Adapting CoRe and Storyline as tools to promote learning and coherence in a chemistry education course

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Introduction

The following text describes the implementation of Content Representations (CoRe) and Storyline in a course for future chemistry teachers at the University of Bergen (UiB) and experiences made. The work was done in the context of the ERASMUS+ project DECoSTE. The tools are meant to support coherence in science teacher education and enhance learning of future teachers.

I new the CoRe before the ERASMUS+ collaboration started and appreciated its potential to depict and develop science teachers pedagogical content knowledge (PCK). At the same time, I was reluctant to include the CoRe as a tool in my course work because of two reasons: 1. It seemed to be a long way developing PCK with help of the CoRe because it required several circles of trying out teaching the same topic and reflecting on the experiences and 2. I struggled to properly understand some of the prompts and could not integrate every aspect into my own thinking about good teaching. In some previous courses, I showed the tool to my PSTs and recommended using it, but that probably never happened.

Established Planning Practice

PSTs plan and conduct lessons several times during their studies. In the fourth year they are supposed to follow at least 30 lessons in each of their two subjects per semester. Normally, the PSTs teach up to 20 lessons per subject and semester on their own. They are introduced to lesson planning in various courses. They also have a planning tool that they are expected to use when preparing the four lessons that university staff attend for evaluation purposes (school visits). This scheme consists of three columns for teaching activities, used resources, and reasons for the chosen activities.

PSTs fill out the form in a way that often does not show coherent thinking regarding relevance of the activities and a meaningful progression. In addition, it seems not very likely that PSTs use the form also when planning their other lessons (a minimum requirement easily turns into what students do at maximum). In many cases, PSTs often rely on textbook resources (competency aims from curriculum as teaching goals, ready-made slides from the publisher, and tasks from the textbooks for practicing knowledge).

Experiences Using the CoRe Tool

First experiences with the original CoRe

As a first trial with very limited resources to use, the original CoRe was introduced in a course in science education in the third year of teacher education. This happened as part of one lecture and did not take longer than 30 minutes. Five students submitted a filled-out form, and one of them filled out for two different subjects. Five CoRes had answers in two columns (two science ideas), the sixth only one. Two of the CoRes contained suggestions for big ideas: 1. active transport in cells involving membranes and proteins and 2. understanding of the light microscope and ability to identify cells. All suggestions look more like teaching goals.

For the first prompt (what students should learn), most of the PSTs formulated factual knowledge (various terms, i.e., components of a cell) or general abilities or understanding (being able to use mole in calculations, understand regulation of enzymes). For the second prompt, many claimed the importance of that knowledge for the subject. Only a few tried to relate it to the students' life.

Teaching activities and approaches to evaluate student learning were mainly traditional. They included an activation of pre-knowledge, instruction that made use of illustrations and observables, examples, and tasks from the textbook. Feedback on learning included asking questions to students, going through tasks in whole class, and oral or written assignments.

In answers to prompts on difficulties to learn about the ideas (prompts four to six) several PSTs mentioned the abstractness of the concepts and the lack of visibility of involved structures as a main feature. PSTs also pointed to the complexity of the topics, difficult concepts and processes, and varying background knowledge of the students as a challenge. One PST mentioned technical challenges regarding the used equipment and possible mistakes and wrong interpretations, another PST limitations by the practice situation. While being relevant, most of the challenges are of a general kind mirroring the breadth of the topics described. Another sign for the generality of the PSTs reflections is that they often copied their answers for the two ideas.

The picture that emerged from the few examples showed generalized reflection around subject ideas of very different grain size. Only in a few instances, PSTs were more specific. In two cases, PSTs mentioned inquiry and described instruction that included artefacts and phenomena. At the same time, they also stressed the need for theory and instruction of theoretical concepts. As one can expect from their limited experience, the PSTs showed little concrete thinking about challenges connected to the scientific ideas to be learned. Hence, it was difficult for them to formulate aspects that could guide their planning to more specific approaches.

Adaptations to the CoRe Tool

A CoRe displays professional knowledge of a teacher related to teaching specific topics. Reflecting on teaching experiences enriches that knowledge and is the foundation for adjusting teaching in future lessons. Hence, the prompts in the CoRe can support both planning of and reflecting on teaching. Because the CoRe originally has been developed to capture experienced teachers' PCK, not all prompts are equally easy to answer or useful for PSTs. In addition, the CoRe requires developing big science ideas. The literature provides some examples but no systematic way to identify them. Another issue is that big science ideas are portrayed as general, overarching ideas that apply to many different topics. If the CoRe is focusing on such ideas, they are not very appropriate as lesson goals because they are too big (like cross-cutting concepts).

Another planning tool has been developed that has similar features to the CoRe (Ambitious Science Teaching, AST). It has the advantage that it explicitly connects the science ideas to a phenomenon that students should explore and explain. In this vein, the planning tool connects two aspects of the coherent core. I tried out that planning tool before with mixed results. The PSTs found it difficult to decide on the grain size of the science ideas, and choosing a phenomenon was demanding. Regarding the grain size of science ideas, my preliminary stance after trying out the tool several times is that medium or low-level teaching goals are probably more appropriate at least for chemistry. This also opens up for phenomena to originate from laboratory problems and not only real-world situations, which are mainly used in AST.

I therefore decided to merge the CoRe and the planning tool from AST and lay the focus on the planning aspect. The first version of the merged planning tool combined prompt number 1, 2, 7, and 8 from the CoRe with five steps from the AST planning tool (see Appendix A). The tool guides PSTs from scientific topics to scientific ideas that can explain a phenomenon. Prompts were extended with short explanations of what PSTs could do or use to produce fruitful answers. The rest of the CoRe prompts were thought to be addressed in an assignment after the PSTs' school practice to allow for an experience-based reflection.

Experiences Using the Storyline Tool

Pre-service teachers (PSTs; the term student is used for addressing students in school) often plan single lessons where they go through a chapter or sub-chapter of the textbook without paying much attention to connections to previous and following topics. This might be related to the fact that the textbooks treat the different topics as largely independent. They seldom refer back to more general topics when introducing a new topic (i.e., equilibrium when introducing acid-base chemistry). Therefore, the storyline was regarded as a useful tool to make students realise the connections between the topics and include them in their planning. It was also thought to fit well with a phenomenon-oriented approach to teaching and the development of new scientific questions from earlier ones.

The storyline tool was given to the PSTs in the original form complemented with a short introduction in Norwegian and an example from chemistry based on own thoughts and experiences (see Appendix B). The storyline was supposed to be filled in after the planning tool to break down the medium level goal into smaller goals that could be addressed during one or two lessons.

Implementation of Both Tools

The merged planning tool was implemented together with the storyline tool at the start of a chemistry education course for fourth year PSTs. The course is mandatory in the teacher education programme at the Faculty of Mathematics and Science for PSTs with chemistry as one of their teaching subjects. The programme is preparing for teaching in mathematics and the sciences in grades 8-13 with a focus on the upper grades. The course has 15 ECTS and consists of 40 lessons of 45 minutes each distributed over one year. Besides the course, PSTs have two periods of school practice (appr. 70 days). The content of the course can be adapted to some degree, but must follow instructional aims, topics, and literature in the course description.

PSTs used the first two weeks of their practice to find out about relevant topics. Because most PSTs were in the lower grades (8-10) with a combined science subject, only a few had chemistry topics in the following weeks of their practice. Some chose therefore to plan for chemistry topics without a clear perspective to teach the lessons. This became the reason to drop the assignment of working over their CoRe after practice then including all the prompts.

Features of planning examples

It was obviously easy for PSTs to identify relevant topics with subtopics (from textbook) and relate those to curriculum goals. Two topics were chosen by several PSTs. They were chemical reactions (6 PSTs) and the link between chemical bonds and properties of substances (4 PSTs). Four of the plans on reactions focused on discerning chemical from physical changes. The other two wanted to find out what happened during combustion reaction. While all these examples included big science ideas (like chemical bonds and reactions), the specific aims the PSTs formulated could be divided into three groups:

1. Understanding the definition of a concept and learning to distinguish examples from non-examples (chemical reactions)

2. Understanding relations between at least two concepts and how these influence the behaviour of substances (bond-properties relations)

3. Understanding the submicroscopic processes involved in a change (combustion)

Although all groups of aims are relating observable features to the submicroscopic level, only the third group indicates a direction from a phenomenon towards an explanation. In the other two groups, aims were often formulated to be learning the theoretical content to be able to apply it to real-world situations.

Most of the PSTs chose a phenomenon that could be demonstrated while a few proposed to use a physical model to depict a phenomenon that is difficult to observe. There were differences in how easy the phenomenon could be shown to students but more interesting were differences in how close it could be connected to the scientific ideas that were in the teaching plan. One example to inquire into chemical reactions chose mixing baking powder and vinegar, whereas a second chose to burn magnesium and weigh it before and after. While the former experiment at first glance shows that something happens, the latter experiment draws attention to a certain change that can be generalized to characterize chemical reactions, the change in mass. This highlights the importance of phenomena that include contrasts or other regular patterns that are suitable for generalization.

One prompt asked the PSTs to search for more information about the scientific idea they wanted to explore in their teaching. This functioned to make sure that PSTs have a deeper understanding of the idea than is usually found in school textbooks. The PSTs were able to find aspects of their scientific ideas that they did not know before and that would be important to include in the teaching. Examples showed in addition that online resources offered explanations for phenomena that often were too simplistic or even wrong. While this on one side is a challenge because PSTs need to identify the insufficient information, it is something that PSTs on the other side could actively use to teach students critical thinking.

The prompt asking for a causal explanation of the chosen phenomenon worked only in those cases when PSTs had a concrete phenomenon. Otherwise, they described how theoretical aspects were involved and what students should learn be conducting the learning activities. Considering that explanations were often insufficient, this prompt is especially important. However, to become useful, PSTs must detail involved processes and entities and discuss their explanations with peers and more knowledgeable people in addition to reading information.

PSTs' suggestions for how to teach the scientific ideas varied considerably. Whereas some planned a traditional approach consisting of introducing students to the theory, showing examples, and giving tasks to apply the new knowledge, many started by showing something to the students (demonstration or video) and involving students in talk. Student talk both in groups and in whole class was regarded by the PSTs as a possibility to learn about the students' progress and whether they learned the content as intended. Suggested student work was often the application of facts and definitions in a logical way to reach solutions to familiar problems.

Suggestions for how to monitor students' understanding were often general and in a form that mirrored competency goals from the curriculum but on the level of the lesson goals. They can be described as summative goals and are mainly reproductive with a focus on facts and their application. Only seldom, PSTs indicated that students could contribute with new knowledge aspects when working with the subject matter in a certain activity.

Features of storylines

The storylines the PSTs produced after working with the planning tool showed that the lessons contained three to four lessons or lesson sets devoted to one aspect of the overall topic. These aspects could be recognized from teaching resources (textbook and/or internet), and their relations were obvious but somehow far. The lessons were not based on one driving question and one scientific idea on a medium grain size level but on different, although related questions. Each lesson set could be taught independently instead of sub-driving questions emerging out of previous lessons or lesson-sets. Most of the questions in the storyline were "what" and "how" questions. They asked for a description or definition of a term or concept or how different concepts were related to each other. The questions indicated that there were established answers that students should know after instruction.

The descriptions of the lessons were mostly short and added only now and then details that were not mentioned in the planning tool. New aspects were mentioned when lessons addressed other ideas and questions than the one that was developed in more detail. Formulations under "What students learn" were mostly on a general level and in line with the concept focus of the topics. The last column on learning performances contained descriptions of teaching goals, what students should learn, or what students were supposed to do.

Thoughts about Further Adaptations

The experiences reported here are based on the current form the planning tool was administered together with the storyline tool and the very brief or almost absent introduction of PSTs to these tools. At the same time, they resonate with the challenges described in the storyline and CoRe booklets. They underline that prompts must be clear enough to give PSTs an understanding of what is expected from them. PSTs managed to connect relevant aspects of a scientific idea to a phenomenon and arrange a set of instructional activities. However, the approach did not yet succeed in helping PSTs to use the idea of driving questions so that students need-to-know was determining the sequence of lesson activities across several lessons. Here, more work and adaptations are needed to make PSTs understand the meaning of driving questions and link them to phenomena that students can inquire into.

Planning Tool

It would be beneficial for PSTs to be introduced to a few central ideas of a topic and how these ideas can be approached through simple practical activities (i.e., teacher demonstrations and student experiments) before they work with the tools on their own. From the current Norwegian curriculum, PSTs are likely to be in school practice when structure of matter (lower grades) and acids and bases (chemistry in grade 12) are taught. These topics are a good starting point. Further, PSTs could be assigned to identify ideas for other topics in small groups. These suggestions could be fruitfully discussed and evaluated and could serve as a resource for PSTs' future planning. For the learning of the PSTs, the approach with a common introduction to one or two topics and group work followed by an evaluative discussion would shift the development of PCK from the individual PST to groups and supporting supervision.
Regarding the structure of matter, the idea of electrically charged particles is one central idea. It can be further specified into where the charges are located (nucleus vs. periphery), how they can be affected, and what their role is for a substance's properties. Besides the fact that there are two types of oppositely charged particles there is little that can be shown without advanced equipment. The phenomenon that is probably well worth introducing is that things we have around us usually do not interact with each other. But we can make some of them interact by rubbing a plastic and a rubber rod with a cloth. If we move two plastic rods treated

this way towards each other, they repel each other. If we use one plastic and one rubber rod, they will attract each other. The same phenomenon (deflection of a thin stream of water from a tap by a charged plastic rod) can also be used to introduce dipoles.

In the case of acids and bases a central idea is the distinction between strong and weak acids (although this is more a continuous property). This can be inquired into by measuring pH in solutions of different acids (i.e., hydrochloric acid and acetic acid) and the consecutive repeated dilution with water by a factor ten. Then, we can see that in one acid solution pH rises by one unit, whereas pH changes by 0,5-0,6 units in the other solution. Another central idea is that the acidic property of an acid is cancelled out by a basic solution. This can be used to find how much of an acid or base we have in a certain sample.

The examples given here show that the scientific ideas are not directly visible from the phenomena, but that they must be inferred from information that can be collected through practical activities. An inference drawn from a set of data must be validated by further experiments that support the idea. Often, these experiments lead to results that are not expected and thus indicate the need for adjusting the original idea. Such learning resembles scientific research to a larger extent than often used confirmation experiments. At the same time, it is not possible to frame all learning in the same way because it would be too difficult both regarding equipment and scientific content. However, the approach is suited to lay a solid foundation of scientific knowledge and provides students with an understanding of a problem before they are offered a solution.

Regarding the prompts in the planning tool, a revision should first clarify the concept of big idea. It should be made clear that they represent those scientific ideas that make a deep understanding of the topic possible. Each idea is the starting point for a sequence of teaching activities that introduces a problem based on data or observations (the phenomenon) that lead to further activities to solve a part of the problem. Instead of asking PSTs to search for new knowledge regarding the topic, the prompt should explicitly ask for how the scientific idea could be approached using practical activities and what steps students would take from observation to a tentative conclusion. Taken together, this approach to teaching aims at reaching one or several of the curriculum goals of that topic. The prompt on suggested teaching activities should require a more detailed sequence that can help students to reach a useful conclusion starting from observing the phenomenon. This also calls for shifting the focus from a causal explanation of the phenomenon to what can be inferred with some confidence from the initial and later observations. By specifying what could not be inferred by the data, PSTs could identify further questions that their students could investigate later.

Storyline Tool

The storyline tool filled in by the PSTs did not yield substantially different or more information than the planning tool. It seemed to function as a vessel for the PSTs' ideas that they developed using the planning tool and some additional subtopics. Therefore, the storyline tool should be adapted to the prompts in the planning tool and provide space and support (scaffolds) for writing down the ideas.

As a digital version, this new scheme can function as a plan that can be updated with new ideas and adapted following experiences from the teaching. Over time, this could become a guide that can be shared with colleagues, especially younger ones, to help them reach higher levels of teaching quality without developing the whole sequence on their own. A different approach could be to develop a unit and introduce it to PSTs in their studies. If they adopt parts of it with success in their practice, it would be worthwhile to develop more topics. In the end, the material could become a new type of teaching resources for chemistry teachers who want their students to achieve deep understanding of the subject. When taught in the intended way, students will write their own "textbook" and will rely less on the current ones that often do not explain the concepts in a comprehensible way to novices.

Reflection on further use of the DECoSTE Tools

After the implementation of three of the DECoSTE tools in a course, I intend to do some further adaptations and at the same time use some more time for the work with the PSTs. The adaptations are supposed to lead to better coherence and hence more learning.

Using *trackit* (https://sciedu.fi/trackit/) early in teacher education would be meaningful. PSTs can learn to observe systematically, and the time graphs offer data that trigger interpretations and reflections. It would be interesting to start using *trackit* already in the first year when PSTs are out in the schools for one to two weeks. However, this depends on colleagues who are responsible for the respective course. The next possibility to introduce *trackit* would be in the second year. *Trackit* could then be used by PSTs regarding their own teaching in the third and fourth year when PSTs are teaching in school for an extended period. It would be useful to discuss activity patterns with teaching staff from the university. Over time, when supervisors in the schools regard the tool as helpful, they could do the same with other lessons. In the reflective discussions, prompts from the CoRe should be used to focus PSTs on relevant observations and their interpretation in the lesson and how this information can be further used to improve the planning. Questions to ask are what students struggled with during the lesson, what indication for learning the PST has, and what changes to the teaching plan have the potential to improve the learning. In this way, PSTs could advance from hoping that their teaching leads to student learning towards identifying evidence that supports such claims.

After the reflective discussions following a lesson, PSTs could work with a written assignment to continue reflection and work with those prompts from the CoRe that address knowledge from experience. In this way, PSTs would not think through these prompts on a shallow basis or in a general manner but based on their concrete experiences from a specific lesson. What they learned when conducting the lesson, would be used to answer the prompts as concrete as possible. At the same time, the answers would be useful to adapt the lesson plan for the next time they are teaching the respective topic. These reflections include what students thought about the phenomenon before the unit, what was difficult for the students to do and work with, and what understanding different students arrived at during the unit.

Appendix

Appendix A: Planning tool implemented in the course

Planning and reflection tool
Here are some questions or invitations to help you as you plan lessons that are inquiry-based and lead to a deeper understanding in your students. The steps will lead you from topic to scientific ideas worth teaching. The scientific ideas are general and can help explain many different phenomena. Thus, this teaching can create connections between different topics. The form has been developed with inspiration from various sources (see references).

1. Identify an **important topic** from the textbook that you want to teach. Use the book also to find relevant sub-topics (approx. 8-10). It is enough that you note key words.
2. Use the curriculum to find all **curriculum objectives** that you can associate with your chosen theme. Here you can copy straight from the curriculum.
3. **What do you want your students to learn related to the overall scientific idea?** Formulate at least one scientific idea that you think students should learn to gain a deeper understanding of the topic. Formulate the idea(s) as a relation between different concepts. You could also use the following formulation: If students learned "this idea", they would also understand "these topics." **Why is this important to know for students?** Give a brief rationale for why the overall idea helps to understand several other phenomena.
4. What can make this idea **meaningful to students**? Think about **experiences** that students have that they can relate.
5. **Look up information about the scientific idea** (e.g., wikipedia, encyclopedia, naturfag.no or talk to someone who knows more) to be able to write a causal explanation (why does it happen). Note down **three new aspects** that were not clear to you previously. You need a good understanding yourself to be able to help students achieve something.
6. Choose a **phenomenon (experiment, demonstration, video, or image) that anchors** the central scientific idea. Briefly describe what is happening.
7. Create a **causal explanation** for the phenomenon. This explanation should be free of gaps and be just above the level that you think students should achieve. Also, sketch out a diagram that your students will use to draw their models (use a separate sheet of paper and paste a picture at the end of the document). You can use "before, during, and after the process" or two side-by-side situations to be compared.

8. **What approaches and teaching activities** would you like to use (and what reasons do you have for choosing these for working on the idea)? Remember to include activities that lead to observations, group activities where students can discuss their views and ideas, and whole-class discussions, and whole-class discussions where students share and evaluate their ideas.
9. What ways do you have to **bring out students' understanding** (or confusion)? Write **two indicators of goal achievement** (not tiered into high, medium, and low, but use some of the key scientific practices (argue, use evidence, or model) together with a scientific idea). The learning can also be documented during the process itself. So, it is not necessary that students produce everything towards the end of the lesson.

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Appendix B: Storyline tool with example implemented in course

Storyline tool

This tool supports planning a sequence of lessons covering a specific topic with a specific, overarching scientific idea. Therefore, you should first work with the planning tool that helps identify such ideas.

The tool contains teaching activities, learning objectives and outcome descriptions that apply to lessons that are based on sub-questions that the students work on to achieve the overall goal.

It is neither normal for teaching to address one question to achieve deep understanding in a short period of time, nor is it common that just one phenomenon (experiment or demonstration) is enough to understand it. The exploration can go in different directions and needs several inquiry cycles before students are able to formulate a preliminary answer to the original question.

First, you find an example that revolves around the question: What affects the solubility of a substance in water? The descriptions of phenomenon and teaching activities could have been even more detailed so that they correspond better with the learning objectives. But I chose not to write in detail.

Then follows a blank form that can be used for your own teaching topics.

Driving question: What affects the solubility of a substance in water?					
Lesson (number and topic)	Lesson question	Phenomenon / experiment	Description	What students learn (physical term, concept, principle, law, …)	Learning performance
1	Why does more gas form when you dissolve a second effervescent tablet after the first one?	Video: Tub with water and reversed measuring cylinder filled with water. First tablet produces ca. 10 mL. Second tablett produces ca. 25 mL.	Talking about observations Ask for suggestions for explanation Test suggestions: • Divide tablet in two halves: first part does not give any gas, second part gives ca. 10 mL • Dissolve a third tablet: gives at least as much gas as nr. 2	Gas can dissolve in water; The amount is not unlimited	Students discuss possible explanatory ideas; students can develop experiments to support or refute the solution hypothesis

2-4	Why do different gases have different solubility?	Video: hydrochloric acid or ammonia fountain: flask filled with HCl or NH3 gas, rubber cork with glass tube with a tip inside the flask, put in a container with water; The water slowly rises in the tube. When the first drop comes through the tip, a jet of water shoots into the flask and fills it.	Talking about observations Develop assumptions about why; collecting phenomena from everyday life: soda bottles, tap water in a glass, fish bowl Test solubility with air (and CO2) in a syringe.	Solubility is different Pressure and temperature affect, also polarity and reactions	Can from solubility justify type of bonds in a substance and bonds to water as solvent
5-6	What about solid and liquid substances?	Dissolve salt and sugar, with and without heating	Talk about examples with solids and liquids Compare with solids (sugar, salt, flour)	Temperature affects in the opposite direction Pressure does not affect	Can justify why solids dissolve better at higher temperatures
7-10	What happens when we mix solutions of different substances?	Show reaction between table salt and silver nitrate (Petri dish and test tube)	Talk about observations Ask for suggestions for explanation Test some of them	Can separate substances Affected when a part is "removed" from the solution	Can justify rules of solubility

Appendix C: Revised planning tool

1. Identify central scientific ideas of a topic based on the curriculum goals. These ideas are characteristic of the overarching topic and suited to develop a deep understanding of it. Note down how these ideas are connected and in which order you would approach them.
2. Find experiments that will yield data that can lead to the ideas. Keep them as simple as possible. At the same time, make sure that you have enough measurements to be able to discover patterns that students must interpret. Formulate questions that students might have when observing the experiments/demonstrations. Try to find sets of related questions that can provide ever deeper insights into the phenomenon. Try out the experiments to be able to respond to practical challenges and unwanted effects from interfering relations.
3. Set up assignments (step by step) that will help students collect and arrange the data and think about fruitful inferences. Include group phases to allow different ideas to emerge and whole class phases to share and evaluate students' ideas before students continue with the next step. Identify activities/practices that can show students' competence growth. Think also about what could not be inferred from the data but would be useful later. Write down these ideas in the form of questions. Those can be used as driving questions for new steps in the learning process.
4. Note down possible student views that contradict the inferences that you intend them to draw. Prepare experiments (or build those into the experiments you plan) to be able to challenge such views. Be prepared that students will not change their thinking easily. Note down hints that you could provide to help students think in a different way.
5. Arrange the scientific ideas together with the anchoring experiments (or demonstrations) in a scheme that provides an overview of the whole topic and fill in all relevant information that helps you to conduct the unit.

Appendix D: Post-lesson reflection questions (oral and written)

Oral session after conducting the lesson:

- Which of the planned activities in the lesson went as you expected?
    - What did you observe?
    - Why did it work?
- What did students struggle with?
    - What did you notice?
    - What might be possible reasons for that?
    - How could you improve the activity?
- What can you say about students' learning (ask for evidence)?
    - What did you observe?
    - What does that tell you about the learning?
    - What might have interfered with being able to observe students' understanding?

Written reflection

Choose two situations from the lesson that you think are useful for reflection and describe them briefly (what did you do, what did students do). Describe your thoughts about how the teaching worked based on the course literature and your knowledge of the class. Suggest some changes to improve the teaching and continue with new related questions.

- Suggest at least one change in the structure of the lesson that could improve outcomes.
- Suggest at least one student activity that can indicate understanding.
- Suggest at least one demonstration/experiment that shows a new aspect of the phenomenon.
- Describe at least one challenge that students had when conducting an activity.