Chapter 16
From Curriculum to Enacted Teaching of Photosynthesis, the Carbon Cycle and Sustainability in an Upper Primary School Class

Lina Varg

16.1 Introduction

A recent interview study indicated a lack of clarity in science teachers' articulation of their work to offer opportunities for upper primary students (grades 4–6, age 10–12) to practice reasoning (Varg et al., 2022). In addition, grade 6 science teachers were found to view practical work as the most important aspect of science education, while simultaneously implying that their teaching practices mainly consisted of whole-class discussions (Lidar et al., 2019). These findings expose a need to further explore how upper primary school teachers' views of important elements in science education influence their classroom teaching practices. If, for example, practical work or student reasoning are considered fundamental, how does this show in the classroom? A previous Australian case study of a secondary school science teacher enacting reformed curriculum to teach sustainability showed that rather than teaching according to his own convictions, his teaching was strongly influenced by the pressures caused by time constraints and external assessment (Tomas et al., 2022). These findings from secondary school science raise questions about how intentions or convictions and instruction relate to one another in upper primary school science. Teachers often spend considerable time constructing lesson plans to guide their teaching (Ziebell & Clarke, 2018). However, a recent U.S. case study suggests that many teachers devote excessive amounts of time to planning, while expert teachers tend to rely on different strategies, rather than strictly adhering to elaborate plans, to guide their teaching (Hatch & Clark, 2021). Examples of strategies found in their study were the use of open-ended questions and encouraging students to elaborate on their answers. Whether teaching practices are enacted as planned, thereby providing opportunities for students to develop the intended

L. Varg (✉)
Umeå University, Umeå, Sweden
e-mail: lina.varg@umu.se

K. Korfiatis et al. (eds.), *Shaping the Future of Biological Education Research*, Contributions from Biology Education Research,
https://doi.org/10.1007/978-3-031-44792-1_16

knowledge, is an interesting question. It is relevant to study teachers' work and ability to select and use teaching strategies which enable students to develop according to intentions. The present case study of how one primary science teacher enacts her intention for students to practice reasoning around sustainability issues is a contribution to research on the congruence between lesson plans and enacted teaching. Guiding the study were the following research questions:

– How congruent are a primary school science teacher's intentions and the implemented teaching practices?
– What factors impact the congruence between intentions and teaching practices?

16.1.1 Background

A recent study suggested that teachers use different strategies when planning their teaching, such as consulting colleagues, strictly adhering to curriculum, or following the textbook (Hatch & Clark, 2021). Regardless of the chosen path and resources used to plan, teachers' ability to teach in ways that provide adequate opportunities for students to develop the intended knowledge might differ. Teachers governed by national syllabus are navigating a zone, or "space of tensionality" (Lewthwaite et al., 2014), between the intended and enacted curriculum. There is a widespread belief that congruence between intended and enacted curriculum is crucial for reaching educational goals (Pepin et al., 2013; Ziebell & Clarke, 2018). However, the factors impacting this congruence likely vary among different teachers and contexts. Therefore, the need to study possible factors was emphasized as an important step to enable a reduction or elimination of their impact (Tobin et al., 1998). Findings from a case study of a secondary school science teacher show that as he worked to plan and implement a new curriculum on sustainable development, he experienced a narrowing of the space of tensionality, which manifested in feelings of reduced autonomy (Tomas et al., 2022). The teacher further identified the two main factors impacting the congruence as time constraints and the need to cover curricular content to prepare students for an external assessment (Tomas et al., 2022).

Alignment studies researching the congruence between intended, enacted and assessed curricula are quite common, while studies looking closer at the planning processes and influencing factors are rarer (Hatch & Clark, 2021; Ziebell & Clarke, 2018). There are several models for looking at alignment. Porter (2004) proposed four levels of curricula that could be compared: intended, enacted, assessed and learned. However, studying different levels of curricula are bound to produce different results concerning degrees of alignment. For example, using Webb's (1997) model, which assumes that if standards and assessment align, the instruction must be aligned with the curricula, means restricting the view to include only the intended and assessed curricula, while excluding the enacted and learned curricula. Such a view possibly overlooks key details in the teacher's process to reconceptualize intended curricula into teaching practices. Nevertheless, most studies focusing on the relationships between curricula standards and assessment point to a poor alignment (Ziebell & Clarke, 2018). Ziebell and Clarke's (2018) comparative case study included a closer look at the underlying reconceptualization processes. They used categories to explore the types of performances that were explicit throughout curricula, instruction, and assessment to identify promoted performance types. A deeper understanding of teachers' transformation of curricula into efficient teaching is important to identify where there is potential for implementing development efforts. Research on what impacts the congruence between lesson plans, as a teacher's interpretation of the intended curricula, and the opportunities offered through teaching practices has received less attention (Tobin et al., 1998). Reaching an understanding of the planning and how the plans are enacted through teaching requires an insight into the perspective of the teacher responsible for the enacted curricula, rather than an exclusive reliance on assessment data. This study presents an attempt to get a broad sense by following one upper primary science teacher as she moves from the national science syllabus, via her selection and interpretation of it in the form of teaching unit and lesson planning, and finally in her implementation of certain teaching practices in her grade 6 classroom.

16.2 Research Design and Method

To deeply explore and understand how one science teacher reconceptualized and enacted the intended curriculum, an intrinsic case study was conducted (Stake, 1995). This is the case of one science teacher who interprets curricula, plans lessons and teaches in an upper primary school class. As a single case, the aim is not to produce generalizable results. Rather, it provides an example of how various factors impact the congruence between this upper primary science teacher's intentions and teaching practices. The results, in full or in part, could be used and transferred to inform or enrich research and practice. Data were gathered from teacher interviews, documents, and classroom observations. The following sections contain descriptions of the participant, the data gathering process and the analytical approach.

16.2.1 Participants and Setting

The search for a participating teacher for this study was initiated by an e-mail sent to a group of 14 upper primary school science teachers who had previously participated in an interview study (Varg et al., 2022). Anna, which is used as a pseudonym for the teacher in this paper, was planning to teach a teaching unit of suitable length and timing. Therefore, she was asked and accepted to participate. Although this is a convenience sample, Anna did not stand out as significantly different in her approach to teaching science compared to other teachers who participated in the aforementioned interview study (Varg et al., 2022). She had worked at the present small-town school since graduating as a certified grade 4–6 science teacher 3 years earlier. The observations were conducted in a grade 6 class, whose 22 students Anna had taught science since the fourth grade. She described the class as well-functioning and noted that although there were many students with special needs, she and her colleague had worked hard to support the students' improved work effort over the past two and a half years. A letter, containing information about the purpose and design of the study, as well as their rights as participants (Swedish Research Council, 2017), was provided to all participants. The students' parents and Anna also signed a consent form.

The observed teaching unit, called 'Substances around us', was an integrated science topic revolving around for example the carbon cycle, combustion and photosynthesis, human exploitation of natural resources, and human impact on climate change. The lesson content was varied and an overview of one example lesson is provided in Table 16.3. In terms of coverage of the national science syllabus, the subject matter was comprehensive, providing opportunities for different teaching practices. The inclusion of topics, ranging from a submicroscopic to a macroscopic perspective, meant that students had to grasp challenging content (Sirhan, 2007) and this rendered the teaching unit suitable for the study purposes.

16.2.2 Gathering Data

This paper focuses on one aim of the Swedish national science syllabus namely that students practice and develop the ability to search for and evaluate information, communicate, and take a stand on environmental issues. The choice to look closer at this aim was validated by Anna's indication that student reasoning was prioritized in the current teaching unit. Data was gathered from multiple sources during 7 weeks. Semi-structured teacher interviews (Kvale, 1997), documents (national syllabus, Anna's planning documents), and lesson observations enabled the analysis of Anna's transformation of content through the different stages, from curriculum through planning and finally as enacted teaching practices (shown in Fig. 16.1).

Anna initiated the planning process by copying pertinent excerpts from the syllabus text and pasting them in a document she called a *local pedagogic plan* (LPP). LPP offers a planning structure used to transform vague syllabus text into more explicit and tangible teaching methods. Anna's LPP included general objectives, subject content, and competences for students to develop throughout the teaching unit, as these were formulated in the science syllabus (The Swedish National Agency for Education, 2018). Anna organized the plan into separate lessons and

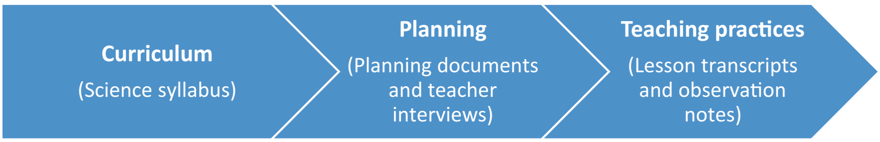

Fig. 16.1 Stages and respective data gathered at each stage

included her interpreted and clarified objectives, teaching activities, assessment methods and knowledge requirements. An example of one transformed lesson plan is provided in Table 16.3.

Two teacher interviews were conducted. The purpose of interview 1, conducted before the observation period, was to gain insights into Anna's plans and intentions for the teaching unit. The interview questions focused on the teaching unit, Anna's teaching objectives, and her routines for planning science teaching. The second interview took place 3/4 into the teaching unit. It was designed to provide insights into Anna's thoughts on science teaching and views on student learning development as the teaching unit progressed. The questions explored whether the observed teaching matched Anna's typical teaching, her perception of the congruence between her intentions and instruction, her rationale for determining lesson objectives, and methods for student assessment. The interviews lasted 28 and 42 min, respectively. They were audio-recorded and transcribed verbatim, resulting in 15 pages of transcripts.

During the seven-week teaching unit, one of two lessons per week was observed to enable a comparison between Anna's intentions, as expressed in planning documents and interviews, and her actual teaching. The lessons were audio-recorded and the verbatim transcripts were combined with written observational notes resulting in approximately 60 pages of narrative records. The observations were conducted to provide data which would enable an exploration of how Anna's initial intentions were transformed into classroom teaching.

16.2.3 Analysis

Data analysis consisted of two parts. The first part was a content analysis (Krippendorff, 2019) comparing all the data to determine what types of learning categories were promoted at the different stages of the transformation. Five selected learning categories that students could be expected to develop in science were used (Table 16.1). The first and last categories originate from Webb's (1997) *depth of knowledge levels* and the middle three are *performance type categories* developed by Ziebell et al. (2017). From the textual data (curriculum, planning documents, interview transcripts, and lesson narratives), units which appeared to promote one of the five learning categories were extracted. For example, a lesson objective formulated in planning documents as "To be able to talk about the carbon cycle, and human impact on it" was categorized as *Recall and Reproduction* (*RR*), while "I really want to focus on reasoning, talking and discussing questions…" (pre-interview) was categorized as *Reasoning*. Since Anna used text copied from the syllabus and placed this in a column next to her own interpretations of syllabus text, the parts of the syllabus intended to be taught and learned during each lesson were easily identified in her plan. The abstracted text units were summarized and rough proportions were estimated to provide an overview of the extent to which each learning category was promoted at each stage. This resulted in a figure (Fig. 16.2),

Table 16.1 Learning categories

Learning categories	Description
[a]Recall and reproduction (RR)	Students reproduce previously taught content.
Performing	Students reproduce previously taught methods or procedures.
Communicating	Students describe, discuss, and represent concepts, use models and diagram.
Reasoning	Students draw conclusions, test hypotheses, make judgements and generalizations.
[a]Extended thinking	Students use higher order thinking processes such as synthesis, reflection, assessment and adjustment of plans over time to solve real-world problems with unpredictable outcomes.

Adapted from Webb[a] (1997) and Ziebell et al. (2017)

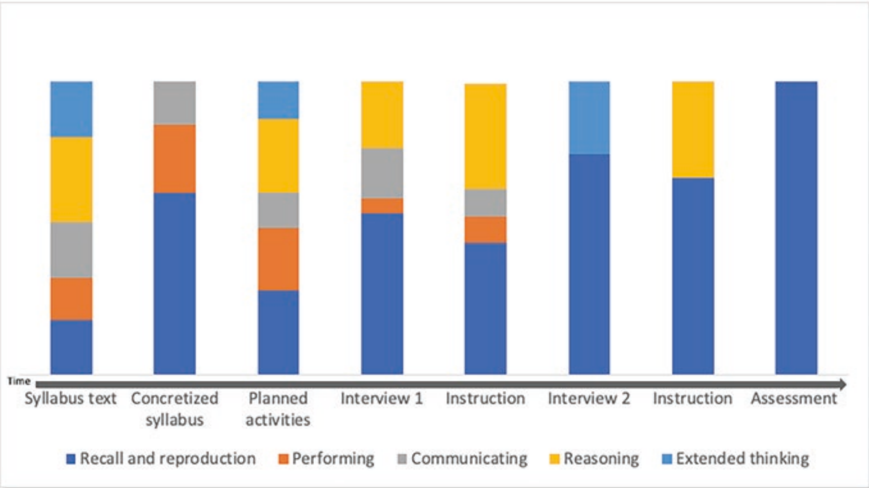

Fig. 16.2 Occurrence of learning categories in different stages over time (visualization)

which should be considered a visualization of the analysis results, rather than a statistical diagram.

The second part of the analysis consisted of an inductive thematic analysis (Guest et al., 2012) of the interview transcripts from the two teacher interviews. These were read several times in an attempt to capture Anna's views of and experiences from teaching science, resulting in the key themes: *Intentions for teaching the topic*, *Planning processes*, and *Factors impacting level of congruence* with accompanying codes (Table 16.2). Excerpts relating to these themes were organized and compared. Some example quotes are presented in Table 16.2, as well as Table 16.3. An important aspect to address here is the concept of "intentions". The intended curriculum usually refers to the "curriculum-as-written" and teachers do not always agree with curricular intent (Lewthwaite et al., 2014). However, Anna expressed a clear

Table 16.2 Themes and codes from interview data

Themes	Codes	Example quotes
Intentions for teaching the topic	Recall and reproduction (RR)	"What is good [about filling in worksheets together in whole-class settings] is that I feel like the whole class is with me. When you [fill in worksheets together, the students] really focus on the white board. Drawing, writing, following along. It feels like a guarantee that everybody finishes it." (RR, Interview 2) "[The students] will grow up and live with [ideas of sustainable development] and therefore it's important to be able to take a stand, communicate, information. It's important. They need to learn and take a stand." (Reasoning, Interview 2)
	Performing	
	Communicating	
	Reasoning	
	Extended thinking	
Planning processes	Use of science syllabi	"I usually create an LPP and I select [from syllabi] the skills that the students will get to practice, and the content, I mean what is in line with the chapter that we will work on." (Use of science syllabi, Interview 1)
	Assessment	
Factors impacting level of congruence	Stress	"I'm 'locked in' during class and that makes it hard, I mean if I said [in the beginning of class] that we will get to the questions, I really want to get to the questions now, let's go now." (Stress, Interview 2)
	Notion of repetitive nature of science education	

Table 16.3 Empirical example: Reasoning

Lesson objective (syllabus)	Clarified objective (Anna)	Planned activity	Interview 1	Enacted activity	Interview 2
"… use knowledge of biology to examine information, communicate, and take a stand **on questions (e.g. natural resource use and ecological sustainability)."**	Photosynthesis, combustion, and some other basic reactions.	Conversation and discussion about human impact on the climate.	"I want to focus on students **discussing and reasoning a lot**. Do more conversation exercises than we've done previously."	[a]See excerpt below from discussion on use of energy.	"About human impact […] it turned out very brief […] I'm thinking **we could have discussed it a lot deeper**. Like what, how can we change our use of these fossil fuels for example."
	Fossil fuels and renewable fuels. Their significance for energy use and impact on climate.				

(continued)

Table 16.3 (continued)

[a]The following episode comes from the example lesson. During one of the reasoning sessions that took place between the readings, one student suggested using electricity instead of fossil fuels to reduce our impact on climate change, and the suggestion resulted in the following interaction (*A* Anna, *S* Students)

A: "What is so good about electricity then? How can we make electricity? In what 2. **ways can we get electricity? How is [it] produced?"**

S1: "Hydropower."

A: "Hydropower, exactly."

S2: "Wind power."

A: "Wind power. S3?"

S3: "The sun."

A: "And solar energy, that's right […] Absolutely, that was a good suggestion. […] Can you think of anything else? What other ways can we think of so that we don't have to emit as much carbon dioxide?"

S4: "Reduce the demand for energy."

A: "Yes, and how can we do that? Do you have any suggestion for how we could 13. **reduce it?"**

S4: "Perhaps, like, I don't know. Use cell phones and such things less."

A: "So you can reduce your use of energy, exactly, and electricity and such. Absolutely. Now let's look at this picture…"

agreement with the syllabus objectives. Therefore intentions, in this case study, refer to syllabus intentions, which seemed to be fully adopted by Anna.

16.3 Results

Results are presented in two parts, one stemming from each type of analysis. The content analysis of all data sources highlights the degree of promotion of the five learning categories (Table 16.1) in different stages of the transformation process from intentions to teaching. An empirical example of how *Reasoning* was approached in planning and teaching is included to enrich these results. In addition, results from the inductive thematic analysis of interview data are used to present Anna's perception of how her intentions and teaching practices match and what factors impact the level of congruence.

16.3.1 Promoted Performances – Content Analysis

All five learning categories were represented in Anna's planning documents. Figure 16.2 shows a rough estimate of the proportion of the five categories as they appeared over time, from selecting syllabus text through planning, teaching and finally assessment. The syllabus text that Anna drew from was slightly dominated by *Reasoning*, while *RR* was more emphasized after the transformation of syllabus text into clarified objectives. All learning categories resurfaced among the planned activities. In interview 1, Anna mentioned *RR* more frequently than the other categories, however, she emphasized *Reasoning* as the main intention for the teaching unit. During instruction, *RR* was most prominent in the classroom, while opportunities for students to practice *Communicating* and *Reasoning* were less common. The two categories *Performing* and *Extended thinking* remained invisible in the classroom throughout the observation period. Final assessment of students' knowledge consisted of a written test asking them to define terms and concepts from a list, which exclusively engaged students in *RR*.

The empirical example presented next serves to deepen the understanding of how *Reasoning* was represented in the planning documents, Anna's expressed intentions (interview), and the classroom teaching. The example reports on a lesson that had slightly varied objectives, depending on where these were found (see Table 16.3 for a summary), which was not uncommon. The syllabus objective was that students should learn to "use knowledge of biology to examine information, communicate, and take a stand on questions (e.g. natural resource use)". Anna shifted focus when transforming the syllabus objective into a clarified objective, which instead listed factual content such as photosynthesis, combustion, fossil fuels and their significance for energy use and climate impact. During the enacted lesson, Anna explicitly told the class, and wrote on the whiteboard, that the lesson objective was that the students would become "familiar with the concept of the carbon cycle and know a little about the processes of the carbon cycle" (Anna, lesson 3 transcript). The activity involved students taking turns to read aloud from the textbook about the carbon cycle. This was followed by short sessions where students summarized and drew conclusions from the readings. The learning category *Reasoning* was strongly emphasized in the selected syllabus text, but less emphasized after the transformation into the clarified syllabus and presentation of objective to the class. In interview 1, reasoning was highlighted as a main intention for the teaching unit. However, as the lesson transcript below shows, questions with the potential to engage students in *Reasoning* were often reformulated into questions of *RR* character during interactions. The interactions seen in the transcript were not unique among the observed lessons, but is rather representative of an overall pattern. In interview 2, Anna addressed this lack of student engagement in *Reasoning*, as described in the section on inductive thematic analysis below.

Anna initiated the interactive sequence with an open-ended question with the potential to promote *Reasoning* (row 1), but quickly changed it into questions which induced *RR*-answers (rows 1–6). In rows 12–13, another open-ended question was asked and one student provided an answer of possible *Reasoning* character. Rather than allowing students to question or build on this and practice *Reasoning* about why and how to reduce energy demand, Anna wrapped things up with a short recap (rows 15–16) and moved on. In short, there were opportunities to engage students in *Reasoning*, but for some reason Anna adjusted the questions and rephrased them as *RR*-questions instead. In interview 2 she reflected upon this and acknowledged that "we could have discussed it a lot deeper" (Table 16.3).

16.3.2 Impacting Factors – Inductive Thematic Analysis

Anna implied in the first interview that “there are always changes” in school and this seven-week teaching unit was no exception. Anna’s planned activities included two conversation exercises specifically intended for students to practice and develop their *Reasoning*. However, none of these exercises were conducted due to changes in the schedule implemented to accommodate a mandatory national Swedish test and a field day. Changes like these are inevitable in schools, and when faced with the task of prioritizing which activities to reduce, Anna chose to omit *Reasoning* rather than *RR*.

One factor that had an impact on the congruence between intentions and teaching, and which surfaced in the interviews, was stress. Anna identified the vast core content and time constraints as the main sources of stress. For example, when asked why they rushed through complex questions and/or answers during class discussion, Anna replied: “You have to move on, move on, move on. Like, ‘well good that I got an answer’ and then you move on” in order to cover the content that needs to fit into the teaching unit. Another factor causing incongruence which was identified in the interviews was a reassuring sense of repetitiveness. Anna expressed a notion of science as a subject that contains a lot of repetition for students during their compulsory schooling. This underpinned a sense of calm that rested on the assurance that students would practice and develop their *Reasoning* skills in secondary school, if not in upper primary school. For example, she said that “[s]ome things come back all the time, for example sustainable development”, implying that if the students don’t grasp the concepts the first time around, there will be more opportunities as they progress through school. On the other hand, Anna indicated that she felt uncertain about what students were expected to know before entering secondary school science. She talked about preparing students by encouraging them to independently search for answers to questions in texts, an activity that primarily requires skills in *RR*.

While the observation results support the interview findings regarding the time limitation of science lessons, they show that most of the lesson time is spent on teaching practices aimed at students learning to recall and reproduce scientific terms and concepts. An example comes from the transcript above, where open-ended questions were replaced with recall questions, and student reasoning was acknowledged, but not further elaborated. Anna suggested that students need “some knowledge about how things work too, to be able to take a stand. They need some background, I mean some knowledge”. Another example was prioritizing teaching terms and concepts while omitting *Reasoning* exercises to make room for extracurricular activities. In summary, while the basis for Anna’s LPP was copied from the science syllabus and thereby showed great congruence, the emphasized learning category *Reasoning* was excluded both from the clarified syllabus and the objectives presented to the class.

16.4 Discussion

In this study, it was found that Anna's main intention to offer opportunities for students to engage in *Reasoning* about subject matter such as photosynthesis, the carbon cycle, and human impact on climate were not efficiently transformed into enacted teaching practices. This resembles the finding from the study of a secondary school science teacher who, despite having "positive dispositions towards and knowledge of ESD", was not able to "make ESD happen" (Tomas et al., 2022, p. 11). There were opportunities for *Reasoning* through Anna's open-ended questions in class. However, the rephrasing of these into *RR*-eliciting questions suggests that factual content was more prioritized and this notion is further supported by the fact that when lesson time was devoted to extracurricular activities, the lessons revolving primarily around *Reasoning* were omitted, while those centered on *RR* remained. This may relate to the results of a previous interview study, which indicated that the most influential teacher role in primary school science is that of "The Encyclopaedia", whose objective is to share established scientific facts, theories, and concepts (Varg et al., 2022). It may also be a sign of the reduced teacher autonomy experienced by the teacher in Tomas et al. (2022) who struggled to cover all factual content of the teaching unit, ultimately at the expense of ESD. The space of tensionality (Lewthwaite et al., 2014) appears to allow mainly concrete factual content to seep through into the clarified syllabus and the enacted teaching. Regardless of whether the activities focused on scientific models such as the carbon cycle or more complex issues such as ESD, Anna hustled to cover factual content to prepare her students for secondary school science. Such a stance is a natural consequence of the "standardized accountable environment" that is encouraged within the current educational discourses (Ryan & Bourke, 2013, p. 412). In this case study, the first transformation occurred right at the beginning of the planning process, when syllabus text referring to *Reasoning* was filtered out while *RR* dominated Anna's clarified syllabus. The learning category *Reasoning* seemed more difficult to transform into clear objectives than *RR*. Understandably, one possible reason for Anna's preference for *RR* is that she was a new teacher and possibly relied on the textbook, which essentially offered content suitable for memorization.

Anna identified two main reasons for the lack of congruence between the intended and enacted curriculum. In addition to the stress caused by the extensive subject matter (as discussed above), Anna expressed a sense of relief in knowing that different learning categories are constantly reappearing throughout compulsory school science education. She expected that if students did not develop proper reasoning skills in upper primary school, they would be able to do so in secondary school. At the same time, she expressed an uncertainty about what was expected of the students when they entered secondary school science. This is similar to what the teacher in Tomas et al. (2022) experienced when considering what the mandatory tests would examine. The observations made it possible to draw some alternate, or complementary, conclusions about the lack of congruence. Although time was a limiting factor in this case, where science lessons were relatively few and short, most of the instruction and all assessment was focused on students being trained to recall and reproduce science facts. Was there a lack of access to suitable teaching strategies to encourage classroom talk of *Reasoning* character or was this emphasis on *RR* a sign of strong academic traditions defining upper primary science (Lidar et al., 2019). Teaching strategies have been found among expert teachers, who resort to these instead of careful lesson planning (Hatch & Clark, 2021). Although Anna asked open-ended questions, her habit of asking several questions in a row resulted in students answering the last ones which tended to be phrased as *RR*-questions. Her planning documents were ambitious and elaborate, but ultimately, and as indicated by Anna (Table 16.2), the lesson plan may have presented an obstacle rather than a tool in her attempts to realize the intention for students to practice and develop *Reasoning* abilities as she hurried to cover factual content instead.

This case study, although small and including only one teacher in one classroom, makes an important contribution to inform researchers, teachers and teacher educators about potential pitfalls to consider during the transformation of intentions into teaching. This may apply particularly to less established content, such as sustainable development and higher order learning categories, like *Reasoning.* This is because their positions within science educational culture are not as pronounced as traditional subject content, which is well promoted in both curriculum and textbooks, and which tends to elicit *RR* (van Eijck & Roth, 2013). Teacher education and professional development efforts could benefit from using these study results to support pre- and in-service teachers, not only in their development of teaching strategies that promote students' reasoning, but also in their efforts to navigate, interpret and transform science syllabi within the space of tensionality. This could help to strengthen teachers' reflexivity and increase their agency, thereby giving them the autonomy needed to handle constant changes in the context and/or culture within which they work.

References

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. SAGE.

Hatch, L., & Clark, S. K. (2021). A study of the instructional decisions and lesson planning strategies of highly effective rural elementary school teachers. *Teaching and Teacher Education, 108*, 103505.

Krippendorff, K. (2019). *Content analysis: An introduction to its methodology* (4th ed.). SAGE.

Kvale, S. (1997). *Den kvalitativa forskningsintervjun*. Studentlitteratur.

Lewthwaite, B., Doyle, T., & Owen, T. (2014). 'Did something happen to you over the summer?': Tensions in intentions for chemistry education. *Chemistry Education Research and Practice, 15*(2), 142–155.

Lidar, M., Engström, S., Lundqvist, E., & Almqvist, J. (2019). Undervisningstraditioner i naturvetenskaplig undervisning i relation till svenska utbildningsreformer i skolår 6. *Nordina: Nordic studies in science education, 15*(2), 174–192.

Pepin, B., Gueudet, G., & Trouche, L. (2013). Investigating textbooks as crucial interfaces between culture, policy and teacher curricular practice: Two contrasted case studies in France and Norway. *ZDM, 45*(5), 685–698.

Porter, A. C. (2004). *Curriculum assessment*. Vanderbilt University.

Ryan, M., & Bourke, T. (2013). The teacher as reflexive professional: Making visible the excluded discourse in teacher standards. *Discourse: Studies in the Cultural Politics of Education, 34*(3), 411–423.

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science Education, 4*(2), 2–20.

Stake, R. E. (1995). *The art of case study research*. SAGE.

Swedish Research Council. (2017). *Good research practice* (VR1710). Swedish Research Council.

The Swedish National Agency for Education. (2018). *Curriculum for the compulsory school, preschool class and school-age educare 2018*. The Swedish National Agency for Education.

Tobin, K., McRobbie, C., & Anderson, D. (1998). Dialectical constraints to the discursive practices of a high school physics community. *Journal of Research in Science Teaching, 34*(5), 491–507.

Tomas, L., Mills, R., & Gibson, F. (2022). 'It's kind of like a cut and paste of the syllabus': A teacher's experience of enacting the Queensland Earth and Environmental Science syllabus, and implications for Education for Sustainable Development. *Australian educational researcher., 49*(2), 445–461.

van Eijck, M., & Roth, W. (2013). *Imagination of science in education: From epics to novelization*. Springer.

Varg, L., Näs, H., & Ottander, C. (2022). Science teaching in upper primary school through the eyes of the practitioners. *Nordina: Nordic studies in science education., 18*(1), 128–142.

Webb, N. (1997). *Criteria for alignment of expectations and assessments in mathematics and science education*. National Institute for Science Education Publications.

Ziebell, N., & Clarke, D. (2018). Curriculum alignment: Performance types in the intended, enacted, and assessed curriculum in primary mathematics and science classrooms. *Studia Paedagogica (Brno), 23*(2), 175–203.

Ziebell, N., Ong, A., & Clarke, D. (2017). Aligning curriculum, instruction and assessment. In T. Bentley & G. Savage (Eds.), *Educating Australia: Challenges for the decade ahead* (pp. 257–276). MUP Publishing.