On the Theory of Content Transformation in Education

The 3A Methodology for Analysing and Improving Teaching and Learning

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Chapter 6

Content-Focused Approach for Improving Teaching and Learning

3A Methodology for Didactic Case Studies

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6 Content-Focused Approach for Improving Teaching and Learning

3A Methodology for Didactic Case Studies

In this chapter, we present a specific novel approach based on case studies of teaching and learning (TL): the *3A Methodology* (M3A). The approach is based on Kansanen's (2006) distinction of four types of teacher education programmes (see Section 6.1) and proposes our own tool for structured content-focused analysis of TL situations. It involves identifying (annotating), analysing TL situations, and suggesting alterations within these situations. In the M3A, authentic TL situations are analysed using the *model of deep structure of teaching and learning* (DSTL). The outcome of the M3A is a didactic case study, the production of which, combined with critical discussion in the professional community, serves to develop teacher thinking and improve practice.

We will show that the M3A is a rational, case-based research approach grounded in the theory of content transformation that has been developed in and for the professional community and that combines inductive and deductive steps to support professional reflection on teaching and to help assess the quality of TL in various didactic contexts.

6.1 The M3A: A tool for teacher professional development

As we elaborated in detail (Janík et al., 2019a, pp. 7–9), during the 19th century (in continental Europe), the academization of teacher education resulted in the reliance of teacher education programs on academic disciplines as they arrived at universities. This development was beneficial because academization enables to rise the status of teacher education and the teaching profession. However, it was also problematic in that it resulted in the fragmentation of teacher education curricula into specialized disciplines that were only loosely connected. During the 20th century, it was gradually acknowledged that the nature of teaching expertise is transdisciplinary and its grounding in empirical research of practice is necessary. The knowledge base for teaching should be built up, which should signify the progress on the way towards teaching as a recognized profession. Being a recognized profession means – among other things – being a specific form of calling that deals with fundamental soci(et)al challenges and problems that people are confronted with (Stichweh, 1997). The specific nature of a profession is due to its dedication to the knowledge

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base of the respective academic discipline. This is why teaching as a profession is connected with academic disciplines that deal with the phenomena that form the respective professional fields in practice.

Over decades, teacher education has become more research driven. Various recent teacher education programs have been labelled "research-oriented", "research-based", or "inquiry-based", etc. (Kansanen, 2006; Rudduck, 1985; Toom, 1985; Toom et al., 2010; Westbury et al., 2005). In these research-based teacher education programmes, research is understood as a stance or perspective that goes across teacher education curricula. (Future) teachers are seen as "producers" as well as "consumers" of research (findings). They are on the way to reflecting and conceptualizing teaching practice; they strive to develop a language for describing, analysing, interpreting, evaluating, justifying, and improving the teaching practice:

> The aim of research-based teacher education is to be able to make educational decisions based on rational argumentation in addition to everyday or intuitional argumentation. The skill of thinking along the lines of research principles presupposes a general understanding of all-round research methods, as well as a positive attitude towards the research. This means that the teacher is also able to do his/her own research if this is necessary.
>
> (Kansanen, 2006, p. 11)

To reveal the specific nature of research-based teacher education programs, we adopt the distinction based on Kansanen (2006). In his conceptualization, four basic types of teacher education programs result from outlining the structural background in two dimensions (deductive – inductive) and two ways of justifying (intuitive – rational).

> If the way a program is justified is intuitive and its structure is inductive, the program may be described as *Experiental*. Activities originate in practice and are based on the student teacher's own experiences. […] If the student teachers are left on their own, there is no guarantee of any development towards a deeper understanding of the teaching-studying-learning process. […]
>
> The more we add supervision and support to personal experience the closer we approach the *School-based* model. [The model] is seen here as intuitive and deductive, it might just as easily be rational if we presume that supervision meets this requirement. […] This model resembles the well-known idea of apprenticeship. […]
>
> The content of a program may be built on *cases*, problems or other selected units. These units are thought to cover all the essential topics required in teacher education. As it starts from practice, it is inductive by nature. If the whole program is built in a systematic manner it could be called rational. […]

> If the program is built deductively and justified rationally an appropriate organizing idea might be a *Research-based* program. In practice, it means that all courses and units are integrated in research-based thinking. […] All stages deal with an integrated combination of theory, practice and research-based justification.
>
> (Kansanen, 2006, pp. 18–20)

Using Kansanen's distinctions, we developed the M3A as a tool for helping teachers work on improving TL in the course of their professional development. M3A is research-based and therefore rational, it is case-based, and content focused. It acknowledges the expert view as well as practitioner view, it is rather theory-driven, but also practice-anchored. As a methodology, it is predominantly of qualitative nature; however, it allows to strive for quantitative generalization. In this vein, it connects both, inductive and deductive perspectives. Thanks to these characteristics, M3A helps to build a bridge between theory and practice in education (see Figure 6.1).

6.1.1 Characteristics of the M3A

There are several points in which M3A aligns with *research-based* approach. The term "research-based" is used to indicate approaches that are developed in close connection with research on TL and their quality. Data (especially video data that form the core of our analyses through M3A), as well as research findings, are used within teacher education to illustrate various aspects of TL practices and to stimulate teachers' thinking (professional vision) regarding possible ways of dealing with particular classroom situations. We believe that the idea of researching TL practices with regard to its improvement (which is the core of M3A) is typical for and inherent to promising approaches to teachers' professional development. It means that proponents of these approaches

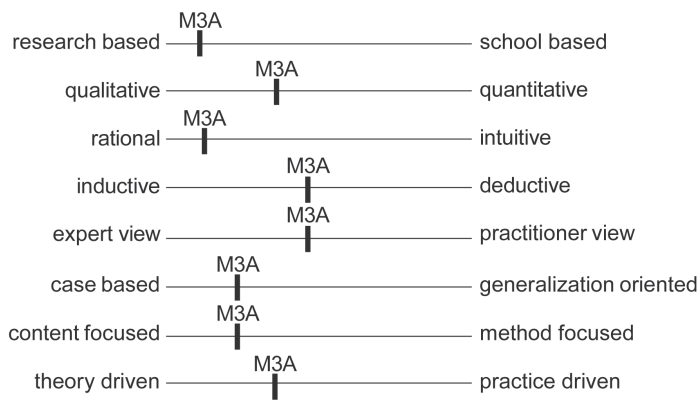

Figure 6.1 Characteristics of the 3A Methodology

deal with professional situations in a way that is similar to research. They investigate their practice (using description, analysis, and evaluation) and they provide and implement suggestions for its improvement. Because they are professionals, they justify their decisions using the appropriate language of their profession.

The M3A is *rational* and *deductive* in nature because it is based on a theory (specifically on the theory of content transformation – see Chapters 3–5). At the same time, it includes *inductive* procedures because it is based on analysis of cases from authentic practice and strives for analytical generalization. Of course, there are many points in the analysis of practice that we cannot do without intuition and creativity in the situation. Therefore, if we want to capture the position of M3A in the scheme, we put it in the rational (left) part, but with a slight shift towards the intuitive area. M3A thus connects three perspectives: it is not only *theory-driven* (knowledge-for-practice) but also *practice-based* (knowledge-of-practice) and *expert-focused* (knowledge-in-practice) (Cochran-Smith & Lytle, 1999; see Peercy et al., 2020, pp. 272–273).

The M3A makes use of case studies, i.e., studies of unique cases that serve as exemplars of general phenomena and solutions within the particular professional practice. This is true for many professions including, e.g., sports coaching (Schierz et al., 2006), nursing (Benner, 1984), and also teaching (Kiel et al., 2011; Shulman, 1996). In the teaching profession, developing and analysing didactic case studies provides opportunities to build a profound understanding of TL and therefore is essential for improving instructional quality. As proved by Shulman (1996, see also Brandt, 1992), case studies are effective in documenting teachers' thinking about and reflecting on teaching. They bring clarification and understanding and can help to induce changes in teachers' practices (Shulman, 1996, pp. 478–481) and so succeed in bridging the gap between theory and practice in education. That is why Grauer (2012, p. 69) claims that "case study research is making a comeback in educational research because it allows researchers a broad range of methodological tools to suit the needs of answering questions of 'how' and 'why' within a particular real-world context".

As the M3A is content-focused, we use a special form of case study – *a didactic case study.* A didactic case study is a variant of a case study that focuses on TL with the intention to propose suggestions for improvement. Didactic case studies can therefore be equally well applied in both research and teacher education. Their narrative form is supplemented in the didactic case studies by a situational semantic-logical analysis of TL – thus combining both key modes of thought (Bruner, 1985, p. 97; Hadzigeorgiou, 2016, p. 84). In this way, the didactic case study can describe and explain the complex system of situational relationships and especially their changes that accompany the development of the case. At the same time, it is possible to monitor not only the context within the observed case, but also external relations and influences that affect it. For these reasons, the case study can provide the basis for

discovering previously unknown qualities of practical experience as well as for specifying or developing terminology that supports the solution of problems from professional practice.

6.1.2 The M3A as a bridge between theory and practice

The M3A serves as bridges between practising and theorizing; they link examples of practice with theoretical constructs and thus make theory easier to grasp. They can act as the underpinning of the knowledge base for teaching and be organized in *case collections* or *case libraries*. Within M3A, case studies are generated that are content-bound (the focus lies on ways in which students encounter specific educational content), rooted in genuine practice (real-life TL situations are analysed), and theory-laden (explanations of the semantic-logic structure build on content theories as well as didactic theories). They are a means of developing (teachers') pedagogical content knowledge, the discourse of the teaching profession, and didactic theory.

Knowledge develops through communication and cooperation between those who share experience and reflect on it. For such groups, we use the label *communities of practice*. According to Wenger (2004, p. 1), "communities of practice are groups of people who share a concern or passion for something they do and learn to do it better as they interact regularly". A professional community aims at constructing a specific type of knowledge (i.e., knowledge for improvement[1]) that is shared within the community on the theoretical level and used in practice. Within our approach (M3A), such a community is made up of teacher-practitioners and researcher-teacher educators, who usually participate in the analysis of TL through M3A.

The medium for communication between members of the professional community is professional language, which makes it possible to formulate *lege artis* judgments and statements about TL in a knowledge-sharing cycle. For Peschl (2006), all knowledge sharing takes place in the space between three vertices of a triangle: (i) individual knowledge (i.e., subjective), (ii) shared understanding within a particular community of practice (i.e., inter-subjective), and (iii) explicit externalized knowledge (i.e., "objective") – see Section 3.1.

The work on TL quality within M3A builds on observing and analysing TL situations (is research-based) as well as on proposing and verifying alternatives for improvement of TL (is design-based). Nevertheless, it is *content-focused* because following the *Bildung tradition*, and it responds to the problem of "shedding the content" of school education which seems to be the grand challenge of education in the age of accountability (cf. Hillen, 2015; Janík et al., 2019b; Willbergh, 2011).

The aim of using case studies to initiate knowledge sharing in a professional community is to help develop teachers' (and all other participants') *pedagogical content knowledge for successful content transformation*. Developing a case study requires the authors to *explicitly* analyse and re-construct the transformation of educational content within an authentic TL situation. In order to

do that, the authors must be endowed with precise and reliable *professional vision* (Sherin, 2014) – the capability to identify and interpret phenomena or moments within TL situations or curriculum that are essential from a didactic point of view. Thanks to careful theoretical and methodological reasons and methodical elaboration, it is then possible to generalize the research reflections on TL to a desirable extent.

These notions lead to a conclusion: M3A enables research on TL is its most elaborate form of *professional reflection*, in which researchers (teacher educators) may closely cooperate with teachers. The difference between research-reflection-on-teaching and the reflection-on-teaching commonly used by teachers in practice is only in its degree of consistency, formalization of the reflective process, and especially in the depth of its theoretical interpretation. Only thanks to theory and research do findings from reflections become part of the *expert discourse* (academic, professional) and enable the dissemination and accumulation of knowledge in the field of TL. The proposed M3A represents a structure for what is done often intuitively in the teacher professional community. It brings a clear framework for a didactic case study that is theoretically supported and methodologically restrained.

6.2 The M3A and its objectives

As explained above, "3A" stands for a three-step methodology consisting of annotating, analysing, and altering a particular TL situation. The M3A is a systematic process of reflection and qualitative analysis of teaching, connected with the evaluation of the quality of TL and proposing of improvement changes – so-called alterations. The concept of M3A draws on *reflective practice* and, along with it, the tradition of Korthagen et al.'s (2001) *realistic teacher education*. Another tradition that inspired M3A is didactic analysis sensu Klafki (2010).

In line with the content-based approach, the starting point for the proposed research approach is the way *content is dealt with in the classroom*. The premise of this approach is that students learn within a *learning environment*, which is constituted by its *(educational) content* during interactions between the teacher and the students. The learning environment provides the students with *opportunities to learn* and *to understand the content* through working on learning tasks. The learning environment affects students' learning through symbolic interactions that cause the students to understand the content (see Blumer, 1986). The continental European and Scandinavian didactic tradition call this process *semantization* and together with *instrumentation*[2] pinpoints it as the primary object of didactic research (see Gruschka, 2013; Hopmann, 2007; Janík et al., 2019c; Willbergh, 2011). These constructs include both a *subjective* aspect – student experience – and *intersubjective* and *objective* aspects: content of a discipline (e.g., Physics) or the whole field of education (e.g., Science). The examination of semantization and instrumentation in TL is complicated because causal relations between the qualities of

the learning environment and its impact on the subject's mental structures are not available for direct observation. Understanding the students' mental processes during TL is therefore only possible through the analysis of observable ("surface") manifestations. The main objective of didactic case studies is thus ("from the surface to the depth") to analyse and evaluate how knowledge from culture (or disciplines) is incorporated into the student experience through TL.

The M3A allows us to investigate a TL situation in its complexity – we call it *integrity* (see Section 6.3.2) – i.e., how and how well the content is transformed into aims, how and how well are the aims transformed into tasks, respectively into students' activities and how and how well does the concrete TL unfold – how the tasks are solved by the students and thus how the content is learned by students. We argue that this complex phenomenon is impossible to examine empirically and theoretically by means of other research methods based on empirical data categorization using either a quantitative or qualitative approach.

By means of case studies based on M3A, it is possible to identify TL situations that serve as examples of how educational aims, content and students' learning meet and intersect in instruction and by building case studies around such TL situations. The proposed approach draws on the idea of reflective practice in teacher education; it has great potential for teachers' professional development.

The M3A objectives are:

- to understand (*annotation* and *analysis*) and evaluate (*alteration*) teachers' professional practices in shaping the learning environment and supporting students' learning;
- to use the findings gained from M3A to *support teachers* in improving (*alteration*) the quality of teaching.

Research with M3A presupposes *pedagogical content knowledge*, in which the researcher should not differ from the teacher. Mutual cooperation between the researcher and the teacher-practitioner is important because the researcher brings their knowledge of theory and methodology, while the practitioner brings their acquaintance with the students and rich experience with educational practice. One can hardly do without the other when reflecting on teaching.

In their characteristics (reflecting teaching practice, case-based, theory-driven and aiming at improving teaching), the M3A is similar to *action research*.[3] However, the centre of the M3A lies in deep understanding of how TL relate considering the content while the centre of action research lies in introspection of teacher's acting and/or pedagogical skills – i.e., one's own professional activity. Through action research, the teacher explores their own teaching practice. During their professional education, teachers themselves should learn to use research findings to support the quality of teaching and

to develop their reflective competence. The most effective way to do so is to get acquainted with the methodology of teaching research, get familiar with its methods and learn to use them in practice. Considering that, the M3A can be a suitable methodical support for action research as well as for structured reflection and evaluation of teaching quality.

6.3 The M3A procedure: Annotating-analysing-altering TL situations

The M3A is content-oriented. This follows from the fact that no didactic judgements or opinions on TL can avoid the existence of educational content. In this sense of Klafki (2010), we characterize the M3A as efforts focused on the "content aspect of education". Beside this, didactic efforts and reflections cannot neglect the student or the teacher as the main actors in education. Without them, content could not manifest itself in teaching; it could not become active and would not acquire its social function and cultural value. However, for teachers, it is the content that is the starting point of both, *planning* and *reflecting* a lesson. The content is the basis for three fundamental teaching questions:

- *What should my students learn in the lesson?* (primary question of preparation for teaching);
- *What were my students really learning?* and
- *What have they really learnt in the lesson?* (primary question of reflection and evaluation of the teaching quality).

For these reasons, we characterize the M3A as a c*ontent-focused approach to reflection*, *evaluation*, and *improvement of TL*. The starting point for the analysis and evaluation of TL is the organization (structuring) of content in teaching through three successive phases: *annotation*, *analysis*, and *alteration*. The division of the methodological procedure into three steps determines the basis of the structure of the M3A (see Figure 6.2).

6.3.1 First step: Annotation

Annotation provides the basic information about the setting of the situation within the lesson. It comprises two parts: the *context of the TL situation* and the *didactic grasping of the content and teacher and students' activities.*

6.3.1.1 The context of the TL situation

First, the characteristics of the lesson (the key topic and characteristics of the class), as well as the curricular context (the previous lesson, the current aim, and future lessons), are described.

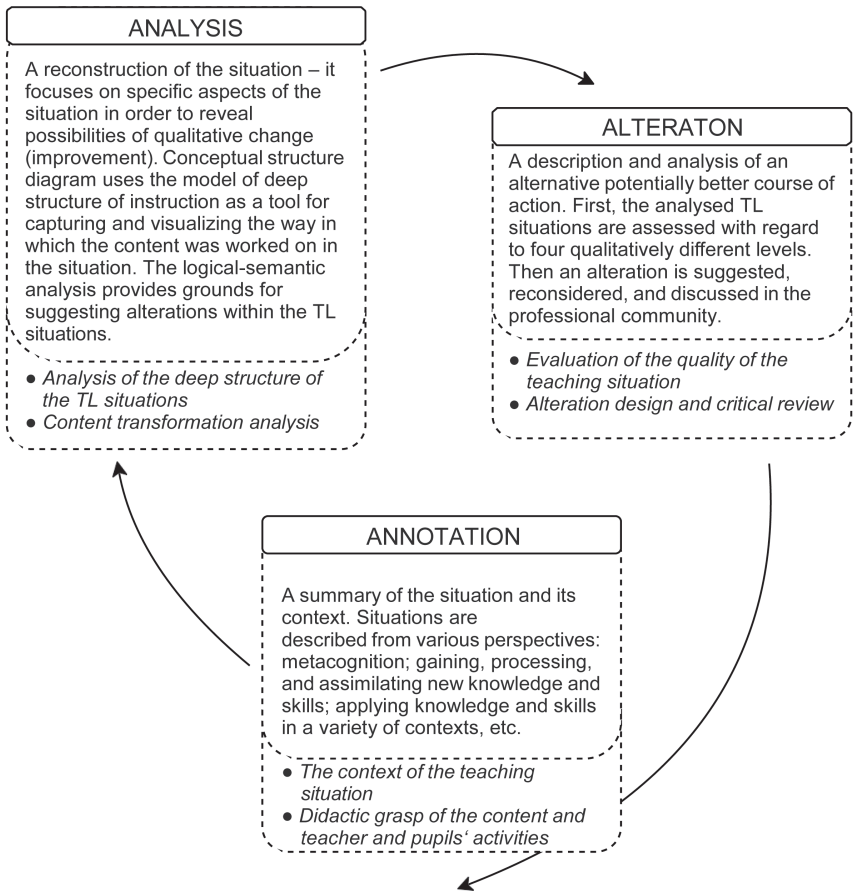

Figure 6.2 Steps of the 3A Methodology

6.3.1.2 The didactic grasping of the content and teacher and students' activities

The second part of annotation should contain an explanation of the overall didactic grasping of the content – what objectives the teacher pursued, how they arranged the content, and how they communicated it to the students (concepts, methods, etc.). A description of the teacher's and students' activities giving an overview of the course of the TL situation will be provided.

6.3.2 Second step: Analysis

Analysis provides a description of the situation under study with respect to its objectives.

6.3.2.1 Analysis of the deep structure of the TL situations

This step involves highlighting those moments of TL that invite the extraction of key situations (critical or excellent) and the proposition of alterations. It consists in describing the obstacles to learning encountered by the students in solving the tasks; analysing the relationships between the learning objectives, the students' mastering of the content and the demands on their understanding of the learning content; and identifying and analysing the key TL situations that had a positive (productive aspects) or negative impact (didactic formalisms) on learning (see *integrity* in Figure 6.3).

The M3A concentrates on the analysis of the semantic-logical structure of educational content while considering the design of the TL situation (see Chapter 3, Sections 4.4.8 and 4.4.9). To visualize the semantic-logical structure of a TL situation, a specific tool – conceptual structure diagram – is used, which makes use of the *model of the DSTL*. It works also as the theoretical support for the situational *concept analysis* of TL regarding a cognitive, resp. conceptual change (see Chapter 4). The structural components of the model of the deep structure of TL situation should not be understood as quantitative variables; rather they are central categories that serve as clues for the conceptual analysis of TL and analytic generalization.

The model of the deep structure of TL (and therefore the conceptual structure diagram) presupposes that the students enter TL situations in state n of their dispositions and leave in state $n + n_1$, i.e., their dispositions (knowledge, attitudes, skills, and competences) are enriched. This elementary Vygotskian or Krashenian notion is reflected in the model by distinguishing two levels of the TL situation and therefore two perspectives on its didactic assessment. One is the level of the students' natural experience, in the model of the deep structure of TL situation referred to as the *thematic level*. It represents state n of the students' dispositions. The other level captures the particular field's content conceptualizations. It is referred to as the *concept level*; it includes specific knowledge from within the respective discipline and represents (models) the expected state of $n + n_1$.

The conceptual analysis of the TL situation starts at the concept level because that is where the semantic-logical structure of the educational content is captured and anchored. However, the educational content on *the concept level* has no didactic meaning, unless it is viewed from the perspective of the thematic level. It is apparent that the relationship between the two levels is dynamic; the development of the students' dispositions leads to their experience being enriched, and it changes the didactic perspective from which the concept level is constructed. Nevertheless, the basic distinction between the two levels is unchallenged because the concept level is structured by the (objective and intersubjective) theoretical field or discipline, while the *thematic level*'s structure is given by the students' (subjective) empirical experience.

The two described levels of the model of the deep structure of TL are not enough for the qualitative analysis of TL within our approach (see Section 3.6).

In it, we focus on the practice in general comprehensive education, where educational aims are not limited to specialized scientific or artistic disciplines but rather transcend into the more general humanistic domain, where students are educated as complex beings in the current social and cultural context. In the Czech curricula (Ministry of Education, Youth and Sports, 2007), the general comprehensive principle is represented by the construct of key competences.[4] The term refers to the highest and most abstract educational aims in the curriculum of comprehensive education. In the model of the deep structure of a TL situation, we use the term *competence level* to refer to a third level of the TL situation; the competence level captures the general aims which general comprehensive education targets.

The three levels of the model of the deep structure of a TL situation provide the framework for analysing TL situations and thus building a case study. For each analysis, the model is concretized into a conceptual structure diagram, which captures the didactically relevant aspects of the analysed TL situation and helps to interpret and analytically generalize findings from each case study.

To sum up, in the conceptual structure diagram, three levels are distinguished (see Figure 6.3). The movement between the thematic and the concept levels is one of the *concept-anchored abstraction of experience*. It involves the recursive process of content transformation between the content in a form that is easily accessible to students through their own experience on the one hand and the content in a form that is field-organized and abstract on the other. The movement between the concept and the competence levels is a recursive process of the students acquiring and developing general and versatile principles of thinking and acting. Also, moving downwards in the diagram represents the *decontextualization* of authentic experience, whereas moving upwards refers to the *operationalization* of general dispositions. In the diagrams, the individual concepts on different levels are connected with arrows where explicit or implicit links were made in the TL situation. A higher density of connections signifies that ontodidactic, psychodidactic, and cognitive transformations are in congruence (see also Figure 6.5).

6.3.2.2 Analysis of content transformation towards alteration

Distinguishing these three levels makes it possible to consider the relationships between the students' everyday experience, the substantive and syntactic structure of the content in the field and the educational aims. The didactic quality of the TL situation is closely related to the *integrity* of all three levels, i.e., the degree to which there is an accord between instructional aims, curricular content, and students' activity and communication.

These main components of the conceptual structure diagram help organize the professional discourse about the didactic transformation of content within the TL. To assess the quality of the TL situation is to observe the *coherence* of the individual components, i.e., their *integrity*.

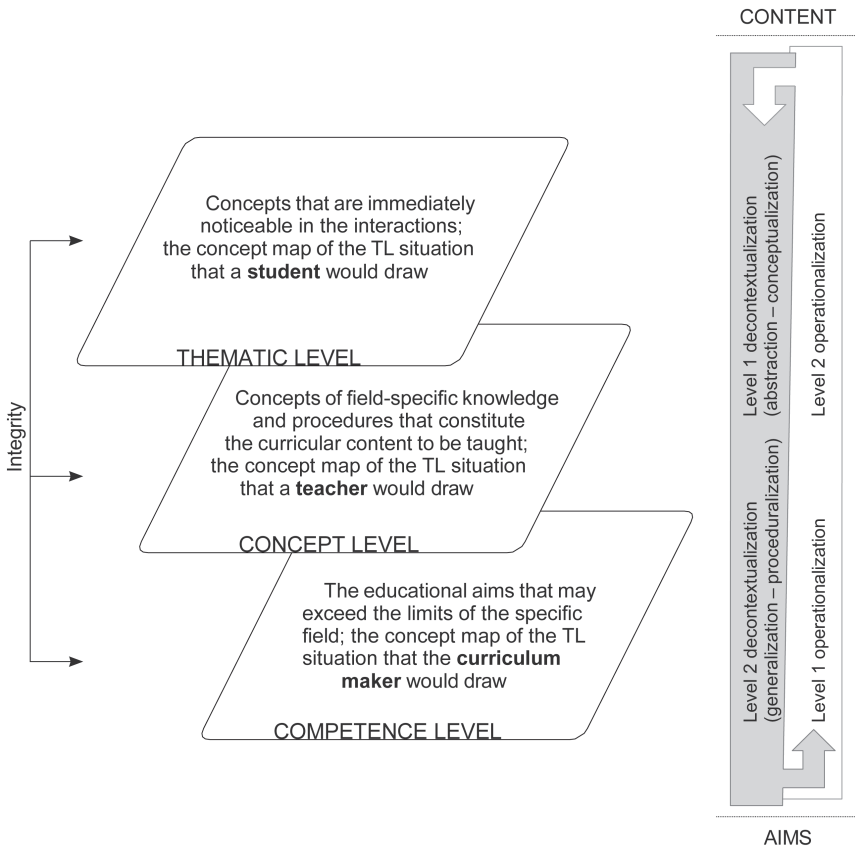

Figure 6.3 The conceptual structure diagram

6.3.3 Third step: Alteration

Alteration provides an assessment of the quality of the situation (justified by the analysis in the previous section) and, on its basis, an alternative and potentially better course of action.

6.3.3.1 Evaluation of the quality of TL situations

The TL situation under study is categorized as failing, undeveloped, encouraging, or elaborating, and thus its educational quality and the urgency of alterations of TL situation is decided. The quality of TL is seen as dependent on the *integrity of TL*, i.e., on the quality of relationships between (i) TL content, (ii) TL objectives, and (iii) the activities of a teacher and students. The better these three basic determinants of quality are integrated, the higher the quality of a TL situation is. The visualization through the conceptual structure

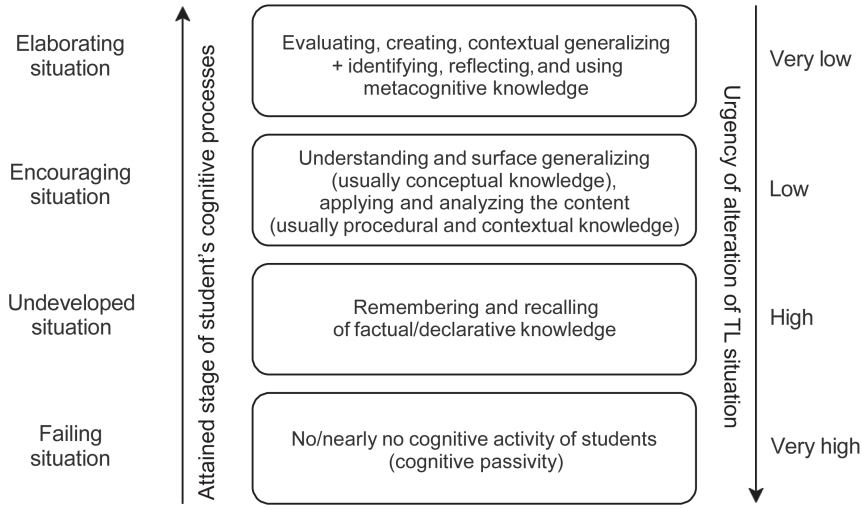

Figure 6.4 The quality of TL situation depending on the attained stage of cognitive learning objectives

diagram helps us consider the opportunities to learn and cognitive processes students used in the analysed TL situation and thus how the content is transformed through tasks into active content that brings a cognitive change in the student's mind (see Chapter 4).

The key component of such evaluation is the cognitive level that students attain. We argue that a high level of integrity between instructional aims, curricular content, and students' activity results in a high level of attained cognitive learning objectives. Thus, the higher cognitive learning objectives students attain, the qualitatively better the situation is, and thus there is a lower need for alteration of the situation. And vice versa – the less consistency between instructional aims, curricular content, and students' activity, the lower the level of integrity of TL, the lower the level of the attained cognitive learning objectives (see Figure 6.4). Attained cognitive level is therefore a sign of integrity.

6.3.3.1.1 THREE STAGES OF THE QUALITY OF COGNITIVE LEARNING OBJECTIVES

Many different categorizations have been proposed to distinguish among different qualities of cognitive learning objectives. Within M3A, we make use of *Bloom's taxonomy* of cognitive objectives in education (cf. Anderson & Krathwohl, 2001). Its basic idea is that cognitive learning objectives can be distinguished in terms of quality according to the degree of cognitive and creative involvement of students during activities and communication in the classroom.

We will only use three graduating levels of categorization here to differentiate the quality of *attained* cognitive processes (see Figure 6.4):

- The *first level* comprises cognitive learning objectives which are reflected in the students' basic knowledge (declarative): knowledge of more or less isolated concepts. Students recall or recognize them, but they do not explain or master them better;
- The *second level* is reflected in the students' understanding of the concepts associated with the application and analysis of the content in more depth (i.e., mostly procedural or contextual knowledge). Students give examples, organize, compare, point to concepts that they can clearly explain, and discuss them in dialogue at least at a basic level;
- The *third level* comprises cognitive learning objective quality in which students are familiar with the content to the relatively highest extent possible which the student can master at their age. Students generalize their empirical experience and at the same time can, in the opposite direction, operationalize concepts to specific procedures, examples and demonstrations. In addition, students creatively use and develop their knowledge with sensitivity to the relevant cultural context. Finally, students at this level master *metacognition* – they think about their own actions or their thought processes.

When teaching, teachers should strive to achieve objectives at the third qualitative stage. However, they should take into account that the previous two stages must precede it. It does not make much sense to encourage a student, for example, to generalize and understand broader cultural contexts, if they do not master the basic concepts that will provide them with the necessary support for generalization. Therefore, when evaluating the quality of TL, it is important to consider all the circumstances of teaching, which decide which objective level it is desirable to pursue in the particular situation.

As indicated in Figure 6.4, the higher level of cognitive learning objectives students *gain/use* in the lesson, the less urgent the alterations the TL situation calls for. Next, we will describe the levels of quality of TL situation based on this fact.

6.3.3.1.2 FOUR LEVELS OF THE QUALITY OF TL SITUATIONS

The analysed teaching situations differ from each other in their benefit for students. Therefore, they can be classified into graded (serial) categories according to their quality (see Figure 6.4):

- An *elaborating situation* is a situation in which students generalize the acquired knowledge with appropriate understanding and in different contexts either directly in the extracurricular reality or in model school activities that

are close to them. It is a situation in which students work consciously with their metacognitive strategies, evaluate, learn from mistakes, demonstrate their competence in appropriate task (test) situations and are able to explain meaning in a broader social, cultural, ecological, etc. context, appropriate to their age. Teaching is motivating for students, with a positive consequence for the connection between the development of competence and acquiring knowledge. This kind of situations could be referred as didactic excellence (Section 7.3).

- An *encouraging situation* comes when a teaching conducts student to engage in a dialogue, to discuss the presented topics, to classify, to reason, explain and draw conclusions based on their basic knowledge. Teaching is usually motivating for students with a positive consequence for the quality of learning.
- An *undeveloped situation* refers to a situation that leads students to gain knowledge, but students do not understand them well enough. Under certain circumstances, the teaching can be motivating for students, but without a more significant positive effect on the quality of learning and students gain factual knowledge without deeper understanding. Didactic formalisms (see Section 7.2) are often, however, not as harmful as in a failing situation.
- A *failing situation* is a situation that does not give students the opportunity to reach even the basic cognitive learning objective (quality level "zero").

The quality level determines the urgency with which the situation "calls" for improvement – *alterations*. Logically, the greatest urgency of alterations is characteristic of *failing* situations. On the contrary, the best situations, *elaborating* situations, do not require alterations (possible alteration can be suggested, but it would probably not improve the situation).

A schematic overview of these basic connections for the evaluation of TL situations is given in Figure 6.4.

6.3.3.2 Alteration suggestion and its critical review

Alteration is a (suggested) alternative course of action that takes account of the inconsistency in integrity found in the analysis. Alterations should be reconsidered and discussed in the professional community. We consider suggesting alterations within the situations as a way of teachers' professional learning. It is explaining and critically arguing for alterations that lie at the heart of case studies' contribution to the development of the key disposition of the teaching profession – the pedagogical content knowledge.

A critical review of the alteration takes place on the basis of reflection – a *thought experiment* combined with a qualified estimate of the consequences that could occur in practice after performing the alteration. It is desirable to subject this experimentation to debate in the professional community (e.g., in a seminar group in teacher education). However, it can also be implemented

in practice. Nevertheless, it will never be the "same" teaching, so practical verification cannot be as reliable as, e.g., repeating a physics or chemistry experiment. Still, it always brings important findings and contributes to the development of teachers' professional competencies.

6.4 An example of using M3A to develop a didactic case study: Experiment as a learning tool in chemistry

Case studies in our approach are developed for the above-mentioned purposes. We established a collection of case studies for use within pre-service and in-service teacher education as well as within research on TL.

In this section, we show an example of a didactic case study using M3A (Rusek et al., 2016, pp. 80–87).

Experiment as a learning tool in chemistry

Annotation

Context of the situation – Aim, topic, continuity

The analysed TL situation was carried out in a Chemistry lesson taught in the first year (age of students 15–16) of an upper-secondary vocational school (economic lyceum, i.e., non-chemistry specialization) in 2015. The topic being covered was *sodium bicarbonate* as an example of *salts*. Other discussed content included acids, bases, and neutralization as a reaction that produces salts. Also, an experiment was used to provide the students with an opportunity to develop their inquiry skills.

According to the state curriculum (Ministry of Education, Youth and Sports, 2007, p. 25), the aim of Chemistry education in this context is to "teach students to use the knowledge of natural sciences in their professional and personal life, ask themselves questions about the world and seek relevant evidence-based answers". The students are expected to understand concepts and their contexts and also their relationships to observed phenomena.

Didactic realization of the content (activities of the teacher and the students)

First, the students were asked to identify the "white substance on the plate" by testing its properties. Then their attention was shifted to the *process* of identification by employing *taste* to explore the qualities of a lemon. The teacher then emphasized the link between chemical

properties (and their measurement) of a substance and everyday experience (with its characteristics). The core activity of the situation was an experiment involving the use of a pH indicator to determine the properties of the outcome of the neutralization reaction.

Analysis

Analysis of the structure of content (using the conceptual structure diagram)

To analyse the TL situation, a conceptual structure diagram (see Figure 6.5) was developed, which aims to capture the logical-semantic structure of the situation.

The thematic level includes aspects of students' everyday experience, such as sourness, change of colour of the pH-indicator paper, chemical properties of substances (as a general idea). These aspects reflect "deeper" specialized concepts on the *concept level*.

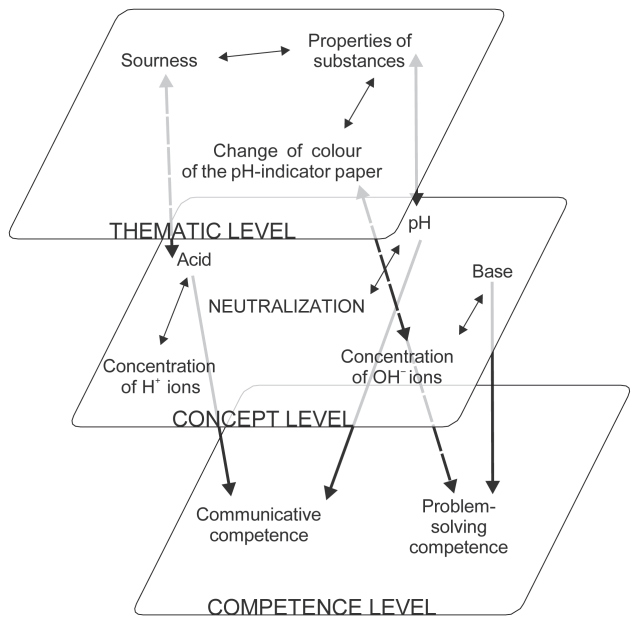

Figure 6.5 The conceptual structure diagram of the TL situation

Source: Adapted from Rusek, M., Slavík, J., & Janík, T. (2016). Obsahová konstrukce a didaktické uplatnění přírodovědného edukačního experimentu ve výuce na příkladu chemie [Content Construction and the Didactic Use of Scientific Educational Experiment in Chemistry Teaching]. *Orbis Scholae*, *10*(2), 86. Reprinted with permission.

The core specialized concept of the situation is *neutralization*. All other concepts on the *concept level* (concentration of OH^- ions, base, pH) and their relationships are included to help clarify various aspects of neutralization.

The competence level shows that the situation aimed to develop the students' problem-solving competence (e.g., formulating the hypothesis to be tested by the experiment) and their communication competence (e.g., the need to negotiate the parameters of the experiment).

Analysis of content transformation towards alteration

The conceptual structure diagram helps uncover several problems in the way the TL situation was implemented. The core concepts of the *concept* and *thematic* levels were not satisfactorily linked, causing problems for the students' learning processes. *Neutralization* somewhat failed in the role of the central concept that would invite the students to inquire on their own and (re)construct their understanding of the relevant specialized (chemical) facts.

To understand the concept of *neutralization* in chemistry well, the students ought to build on their knowledge of chemical properties of acids and bases, and of the changes in these properties brought about by a mutual reaction. Without understanding how the balance of anions and cations is characteristic of chemically neutral environments, the students cannot grasp abstract propositions about the products of neutralization (salt and water). The aim to develop scientific competencies in students does not seem to have been achieved in the analysed TL situation.

While the teacher does try to cognitively activate students (e.g., inspire them to participate in interactions and experimenting), the discrepancies in the logical-semantic structure of the educational content prevent the students from understanding the key aspects of the TL situation. It can be concluded that the activation is *not* cognitive.

Alteration

Assessing the quality of the situation

Unfortunately, the teacher was not very successful in involving the students in the situation (did not inspire them to participate). The video recording shows that the students were distracted by less relevant aspects of the reaction (hissing sounds of the escaping carbon dioxide) and did not acquire a deeper understanding of the chemical processes that the experiment aimed to exemplify. The desired "movement" between the thematic

level and the concept level, which is a prerequisite for successful learning, was not achieved. The situation can be categorized as *2 – undeveloped* (see Section 6.3.3).

Suggested alteration and its justification

For the situation to be more successful in providing students with opportunities to develop general or subject-specific competencies, more attention should be paid to the understanding of key concepts such as *substance* or *property*. These concepts can be constructed through students' active participation and manipulation (*distinguishing*, *categorizing*, and *classifying*). A preceding activity might focus on classifying various objects based on their properties (colour, shape, state of matter, taste, etc.) and arguing for different arrangements. An experiment (as a core activity of the situation) could then be structured by subtasks such as *prepare a neutral solution of sodium bicarbonate and lemon juice using appropriate quantities of each*. Such an approach would make it easier for the students to be involved in the situation and engage in the specialized (chemistry) reasoning.

6.5 Generalizing findings across cases

The ultimate aim of our approach is to generalize findings from particular case studies as presented above to arrive at abstract and theoretical categories that could explain patterns in the deep structure of TL. Such patterns bring a better understanding of the general aspects of TL quality. To achieve this, we apply generalization in the sense of Yin's *analytic generalization* (Yin, 2014). Its purpose is to denote the significant and logical link between the theoretical construct and the verification of its validity for real cases. When a particular theoretical construct repeatedly proves to be useful for interpreting particular cases, its potential for generalization is confirmed and its validity is verified, which consequently results in the replication of the particular theory (or its constructs). "Replication" refers to the application of theoretical constructs in order to clarify real cases. Replication logic in didactic case studies should result in the questions being solved of *how* the learning environment is created and *why* it is possible to attribute a certain degree of the quality of TL to this environment. In case studies, this process takes place through the description and explanation of *relational changes* that can be recorded during communication and acting in the learning environment. That is why the analytic generalization is useful not only for research purposes but also for supporting teachers in practice when they strive to improve TL.

Analytical generalization uses the interpretation of one unique case to test the theory (i.e., to verify the validity of replication) and uses the findings practically (Yin, 2014). Yin (2014) makes a point of distinguishing analytic generalization from the generalization of categorical data from sample to population. He claims that these are two very different conceptions: *replication logic* (of analytic generalization) and *sampling logic* (of statistical generalization).

According to Yin, analytic generalization is a two-step process. In the first step, conceptual claims are formulated that suggest a link between theoretical constructs and empirical findings. In the second step, hypotheses are formulated on a conceptual level, i.e., over concrete examples. The conclusions should then show how empirical findings support or challenge the original theory (Yin, 2011). To build on Yin's distinction, the first step of analytic generalization draws on two knowledge bases: *the theoretical base* consists of a set of theoretical constructs, while *the empirical base* includes hypothetical statements related to the object of observation.

Shulman (1996, p. 466) states that generalization from case studies is triggered by the question "What is this a case of?" The question shows that an individual case can only be explained through its connection with other cases using general theoretical constructs within a shared interpretation framework. The point is not to find an isolated characteristic (or correlation between variables or factors) but to suggest a new way of thinking, categorizing, or organizing to discover a new approach to assessing, distinguishing, or comparing the analysed situation (see Goodman, 1988). In this way, new horizons for the pedagogical thinking of teachers are opened. Case studies created with the M3A may than serve as a ground for analytic generalization through a multiple-case study as described in the following chapter.

Notes

1 In general, research is a means of generating descriptive knowledge (what-knowledge), procedural knowledge (how-knowledge), and explanatory knowledge (why-knowledge). For research in education, these kinds of knowledge often are not enough. What is expected of research in education is the producing of knowledge for change (how-differently knowledge) and knowledge for improvement (how-better knowledge), which would better answer the expectations of practitioners (Prenzel, 2012).
2 The students *semantise* the content (*Inhalt*) (i.e., learn what is being taught) and thus *instrumentalise* their experience (in the context of the particular field), whether it be *experimental* or *symbolic* (see Kvasz, 2014, p. 118).
3 Action research in education is a reflective feedback process in which participants systematically and carefully examine and evaluate their own teaching practice using qualitative research techniques. The essence of action research is to design and verify an "action" that will bring a qualitative change (cf. Elliot, 1991; McNiff & Whitehead, 2013).
4 The key competences that are defined in the Czech curricular documents are in some aspects similar to key competences that were later defined by the European Commission (https://ec.europa.eu/education/policy/school/competences_en), while in other aspects they are conceptualised differently.

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