Chapter 18
From General Science Teaching to Discipline-Specific Science Teaching: Physics Instruction and Students' Subject-Related Interest Levels During the Transition from Primary to Secondary School

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18.1 General Framework and Conditions of Science Teaching in the Transition from Primary to Secondary School

The transition from primary to secondary school is a defining characteristic of the German education system (Koch 2008). After having finished fourth grade of primary school, German students transfer – depending on their prior achievement – to one of several different tracks of secondary school. Students with the lowest

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achievement usually transfer to the ‘Hauptschule’, a kind of basic general education comprising 6 years of schooling, subsequently called ‘lower secondary school’. Students with the highest achievement usually transfer to the ‘Gymnasium’, subsequently called ‘grammar school’. This track provides an intensified general education comprising 8 to 9 years of schooling and prepares students for university.

Irrespective of the particular track of secondary school, the (former) primary school children face significant changes in the structure of science teaching, by the time they enter the new schools. The subject of general science, which encompasses natural sciences and social studies at the primary school level, does not retain its original form. A closer look at the science component of the German school curriculum shows that there is a preponderance of combined sciences taught at grades 5 and 6 (students aged 11–12), or an integrated single science subject. In the following year, however, science is separated into different subject disciplines (Möller 2014). In accordance with the changes to the pedagogical framework, corresponding changes in the form of the science teaching and in the professional background of the teaching personnel are also in evidence. Primary school teaching staff is normally only generally educated in science. They usually have limited content knowledge of individual scientific disciplines and a more school-oriented approach to the field, whereas science teaching staff at secondary schools tends to be more subject specialists with a stronger content knowledge of their discipline, but with less overall pedagogical interest (Gess-Newsome 1999; Harlen 1992; Möller 2014).

The study presented herein examines a) to what extent students perceive these changes in instructional quality when moving from primary to secondary science education and b) to what extent the students’ interest levels in science change during that period. Since it has been firmly established that, in particular, the students’ interest in physics declines at the secondary school stage (Daniels 2008; Hoffmann et al. 1998), this study concentrated on the area of physics-related teaching.

18.2 The Change in Science Teaching Associated with the Transition from Primary to Secondary School

In the research of science education, constructivist theories are considered as important for both teaching and learning and are also often cited in the promotion of performance-related and motivational goals (Treagust and Duit 2008; Wandersee et al. 1994). In this regard, there is a particular focus on the discussion of theoretical learning approaches to so-called ‘conceptual change theories’, on theories of situated cognition and on social-constructivist approaches, which promote an understanding of learning as an active social and contextual construction process (Gerstenmaier and Mandl 1995; Reinmann-Rothmeier and Mandl 1998; Treagust and Duit 2008). Scientific learning, which aims at theoretical and practical knowledge, should create possibilities for restructuring prior knowledge (Treagust and Duit 2008), for the use and acquisition of concepts from real-life immediate and meaningful contexts (Stark 2003), for a joint exchange and analysis of assumptions and explanations (Mietzel

2007) and for an accessible and clear language in the teaching (Wagenschein 1992). Earlier findings (Bredderman 1983) indicated that hands-on activities, such as self-executed experiments, should by themselves contribute to motivational target areas. Current investigations suggest that such activities should be combined with reflective processes in order to produce a positive effect on motivational learner outcomes (Holstermann et al. 2010; Jocz et al. 2014; Potvin and Hasni 2014).

So far, there have been relatively few studies covering science or physics-related teaching with respect to the characteristics identified here; longitudinal studies focusing on the transition from primary school to secondary school have been missing entirely. Overall, German and international studies show that hands-on activities are used relatively frequently in primary schools, whereas teaching aimed at developing understanding through questioning is less common. Furthermore, children are encouraged towards their own research and discovery, whereas taking notes from the board is a more marginalised activity (Gais and Möller 2006; Logan and Skamp 2008; Rennie et al. 2001). For secondary school education, there is evidence that instruction is often more teacher centred, which leaves only limited space for independent learning. Experiments often take the form of demonstrations, whereas real-life or application-specific references play a lesser role in secondary school teaching (Danaia et al. 2013; Reyer et al. 2004; Seidel et al. 2007). Moreover, with regard to students' perceptions of physics teaching at the secondary school stage, there are signs of gender differences. Labudde and Pfluger (1999) found that boys perceive more subject relevance to their daily lives than girls do. The same applies to students' perception of 'teaching for understanding' within science instruction (Reyer et al. 2004).

18.3 The Change in Levels of Interest in Science Associated with the Transition from Primary to Secondary School

In accordance with the educational concept of *scientific literacy*, science teaching should not only build up discipline-specific knowledge but also aim to generate positive motivational orientations (OECD 2006). In this respect, Prenzel (2000) argues that a scientifically literate person should at least have a slightly pronounced interest in terms of open-mindedness towards science. Although a deep, pronounced interest in science is thereby not regarded as absolutely necessary, it is considered as pedagogically desirable (Prenzel 2000).

In terms of the 'person-object theory of interest', the concept of 'interest' refers to a special relationship between a person and an object (Krapp and Prenzel 2011). This relationship is characterised by a high subjective evaluation of the object of interest (value-related valences). Furthermore, it implies that the person has positive emotional experiences while engaging with the object (feeling-related valences; Krapp and Prenzel 2011). Additionally, it is assumed that an enduring interest leads to a broad knowledge of the object and is characterised by the desire to learn more about it (cognitive-epistemic component; Krapp and Prenzel 2011). Such a deeply anchored and relatively permanent individual interest can be contrasted with the situational interest, a state, which is mainly caused by external stimuli. In the context of school, these stimuli can be identified in the arrangement of the learning environment, for example (Krapp and Prenzel 2011).

Although much emphasis has been placed on the importance of building up science-related interests, it has also been established that the students' average interest levels in science and school science undergo a significant decline during the secondary school phase (e.g. Barmby et al. 2008; Daniels 2008; Hoffmann et al. 1998; Hutchinson et al. 2009). A large body of research referring to the students' 'attitudes' (a construct closely related to the students' interest levels) towards science and school science seems to confirm this downward trend (e.g. Barmby et al. 2008; George 2006; Gottfried et al. 2001; Reid and Skryabina 2002; Sorge 2007). As for the UK, the findings of the current ASPIRES project indicate that British students continue to enjoy their science lessons in secondary schools and still hold positive attitudes towards school science by the ages of 12 to 13 (DeWitt et al. 2014). However, German studies suggest that the students' interests in science – as far as the discipline physics is concerned – decline at the secondary school stage (Daniels 2008; Hoffmann et al. 1998). Physics-related interests show the steepest decline immediately after the introduction of subject-specific physics teaching (Hoffmann et al. 1998). In addition, girls already manifest a lower general interest level in physics at the very start of the secondary school education (Hoffmann et al. 1998). Furthermore, they are less likely to continue with physics when it is no longer compulsory (Mujtaba and Reiss 2014).

In contrast to the findings identified at the secondary level, findings of the representative school studies of IGLU-E, TIMSS 2007 and TIMSS 2011 indicate that German fourth grade students have a relatively positive attitude towards general science lessons and consider the content as meaningful and relevant (Kleickmann et al. 2012; Prenzel et al. 2003; Wittwer et al. 2008). In addition, IGLU-E suggests that primary school students are curious and open-minded towards selected science topics ('Animals and Plants', 'Experimenting and Methods of Investigating') and the related scientific working methods (Prenzel et al. 2003). As for the TIMSS 2011 study, no significant gender differences were established with regard to the motivational outcomes (Brehl et al. 2012). To summarise the findings, positive motivational orientations towards the 'general science' subject with its multiple perspectives (including the natural sciences) by the end of students' primary school phase stand in contrast to the predominantly occurring problematic developments in the subsequent secondary school phase, which particularly holds for the German school system.

18.4 Research Question

The diverging findings for primary and secondary schools on the design of science teaching and the manifestation of student interest levels in the sciences cannot be completely compared and referenced to each other due to the differing nature of their subject content (general/natural sciences at the primary school level vs. natural sciences/physics at the secondary school level). However, they reveal the significance of the interface between the schools. Moreover, they invite the question whether the downward trend observed, along with the gender differences in the physics-related interest ratings of the secondary school students, could be conditioned by the perceived changes in the teaching style which accompany the switch from primary to secondary school. Since no appropriate longitudinal studies have been available in Germany so far, this research question will be examined within the context of the PLUS project.[1] In the current article, two central variables of the project will be analysed: the perception of the physics-related instruction and the development of the physics-related interest levels, each in the context of the transition from the final year of primary school (German grade 4, students aged 10) up to the third year of secondary school (German grade 7, students aged 13–14). Special emphasis is placed on the following research questions:

– How does the students' perception of the physics-related instruction change?
– How do the physics-related interest levels of the learners develop (both situational interest in physics-related instruction and individual interest in physics)?
– Are there any gender-specific differences in the students' perception of the instructional design and in the development of their physics-related interest levels?

18.5 Method

18.5.1 Overall Design and Sample

In order to answer the research questions, we used longitudinal study data from the PLUS project. The study took place in the German state of North Rhine-Westphalia and was carried out from 2008 to 2013. The participating schools were located both in rural and in urban areas and represented different geographical regions of the state. Based on an initial survey of 1,396 fourth graders in their last year of primary school (av. age 10.27 years, 46.8 % female), 568 students could be pursued through their transition into the first year of secondary school (fifth grade, av. age 11.57 years). In the sixth grade (av. age 12.61 years), 452 students continued to take part in the study and by the seventh grade (av. age 13.55 years) 443 did so. Of these 443 students, data from 348 students (46.8 % female) could be collected for each measurement time

[1] 'PLUS' is a German abbreviation for '*P*rofessionswissen von **L**ehrkraften, naturwissenschaftlicher **U**nterricht und Zielerreichung im Übergang von der Primar- zur *S*ekundarstufe', meaning 'Students' transition from primary into secondary school – professional knowledge of teachers, science instruction and student outcomes in science'. The PLUS project was funded by the German Research Foundation (*D*eutsche *F*orschungs*g*emeinschaft, 'DFG') and is embedded within the DFG research group '*nwu* Essen' (abbreviated from the German '*N*atur*w*issenschaftlicher **U**nterricht', meaning 'science teaching').

('matched students'). This data mainly concerns students who made the transition to a German grammar school or to a German lower secondary school, which form the two extremes of the German school system from a performance-related perspective. The 348 students who continuously took part in the study came from 131 different secondary school classes. Compared to their classmates, the matched students did not differ much in terms of cultural capital (determined by an item on the approximate number of books at home) or the language spoken at home. However, in comparison with a representative sample for North Rhine-Westphalia that came from the 2006 Progress in International Reading Literacy Study (PIRLS), the matched PLUS students, on average, had access to more books at home (40.7 % vs. 32 % of students with >200 books at home; Stubbe et al. 2008) and spoke German at home more frequently than the comparison group (85.1 % vs. 74.6 % of students with response 'always'; Schwippert et al. 2008). Thus, the PLUS sample must be considered as a slightly positively selected sample.

All of the questionnaires used within the longitudinal survey were completed by the end of each school year. Whereas the individual interest levels in physics could be annually surveyed, all of the instruction-related constructs (student ratings of teaching and situational interest levels) were limited to those school years in which physics-related instruction was actually given. Since German schools at secondary level are free in deciding how to schedule the number of physics lessons prescribed by law, the timetables for physics instruction differ between schools. Within the PLUS project, seven different teaching patterns were identified.

As shown in Table 18.1, these characteristic teaching patterns are strongly interrelated with the type of school the students were attending. For example, pattern 1 contains primarily lower secondary school students, since they usually took part in physics-related science instruction on a continuous, albeit limited, basis, whereas patterns 2–6 concern mainly grammar school students.

Table 18.1 Overview of the seven resulting teaching patterns

Pattern	MT1 4th year primary	MT2 1st year secondary	MT3 2nd year secondary	MT4 3rd year secondary	*N MT*	*N* students	Predominant type of secondary school
1	X	X	X	X	4	129	Lower secondary school
2	X	o	X	X	3	58	Grammar school
3	X	X	o	X	3	66	Grammar school
4	X	X	X	o	3	25	Grammar school
5	X	X	o	o	2	20	Grammar school
6	X	o	X	o	2	151	Grammar school
7	X	o	o	X	2	20	Lower secondary school

X physics teaching took place, *o* no physics teaching, *MT* measurement time

18.5.2 Analytical Method

In order to analyse the longitudinal changes in the students' ratings of their physics-related instruction and of their physics-related interests, variance analyses with repeated measurements (repeated-measures ANOVAS) were carried out. To account for gender-specific differences, a corresponding between-subjects factor was included in the analysis. Students with missing data for individual measurement times were eliminated from the respective partial analysis by means of a listwise deletion.

An important prerequisite for carrying out variance analyses with repeated measurements relates to the homogeneity of the variances and the covariances for the different measurement times. In cases where this prerequisite was not satisfied, the Huynh-Feldt correction was used.

To determine the practical relevance of statistically significant results, we calculated the effect size η^2_p*(partial eta*^{2}*)*. By taking into account Cohen's (1988) taxonomy, $\eta^2_p \approx .01/.06/.14$ is considered as small/medium/large effect (Bühner and Ziegler 2009).

18.5.3 Data Collection Instruments

The development of the data collection instruments made it necessary to consider the specific requirements of the target group. Given that the students were in the wide age range from about 10 to 14 years, the questionnaire made relatively low demands on the students' level of reading competence and on their working memory capacity.

The basic concept of the students' questionnaire for their rating of physics-related instruction was formed by the moderate-constructivist learning theories described above. On this basis, five scales were operationalised: cognitively activating students' experiments, practical activity, daily reference, student-generated explanations and lack of clarity. With the exception of the scale for practical activity (three response items), each scale of the students' questionnaire has five response items, which they could answer by using a four-level Likert scale (from 'totally disagree' to 'totally agree').

As Table 18.2 shows, the internal consistency of the test can be described as acceptable to good on the basis of Cronbach's alpha values of 0.64–0.85 for the different measurement times. The five-factor structure of the questionnaire accepted on the basis of theory could be confirmed for all measurement times through confirmatory factor analyses ($.936 \leq \text{CFI} \leq .975$, $.031 \leq \text{RMSEA} \leq .056$, $.801 \leq \text{WRMR} \leq 1.047$).

The questionnaire for the students' interests comprises questions on both the students' individual interest levels in physics and their situational interest levels in physics-related instruction. Both constructs were thereby recognised on the basis of a four-level Likert scale with the aid of five (individual interest) and six (situational interest) items, respectively. Given that the items on the situational interest refer to the immediately preceding physics-related instruction, the students should be thinking back to their last two physics topics in class. In order to identify the

Table 18.2 Scales for establishing the student ratings of physics-related instruction

Scale *Item examples*	α 4th year primary	α 1st year secondary	α 2nd year secondary	α 3rd year secondary
Cognitively activating students' experiments	.68	.79	.80	.83
We could often observe something that did surprise us				
Practical activity	.66	.82	.83	.85
We could run many experiments by ourselves				
Daily reference	.73	.79	.79	.82
Our teacher asks us again and again to give examples of our everyday-life experiences				
Student-generated explanations	.64	.77	.81	.83
Our teacher is interested in our explanations				
Lack of clarity (negatively formulated)	.64	.69	.73	.72
Our teacher often explains with foreign words we do not understand				

Table 18.3 Scales for identifying the students' individual interest levels in physics and their situational interest levels regarding physics-related instruction

Scale*Items examples*	α 4th year primary	α 1st year secondary	α 2nd year secondary	α 3rd year secondary
Individual interest level in physics	.81	.82	.85	.86
I absolutely want to learn more about these topics				
Situational interest level in physics-related instruction	.79	.86	.86	.86
I always looked forward to the lessons				

individual interest levels in physics, the students were presented with three typical themes from physics as reference points. These themes were *sound, magnetism* and *light*, as these are taught in conformity with the current curricula in North Rhine-Westphalia at both the primary school level and the secondary school level.

As reflected in Table 18.3, Cronbach's alpha coefficients for all four measurement times indicate a satisfactory-to-high reliability of the scales employed. Confirmatory factor analyses on the basis of available cross-sectional project data support the distinction between the constructs that was assumed in the theory. In addition, evidence could be found for a strong measurement invariance of both interest scales between the final year of primary school (German grade 4) and the second year of secondary school (German grade 6). This data supports the conclusion that the measurements of the constructs in primary school and in the early phase of secondary school have been conducted equivalently and can therefore be compared to each other (Kleickmann 2011; Tröbst et al. 2015).

18.6 Results

The following sections give report on the longitudinal survey results that correspond to the research questions mentioned above. At first, the findings on the students' perception of physics-related instruction are presented. As a second step, the parallel development of the students' physics-related interest levels is reported. The third research question relates to both of the two previous ones. Therefore, the gender-specific results will be considered within the two chapters which deal with the first two research questions, respectively. However, they will only be mentioned, if significant differences between boys and girls are in evidence.

Whereas the development of the individual interest levels in physics could be continuously analysed from the final year of primary school to the third year of secondary school (students of ages 10–14), the analyses of the remaining constructs were carried out separately for the students who belonged to the teaching patterns outlined above. Subsequently, result reports are given for the four most common patterns (1, 2, 3 and 6), which exhibit a sample size of at least 30 students. Due to the strong interrelations of the teaching patterns and the different types of secondary school, solely the learners of the predominant school type of each pattern have been taken into consideration within the respective analyses. Hence, it was not possible to draw statistical comparisons onto how the students' perception of their physics instruction and the students' interests in this school subject develop within the different types of secondary school. In these cases, comparisons between grammar school students and lower secondary school students can only be carried out in an approximate and descriptive manner.

18.6.1 Findings on the Students' Perception of Physics-Related Instruction

The variance analyses for the students' perception of physics-related instruction show that the 52 students who were continuously taught physics from their final year of primary school until the third year of secondary school (pattern 1) exhibit a marked decline in four of the five characteristics tested (see Fig. 18.1).

The declines are significant without exception ($p < .001$), with medium to large effects ($.10 \leq \eta^2_p \leq .29$), and appear similarly among boys and girls. Thus, when considering the between-subjects factor of *gender*, neither significant main effects ($.181 \leq p \leq .901$) nor interactions of the factors of *time* and *gender* ($.299 \leq p \leq .825$) are in evidence. Students perceive a particularly significant decline for the category of practical activity between the final year of primary school and the first year of secondary school ($\eta^2_p = .29$). By contrast, the change in the perceived clarity of the instruction ($\eta^2_p = .10$) is less pronounced, although a negative trend was likewise evidenced. The slight fall in ratings seen for 'daily references' in Fig. 18.1 does not become statistically significant ($p = .056$). Figure 18.1 indicates that the

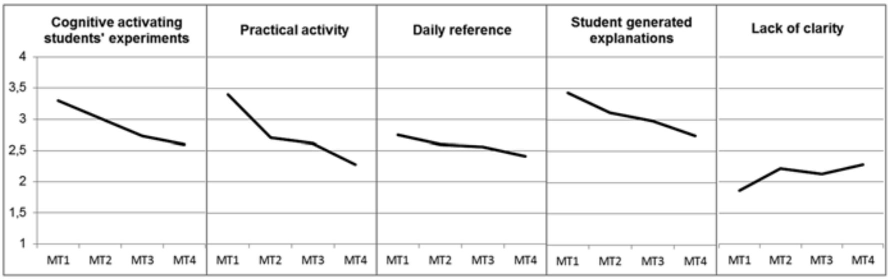

Fig. 18.1 Mean values of lower secondary school students' ratings of instruction – pattern 1 (*MT* measurement time; lack of clarity: The higher the value on this scale, the more unclear the students rate their instruction to be.)

strongest changes are observed from the final year of primary school to the first year of secondary school (i.e. grades 4 to 5) and from the second to the third year of secondary school (grades 6 to 7), respectively. Supplementary separate analyses confirm that the lower secondary school students do not manifest any significant differences in their ratings between their first and second year at secondary school ($.122 \leq p \leq .736$).

As already shown with the lower secondary school students (pattern 1), we also observe significant declines with large effects among the grammar school students (patterns 2, 3 and 6) in (almost) all scales (see Table 18.4). It is exclusively in the patterns 2 and 3 that no significant changes over the time period can be established for the scale of 'daily references', with $p = .275$ and $p = .107$. In pattern 6, similarly, there are significant changes in all scales showing a negative effect on average. Thus, learners' responses likewise show declines in their ratings over time. Throughout all patterns, the students perceive that practical activities – when compared with the other teaching characteristics – show the steepest decline over time.

When considering the between-subjects factor of *gender*, we did not observe any major effects ($.052 \leq p \leq .685$) in patterns 2 and 3. Nevertheless, there are interactions between the factors of *time* and *gender* in pattern 2 in the three scales 'cognitively activating students' experiments' (F (2, 56) = 3.157, $p = .050$, $\eta^2_p = .10$), 'student-generated explanations' (F (2, 56) = 4.016, $p = .023$; $\eta^2_p = .13$) and 'lack of clarity' (F (2, 56) = 4.331, $p = .018$, $\eta^2_p = .13$), each involving average effects. Figure 18.2 illustrates how the split between the genders for the three cases, particularly between the second and third years of secondary school (i.e. grades 6 to 7), significantly widens. During this period, girls perceive more teaching characteristics that promote understanding than boys do.

In pattern 6, we observe significant gender differences only for the scale of '*lack of clarity*' (F (1, 122) = 52.405, $p = .002$; $\eta^2_p = .08$). Accordingly, girls rate their teaching at both measurement times to be somewhat clearer than the boys do. An interaction between the two factors of *time* and *gender* is not found.

Table 18.4 Results of the variance analysis with repeated measurements for the ratings of instruction for the different patterns and subsamples

Scale	*df*	*F*	*p*	η^2_p
Pattern 2 – grammar school students, N = 30				
Cognitively activating students' experiments	2, 58	10.714	<.001	.27
Practical activity	2, 58	12.374	<.001	.30
Daily reference	2, 58	1.321	.275	.04
Student-generated explanations	2, 58	10.026	<.001	.26
Lack of clarity	2, 58	11.091	<.001	.28
Pattern 3 – grammar school students, N = 44				
Cognitively activating students' experiments	1.834, 78.876[a]	14.496	<.001	.25
Practical activity	2, 86	37.723	<.001	.47
Daily reference	2, 86	2.297	.107	.05
Student-generated explanations	1.712, 73.604[a]	8.708	<.001	.17
Lack of clarity	1.796, 77.230[a]	13.506	<.001	.24
Pattern 6 – grammar school students, N = 124				
Cognitively activating students' experiments	1, 123	31.843	<.001	.21
Practical activity	1, 123	54.802	<.001	.31
Daily reference	1, 123	11.395	<.001	.09
Student-generated explanations	1, 123	24.557	<.001	.17
Lack of clarity	1, 123	52.647	<.001	.30

[a]Adjustment for variance in accordance with Huynh-Feldt correction

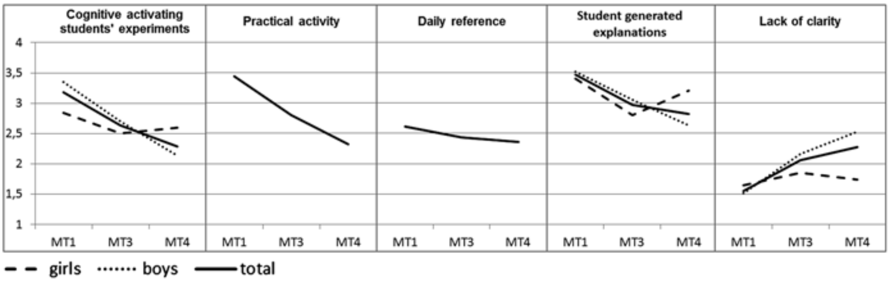

Fig. 18.2 Mean values of grammar school students' ratings of instruction – pattern 2 (*MT* measurement time)

18.6.2 Findings on the Development of Physics-Related Individual and Situational Student Interest Levels in the Transition from Primary to Secondary School

As shown in Table 18.5, the result of the variance analysis indicates that students' individual interest levels in physics undergo a significant decline between the final year of primary school and the third year of secondary school (grades 4 to 5). The

Table 18.5 Results for the two-factor variance analysis with repeated measurements and gender as between-subjects factor for the individual interest levels in physics

Source of variation	*df*	*F*	*p*	$\eta^2 p$
Individual interest levels in physics – students from all types of secondary schools, N = 327				
Measurement time (MT)	2.85, 924.69[a]	224.18	<.001	.41
Gender	1, 325	14.09	<.001	.05
MT × gender	2.85, 924.69[a]	1.451	.228	.00

[a]Adjustment for variance in accordance with Huynh-Feldt correction

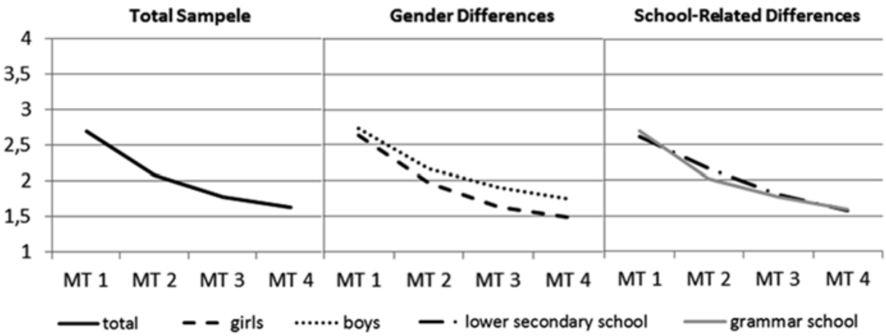

Fig. 18.3 Mean values for learners' individual interest levels in physics for the whole sample and the subgroups observed (*MT* measurement time)

effect ($\eta^2_p = .41$) observed invites the conclusion that there is a high practical relevance of the result. This finding is not only evident in the whole sample but also applies equally to students in grammar schools and in lower secondary schools. After the inclusion of the between-subjects factor for *type of secondary school* into the analysis, we see neither evidence of a significant main effect for the between-subjects factor ($p = .769$) nor an interdependency of the factors *time* and *type of secondary school* ($p = .303$). In terms of the development of their individual interest level in physics, it does not seem to matter whether the learners enter a grammar school or a lower secondary school after the primary school phase ($\eta^2_p = .00$ for the main effect and the interaction; $N = 276$). By contrast, the gender of the learners has a notable, albeit small ($\eta^2_p = .05$), effect on the manifestation of the individual interest level in physics (see Fig. 18.3). In contrast to this main effect of gender, the interaction of the factors *gender* and *time* is not significant. However, the descriptive findings (see Fig. 18.3) indicate that the gender differences in the students' final year of primary school are smaller than in the subsequent years. Supplementary variance analyses for the individual measurement times confirm this impression. They provide evidence that the gender differences in the final year of primary school cannot be ranked as significant, F (1, 325) = 1.753, $p = .186$, $\eta^2_p = .01$. Beginning from the first year of secondary school, however, the individual interest levels in physics differ significantly between the genders.

Table 18.6 Results of the variance analysis with repeated measurements (and gender as between-subjects factor) for the situational interest levels in physics-related instruction for the patterns 1, 2, 3 and 6.

Source of variation	*df*	*F*	*p*	$\eta^2 p$
Pattern 1 – lower secondary school students, N = 49				
Measurement time (MT)	2.81, 132.02[a]	17.05	<.001	.27
Gender	1, 47	3.02	<.001	.06
MT x gender	2.81, 132.02[a]	2.72	.050	.06
Pattern 2 – grammar school students, N = 30				
Measurement time (MT)	2, 58	60.57	<.001	.68
Pattern 3 – grammar school students, N = 45				
Measurement time (MT)	2, 88	58.80	< .001	.57
Pattern 6 – grammar school students, N = 124				
Measurement time (MT)	1, 123	157.60	< .001	.56

[a]Adjustment for variance in accordance with Huynh-Feldt correction

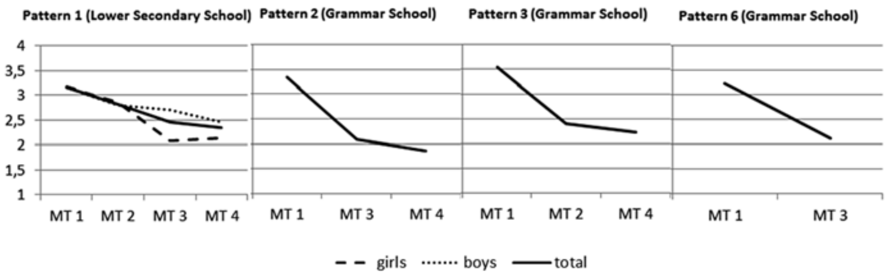

Fig. 18.4 Mean values for situational interest levels of learners in physics-related instruction for patterns 1, 2, 3 and 6 (*MT* measurement time)

A look at the situational interest levels in physics-related teaching shows evidence for a significant decline in all four patterns observed. As can be seen from Table 18.6, the declines are highly significant across all patterns. When compared with the lower secondary school students (pattern 1), an even more marked decline can be noted among the grammar school students (pattern 2, 3 and 6) for their situational interest levels between their final year of primary school and their third year of secondary school ($.56 \leq \eta^2_p \leq .68$).

Figure 18.4 further supports the conclusion that the massive slump in the situational interest levels coincides with the transition to grammar school, i.e. with the introduction of grammar school-type physics instruction. This appears to affect boys and girls to an equal extent, given that the situational interest levels do not differ significantly among the grammar school students ($.116 \leq p \leq .859$). Compared to the grammar school students, the situational interest levels of the lower secondary school students decline more slightly after the school transition. However, there are gender differences herein that can be observed after the end of the first year at secondary school. As Fig. 18.4 shows, the gap between the genders widens significantly in the second year of secondary school. In the third year, those differences in favour of the boys remain clearly visible, albeit a little diminished. This observation corresponds to the significant main and interaction effects that can be found after the inclusion of the between-subjects factor of *gender* in the analysis (see Table 18.6).

18.7 Discussion and Outlook

When combined, the findings from the longitudinal study presented herein indicate that the transition from primary school to secondary school in North Rhine-Westphalia involves a negative development in students' ratings of physics-related instruction. At the same time, there is a marked and simultaneous drop in both the learners' physics-related individual and situational interest levels. Since the PLUS sample can be described as slightly positively selected in terms of cultural capital, the downward trends may be even more pronounced in the overall student population.

Whereas the uniform decline of the students' individual interest levels could also be explained by a development-related differentiation of this long-term interest, the sharp decline of the situational interest levels after the transition to secondary school, which is particularly pronounced for grammar schools, points to a specific influence of the school learning environment. The analyses show that learners perceive a clear decline in cognitively activating students' experiments, in practical activities, in student-generated explanations as well as in the clarity of the instruction in their physics-related teaching. Against this background, the downward trend in situational interest could be connected with these pedagogical changes. Initial findings from further cross-sectionally applied investigations within the PLUS project (Tröbst et al. 2015) support this assumption. Beyond that, qualitative data from supplementary interviews with 18 children of the quantitative PLUS sample indicate that particularly the perceived difficulty of physics instruction as well as practical activities seem to play a key role for the students' interest in school science (Walper et al. 2014). Recent findings from the ASPIRES project seem to confirm these results. The study revealed that British secondary school students whose attitudes towards school science remained positive did not find science more difficult in secondary than in primary school. Moreover, the authors reported that most of the students with increasingly positive attitudes towards school science experienced either more exciting experiments or an increased number of practicals within secondary education (DeWitt et al. 2014). To further underpin these results and to identify in more detail how the changes in the learning environment influence the students' interest development, further analyses shall be carried out with the longitudinal data of the PLUS project.

When the ratings of instruction and the physics-related interest levels are compared between girls and boys, a notable finding in the data pattern emerges. Whereas lower secondary school students seem to rate their instruction almost identically, the situational interest level of the girls in their second and third years of secondary school is distinctly lower than that of the boys. At grammar schools, an opposite pattern can be observed: Here, the girls give increasingly more positive ratings than the boys for their physics instruction throughout the entire time period on the basis of the teaching characteristics identified, but the situational interest levels of the genders do not appear to differ from each other. It is possible that these seemingly paradoxical effects can be explained by the higher individual interest level of the boys. It would thus be possible that a more strongly defined prior interest in physics compensates possible weak points of the instruction, whereas the form and style of the teaching could be more significant for the girls who, on average, approach the subject with a lower initial interest level. This assumption is supported by the findings of further studies which have indicated that girls react in a more sensitive way than boys to an increase in the quality of the physics teaching (e.g. Wilhelm et al. 2012).

The presented analyses on the average development processes cannot explain the extent to which the teaching characteristics analysed herein influence the development of the students' level of interest at the individual level. More advanced analyses are planned within the PLUS project in order to pursue the question over the connection of both constructs during the transition phase from primary to secondary school at the individual level. In the course of this, the broad sample available should be better exploited with the aid of the process of multiple imputation of missing values. Furthermore, the underlying multiple-layered structure of the data (such as the nesting of the students within different classes) will be taken into consideration, which was not the case in the analyses of variance presented here.

Despite the occasionally small subsamples involved, the findings presented here underline the subject-specific significance of the transition from primary school to secondary school. Against this background, we can hope that this system-related interface will enjoy a stronger focus of attention in primary and secondary science education in the near future. Both science education researchers and (future) teaching staff should be open to issues associated with physics-related instruction at the respective adjoining school level in order to combat the obstacles more effectively than they have been able to in the past. The theme should also receive additional consideration in the education and training of teaching personnel.

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