



Subject-Specific Genres and Genre Awareness in Integrated Mathematics and Language Teaching

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Received 8 May 2016 • Revised 16 June 2016 • Accepted 19 December 2016

ABSTRACT

The increasing attention devoted to the role of language in the different school subjects calls for approaches of integrated subject matter and language teaching and learning. In this article we argue for the importance of subject-specific genres for integrated mathematics and language teaching. Based on an exemplary analysis of geometric construction texts we show that subject-specific genres in the context of schooling might be influenced by different academic and institutional contexts. In a case study of a classroom discourse in 7th grade about geometric construction texts we show how these different contexts pose a challenge for teaching this genre. As a result, genres in school mathematics might appear as blended genres. Based on our findings we refine the notion of genre awareness as an important aspect of teacher knowledge in order to better prepare teachers for the challenges of integrated subject matter and language teaching.

Keywords: genre, genre awareness, geometric construction, geometric construction text, geometry, subject-specific genre

INTRODUCTION

In the past decades an increasing awareness of the important role of language as a communicative and cognitive tool is noticeable in subject matter teaching. Smit (2013) even proposes a linguistic turn in educational research, which puts new demands on educators, designers and researchers in order to foster students' development of their language awareness when learning subject matter content.

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State of the literature

- Recent research emphasizes the important role of language for mathematics learning and calls for approaches integrating language and mathematics learning and teaching.
- So far, research regarding linguistic properties of mathematical language tries to identify special features of mathematical language and acknowledges the existence of different genres in mathematics.
- Genre-pedagogy and genre-based approaches show that taking genres as basis for subject matter learning is a fruitful way for integrated subject matter and language teaching and learning.

Contribution of this paper to the literature

- The analysis of the genre of geometric construction texts from different perspectives (disciplinary mathematics, didactics of mathematics, and mathematics education) will contribute to an epistemological understanding of the notion of subject-specific genres.
- The analysis of an episode of classroom discourse shows that dealing with mathematical genres in school is a specific challenge, because genre features have to be implemented in a consistent way in order to foster an integrated subject matter and language learning.
- The notion of genre awareness as an important aspect of teacher knowledge is refined.

It is widely acknowledged that subject matter and language learning have to be integrated, because teaching language as something separate from content prevents learning in authentic contexts and does not provide access to subject-specific language learning. For second language learning, Gibbons (2002) suggests the integration of language learning with curriculum content and argues: *“From a language-teaching perspective, then the curriculum can be seen as providing authentic contexts for the development of subject-specific genres and registers”* (p. 119).

In the literature, we find many claims that relate to mathematical discourse, mathematical texts or the mathematical register in general without taking the particularities of the specific mathematical topic or activity into account. Based on a comprehensive literature survey of demands and properties of mathematical language in general and of mathematical texts in particular Österholm and Bergqvist (2013) conclude that *“it seems difficult to make claims that are valid for all mathematical texts or for mathematical language in general”* (p. 752). Scholars in the field call for more differentiated views of mathematical texts, discourses and genres. Prediger and Wessel (2013) argue for multiple mathematical registers. Moschkovich (2010) suggests that *“mathematical discourse is not a single, monolithic, or homogeneous discourse”* (p. 153). Whereas she thinks of a spectrum of discourse practices in different contexts such as *“academic, workplace, playground, home, and so on”* (p. 153), Morgan (1998) also draws attention to different genres of text: *“Just as there are a number of varying social practices that may be labelled as mathematics [...] there are a variety of genres of text that may be called mathematical (e.g. research paper, textbook, examination question and answer, puzzle, etc.)”* (p. 8).“

The notion of genre has been recognized by several researchers in mathematics education as a useful way to think about different kinds of texts within mathematics education. Until now, scholars mostly refer very broadly to the notion of genre in order to acknowledge the existence of a variety of texts within mathematics and mathematics education. Very few in-depth analyses of mathematical genres have been presented so far. Among them are the analyses by Gerofsky (1999) and Smit (2013). Gerofsky (1999) uses genre pedagogy as a theoretical framework “to uncover hidden cultural meanings, assumptions and intentions inherent in the generic forms of schooling” (p. 36). Smit (2013) designs learning opportunities, which “facilitate pupils’ development of the language required for learning content” (p. 102) building on genre pedagogy. Both approaches contributed to a better understanding of subject-specific genres in mathematics education and led up to implications for teaching and learning mathematics. Whereas Gerofsky (2004) provides a comprehensive analysis of mathematical word problems as a well-known mathematical text type, Smit (2013) used genre pedagogy in order to design, enact and evaluate a ‘new’ pedagogical genre that she calls interpretative description of a line graph.

However, until now there is a lack of theoretical understanding of the subject-specific genres in school mathematics. On the one hand, a general and comprehensive survey of subject-specific genres in school mathematics is still missing. On the other hand, there is a dearth of research into the features of subject-specific genres in school mathematics.

In this article, we address subject-specific genres as a way to integrate subject matter and language learning. We focus on one particular genre of school mathematics, namely geometric construction texts. In German secondary education, a geometric construction comprises a drawing and a verbal step-by-step description of the single construction steps, which we call geometric construction texts. These are labeled with a fixed and unique technical term in the German speaking context (“Konstruktionsbeschreibung”) and always occur in a well-defined mathematical context, namely geometric constructions.

The aim of this paper is twofold: On the one hand, our in-depth analysis of genre features will contribute to the understanding of another particular subject-specific genre in mathematics education. On the other hand, we will use geometric construction texts as an exemplary case to generally show how school mathematics genres are influenced by different contexts. Thus, our analysis will also contribute to an epistemological understanding of the notion of subject-specific genres. Analyzing a particular instance of teaching geometric construction texts in a 7th grade German mathematics classroom, we will show how genre features derived from different contexts of situation might be blended in instruction and lead to the implementation of inconsistent genre features.

Our analysis is guided by the following questions:

- 1) What are the functional and language features of geometric construction texts in the different contexts of situation, namely disciplinary mathematics, didactics of mathematics, and school mathematics education¹?
- 2) Are geometric construction texts a single genre or do they have to be considered as different genres depending on the context of situation?

- 3) How do the different contexts of situation influence the teaching of geometric construction texts in mathematics classrooms?
- 4) What are the consequences for teaching geometric construction texts in mathematics classrooms?

In order to answer these questions, we first clarify the meaning of genre and discuss the role of the context of genre. This results in a differentiation of genres in terms of their relevant contexts (section 2). To analyze features of genres in different contexts of situation, we develop a model of genre (section 3). Methodologically, we use this model as a tool to analyze genre features from three perspectives: 1) particular text exemplars, 2) didactical teacher education literature and 3) classroom discourse. We describe our methods in section 4. The analysis of geometric construction texts in three different contexts of situation (disciplinary mathematics, didactics of mathematics and school mathematics education) and the discussion whether geometric construction texts have to be considered as one genre or as different genre is set out in section 5. Section 6 explores how genre features are implemented in classroom discourse. Based on this analysis, we describe how different contexts of situation influence the teaching of geometric construction texts and lead to the implementation of blended genres. As a consequence of our analysis, we refine the notion of genre awareness as a way to prepare teachers for integrated mathematics and language teaching (section 7).

GENRES AND THEIR CONTEXTS

In this section we clarify the meaning of genre and discuss the role of the context of a genre. This results in a differentiation of genres in terms of their relevant context.

Learning at school comprises learning with and from texts. In doing so, “particular text or discourse types”, so called *genres* are used (Schleppegrell, 2004, p. 82). Having a genre available means possessing a schema of particular texts which serve a similar communicative function.

The origins of genre pedagogy lie in “the inequality between students with respect to participation in the learning activities of the school, including both classroom learning and individual learning from reading” (Rose & Martin 2012, p. 304). Therefore, it has been widely adopted in second language learning (Hyland, 2007). Nevertheless, focusing subject-specific genres is not merely a fruitful way to integrate language learning with curriculum content for second language learners, but rather for all learners in terms of developing their academic language. Since thinking about the educational experiences that promote the development of language proficiency is a crucial task for educators of all students (Snow & Uccelli, 2009), we will neither make an explicit distinction between first (L1) and second language (L2) learners, nor will we address the issue of L2 learners in mathematics in particular. Participating in a school mathematics culture requires reading and writing mathematical genres for all learners.

Genre is an abstract concept of using language in texts. “It is based on the idea that members of a community usually have little difficulty in recognizing similarities in the texts they use frequently and are able to draw on their repeated experiences with such texts to read,

understand, and perhaps write them relatively easily” (Hyland, 2007, p. 149). According to Schleppegrell (2004), the „ability to realize the genres that are characteristic of particular social contexts allows participation in and mutual understanding of those contexts” (p. 83). In summary, genres are patterns of cultural-social interaction in a specific context.

What is regarded as the relevant context of a genre differs among scholars in the field. Referring to the metaphor of context as “that which surrounds”, Cole (1996) distinguishes different layers of context of a learning situation: the task, the lesson, the classroom, the school, the community. Depending on the scope of the context, which is in focus, different genres might be relevant. With regard to genre pedagogy, Martin and Rose (2008) and Gibbons (2002, p. 2) differentiate between two kinds of contexts: the context of culture and the context of situation. Context of culture means that “speakers within a culture share particular assumptions and expectations, so they are able to take for granted the ways in which things are done” (Gibbons, 2002, p. 2). Martin and Rose specify the relationship between context of culture and the context of situation. They model the genre at the stratum of culture beyond the context of situation. According to this, the context of culture entails the context of situation, which in turn entails the text in context: “So patterns of social organization in a culture are realized (‘manifested/ symbolized/ encoded/ expressed’) as patterns of social interaction in each context of situation, which in turn are realized as patterns of discourse in each text” (Martin & Rose, 2008, p. 10). It is important to emphasize that the context of situation of a text determines the genre. Variations in the context of situation lead to different kinds of genre. To understand this relationship, it is necessary to specify the context of situation. Therefore, Martin and Rose (2008) as well as Gibbons (2002) refer to Halliday’s (1985) three social functions of language: field, tenor and mode. Field, tenor and mode form the context of situation of a text.

Field refers to what is happening, to the nature of social action that is taking place: what it is that the participants are engaged in, in which language figures as some essential component.

Tenor refers to who is taking part, to the nature of participants, their statuses and roles: what kinds of role relationship obtain, including permanent and temporary relationships of one kind or another, both the types of speech roles they are taking on in the dialogue and the whole cluster of socially significant relationships in which they are involved.

Mode refers to what part language is playing, what it is that the participants are expecting language to do for them in the situation: the symbolic organisation of the text, the status that it has, and its function in the context. (Halliday, 1985, p. 12)

Halliday uses the term ‘register’ to refer to these three dimensions. Register comprises field, tenor and mode and contextualizes language (Martin, 1997). Distinguishing register from genre makes it possible “to model genre at the stratum of culture, beyond register, where it could function as a pattern of field, tenor and mode patterns” (Martin & Rose, 2008, p. 16).

Research related to genre focuses different kinds of contexts of situation and thus identified and described a variety of genres. On the one hand, Systemic Functional Linguistics distinguishes elemental genres such as narrative, recount, arguments, exposition etc. These are contextualized in the culture as a whole and do not take into account any specific layers of context of a learning situation as described by Cole. On the other hand, genre-pedagogy (Schleppegrell, 2004; Gibbons, 2002; Hyland, 2007) focuses on the school as the relevant context. Their representatives argue: "Because school is a culture with its own expectations for particular ways of using language, students need to learn about the genres of schooling and the purposes for which they are useful" (Schleppegrell, 2004, p. 83). Focusing on the school-level context, Schleppegrell (2004) and Gibbons (2002) identify a number of school-specific written genres: recount, narrative, procedure, report, account, explanation, exposition, discussion and argument. Gibbons uses the term 'text type' to refer to these school-specific genres (Gibbons, 2002, p. 54) and to delineate them from elemental genres. Referring to Schleppegrell (2004) we prefer the term 'genres of schooling'.

Schleppegrell (2004) goes one step further and focuses on one particular subject, namely science education, as a particular part of the context of schooling. Referring to the context of science education, she refines the list once more to common genres in science education, namely procedure, procedural recount, science report and science explanation.

In this paper we will focus on another subject, namely mathematics. Our interest is to apply genre theory to mathematics education. We argue that besides the genres of schooling every school subject has evolved its own genuine subject-based genres either reflecting the culture and context of the discipline in question or serving particular didactical/pedagogical purposes of the subject. We call these genuine subject-based genres subject-specific genres.

Figure 1 shows the relationship between different kinds of genres depending on the determining context. It is important to note that the figure only refers to the above explanations and contains contexts and genres relevant for this paper. In principle, the figure can be extended by different contexts of situation. Furthermore, contexts of situation are not always clearly separable and sometimes overlapping.

A MODEL FOR ANALYZING GENRE-FEATURES

The common method to analyze genre features is to derive them from particular text exemplars that realize the genre. An empirical analysis of the teaching of genre features is not common in the field of genre pedagogy. Therefore, we have to develop an appropriate analytic tool for analyzing genre features from different sources, namely given exemplars of the text that realize the genre, didactical literature for teacher education that refer to genre features (question 1) and classroom discourse that focusses on genre features (question 3).

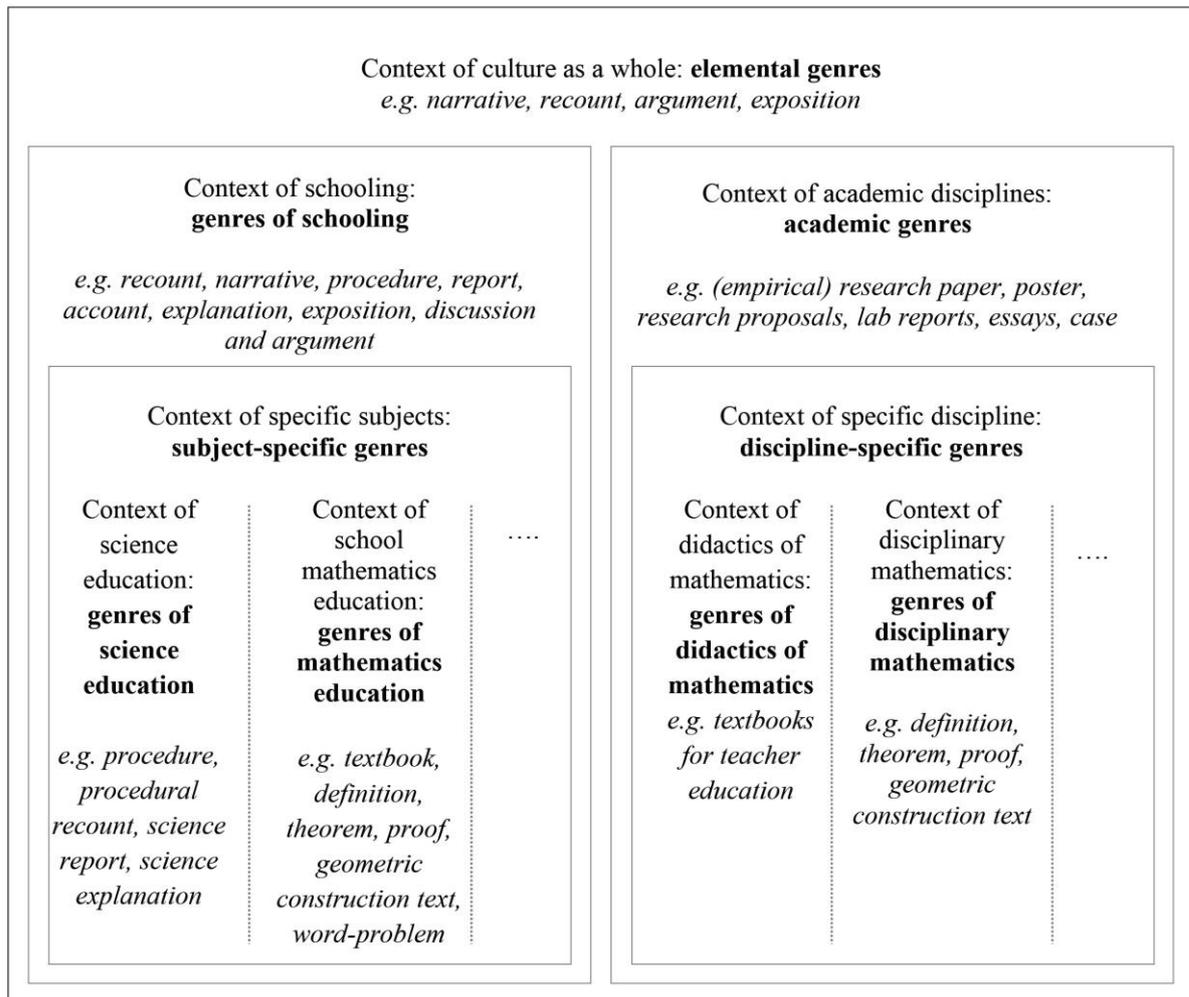


Figure 1. Genres depending on the determining context

Our model integrates three approaches: the characteristics of a genre stated by Gibbons (2002), Sandig's (1997) "model of a text convention", which helps to specify what constitutes a genre, and the modeling of context by Martin and Rose (2008).

Gibbons mentions four characteristics that make a genre different from another genre: 1) a specific purpose, 2) a particular overall structure, 3) specific linguistic features, 4) shared by members of a culture. Sandig (1997) refers to analogous characteristics, but in line with a functional view on language Sandig adds a general distinction between the linguistic function and the linguistic form of a genre. According to Sandig (1997), a genre is essentially constituted by a type of act and a text type. While the type of act refers to the properties of a genre in the sense of communicative functions and the context of situation (social function, the context in which it is used, the involved parties), the text type refers to the features of the genre in the sense of the language structure and the corresponding linguistic means to

realize the genre (speech acts, sequence pattern, formulation pattern etc.). Finally, it is the relationship between type of act and text type that constitutes the genre. The type of act directs the expectation of the text type while the features of the text type, especially the formulation patterns, indicate the type of act.

For our analysis, we draw on Sandig’s general distinction between type of act and text type. It is possible to match Gibbons’ characteristics of a genre to the text type and type of act: the specific purpose and the fact that a genre is shared by members of a culture are aspects of the type of act while a particular overall structure and specific linguistic features are aspects of the text type. We integrate these characteristics into the model of Sandig. For that, it is necessary to explain what it means that genres are shared by members of a culture. Following Gibbons (2002), this means that “genres are cultural” (p. 54) and knowing the context of culture is the basis for understanding genres. As already mentioned, Gibbons (2002) as well as Martin and Rose (2008) refer to Halliday’s three social functions of language *field*, *tenor* and *mode*. Compared with Gibbons (2002), Martin and Rose (2008) specify the relationship between genre and context of situation (field, tenor and mode). They elucidate the role of field, tenor and mode in relation to the linguistic features of a genre and show that the context of situation varies according to the three register variables field, tenor and mode. Therefore, we integrate the modeling of context of situation by Martin and Rose (2008) in our genre model. Thus, we emphasize that the features of the text type vary dependent on the type of act and underline the interplay of type of act and text type features that makes a genre different from another.

Our synthesis of the characteristics of a genre stated by Gibbons (2002), of Sandig’s (1997) “model of a text convention” and the modeling of context by Martin and Rose (2008) results in the model of genre features summarized in Table 1.

Table 1. Model of genre features

Type of act	Text type
<i>Field</i> : topic of the text	<i>Structure of the text</i>
<i>Mode</i> : Specific social purpose/function of the text	<ul style="list-style-type: none"> • constitutive and facultative speech acts • sequence pattern/organizational structure
<i>Tenor</i> : relationship between involved parties (writer and reader)	<p data-bbox="783 1709 999 1742"><i>Language features</i></p> <ul style="list-style-type: none"> • lexical features, e.g. technical language, style • grammatical features/grammatical constructions (e.g. connectives, adverbs, tense,...)

METHODOLOGY

Methodologically, we approach geometric construction texts from three perspectives: 1) We examine written text exemplars in terms of their genre features; 2) we collect descriptions of genre features from the didactical literature; 3) we analyze an audio-recorded and transcribed episode from a classroom discourse, in which geometric constructions and their descriptions were taught in a 7th grade mathematics class, in terms of explicit statements of genre features. For this end, we are using our model of genre features developed in the previous section. Our overall methodological approach is to use this model as a category system within qualitative content analysis (Mayring, 2015) in order to identify genre features from all three perspectives. Qualitative content analysis provides the appropriate rules and procedures for a methodological controlled analysis of text in order to categorize the textual material according to the categories of our model of genre features.

In the analysis of the classroom episode we complemented this method by conversation analysis (Sacks, Schegloff, & Jefferson, 1974) in order to understand the organization of interaction when teaching geometric constructions, particularly how text features are introduced and justified.

GENRE-FEATURES OF GEOMETRIC CONSTRUCTION TEXTS

In this section we analyze geometric construction texts in three different contexts of situation, namely disciplinary mathematics, didactics of mathematics and school mathematics education. For analyzing geometric construction texts in the context of school mathematics education, we use geometric construction texts in mathematics textbooks. We regard mathematics textbooks as cultural artifacts that present the mathematical content potentially implemented into the classroom (Valverde et al., 2002).

Our analysis will reveal that geometric construction texts are not homogenous entities, but multifaceted with sometimes contradictory characteristics that are dependent on the context of situation.

Geometric Construction Texts in the Context of Disciplinary Mathematics

The combination of drawing and construction text of the geometric construction can actually be traced back to Euclid and has epistemological reasons: While the verbal description describes and defines the geometrical figure – the theoretical object with its properties – the drawing is a graphical representation of the figure (Parzysz, 1988; Sträßer, 2015). Compared to the drawing, the verbal description captures the history of the construction and thus allows to check whether each step is consistent with the axioms and theorems of geometry or not. Therefore, geometric construction texts are a special case of mathematical proof, namely an existence proof of the constructed geometrical objects. Consequently, their discourse function within the mathematics community is justification and their type of text corresponds to that of mathematical proof. Considering geometric approximations, the importance of the distinction between drawing and figure becomes most apparent. While the solution of the problem on the level of the drawing might yield an acceptable solution, the geometric construction text reveals that the solution is ‘only’ an approximation and not an exact construction of the geometrical object in question (Kadunz & Sträßer, 2007).

Geometric construction texts can also be regarded from an algorithmic perspective. From this perspective, the construction problem defines the given initial configuration and the (unknown) target configuration, while the geometric construction text is the algorithm, which yields a (unique) target configuration for every initial configuration (Holland, 2007, p. 80). Some Dynamic Geometry Systems (DGS) even use geometric construction texts as the user interface.

Geometric Construction Texts in the Context of Didactics of Mathematics

In order to analyze the genre of geometric construction texts in didactics of mathematics we refer to the relevant literature for teacher education in Germany. Switching the context from mathematics to didactics of mathematics yields further and different properties of geometric construction texts. Weigand et al. (2009) state that there are no definite norms for geometric construction texts. However, the authors name two principles, which are relevant for geometric construction texts: 1) They are supposed to provide a comprehensible and comprehensive account of the single constructions steps for someone else. 2) The language of geometric construction texts is supposed to adjust to learners' language and should develop from everyday to technical (mathematical) language, i.e. the didactical literature does not convey any norms of language features of geometric construction text in the school mathematics context.

Geometric construction texts serve several didactical functions (Weigand et al., 2009): They provide a good opportunity to verbalize actions, to write about mathematical procedures, and to communicate in the classroom. For learners they are supposed to serve as a report of the problem solution. Furthermore, they are a means to understand and evaluate the solution of the problem on the level of the drawing for learners and teachers. These functions are supposed to be realized by a comprehensible (verbal) description of the single steps of a geometric construction, which is sequenced in the order of the (basic) construction steps.

Geometric Construction Texts in the Context of Mathematics Textbooks

Figure 2a (translation in Figure 2b) provides an example of a geometric construction with geometric construction text from the textbook that the teacher and the students used in our case study.

A qualitative content analysis of widespread German mathematics textbooks for grade 7 based on the categories of our model of genre features (Table 1) reveals that the geometric construction text in Figure 2a is a prototypical example of a geometric construction text in terms of its text type features. Whereas it is expressed in the mathematics teacher education literature that the language features of geometric construction texts allow for variability, prototypical language features can be found in mathematics textbooks. Our analysis of this geometrical construction text reveals the following text type features:

1. Each step of the construction is numbered (sequence pattern/organizational structure).
2. Only main clauses (grammatical feature).
3. Short imperative sentences (grammatical feature).
4. Technical terms (line, circle, radius, intersect) (lexical features).

5. Symbols ($c=5.5$ cm, $b=4.4$ cm, $a=3.6$ cm, A, B, C) (lexical features).

Characteristics of the type of act are commonly not explicated in mathematics textbooks.

Despite the fact that the mathematics teacher education literature promotes that the language of geometric construction texts is supposed to adjust to the learners, it is likely that the geometric construction texts in mathematics textbooks (and in automatically provided geometric construction texts in DGS) act as normative models (Dowling, 1996; Luke, de Castell, & Luke, 1989; Olson, 1989).

Table 2 summarizes the features of geometric constructions texts in different contexts and answers our first question. The features are categorized according to our model of genre features (Table 1). Our analysis was not able to unveil the manifestation of every category in every context of situation. Nevertheless, it is apparent in Table 2 that the genre features vary according to the context of situation.

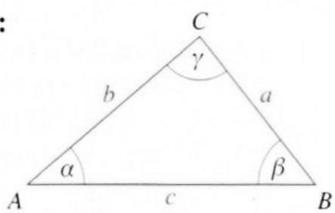
Geometric Construction Texts as Blended Genre

Our analysis of geometric construction texts in three different contexts of situation (disciplinary mathematics, didactics of mathematics, school mathematics education) reveals

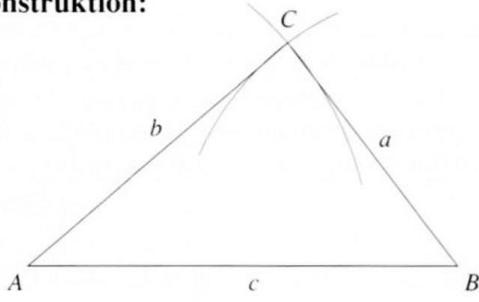
Konstruiere das Dreieck ABC mit $a = 3,6$ cm, $b = 4,4$ cm und $c = 5,5$ cm.

Gegeben: $a = 3,6$ cm; $b = 4,4$ cm; $c = 5,5$ cm **Hinweis**

Planfigur:



Konstruktion:



Konstruktionsbeschreibung:

1. Zeichne $c = 5,5$ cm.
2. Zeichne um A den Kreis mit dem Radius $b = 4,4$ cm.
3. Zeichne um B den Kreis mit dem Radius $a = 3,6$ cm.
Die beiden Kreise schneiden sich in C .
4. Verbinde A mit C und B mit C .

Beim Konstruieren eines Dreiecks kannst du in diesen Schritten vorgehen:

1. Schreibe auf, was gegeben ist.
2. Zeichne ein beliebiges Dreieck als Planfigur und beschrifte es (siehe Methode S. 114).
3. Konstruiere, nachdem du dein Vorgehen mit-hilfe der Planfigur geplant hast.

Figure 2a. Example of a geometric construction with geometric construction text from a German mathematics textbook (Koullen, 2006). (Translation in Figure 2b)

Construct triangle ABC with $a = 3.6$ cm, $b = 4.4$ cm, and $c = 5.5$ cm	
Given: $a = 3.6$ cm, $b = 4.4$ cm, $c = 5.5$ cm	<p>Tip You can follow these steps in order to construct the triangle:</p> <ol style="list-style-type: none"> 1. Write down the givens. 2. Sketch an arbitrary triangle and add the labels (see method p. 144). 3. Carry out the construction of the triangle after having planned how you will proceed with the help of your sketch.
<p>Sketch Construction</p>	<p>Geometric construction text:</p> <ol style="list-style-type: none"> 1. Draw line $c=5.5$ cm. 2. Draw a circle around A with radius $b=4.4$ cm. 3. Draw a circle around B with radius $a=3.6$ cm. Both circles intersect in point C. 4. Connect A and C as well as B and C.

Figure 2b. Translation of Figure 2a

that the genre features vary dependent on the context of situation. These variations are especially visible in the mode and in the linguistic features. While the mode in disciplinary mathematics is that of justification, the mode in didactics of mathematics is that of reporting or describing.

As explained in section 3, a genre is constituted by the relationship between type of act and text type. The type of act directs the expectation of the text type while the features of the text type indicate the type of act. Consequently, differences in the type of act (e.g. in mode) also yield differences in the text type features of the genre and vice versa. Regarding the case of geometric construction texts this means that on the one hand, it is possible to derive language features that are related to the reporting mode explicated in the didactical literature: Geometric construction texts are usually written after the construction problem was solved on the level of the drawing. This retrospective perspective is typical for procedural recounts (Martin & Rose, 2008), which reflect (experimental) activities that have been done and thus provoke the use of the past tense. On the other hand, we can infer the type of act from the use of the imperative mood that is typically realized in mathematics textbooks. A prospective perspective and the use of imperative commands as in the example from the mathematics textbook is typical for the genre 'procedure', which aims at directing the actions of a possible reader (Martin & Rose, 2008).

Due to the variations of genre features in the different contexts of situation, geometric construction texts do not appear as a homogeneous and consistent genre. Nonetheless, it is

Table 2. Genre features of geometric construction texts in different contexts of situation

Type of act	Text type
1. Geometric construction texts in disciplinary mathematics	
<p><i>Field:</i> step-by-step-description of geometric construction</p> <p><i>Mode:</i></p> <ul style="list-style-type: none"> • justification/existence proof <p><i>Tenor:</i></p> <ul style="list-style-type: none"> • mathematicians 	<p><i>Structure of the text</i></p> <ul style="list-style-type: none"> • sequence of single basic constructions in the order of the construction
<i>Language features</i>	
2. Geometric construction texts in didactics of mathematics	
<p><i>Field:</i> step-by-step-description of geometric construction</p> <p><i>Mode:</i></p> <ul style="list-style-type: none"> • comprehensible (verbal) description of single steps in geometric constructions • report of problem solution verbalization of actions • classroom communication <p><i>Tenor:</i></p> <ul style="list-style-type: none"> • learner and teacher 	<p><i>Structure of the text</i></p> <ul style="list-style-type: none"> • sequence of single basic constructions in the order of the construction
<i>Language features</i>	
<i>Language features</i>	
3. Geometric construction texts in textbooks	
<p><i>Field:</i> step-by-step-description of geometric construction</p> <p><i>Mode:</i></p> <p><i>Tenor:</i></p> <ul style="list-style-type: none"> • learner and teacher 	<p><i>Structure of the text</i></p> <ul style="list-style-type: none"> • sequence of single basic constructions in the order of the construction
<i>Language features</i>	
<i>Language features</i>	
<i>Language features</i>	

questionable, if geometric construction texts have to be considered as different genres. We argue that geometric construction texts will be easily recognized due to the occurrence of geometric construction texts in the context of geometric constructions (field) together with the step-by-step verbalization of construction steps (structure of the text). Furthermore, Feilke (2012) argues that the function and form of disciplinary genres is sometimes transformed in the context of schooling serving pedagogical and didactical functions. This also seems to be the case with geometric construction texts. While geometric construction texts have to be considered as a case of argumentative genre (existence proof) in disciplinary mathematics, their function in the pedagogical context is changed. Consequently, we consider geometric construction texts as a **blended genre** with varying features due to transformation in the context of schooling.

This fact poses particular challenges on teaching this genre. In the next section we will show how genre features of geometric construction texts from different contexts of situation are blended in the teaching of the genre.

GEOMETRIC CONSTRUCTION TEXTS AS A MATHEMATICAL GENRE IN CLASSROOM DISCOURSE

In this section we analyze one episode from a classroom discourse, in which geometric constructions and their descriptions were taught in a 7th grade mathematics class with 29 students. The questions that guided our analysis were, how the teacher implemented geometric construction texts in mathematics classroom and how the different contexts of situation influence the teaching of geometric construction texts (question 3).

The teacher has neither been introduced to genre-pedagogy before nor is he familiar with the recent efforts to foster language learning in the subjects. Here, we present an in depth analysis of one episode, where the geometric construction text is introduced for the first time. The methods of our analysis were described in section 4. This episode captures exemplarily what we have found in the whole lesson.

The Episode

After introducing the general problem of constructing triangles from only a few given properties – in this case the length of the three sides – the teacher develops a sketch of a triangle on the black board in order to mark the given magnitudes. During this activity he also repeats how sides and vertices of a triangle are labeled. The episode starts with the teacher developing a solution of the problem together with the students.

- 147 T: Now we can start with the actual drawing. Any suggestions how we
148 carry out the construction? Frank?
149 S: First we draw the base. So, AB 3.2 cm
150 T: Ok. Let's do it. We use our 'Geodrieck'² and draw the base with 3.2 cm. It is
important
151 that you immediately add the labels of the vertices at the ends of your side,
152 so you don't get confused. Instead of labeling the vertices

- 153 you can also add the measure of the side. This way, you've got
 154 all the important information. And since I know how much you like writing and
 155 how much you like to work neatly, we will write
 156 a description of our construction right next to our drawing. We will do that
 157 exemplarily today and will come back to it later, so that everyone
 158 knows how we proceeded. The description of the geometric construction next to the
 drawing
 159 and now it is important to be mathematically precise
 160 in verbalizing and describing what we did, Sophie?
 161 S: We have drawn the base from A to B with 3.2 cm.
 162 T: Exactly, but we won't use such a complicated phrasing
 163 'we have drawn the base', but the imperative mood
 164 'draw line segment', because it is a line segment from one point to the other, AB
 165 with length 3.2 cm. This is the first step. This is
 166 easy. Now it's going to be a little more difficult. We have two more sides given
 167 and the triangle is supposed to look exactly as requested in the end. What will be
 168 the second step? What do we have to do next?

In the first sequence (line 147-154) the teacher and the students develop the actual drawing of the construction. In the first turn the teacher initiates the activity and asks the students for suggestions how to carry out the construction (lines 147-148). One student answers by suggesting a first step of the construction. The teacher affirms (line 150) and starts to explain how to draw the triangle by using the 'Geodreieck' and how to label the vertices respectively adding the measure of the side. While explaining the procedure, the teacher carries out the drawing. When finishing the explanation and the drawing, the teacher leads over to the next sequence: the writing of the geometric construction text (lines 154-165).

The second sequence starts with justifying writing the text by referring ironically to the students' general motivation to write (*...since I know how much you like writing and how much you like to work neatly*, lines 154-155) and by referring to the function of the text (*so that everyone knows how we proceeded*, lines 157-158), followed by the stipulation that the text has to be located next to the drawing. Then the teacher explicates the requirement "*to be mathematical precise*" when verbalizing and describing what they did (lines 159-160). Sophie frames the beginning of the text by saying "*We have drawn the base from A to B with 3.2 cm.*" (line 161). He evaluates Sophie's answer as being too complicated and revises and rephrases her answer by stating to use the imperative mood "*draw line segment*" (line 164). The first sequence ends with the teacher's conclusion: "*This is the first step.*" (line 165)

Qualitative Content Analysis of the Episode

The second sequence offers several instances in which the teacher relates to features of geometric construction texts. In the first place, the teacher explicitly refers to one important social function of geometric construction texts in the second sequence: "*so that everyone knows how we proceeded*". The indefinite pronoun "*everyone*" is used to denote an indefinite addressee. In the second place, the function is explicated that every step, i.e. the

chronological genesis of the construction, has to be described. However, a comprehensible rationale for writing geometric construction texts is not given. The teacher does not provide the students with reasons that give insight into the mathematical significance of a geometric construction text. Furthermore, he introduces language features of a geometric construction text explicitly by referring to a mathematical precise language and the use of the imperative mood. This is in accordance with the style of the geometric construction description from the textbook that is used in the class.

The teacher explicitly addresses type of act-as well as text type features of geometric construction texts. Table 3 summarizes the utterances that explicitly refer to the categories of our model of genre features.

Conversation Analysis of the Episode

In the second step of the analysis, our aim is to focus the relationship between the organization of sequences and language structure in order to understand how the teacher teaches geometrical constructions and writing geometrical construction texts and which role the use of language plays in it.

Analyzing the sequential organization of this episode shows that the teacher at first focuses on the actual drawing of the construction (= first sequence). After that he introduces how to write a geometric construction text (= second sequence).

Table 3. Synopsis of genre features explicitly referred to by the teacher

Type of act	Text type
<p><i>Mode</i> „Since I know how much you like writing and how much you like to work neatly we will write down a construction script next to our drawing“ „... so that everyone knows the way we proceeded.“ <i>Tenor</i> „everyone“</p>	<p><i>Structure of the text</i> sequence following the sequence of the construction steps each step numbered</p> <hr/> <p><i>Language features</i> „it is important to be mathematical precise in verbalizing and describing what we did“ responding to student’s suggestion: „Exactly, but we will not use such a complicated phrasing, but the imperative mood ,draw line segment“</p>

This succession of steps implicates that the students use the present tense when developing the construction (line 149). Against this, the writing of the geometrical construction text is accomplished from a retrospective perspective. This retrospective perspective becomes apparent in the way language is used. When justifying writing the text the teacher refers to the function of geometric construction texts and explains this function using the past tense ("*how we proceeded*", line 158). Furthermore, he uses past tense to refer to the activity of drawing in the first sequence "*it is important to be mathematical precise in verbalizing and describing what we did*", line 159-160). Accordingly, Sophie gives her answer using the present perfect (*We have drawn the base from A to B with 3.2 cm.*, line 161). With reference to the organizational structure of this episode this is a coherent answer and indicates how aptly the student replies to the teacher's language.

The teacher's revision of Sophie's answer by using the imperative mood can only be explained referring to the language features of geometrical construction texts in the mathematics textbook. The teacher does not provide any arguments why the imperative mood should be used. The students can only infer from the teacher's reaction ("*we won't use such a complicated phrasing*", line 162) that the imperative mood seems to be less complicated than the present perfect. This is likely to be confusing since the teacher himself provoked the use of the present perfect due to his own use of the past tense.

Furthermore, we find two instances in our analysis where the teacher adjusts students' wordings. In the first instance, the teacher shifts quickly between different denominations of a line and addresses the two possibilities of either label the vertices with capital letters or the side with the corresponding length, respectively (line 152). In the second instance, the teacher first repeats the wrong term 'base' that the student offered and substitutes it with "*line segment*" (line 164) while also changing the grammar from past tense to imperative mood. He does not provide an explanation, why he changes the technical term, but justifies the use of "*line segment*" en passant ("*because it is a line segment from one point to the other*" (line 164)).

Adjusting students' wordings might be motivated by the requirement "*to be mathematical precise in verbalizing and describing what we did*" (line 159-160). However, he does not make this explicit to the students.

DISCUSSION

The analysis of the episode reveals that the teacher implements important genre features of geometric construction texts. The main theme of the lesson is to solve the geometric construction problem on the level of the drawing. The geometric construction text is introduced as a supplement to the drawing. Therefore, geometric construction texts are introduced from the retrospective perspective after a construction step has been carried out on the level of the drawing. The mode that is enacted in the learning situation induces the use of the past tense when verbalizing the action. This is coherent with the teachers own use of language in the classroom communication. Accordingly, the realized type of act (mode) is that of reporting (the problem solution) or of verbalizing (actions). Thus, the teacher enacts one particular mode as a feature of the type of act of geometric construction texts in the classroom discourse.

Furthermore, the teacher introduces the sequence model and the use of the imperative mood as features of geometric construction texts. These text type features match the features of geometric construction texts as procedures, which are passed on by the textbook. He explicitly refers to these text type features in the classroom discourse and realizes them in the developing written text product. The imperative mood, however, is appropriate for a different type of act (mode), namely a comprehensible (verbal) description of single steps in geometric constructions. Consequently, the implemented text type features do not coincide with the explicated type of act features. Furthermore, they would have required a different structure of the lesson. An interplay between the type of act and text type features is neither explicitly addressed nor is it inherent in the classroom discourse.

In summary, the teacher borrows properties from different contexts of situation, namely didactics of mathematics and school mathematics education (textbooks) and blends them in instruction. Therefore, his implementation is characterized by inconsistencies between the type of act (function) and the text type (form) of the genre. As a result, two different genres of schooling play a part in the episode: procedure and procedural recount. While the student's use of the present perfect is in accordance with the whole classroom discourse and refers to the genre of procedural recount the teacher changes the perspective from retrospective to prospective and offers the imperative mood, which is a typical feature of the genre procedure. Although we cannot infer any substantial effects on students' learning of geometric construction texts it is questionable if this blending does contribute to the development of language proficiency in mathematics. Even if the students are able to write geometric construction texts after instruction, it is likely that the students do not understand the reasons for the language features. From our point of view, this should be a goal for integrated subject matter and language learning.

Furthermore, we cannot infer from the limited data why the teacher introduced geometric construction texts in the way he did. We can see that he generally seems to be motivated to communicate features of geometric construction texts to the students. Therefore, we hypothesize that he is probably not aware of other features, and especially not the interrelations between type of act and text type. Otherwise, he would have probably communicated these to his students.

CONSEQUENCES FOR TEACHING SUBJECT-SPECIFIC GENRES

Our analysis of geometric constructions texts reveals that different contexts of situation inform the features of this subject-specific genre. As a consequence, the features of this genre vary according to the context of situation and a blended genre emerges. Our analysis of the episode revealed how these varying and sometimes conflicting features were blended in the teaching of the genre in the classroom. While a geometric construction text with similar features as in the used textbook was developed in the classroom, the teacher's contradictory explications of genre features are likely to impede the students' understanding of the relationship between the genre's function (type of act) and form (text type).

Subject-specific genres play an integral role with regard to integrated subject matter and language teaching. While their type of act relates to subject specific learning goals, their text

type features enact their subject specific function with the appropriate genre-specific linguistic means. Therefore, we see it as an important aspect of successful integrated subject matter and language teaching that type of act and text type features of a genre are enacted in a consistent, mutually related manner. Therefore, we ask how to empower teachers to teach subject-specific genres in this way. From our point of view, the answer to this question and to our fourth question (What are the consequences for teaching geometric construction texts in mathematics classrooms?) lies in what Devitt (2009) has termed “the teacher’s genre awareness”, i.e. “the teacher being conscious of the genre decisions he or she makes and what those decisions will teach students” (p. 339). We argue that “genre awareness” is an important aspect of teacher knowledge in order to contribute to a successful subject matter and language integrated teaching. Since Devitt’s definition of the teachers’ genre awareness remains vague, our aim in this section is to detail the notion of genre awareness based on our analysis of geometric construction texts as a subject-specific genre and its implementation in the classroom.

In our analysis of the episode we concluded that the teacher was probably not aware of the multiple and inconsistent features of geometric construction texts. Accordingly, we argue that an important prerequisite for an integrated teaching of mathematics and language is to know about the features of subject-specific genres and possible genre-variations. In order to contribute to subject-specific learning goals, it seems vitally important to know about the epistemologically grounded subject-specific functions of the genre.

However, mere knowledge about the genre features and possible variations does not seem to suffice. On the one hand, our analysis of geometric construction texts has shown that type of act and related text type features of a genre might even be ambiguous or contradictory due to influences from different contexts of situation. On the other hand, our case study of the implementation of geometric construction texts in a mathematics classroom revealed how the language of the teacher induces features of the genre, which conflict his explicit teaching of genre features. The latter aspect is also inherent in the whole classroom discourse: Introducing geometric construction texts as a retrospective of what was done and at the same time seeking for the imperative mood as the appropriate language for geometric construction texts implements an inconsistent genre, which is likely to yield confusion or misunderstanding. Besides knowing about genre features and possible variations it is also important for teachers to know about the mutual dependencies and possible incompatibilities of genre features. This knowledge is a prerequisite for designing appropriate learning arrangements. As suggested in genre-pedagogy, an ‘appropriate’ learning arrangement starts with setting the context, i.e. “revealing genre purposes and the settings in which it is commonly used” (Hyland, 2007, p. 159). In the case of geometric construction texts this could be achieved by focusing on

- a) the epistemological function as an existence proof;
- b) the didactical functions (report of the solution of the problem, verbal description of single steps in geometric constructions, the verbalization of actions and the communication in the classroom).

The introduction of further genre features has to relate to and has to be consistent with the genre purposes, which are inherent in the learning arrangement. Finally, the language of the teacher has to adjust to the implemented genre purposes and related genre features.

In summary, genre awareness comprises

- a) knowledge about genre features, their interrelations and possible variations
- b) to design learning arrangements according to genre purposes,
- c) to use a language that is consistent with the enacted genre purposes and to implement genre features that are consistent with the learning arrangement and the enacted genre purposes.

CONCLUSIONS

Referring to genre pedagogy and the question of the relevant context of a genre we argued that focusing subject-specific genres is a promising approach for integrated subject matter and language teaching, because

- a) the type of act of a subject-specific genre is grounded in disciplinary and in subject-specific didactical purposes,
- b) the text type features are means to achieve these purposes.

Our analysis of geometric construction texts revealed that genre features vary according to the context of situation under consideration. Genre features of different contexts of situation influence the classroom discourse of subject-specific genres. The challenge in integrated subject matter and language teaching is to implement subject-specific genres in the classroom with consistent interrelations between function and form.

We suggested “genre awareness” in subject matter teaching as an important aspect of teacher knowledge in order to address this problem. We have argued that genre awareness comprises

- a) knowledge about genre features, their interrelations and possible variations
- b) to design learning arrangements, according to genre purposes,
- c) to use a language that is consistent with the enacted genre purposes and to implement genre features that are consistent with the learning arrangement and the enacted genre purposes.

Although grounded in the empirical analysis of a case, genre awareness is a theoretical and normative concept. The question remains, if teachers’ genre awareness will actually improve students’ understanding and writing of geometric construction texts. This will be an aspect of further investigation.

So far, it is not common to apply genre theory in order to analyze the implementation of genre features into the classroom. Our methodological approach to analyze classroom discourse based on our model of genre features proved to be fruitful in order to better understand the implementation of genre features into the classroom. Therefore, our methodology contributes to the methodological repertoire of research into genre-pedagogy.

NOTES

1. With the term „didactics of mathematics“ we refer to the scientific discipline that investigates the teaching and learning of mathematics and is in charge of mathematics teacher education. „School mathematics education“ refers to the teaching and learning of mathematics in school.
2. In German speaking countries the common tools used for geometric construction are compass and ‚Geodreieck‘. A ‚Geodreieck‘ is a special set square or triangle combining a 90-45-45 triangle with a protractor and a ruler into a single tool made of clear plastic.

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