects of research knowledge (per research phase)	-	=	+
research theme (getting oriented)*	-	-	-
research question (getting oriented)	2	1	3
literature study (finding focus)	1	1	4
research methods (making a plan)	0	1	5
research sample & instruments (collecting data)**	0	3	3
data analysis (analyzing and concluding)	0	2	4
concluding (analyzing and concluding)	2	0	4
referencing (reporting and presenting)*	-	-	-
writing the research report (reporting and presenting)	0	0	6

* On these aspects, research knowledge development could not be measured by the oral tests.

** The aspects *research sample* and *research instruments* were merged during the interview.

The oral test data also revealed that teacher-researchers' knowledge of the quality criteria increased. Before participating in the TR-course, all six teacher-researchers had some ideas about the quality criteria, but they could not give a complete answer. After having participated in the TR-course, the answers of four of the six teacher-researchers showed improvements (one answer remained the same and one answer was less elaborate). They were also somewhat better in indicating the different phases of the teacher research cycle after having participated in the TR-course. Three of the initial answers were correct, the other three answers contained relevant elements but were incomplete or the order of the elements was incorrect. After having participated in the TR-course, four answers were correct and two answers contained relevant elements but were incomplete or the order of the elements was incorrect.

4.3 Difficulties in the Process of Conducting Teacher Research

During the TR-course, questions teacher-researchers asked in consultation hours and via email were documented. In total, 132 questions were posed of which 112 could be categorized as related to aspects of research knowledge (20 questions were of an organizational, practical nature). Most research knowledge related questions were asked about the phase of getting oriented (21%) and the phase of reporting (30%, of which 6% on referencing only). There were questions about the phase of data collection (19%) – which were not about the research sample but on research instruments only - and the phase of analyzing and concluding (13%). Fewer questions were asked about the phase of finding focus (9%) or making a plan (8%). No questions were asked during consultation hours or via email about the quality criteria.

The documentation of questions provided a clear picture of what the teacher-researchers were engaged in concerning their research. Their questions reflect the research cycle. At the beginning of the school year, most questions were about the orientation phase. During the school year, more questions arose about the planning and data collection phase. At the end of the school year, the majority of the questions concerned reporting about the research. Table 7 gives an overview of these findings.

Table 7. Teacher-researchers' questions in consultation hours and via email per research phase (numbers are frequencies, N=112)

theme of questions	phase of getting oriented	phase of finding focus	phase of making a plan	phase of collecting data	phase of analyzing and concluding	phase of reporting and presenting	total
getting oriented	4	10	4	3	2	1	24
finding focus	-	2	-	4	2	2	10
making a plan	-	1	-	6	1	1	9
collecting data	-	2	-	15	2	2	21
analyzing and concluding	-	-	-	7	5	2	14
reporting and presenting	1	2	2	5	8	16	34

5. Conclusions

The purpose of this study was to gain insight into the development of teacher-researchers' research knowledge during a one-year course on teacher research. To enhance the credibility of its findings the study included (a) teacher-researchers' self-reported research knowledge development, (b) teacher-researchers' research knowledge development as measured by tests and (c) teacher-researchers' self-reported difficulties during the process of conducting research as established by logbooks.

The phases of the research cycle (as retrieved from handbooks on teacher research) provided a starting point for defining research knowledge. Ten aspects concerning the phases of the research cycle were used to examine the research knowledge in teacher-researchers. The aspects were used for data analysis in all data sources: questionnaires, interviews, concept maps, oral tests and logbooks.

Based on the results of this study, it can be concluded that teacher-researchers reported a positive development in their research knowledge. These findings are in line with findings of Geerdink et al. (2016), van der Linden et al. (2015) and Vrijnsen-de Corte (2012). The results of the questionnaire show that although teacher-researchers report quite positively on their initial research knowledge, they also experience a growth in their research knowledge on all aspects. This in in line with the findings in the interviews in which teacher-researchers indicated an overall positive development of their research knowledge.

Teacher-researchers' research knowledge development is however not readily evident from the analysis of the teacher-researchers' concept maps as no difference was found in research knowledge between the pretest and posttest. However, teacher-researchers themselves found their second concept maps better structured and more written from experience rather than from knowledge only. Indeed, findings of the oral research knowledge test show that teacher-researchers did positively develop their research knowledge on a number of aspects. This study confirms findings of Reis-Jorge (2005) who found that teachers' knowledge of selecting research methods, developing instruments, analyzing and concluding increased during a TR-course. Furthermore, a positive knowledge development was observed in teacher-researchers understanding of the research process and the quality criteria after having participated in the TR-course. The findings of this study are in line with findings of van der Linden et al. (2015) who also found an increase in teachers' knowledge about research in a setting of a course in teacher research.

Concerning the process of conducting teacher research, findings indicate that teacher-researchers had most difficulties in the phase of getting oriented (formulating research aims and questions), collecting data (developing research instruments), and reporting (writing about the research).

6. Discussion

The participating teacher-researchers in the TR-course reported having already substantial research knowledge before participating in the TR-course. It can be hypothesized that they felt confident in their research knowledge as they did already conduct some research as prospective teachers during their higher vocational or university education. The fact that they also reported an increase in their knowledge, may be explained by the self-efficacy theory of Bandura (1982), stating that people's self-efficacy increases when they gain new skills.

The difference in knowledge development as measured by the concept maps and the oral tests may be explained by what Reis-Jorge (2005) refers to as *accessible input*. Accessible input are those parts of all knowledge input that a learner actually takes in. These are the parts a learner finds most relevant for (in this study) conducting research. Both the concept maps drawn

before and after the TR-course showed overrepresentation of items concerning the phase of analyzing and concluding. Indeed, the supervisors observed a focus of teacher-researchers on the results of the research. Ponte et al. (2004) similarly observed that 'left to themselves teachers […] reflected mainly on desirable action and not on what they were actually doing' (p. 586). During the interviews of this study, it indeed became clear that the practical applicability of the findings was highly valued by teacher-researchers. The focus on the analyzing and concluding research phase may have resulted in concept maps that were structured quite similarly. Hence, no positive development in research knowledge in the concept maps was observed. As in the oral test the teacher-researchers were explicitly asked about all aspects of research knowledge, they were forced to think about more aspects than the ones they found most relevant. This may have resulted in a more complete picture of their knowledge development.

The fact that teacher-researchers, as shown by the questions they asked to the supervisors, encountered most difficulties in getting oriented, collecting data, and reporting may be explained by the following considerations. Teachers' questions concerning getting oriented may be a result of the difference in setting between research (indicated by some teacher-researchers as slow, patient, postponing action) and educational practice (indicated as dynamic, fast changing, direct action). Teachers may be less used to make a thorough orientation on educational practice as they do not have the time to do so in their daily practice (Verbiest, 2003). Ponte et al. (2004) suggest that 'daily practice tempts teachers to seek immediate […] solutions' (p. 587). Teachers' questions concerning collecting data (more specifically: developing instruments) may be explained by a difference between theoretical (academic/scientific research) and more practical research (e.g. teacher research). In teacher research, stakeholders play an active role as subjects or critical friends (Meyer, 2000), more than in theoretical research. Teacher-researchers are probably less familiar with the inclusion of stakeholders in their research as most research conducted during their higher vocational or university education likely was theoretical research. This assumption was confirmed by several teacher-researchers who indicated that they had conducted only theoretical research before participating in the TR-course. Understandably, in this case more questions arise on developing instruments than on conducting a literature study. Finally, the need for support in reporting on research, may originate from the fact that this kind of reporting is likely not part of teachers' daily activities.

The findings of this study are hard to generalize to other settings, bearing in mind the small sample size and the context dependent setting. However, the small sample size made it possible to use a variety of methods and make an in-depth study of the research knowledge development in teacher-researchers who attend a TR-course. As the data corroborate with other research in the field, the findings are applicable in other educational settings in which teachers conduct research (Greene, 2007; Johnson & Onwuegbuzie, 2004).

A next step in a follow-up study would be to investigate how teacher-researchers' research knowledge effects their educational practice. It was beyond the scope of this study to examine to what extent teacher-researchers integrate their research findings into their teaching practice in order to improve this practice. However, it would be valuable to investigate what impact

conducting teacher research has on teaching practices. Future research could also investigate whether teachers with more knowledge on research are also able to conduct better research.

Altogether, this study showed that teacher-researchers develop research knowledge during a one-year course in teacher research. Hence, this study supports educational literature in which teacher research is considered as a promising strategy for teachers' professional development.

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Notes

Note 1. In the Netherlands, first and second degree teachers are allowed to teach at all forms of secondary education. Only first-degree teachers are allowed to teach during the last three years of the two highest educational levels.

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