Chemistry Education Research and Practice

Accepted Manuscript

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The use of a student group log to facilitate student and teacher learning

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Abstract

In 21st century education students should have ample opportunities to collaborate on authentic problems. Many teachers however find it difficult to make the transfer from teacher to student-centered education. Giving students autonomy can be disquieting to teachers, as they fear to lose control of student learning. Teachers in a teacher development team developed context-based student learning material on the topic 'salts'. Self-regulating student cooperative groups would work autonomously during a number of weeks using this material. To monitor the "what and how" of these groups, a student group log was developed. In this log all the work the group performed in class had to be noted and during each lesson a number of questions to stimulate interaction and reflection had to be answered. This research describes how students and teachers used and perceived the group log during their cooperative journey when studying the material on 'salts'. Results show that students were positive, and especially appreciated teachers' quick feedback. The log stimulated student interaction, guided the learning processes, and stimulated student reflection. To provide feedback, teachers needed between 3-5 minutes per log after each period, and stressed that this was well invested time as they could now monitor student progress.

Introduction

In September 2013 new mandatory high school examination programs for all the natural sciences, including chemistry, were introduced by the Dutch Ministry of Education. Characteristics of this program include the context concept approach, in which students learn concepts starting from an appealing context (Bencze & Hodson, 1999; Bennett & Lubben, 2006; Gilbert, 2006), and more student autonomy in determining the content and the process of their learning (Bianchini, 2011; Driessen & Meinema, 2003). Another important characteristic is the focus on two central concepts: the particle concept (all matter consists of small particles such as molecules, atoms, ions) and the micro–meso–macro concept [the structures at molecular level determine properties at meso- and macro-level, (Meijer, 2011)] .

Preparing teachers for a curriculum change, like the introduction of a context concept approach, is not a simple task (Bakkenes, Vermunt, & Wubbels, 2010; Fullan, 2007). The purposes and goals for teaching science at a particular grade level change and this affects instructional decisions about teaching science (Friedrichsen, Driel van, & Abell, 2011). This in turn has its bearing on teaching and learning material, on how students learn and the difficulties they will face, and on assessment strategies

and instruments. Teachers need to bring their Pedagogical Content Knowledge (PCK) in line with the new requirements. After Shulman (1986), quite a few scholars have conceptualized PCK in different ways (Bucat, 2004; Hashweh, 2005; Magnusson, Krajcik, & Borko, 1999; Park & Oliver, 2008; Van Driel, De Jong, & Verloop, 2002). In a recent model (Gess-Newsome, 2015), PCK is defined as both a knowledge base and as a skill when involved in the act of teaching. Changing teacher PCK is possible but it is not an easy process and it involves reflecting on current practices in the light of student learning (Schneider & Plasman, 2011).

This research is about the use of a student group log to assist teachers to change from teacher centered and teacher dominated classes to classes with more student autonomy when using learning material in a context concept approach. In the next section effective professional development to modify PCK will be briefly highlighted, followed by the way the teachers in a participatory approach (Könings, Seidel, & Merriënboer, 2013) designed the context concept learning materials and the accompanying student group log.

Theoretical framework

Literature shows that effective professional development in which teachers expand or modify their PCK should: (a) focus on content and the way students acquire this content, (b) facilitate active teacher participation, (c) consist of linked and coherent activities, (d) have sufficient contact time for participants to meet and reduction of school work, (e) foster cooperation in a learning community (Avalos, 2011; Bencze & Hodson, 1999; Desimone, 2011; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Schneider & Plasman, 2011). Our own research (Coenders, Terlouw, Dijkstra, & Pieters, 2010) showed that when the goal of a professional development program is to change classroom teaching, teachers need to go through two phases: a development phase in which teachers in a team develop student learning material plus the pedagogy, followed by a class enactment phase where teachers enact this learning material in own classes and discuss the outcomes (Coenders & Terlouw, 2015).

Based on the above elements a teacher design team (TDT) (Handelzalts, 2009; Lumpe, 2007) was set up, in which teachers from different schools under the guidance of a teacher educator redesigned existing innovative modules (series of lessons), class enacted the resulting materials, and discussed learning processes and outcomes.

One of the advantages of (re)developing student learning material in a TDT is that this increases teachers' sense of agency and ownership. Moreover during this (re)development process teachers concurrently prepare for their own class enactment by immediately taking practical aspects into account (Doyle & Ponder, 1977), thereby linking their own professional development to student learning (Fishman, Marx, Best, & Tal, 2003) . In the discussions during the redevelopment of a module in which cooperative learning would be introduced to allow student groups to work rather autonomous throughout the module, teachers expressed their anxiety about students' ability to work independently as a group with little teacher direction. Teachers feared that students would not stay on task and not focus enough to get to understand the content, and that this would result in lower grades on the final

test. To address these concerns a student group log was developed so that teachers could monitor the processes the student groups engaged in and the progress students made.
The questions guiding this research were how such a log is perceived and used by both teachers and students.

The context of the study

This Teacher Design Team (TDT) consisted of nine experienced chemistry teachers under the guidance of a chemistry teacher educator. All teachers had a master's degree in chemistry plus a teacher qualification. The group met monthly for a three-hour session, completing a total of ten sessions (30 hours).
The title of the redeveloped module is "Do plants grow better with Chili saltpeter", and deals with ions, salts and their characteristics. "Ionic compounds" is a common topic in introductory chemistry and all the teachers were familiar with it. This module however contained a number of modifications to normal practice: (a) the student groups would work autonomously; (b) using group roles (chief, writer, timekeeper, material person/questioner) in the collaboration process (Ebbens & Ettekoven, 2005); (c) on rather open assignments and practical work, and for a period of several weeks (16 periods), and (d) student groups were assigned a specific interest group (as researcher, farmer, environmentalist, manufacturer, consumer) and, as their final group assignment, had to prepare a poster substantiating the vision on the use of fertilizers from this interest group's perspective (See Appendix C for an example of such a group poster). The module was written for Form 4 (15-16 year old) VWO-students (pre-university stream). Chemistry was a compulsory subject for these students and this was their second year of chemistry. The teachers from the TDT wanted to be able to compare student learning to previous years and therefore decided to also assess student learning with a final written test similar to the tests from previous years. Although this test did not include context information but only straightforward chemistry questions, the final grades were similar to those in previous years.
As teachers during the development of the module feared that their students would not be able to work in groups for such a long time, both in terms of competences but also with respect to staying on task, a student log was developed to monitor both the processes the groups went through as well as student progress and performance. Each group, consisting of four students, received a group log at the beginning of the module. The log consisted of an introduction, where the use of the log and the cooperation plus the revolving roles are explained, followed by two pages for each period: an empty left hand side page and a right hand side page with six specific questions that had to be answered by the group. The empty left page was for the students to write down all answers to questions, all observations and results of practical work or other activities (see Appendix B). The questions on the right page were about the cooperation process, and also provided a space to plan the lesson and to encourage reflection on what was done, what the result of their effort was, and what, according to the group, was learned during the lesson (see Appendix A). The group logs had to be completed each period and had to stay in school. The idea was that the teacher would go over the logs after each period to mark them in terms of correct and wrong answers and comment on the cooperation process and the pace. During the

development of the module and the log no consensus could be reached about whether or not also to grade the logs, and so this was left to the teacher's discretion.

Even after the discussions during the development of the module and log the teachers expressed concerns about the feasibility in school practice: will the students be able and willing to use the logs, how much time will it take the teacher to go over each log, and what will it bring to both students and teacher?

Therefore class enactment of the log resulted in the following research questions: 1) how do students and teachers use the log, and 2) how do they assess the log and its different components?

Research method

As we were specifically interested in how teachers and students used and assessed the group logs, a multiple-case study design was used (Yin, 2003) in which each of the implementing teachers and their students was considered one case.

Participants

Four of the nine teachers from this TDT class enacted the module and the log, the others did not teach this topic this period of the school year. These four teachers were from three high schools. All teachers had a master's degree plus a teaching qualification, and none had previous experience with cooperative learning nor with a log. All were experienced teachers with more than 4 years teaching experiences, and all participated voluntarily.

Instruments

To answer the research questions three instruments were used: a semi-structured interview with each of the teachers (the two teachers in one school were interviewed together as they had collaborated very closely), and semi-structured group interviews with a selection of the students at each school, and the completed student group logs of the four classes. We interviewed three to four students per school. The students were recruited by the teacher. In class the teacher explained that we wanted to know how students perceived the material and especially the group logs. Because in each school enough students volunteered to be interviewed, it was possible to include students from different groups in the final selection.

Analysis

All the interviews were transcribed verbatim and coded using atlas.ti. The questions from the interviews served as initial codes, the logs were used to verify specific statements both from teachers and from students (Gibbs, 2007). For each code teacher and student answers were combined, when possible, in a word table. Further analysis resulted in seven categories to answer the two research questions. For the question "how do students and teachers use the log?" the following three codes are relevant:

(1) teacher comments and required time; (2) student use of teacher comments; (3) grading. To answer the question “how do students and teachers assess the log and its different components?” four categories proved suitable: (4) usefulness of the log; (5) use the log to influence the learning process and student learning; (6) roles and cooperation; (7) practicality of specific questions. The results are reported in the section below.

Results

The results for the seven categories are reported below. To facilitate reading we have given the teachers arbitrary names: John, Tess and Julia. The answers from the two teachers who were interviewed as a team, as they had cooperated very closely during class use, will be reported under Tess.

However we will start by describing the development of teacher PCK with respect to the use of a student group log.

Initially the inclusion of a group log was not intended. The original idea was to redevelop a module on the topic ‘ionic compounds’’ in which students would start the learning processes from an appealing context and in which students could work rather autonomously. During the discussions the question about whether or not students would be able to deal with autonomy regularly surfaced. The teachers were afraid that students would be easily distracted and not stay on task. Based on findings from the literature, the chemistry teacher educator made two recommendations: introduce cooperative learning with student group roles, and use a group log to monitor what students do in class and to guide their learning. None of these teachers had experiences with this kind of cooperative learning, and none had ever used group logs before. Gradually, during a number of meetings, ideas of how students would have to cooperate in their groups through the introduction of group roles, and ideas for a group log, were generated. But the discussion revolved all the time around two important aspects for the teachers: will the students without teacher direction be able to learn what they are supposed to learn, and will teachers be able to monitor the process and progress. This discussion resulted in the specific configuration of the group log: a section to guide and monitor the process (the right hand side pages, see Appendix A) and a section to monitor progress (the left hand side pages, see Appendix B).

However, another concern appeared: how much time will it take the teacher to go over each log after every period? Several scenarios were discussed. The teacher could mark the logs by indicating correct answers and mistakes. On top of this the logs could be graded. And finally teachers could correct student mistakes. With respect to grading no consensus was reached. Whether or not teachers would grade and how was therefore left to each teacher personally. With respect to making corrections it was felt that this was not the task of the teacher. Class implementation would show how much time actually it would take the teacher to go over each log, during the discussion this could only be estimated.

During a period of five months, in which five meetings were held, teacher PCK with respect to cooperative learning and the use of a group log gradually developed. Although the teachers understood the why and how, they still wondered how it would all work out in practice. This will be reported in the next section.

The seven categories resulting from the interviews

1. Teacher comments and required time

All four teachers went over the logs after each period. All teachers marked the logs and indicated mistakes with a red pen and in some instances the correct answers on the left hand side pages, and all commented upon student collaboration and the progress made on the right hand side pages. Questions like “why is this not filled in or done?” or “why was this not answered?” were jotted down by the teachers. Suggestions to scaffold the cooperation like “it is better to plan the period with the complete group first” and remarks such as “improving a skill is also learning” were also added.

As the teachers initially envisaged that going over the logs would take a lot of time, they were asked how much time they actually spent on reading, marking and commenting the logs. They were also asked how much time they needed for other lesson preparation activities. There answers are shown in Table 1.

	Reading and commenting a group log	*Other class preparation time*
John	2-3 minutes per log, 15 minutes in total per class. No grading.	Little time as all was prepared in advance (before the start of the lessons)
Tess	5 minutes per log, 40 minutes total per class. Grading.	Hardly any other preparation. However the technician had to prepare quite a number of experiments.
Julia	Approximately 5 minutes per log. Around 40 minutes total per class. No grading.	Not during the lessons, was all done during the preparation before the lessons started.

Table 1: required teacher time to go over the logs (read, mark, comment)

John said that reading, indicating mistakes and commenting took him 2-3 minutes per log, so he could finish a class in 15 minutes. And because he did not need class preparation time, as this was all done during the development of the module, these 15 minutes were all the time he needed to prepare for his next class. Tess said she needed about 5 minutes per log and also did not need additional preparation time. Julia also used on average 5 minutes per log and she indicated that one class could be finished traveling home by train. This means that all could finish all logs for a class within 40 minutes. They all responded that they did not have other lesson preparation. All preparation had been done concurrently with the development of the module before class enactment.

2. Student use of teacher comments

The teachers were asked how their students used their markings and comments in the log. The students were posed a similar question. The responses can be seen in Table 2.

teachers	John	Students had to be told what to do with the comments, they needed to get accustomed to this. Sometimes you need to be concrete and then I wrote “do this and this” because the students did not do this by themselves. Nine of the ten used my feedback.
	Tess	The first activity the students did in class was to take their log and look at my comments, then at the grade I had given them.

		Students did not correct their mistakes nor made changes. Stubborn students repeated mistakes, but most students learned from errors made. You need to guide the students on this as it was new!
	Julia	Yes, students looked at my writings and they did make changes when I requested this.
students	John's students	Most of the time we wrote down our mistakes and then how it should have been answered. We looked at what we had done wrong and tried to correct this by writing down the answer we now thought was correct.
	Tess's students	When there was writing in red (this was from the teacher) and it was not a 'good' symbol, we immediately looked at it and often thought what a silly mistake or why did we forget this. We then corrected the mistake before the next period as we wanted a high grade. As time passed we got less and less red! We did learn from our mistakes and we think it was well invested teacher time.
	Julia's students	We looked at the teacher comments and figured out what was wrong. We did not make corrections as it quite often was about what still needed to be done and less about the content.

Table 2: student use of teacher comments according to the teachers and according to the students

John said that his students needed concrete instructions as they initially did not know how to deal with his comments. Finally he thought that students used most of his feedback. John's students said that they went over the specific questions again and then tried to correct the indicated mistakes or provide the missing answer.

The first thing Tess's students looked at when in class were her comments and then the grade given. She experienced that students did not automatically correct mistakes, students needed instructions for this. Her students said that they often wondered how they could have made such silly mistakes. They then corrected the mistakes made. The students indicated that they had learned a lot from the teacher comments and appreciated the time the teacher had invested in providing these comments. They even added that this was "well invested time".

Julia had similar experiences: students make changes, but only when specifically requested. Her students said that often the comments were on the process and less about the content.

3. Grading

During the development of the module and the log no consensus was reached over the issue whether to grade student work or not. Some teachers were in favor of grading as they thought students would then work harder, but some teachers opposed it as they feared it would take them a lot of time and might prompt discussion about the grades, time that students could better use on the content. What teachers would do with respect to grading was therefore left to their own discretion.

During the interview the teachers and the students were asked about the grading used and especially whether and how they felt it had contributed to student learning. The results are shown in Table 3.

teachers	John	No grading of the logs during the module. Only the final poster was graded. I think it is appropriate to urge students who are not on task to get to work, but with these logs there was no need for this. Grading often caused to a lot of discussion on the given grades.

	Tess	I graded each group after every period. The grades were based on a rubric I had made in advance and known to the students. But it would also have worked when I had graded once a week instead of after each period.
	Julia	No grading but I did indicate in writing how I appreciated the work done. Groups did receive a final grade at the end of the module for the completed log.
students	John's students	Not a grade, otherwise we might have put more effort in keeping it neat. Maybe we would have been more detailed if the teacher had graded the log. Grading would not have resulted in better or more learning, but certainly in neater writing.
	Tess's students	Yes, after each period. This provided us with input on what was good and what could be improved. Although we could also get this from the comments the teacher had written in the log. Grading made it easier for us to understand how far you are, we are therefore in favor of grading.
	Julia's students	The final grade of the log constituted 40% of the grade for the module the rest was the test result. The teacher did indicate each period with plus and minus how she appreciated our work, but not with a grade. As the log was graded at the end of the module we made it neater by typing all the answers. Without a grade we would not have done this!

Table 3: how teachers and students assessed grading

John did not grade the logs as he did not think his student needed encouragement through grades, and as he experienced that grading always caused a lot of unrest and discussion as students tend to compare their work and grade with that from neighboring groups and often feel misjudged. And he wanted students not to waste class time on this. John's students indicated that grades would have made them work neater, but that it would not have influenced their learning outcomes.

Tess had made a rubric to grade each period and informed the students about it, but she said that next time she would do this only once a week (once in three periods). Her students appreciated the grades as they felt that it had helped them to work hard.

Julia provided each group with a grade at the end, but did use symbols to rate student work after each period. Her students said that because the log would be graded at the end, they had even typed it before their final submission to make it look better, and of course hoped that this would mean a higher grade.

4. Usefulness of the log

Using a log requires time from the students to fill it in, and from the teacher to read it an provide feedback. The question was therefore in what way teachers and students appreciated the log. The answers are reported in Table 4.

teachers	John	I still wonder whether students experienced it as receiving feedback or as checking on them. You could see that the students had been engaged with the content, which I thought was reassuring. My feedback was used in 90% of the cases.
	Tess	The students see the benefits when receiving feedback on their formulas and equations. I am in doubt on whether students also saw the significance of the questions on the right hand side pages (the process questions). This topic, salts and ions, required charges to indicate ions and these are quite

		often misrepresented or forgotten and it was therefore useful to indicate mistakes immediately.
	Julia	I think the students will assess filling in the log as something I required them to do, especially the questions on the right hand side (on the process). Exchanging information and getting a picture of what students had been doing in class was my most important reason to use the log. Next time I will provide students more directions on how to use it.
students	John's students	The log showed us what we had to do, when it would be due and what we had to complete. The teacher could verify this. We had divided the homework tasks and combined these at school. Therefore each member had to contribute otherwise the others would suffer. The feedback served to see what was wrong.
	Tess's students	The log provided us with a clear overview. It facilitated planning and monitoring what to do. The teacher could see how we worked on it, and provided feedback on this.
	Julia's students	The log contained all data: on the process, our plans and the results. The feedback from the teacher served as starting point for group discussions.

Table 4: usefulness of the log according to teachers and students

John indicated that he wondered whether his students would see the log as an instrument to check on them or to provide feedback on their efforts. He could see that students had been busy in class and in that aspect the log was very useful. His students were positive as they said that the log served as a planning instrument for the group and to record progress. They also appreciated the fact that they could quickly see their mistakes through the teachers' markings.

Tess thought that her students would appreciate the fast feedback on their answers, but had doubts about students' appreciation of the process and planning questions on the right hand side. Her students however also appreciated these questions as it helped them plan and maintain an overview of the process. They also valued the fact that their teacher provided fast feedback.

According to Julia, her students would see it as something she required, less as a useful instrument for their learning. Her students however appreciated the need to plan ahead and having all the results properly combined and said that it helped them in their discussions.

5. The log to influence learning process and learning

Table 5 shows the answers on the question whether the log contributed to guiding the students' learning processes, and how the log contributed to student learning.

teachers	John	Normally students receive feedback through a summative test. This is not very helpful to guide student learning. The efficiency of the log is much higher as the feedback is in time, regular and students do look at it and make corrections way before the test. I noticed several times a similar mistake. Students themselves often do not notice mistakes they make, but I do. Students had to indicate the major mistakes they had made when working on the module on their group poster at the end of the module, and therefore had to go over their mistakes once more so that they became aware of these. What I loved was that students entered the classroom asking "may we already start sir?".

	Tess	Students do take their tasks seriously and accept the responsibility that comes with a specific task: "I am the writer and the work will be graded so it has to be good as it benefits the whole group". I don't think this way of working is better than traditional classes, but it is different. Our students are not used to preparing experiments at home. To figure out what materials and chemicals to use and to plan the experiment was a new learning experience for them. But it is an important skill. At the beginning of a class the logs were ready and the students could immediately start off.
	Julia	'What did you learn today" was not asked by me, but should have been posed. Students themselves had to list the important words (concepts) they met in the module. Learning is something students relate to tests, and I hope students became more aware of their learning now. How the group members collaborated was not observed by me.
students	John's students	You know what to do, so the log provided clarity. The questions directed us to learning because when you just do the experiments it is not easy to say what you learned from it.
	Tess's students	We did not have many questions, we could immediately start off at the beginning of a class. We started by looking back, then discussed what to do next. Realizing how we benefited from something is good feedback. Normally we would just have done the experiment, but now we had to think about what we had learned.
	Julia's students	In one experiment we had to measure the 'thickness' of a liquid and this proved to be an important word for our list with important words: viscosity. We discussed this before we added it to the list. Apparently we had not understood the assignment as we had only written down the important words we were unfamiliar with, but the teacher then said that we had to write down all important words relevant for the topic, including the ones we already knew.

Table 5: how the log guided or contributed to student learning

John normally provided students feedback after a test at the end of a chapter or topic, but said that this feedback was actually too late and ineffective to influence student learning. The log offered him an opportunity to provide immediate, lesson to lesson, feedback. He said that in the past his students often not even noticed their mistakes, especially when they had incorrect ionic charges, but now he clearly pointed them out in writing. In previous classes he often had to ask students after having entered the class room to take their books and notebooks so that he could start the lesson. Therefore he loved it that his students now entered the classroom and asked "may we already start sir?" and quickly started as they did not want to waste time. His students were also quite happy with the log as it provided clarity about the when and what. They said the question to write down what was learned that lesson was however difficult to answer.

Tess said that her students took the responsibility for the work and that the group roles helped in this. She did not consider this approach to be better, but definitely different and as students enjoyed it she considered it a welcome variation. Especially the teacher feedback, but also reflecting on what is learned was appreciated by Tess' students. Also the fact that they could start the lesson themselves was valued.

Julia had hoped to make students more conscious about their learning through the log, and especially through the questions in the log. She had removed the question "what did you learn today" as she did

not think this to be meaningful. But over time she regretted it as it might have stimulated her students to reflect also on their learning, not just on the process they had gone through. Her students noticed that in the group they sometimes had discussions on concepts some members already understood and therefore could properly explain to the others.

6. Roles and cooperation

What students answered on the questions about how they used the group roles and how they perceived the collaboration in practice in terms of explaining and correcting one another, can be seen in Table 6.

	Roles	Explain, correct one another
John's students	We did not revolve roles but each period someone started and the roles then came naturally. We distributed the homework tasks and assignments and discussed these back at school. This pressured us to do it properly. We had one 'writer' but the answers were formulated by all group members.	We did explain one another. When you have a question you just bring it in the group and the one who understands answers it. When the group could not solve it, the teacher or the technician was called.
Tess's students	We used the roles and revolved these. The advantage is that not one person could determine what to do, but also a more withdrawn student could take up the chief role. The writer jotted down what he knew, but when in doubt consulted the group and then we discussed it. What to do the next period was something we always discussed, we did not want someone to decide on what we were to do.	We did explain stuff in the group. Especially when filling in the log we talked about the answers. We also corrected one another, mostly it was the chief who called us to order.
Julia's students	I personally did not find the roles necessary. However we used them but did not revolve. When someone has put something away as the material person it is easier for her next period to get it, having to explain to another student where it can be found is complicated. When you are the writer you can also ask someone to take over. You need someone with a readable handwriting. What to write in the log was discussed.	The collaboration was fine, when we did not get it we called the teacher. We did not disagree after discussion.

Table 6: how students used group rolls and group collaboration

According to the students all teachers had introduced and explained the student group roles. In practice all groups used the roles, however some groups never revolved these.

John's students said that taking a specific role happened automatically, someone just started and took the leadership role and the student who had finished first filled in the log and took the writer's role. They did explain to one another in the group but also sometimes had to ask the teacher for clarification.

Tess's students did change the roles and they said that they appreciated this. They had discussions when, for example, the writer did not know how to answer a specific question, or about preparing for the next period. The chief also had the task to call a student to task when doing something else.

Julia's students felt that the roles were unneeded, nonetheless they used them but did not revolve the roles. When a student had a specific role often another was asked to do a task belonging to that role. They also had reasons for not revolving roles as they said "when someone writes unreadable it is better when this person does not write". These student were positive about their cooperation.

7. Usefulness of specific questions according to students

The student answers to four questions related to the usefulness of specific aspects of the logs can be seen in Table 7. The four questions are shown in the first row.

	Was the homework done?	*What are we planning this period?*	*What did we do this period?*	*Set homework*
John's students	When you know what is not done yet you can still do this in class.	Good to plan what to do. It can save time. Thinking ahead is helpful.	This is a useful questions and we did answer it honestly.	We did this but as we worked hard in class there was usually not so much homework.
Tess's students	Yes but we could do most of the assignments in class. Did not have much homework.	We prepared activities in pairs. It is difficult to estimate how much time something will take. And when it takes longer than planned for, you run out of time.	It is helpful to see what we did, but we don't know whether it made us learn more. To realize what we did and to make it explicit however is good.	We hardly had to do set homework, could do almost everything in class.
Julia's students	We did not have homework!	We had to plan a full week ahead, and on top of this also had to plan each lesson. It is not difficult as we could more or less see how much time an activity required.	*This question was not in these students' log.*	Not necessary, only when it came to writing a report for an experiment.

Table 7: students' assessment of specific aspects from the log

In general all students did see advantages in answering the specific questions and were able argue why these were helpful. The only exception was the time indication in the planning phase: students had to plan each period and indicate how much time they thought they were going to spent on each activity. All students said that this question was impossible to answer and therefore advised to remove this question from the next version of the log.

Conclusion and discussion

Teachers and students used the group logs as intended and assessed these as invaluable to provide fast period-to-period feedback, to get insight into student learning, and to monitor and guide cooperation and the learning processes.

Initially teachers had doubts about the feasibility of the logs and therefore had hesitations about the use of the logs in class, especially as they feared that it would take much time to mark them. However after they used them they were all positive and judged the time investment as very valuable and even rewarding. Valuable as it provided each teacher insights into aspects that students had difficulties with, as for example with the ionic charges. Rewarding as the students did use the teachers' comments for their learning. Julia phrased it as follows: "I think it was worth the time as I got more information about my students".

Students also appreciated the logs, they looked at teachers comments and corrected their mistakes when their teacher requested this. Students valued the fast feedback on their efforts and thought it was worth teacher time investment.

There is no consensus about the grading among the teachers or among the students. It is remarkable that the students are content with the system their teacher used: when the work was graded they appreciated it, when it was not graded they did not think they would learn more when it would have been graded. It seems that students get used to a certain practice and appreciate its strengths and weaknesses.

Students needed some time to get used to the new approach, as getting such fast feedback was uncommon, and using this kind of feedback effectively was not normal practice. Correcting mistakes was therefore not an automatic action, but had to be requested by the teacher.

Worthwhile mentioning is that teachers themselves needed to get used to this kind of teaching. Tess formulated this as: "we also have to learn how to best deal with these logs, how can we direct students, what do we do with the logs in class, and is it still necessary to discuss content in the plenary class?".

Essential aspects of log use are the possibility to provide fast feedback, to direct student interaction in the group and the opportunity for students to develop metacognitive skills, without the teacher losing sight of the learning process and progress. Through the design and class use of the group log, teachers get to understand their students better, and this will influence instructional decisions and might lead to more effective practices (Matuk, Gerard, Lim-Breitbart, & Linn, 2016).

Although this material was developed in a TDT, with ample discussion about the log itself and the questions posed to students, the teachers held some reservations until they had the first real class experiences. Changing practice, in fact teachers changing their PCK that has been developed over time, is not easy (Bencze & Hodson, 1999; Gillies & Boyle, 2010), a complicating factor might be teachers' emotions (Van Veen, Sleegers, & van de Ven, 2005). Having teachers use a new pedagogy apparently is not a straightforward process and it clearly requires time and patience and in that aspect our results are similar to what other scholars found (Davis, 2003; Fullan, 2007). Giving teachers opportunities, time, agency and ownership over the curriculum design and the implementation is absolutely necessary. The two phases used in the development process in the TDT, the *(re)design phase* and the *class enactment phase* (Coenders & Terlouw, 2015), proved instrumental for teacher learning.

Acknowledgments. The author would like to thank all teachers in the teacher design team for their cooperation and willingness to discuss, develop and implement the materials, in particular: Jeroen Beltman, Jeannet Brouwer, Leontine de Graaf, Erik Kastenberg, Henk Kloosterboer, Pim de Kousemaker, Herma Mondeel, Eline Velthof, Henk-Jan Visch.

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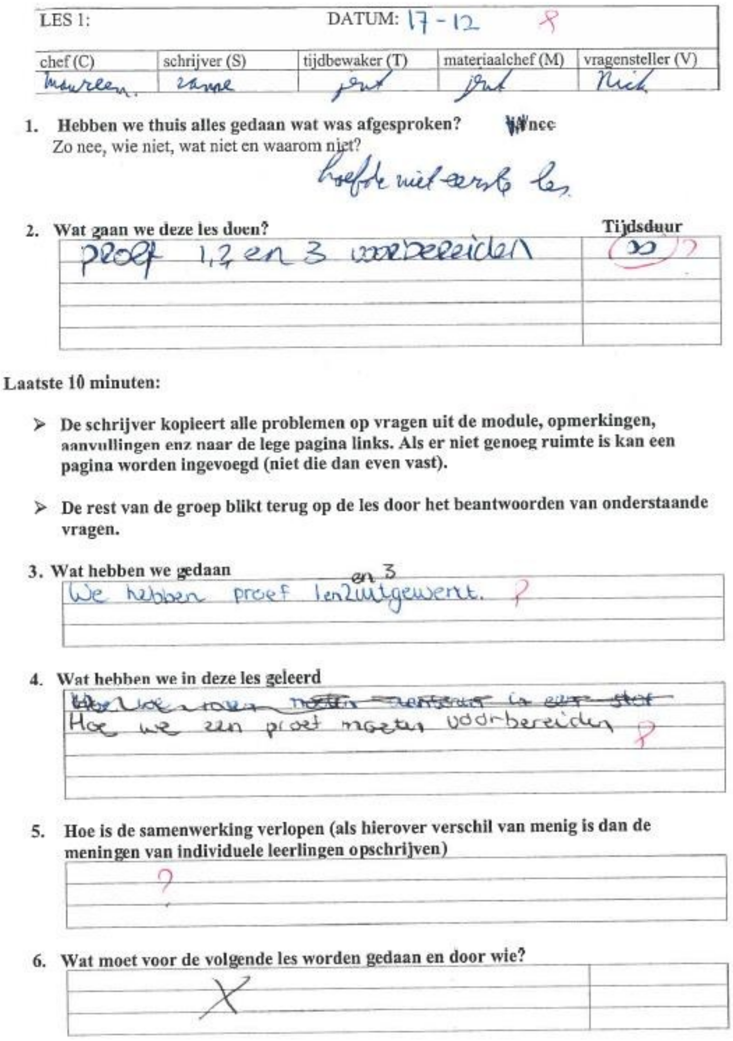
Appendix A. Right hand side page of the group log, showing the six questions for period (les) 1, the group answers plus the teacher marking (in red).


LES 1: DATUM: 17 - 12

chef (C)	schrijver (S)	tijdbewaker (T)	materiaalchef (M)	vragensteller (V)
Maureen				Nick

1. Hebben we thuis alles gedaan wat was afgesproken? Nee
Zo nee, wie niet, wat niet en waarom niet?

2. Wat gaan we deze les doen? Tijdsduur
proef 1, 2 en 3 voorbereiden

Laatste 10 minuten:

➢ De schrijver kopieert alle problemen op vragen uit de module, opmerkingen, aanvullingen enz naar de lege pagina links. Als er niet genoeg ruimte is kan een pagina worden ingevoegd (niet die dan even vast).

➢ De rest van de groep blikt terug op de les door het beantwoorden van onderstaande vragen.

3. Wat hebben we gedaan
We hebben proef 1 en 2 en 3 uitgewerkt.

4. Wat hebben we in deze les geleerd
Hoe we een proef moeten voorbereiden

5. Hoe is de samenwerking verlopen (als hierover verschil van menig is dan de meningen van individuele leerlingen opschrijven)

6. Wat moet voor de volgende les worden gedaan en door wie?

The questions above translated in English:

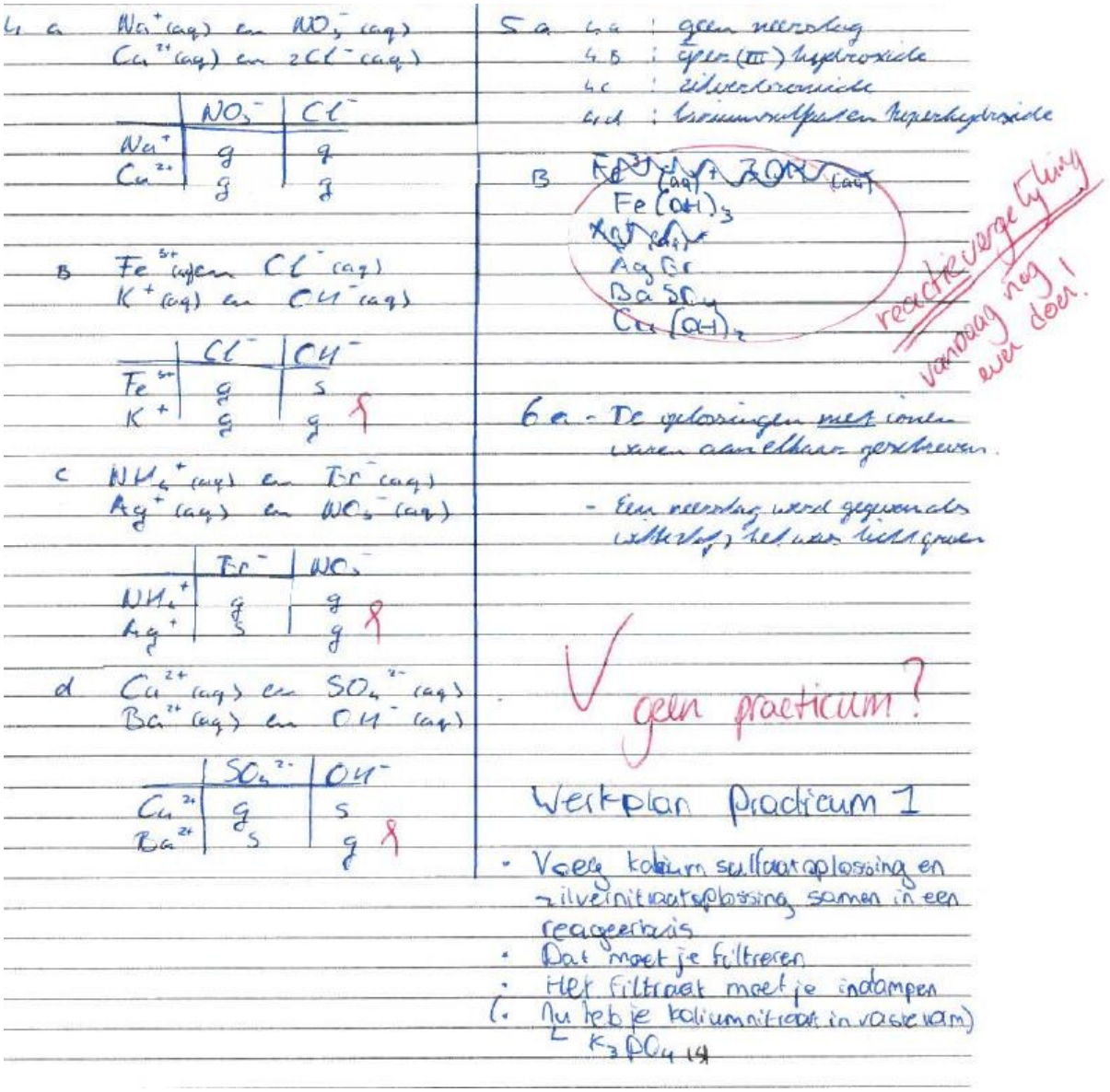
1. Did we do at home what was agreed upon?
2. What are we going to do this period?

Last ten minutes:

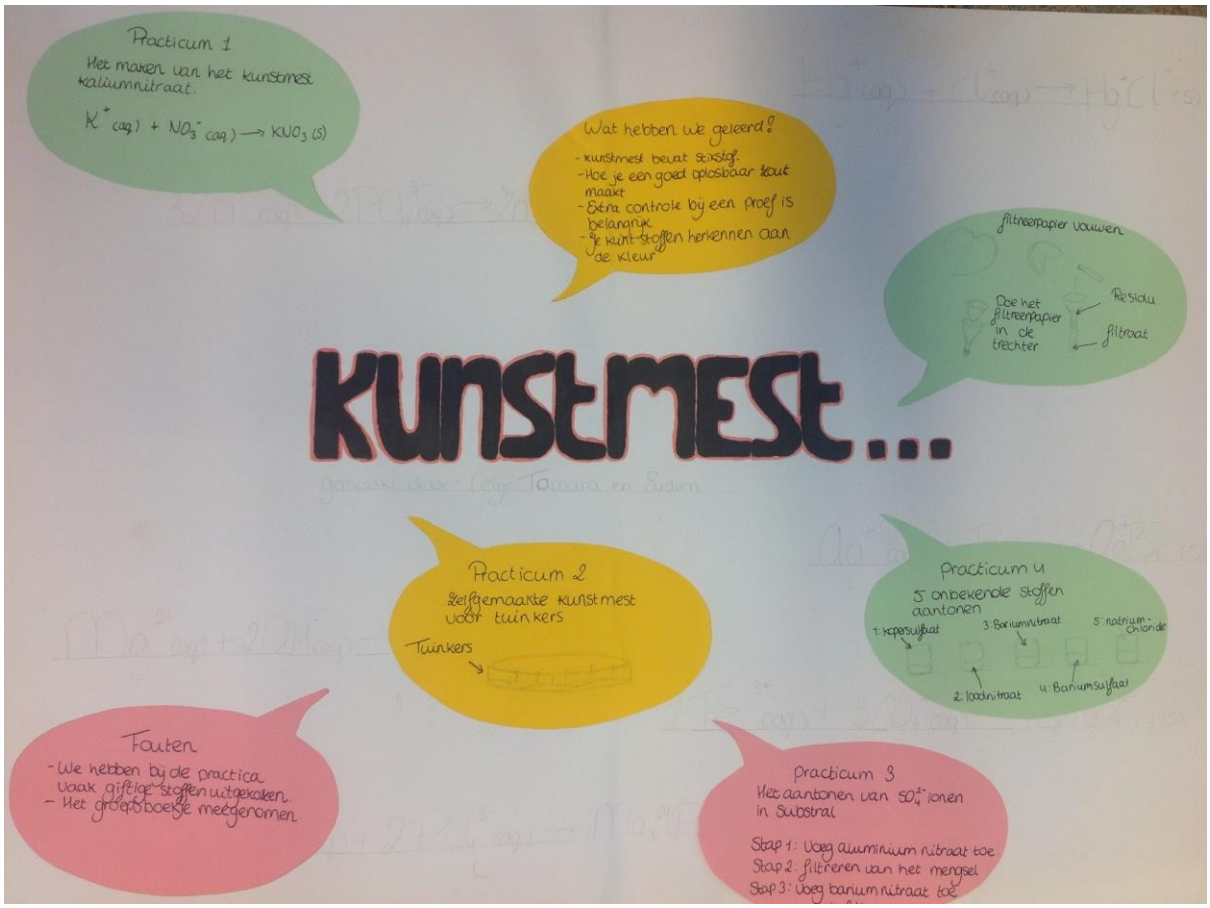
- ➢ The writer copies all answers to questions from the module, remarks, and additions to the empty left hand side page. If space is insufficient a separate page can be inserted (staple this to the log).
- ➢ The rest of the group reflects on the period through answering the following questions.

3. What did we do?
4. What did we learn this period?
5. How did the cooperation go? (When there is disagreement write down the different opinions)
6. What needs to be done before the next period and by whom?

Appendix B. Left hand page of the log, showing student group answers plus teacher marking (in red).



Appendix C: Example of a final group poster.



The translation of the text on the poster reads as follows:

Practical 1

Preparing the fertilizer sodium nitrate

What have we learned?
*Fertilizer contains oxygen
*How to prepare a soluble salt
*Additional check for a practical important
*One can recognize substances by its color

Folding filter paper

Put the filter paper in the funnel — residue — filtrate

Fertilizer

Practical 4
Testing for 4 unknown substances
Copper sulphate Barium nitrate Sodium chloride
Lead nitrate Barium sulphate

Practical 2
Self-made fertilizer for garden cress

Mistakes
*We often selected toxic substances for experiments
* We took the group logs home

Practical 3
Testing for SO_4^{2-} ions in Substral
Step 1: add aluminum nitrate
Step 2: filter the mixture
Step 3: add barium nitrate