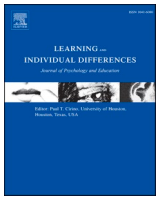
Learning and Individual Differences 112 (2024) 102456

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif



Elementary school students' metacognitive knowledge and its effects on teacher judgments, school track recommendations, and school transitions

Sog Yee Mok [a,*], Kathrin Lockl [b], Markus P. Neuenschwander [c]

[a] University of Teacher Education of the Grisons, Switzerland
[b] Leibniz Institute for Educational Trajectories, Germany
[c] University of Applied Sciences and Arts Northwestern Switzerland, Switzerland

ARTICLE INFO

Keywords:
Metacognitive knowledge
Teacher judgments
School track recommendations
School transitions

ABSTRACT

Teacher judgments of student achievement influence students' school transitions. Teachers not only evaluate student achievements but also other competencies, such as metacognitive knowledge. Therefore, students' metacognitive knowledge could affect teachers' school track recommendations. The aim of this study ($N = 5870$ elementary school students from the German National Educational Panel Study) was to explore the extent to which students' metacognitive knowledge influences teacher judgments, teacher school track recommendations, and students' transition to gymnasium. We employed a multilevel path model to test the effects of metacognitive knowledge on teacher judgments, school track recommendations, and students' transition to gymnasium. Moreover, we found that metacognitive knowledge has a significant indirect effect on school track recommendations and students' transition to gymnasium via teacher achievement judgments. The implications of these results for teacher education are discussed.

Educational relevance statement

Secondary school track assignments based on teacher recommendations have been shown to contribute to inequalities in students' school careers, which can affect their employment prospects. Thus, it is important to investigate the direct and indirect factors that influence students' school careers. Students' metacognitive knowledge can manifest in metacognitive knowledge about learning strategies that rely on this metacognitive knowledge and that affect teacher judgments of student achievement. In turn, these judgments impact teacher recommendations for school tracks and students' actual school transitions. By exploring data from the German National Educational Panel Study, we found that elementary school students' metacognitive knowledge directly influences teacher judgments and indirectly influences teacher school track recommendations and students' transition to a higher secondary school track (i.e.,"Gymnasium") via teacher achievement judgments.

1. Introduction

Teacher evaluations of student achievement affect students' educational trajectories (Neuenschwander & Malti, 2009). Such evaluations are especially important with regard to teacher recommendations for secondary schools and students' actual school transitions (Maaz & Nagy, 2010). The few studies on this topic have shown that teachers' recommendations for elementary school students which secondary school type they should pursue are based on their judgments of various student competencies, which go beyond the official criteria of student achievement in mathematics and reading literacy (e.g., Boone & Van Houtte, 2013). These include aptitudes that are less visible at first glance, such as metacognitive knowledge. Metacognitive knowledge (i.e., knowledge of learning strategies and the conditions under which they can be appropriately used) has been shown to be very important for students' school success (Schneider et al., 2022).

The present study explores the extent to which students' metacognitive knowledge influences teacher judgments, teacher school track recommendations, and students' transition to a higher secondary school track. This addresses a research gap since, to our knowledge, no studies have examined the potential impact of students' metacognitive knowledge on these aspects, which are important for their long-term school careers. The lack of research in this area is surprising, given that teacher recommendations are known to strongly affect whether students attend secondary school in the highest academic track (known as "Gymnasium" in German-speaking countries) or in the middle or lower academic

* Corresponding author at: University of Teacher Education of the Grisons, Scalärastrasse 17, 7000 Chur, Switzerland.
E-mail address: sogyee.mok@phgr.ch (S.Y. Mok).

https://doi.org/10.1016/j.lindif.2024.102456
Received 9 June 2023; Received in revised form 13 February 2024; Accepted 18 April 2024

tracks (known as "Realschule" and "Hauptschule," respectively; Maaz & Nagy, 2010). This allocation to different school tracks at the secondary level has been shown to contribute to inequalities in educational outcomes (Maaz et al., 2008). The current study focuses on the effects of teacher judgments in the German school system, which has a clear tracking system. In a transition situation, these judgments become influential for students' long-term school careers. Moreover, even if school systems in other countries are less rigid and more permeable, such effects may also occur in these countries, albeit in a somewhat weaker form. Thus, it is important to understand the role that elementary school students' metacognitive knowledge might play in teacher judgments of student achievement, school track recommendations, and students' transition to gymnasium. In the following sections, we provide an overview of studies on teacher judgments and school recommendations, which affect students' school transitions, and explain how students' metacognitive knowledge may influence these judgments.

1.1. Teacher judgments

Teachers judge student competencies in school. According to Weinert (2001), competencies not only include knowledge but also learning strategies in a broader sense. Thus, student competencies include metacognitive knowledge about the use of learning strategies. Teachers' judgments of student achievement in a subject refer to student competencies, including content knowledge in the subject (Wyatt-Smith et al., 2024) and various learning aspects, such as strategy use (Carr & Kurtz, 1991). Thus, teacher judgments about student competencies are not only influenced by student achievement (e.g., content knowledge) but also students' metacognitive knowledge.

1.1.1. Teacher judgments of metacognitive knowledge

Many studies have investigated teacher judgments of student achievement (for a meta-analysis, see Südkamp et al., 2012), and some have explored teacher judgments of student characteristics, such as student aptitudes (Brandmiller et al., 2020; Kriegbaum et al., 2019) and students' socioeconomic status, gender, and immigrant background (Brandmiller et al., 2020). Students' characteristics and classroom behaviors are visible to teachers and have been shown to affect teacher judgments (Batruch et al., 2023). By contrast, few studies have focused on teacher judgments of their perceived metacognitive knowledge of students (Carr & Kurtz, 1991; Carr & Kurtz-Costes, 1994; for a review, see Urhahne & Wijnia, 2021). Evaluating student competencies that are not directly visible, such as metacognitive knowledge, can be challenging for teachers (Kriegbaum et al., 2019; Stang & Urhahne, 2016).

According to its broad conceptualization, metacognition is defined as "any knowledge or cognitive activity that takes as its cognitive object, or that regulates, any aspect of any cognitive activity" (Flavell et al., 1993, p. 150). Although various models of metacognition have been proposed with different emphases, one of the most important components of metacognition is metacognitive knowledge (see Brown, 1987;Flavell, 1979; Schraw & Moshman, 1995). Metacognitive knowledge refers to explicit knowledge about oneself as a learner and factors such as task and strategy-related characteristics that affect one's performance (Flavell, 1979; Schraw & Moshman, 1995). It can be assumed that metacognitive knowledge, especially knowledge about strategies, constitutes a prerequisite for the selection of adequate strategies. Empirical support for this view comes from cross-sectional studies that show that metacognitive knowledge is related to strategy use and memory performance (Schneider et al., 1998; Schneider & Pressley, 1997). Moreover, longitudinal studies have demonstrated that general metacognitive knowledge and metacognitive knowledge about strategies are predictive of subsequent strategy use in elementary school children (Grammer et al., 2011; Schlagmüller & Schneider, 2002), which supports the assumption that children would not make use of learning strategies until they have adequate levels of metacognitive knowledge (Schneider et al., 2022). In addition, teachers' perception of students' academic ability is positively correlated with students' metacognitive knowledge about the use of strategies (Carr & Kurtz, 1991). Thus, teachers appear to have a holistic perspective on student achievement: students with higher achievement are perceived as learners with higher metacognitive knowledge (Carr & Kurtz, 1991).

Based on these findings, it can be assumed that students' metacognitive knowledge could become visible to teachers and be relevant for teacher judgments, as children with more sophisticated metacognitive knowledge might approach learning tasks differently by using more elaborate learning strategies in a classroom context. Moreover, they might also reflect more on their own learning activities and show more metacognitive knowledge, such as defining tasks, planning, monitoring, and evaluating. Teachers judge how students approach learning tasks by observing their performance (Efklides, 2006; Salonen et al., 2005).

Taken together, these metacognitive knowledge-related learning strategies inform teachers about how students learn. Moreover, teachers might incorporate these strategies into their judgments about student achievement since they must evaluate not only the latter but also student competencies.

1.1.2. Metacognitive knowledge and domain-specific teacher judgments

Because teachers evaluate a range of domain-specific competencies, engagement, and other characteristics before assigning a school grade to students (Brookhart et al., 2016; Carr & Kurtz, 1991), we assumed that students' metacognitive knowledge also affects teacher judgments of domain-specific competencies. Some studies that have explored students' metacognitive knowledge and teacher judgments are situated within the context of mathematics (e.g., Carr & Kurtz, 1991; Carr & Kurtz-Costes, 1994; Desoete, 2008). For example, Carr and Kurtz-Costes (1994) showed that third-grade elementary students' achievement and metacognitive knowledge predicted teachers' perceptions of their general ability, metacognitive knowledge, self-concept, effort attributions for success, and ability attributions for success. However, few studies have explored students' metacognitive knowledge and teacher judgments of reading literacy, which can be measured through reading and writing tasks (Carr & Kurtz, 1991; van Kraayenoord & Schneider, 1999). For instance, Carr and Kurtz (1991) found a high positive correlation between the students' ability and students' metacognitive knowledge which are both perceived by teachers ($r = 0.82$, $p < .01$). Moreover, a study by van Kraayenoord and Schneider (1999) showed that teacher judgments of third-grade elementary school students' reading achievement were positively associated with students' metacognitive knowledge. Taken together, these studies provide some indication that students' metacognitive knowledge might play a role in the formation of teacher judgments of mathematics and reading.

1.1.3. Judgment of metacognitive knowledge, school track recommendations, and school transition

In many European countries, the transition from primary to secondary education involves the allocation of students to specific school tracks based on teacher judgments of their achievement (Maaz et al., 2008; van Leest et al., 2021). In Germany, teachers generate track recommendations based not only on students' potential for academic success but also their grades, in line with state regulations (Maaz et al., 2008). Teachers usually evaluate student achievement, which forms the basis for their grades (Kriegbaum et al., 2019). In addition to achievement, teachers take other variables into account when providing school track recommendations (Batruch et al., 2023; Sneyers et al., 2018). Students' metacognitive knowledge-related learning strategies (e.g., planning how to solve a task or using an appropriate strategy for a task; Rüede et al., 2023) is one variable that affects teacher judgments of student achievement (Boone & Van Houtte, 2013; Grammer et al., 2011). For instance, Boone and Van Houtte (2013) found that teachers' track recommendations included a consideration of students' planning capacity, as well as their independence, punctuality, and responsibility

(Boone & Van Houtte, 2013). Other studies have also identified associations between school track recommendations and school-appropriate behaviors, such as independence and the ability to plan (Sneyers et al., 2018; Neuenschwander & Malti, 2009). A recent study that explored data from the German National Educational Panel Study found that students' consciousness, which was defined as their ability to be goal-directed, plan, and follow norms and rules, plays a significant role in educational transitions (Gil-Hernández, 2021).

The impact of teacher judgments of student achievement on school track recommendations and school transitions may be explained by the halo effect. The halo effect occurs, for example, when one of a student's positive qualities (e.g., high student engagement in the classroom, such as strategically solving a mathematical problem) positively influences teacher judgments of their achievement (Kaiser et al., 2013; Urhahne & Wijnia, 2021). Drawing on these previous findings, we assumed that student metacognitive knowledge likely has a halo effect on teacher judgments of student achievement. More specifically, we assumed that a high level of student metacognitive knowledge can lead to positive teacher judgments of student achievement. Students' metacognitive knowledge may become visible to teachers through their use of learning strategies (e.g., planning or strategy use; Boone & Van Houtte, 2013; Rüede et al., 2023) related to metacognitive knowledge.

In summary, studies have found that metacognitive knowledge-related learning strategies are positively associated with school track recommendations and school transitions. Based on previous findings (Flavell et al., 1993; Grammer et al., 2011; Veenman et al., 2006), we assumed that students' metacognitive knowledge can be considered a prerequisite for metacognitive knowledge-related learning strategies (e.g., planning and strategy use), which in turn affects teachers' school track recommendations.

1.2. Teacher judgments as a mediator in the relation between students' metacognitive knowledge, school track recommendations, and the transition to gymnasium

As mentioned earlier, teacher judgments of student achievement make reference to different student variables (Urhahne & Wijnia, 2021) and competencies (Weinert, 2001). These judgments affect students' school track recommendations and transition to a secondary school track (Maaz & Nagy, 2010; Pietsch & Stubbe, 2007). School track recommendations and decisions should be based on students' academic achievement, as research has shown that student achievement is the best predictor of school track decisions (Ditton et al., 2005; Glock et al., 2013). However, teachers have a holistic view of student achievement and consider different student characteristics (Carr & Kurtz, 1991; Urhahne & Wijnia, 2021), which supports the halo effect assumption. This influences teacher judgments of student achievement (Urhahne & Wijnia, 2021) and their school recommendations (Batruch et al., 2023). More specifically, teacher judgments of student achievement and different student characteristics or learning strategies in the classroom are integrated into their school recommendations for students (Batruch et al., 2023; Glock et al., 2013). Moreover, studies have found that teacher judgments of student achievement influence school track recommendations, which in turn affect students' transition to a secondary school type after elementary school (Ditton & Krüsken, 2006; Maaz & Nagy, 2010). However, the effect of students' planning as a metacognitive knowledge related construct on school track recommendations has been investigated in only a few studies (Boone & Van Houtte, 2013; Sneyers et al., 2018), and the role of metacognitive knowledge for school track recommendations has not been explored. Moreover, teachers' school track recommendations often shape students' actual school track choices (Rottermann et al., 2015). Thus, we assumed that teachers' recommendations determine students' transition to a particular secondary school track. Since teacher judgments of their academic abilities are associated with student metacognitive knowledge (Carr & Kurtz, 1991), and teacher judgments of student achievement are related to their school track recommendations (Ditton & Krüsken, 2006), we expected to find positive effects of student metacognitive knowledge on both teacher judgments of student achievement and school track recommendations. We also expected that teacher achievement judgments mediate the effect of students' metacognitive knowledge on teachers' school track recommendations and students' school transition. To our knowledge, the effect of students' metacognitive knowledge on teacher judgments of student achievement, school track recommendations, and their actual transition to secondary school have not been investigated. Thus, the present study aims to address this research gap.

1.3. Domain-specific competencies, socio-economic status, gender, and cognitive abilities as important control variables

Previous domain-specific competencies and grades are crucial predictors of teachers' school track recommendations and students' transition to a secondary school track (Maaz & Nagy, 2010). Consequently, most large-scale studies that explore school track recommendations or school transition effect controlled for students' mathematical and reading competencies or grades (Ditton & Krüsken, 2006; Dumont et al., 2019). In addition to domain-specific competencies, other factors may also influence school track recommendations and school transitions. One such factor is socio-economic status (SES). A large body of studies has shown that teacher judgments are directly affected by students' SES (Batruch et al., 2023; Boudon, 1974).

Students' gender can also influence teacher judgments in mathematics and reading literacy. For instance, research has found that teachers tend to underestimate female students' mathematics performance compared to male students who perform and behave similarly. In turn, this underestimation of female students affects the mathematics grade assigned by teachers (Robinson-Cimpian et al., 2014). The converse is true with regard to reading literacy, as teachers demonstrate lower expectations of boys than girls. Some studies have shown the indirect impact of gender on school track recommendations (via teacher judgments; Timmermans et al., 2018) and students' transition to lower secondary school tracks (Neuenschwander et al., 2012). Finally, teacher judgments of student achievement in mathematics and literacy are also affected by students' cognitive abilities. Studies have confirmed that students' cognitive abilities affect teacher judgments (Baudson et al., 2016; Gnas et al., 2022; Sneyers et al., 2018) and influence their transition to lower secondary school tracks (Brandt et al., 2020).

1.4. Present study

The present study has two aims. First, we investigated the effect of students' metacognitive knowledge on teacher judgments and school track recommendations. Second, we investigated the mediating effects of teacher judgments of student achievement on the relation between metacognitive knowledge and teachers' school track recommendations and students' transition to gymnasium. The study is based on data from the German National Educational Panel Study, which includes a representative sample of German elementary school children. In Germany, students attend a comprehensive primary school from age 6, usually for four years (except in Brandenburg and Berlin, where common primary school lasts until Grade 6). They are then assigned to one of three tracks at the lower secondary level. Tracks and school types in secondary education are hierarchical in terms of learning requirements, curricula, level of difficulty, track duration, and attainable qualifications upon leaving school. Regular secondary schools lead to either the lower secondary school leaving certificate ("Hauptschulabschluss"), the intermediate secondary school leaving certificate ("Realschulabschluss"), or the upper secondary school leaving certificate ("Abitur"). The upper secondary school track (i.e., gymnasium) opens the way to tertiary education. However, since the structure of the educational system is very heterogeneous at the secondary level in Germany and the availability of school types and attendance rates differ among federal states

(Henninges et al., 2019), the comparability of school types, especially regarding the lower and intermediate tracks, is limited. Upper secondary school (i.e., gymnasium, which is the highest track) is the only school type that is available in all federal states. Therefore, a distinction is made between upper secondary school (gymnasium) and other school types. To obtain more conclusive findings, we controlled for SES, gender, student achievement in mathematics and reading, and students' cognitive abilities. Accordingly, we focused on the following research questions:

Research Question 1a: To what extent does students' metacognitive knowledge affect teacher judgments of mathematical and written language skills?
Research Question 1b: To what extent does students' metacognitive knowledge affect teachers' school track recommendations?
Research Question 2a: To what extent does students' metacognitive knowledge indirectly affect teachers' school track recommendations via teacher judgments of mathematical and written language skills?
Research Question 2b: To what extent does students' metacognitive knowledge indirectly affect their transition to gymnasium via teacher judgments of mathematical and written language skills and school track recommendations?

With regard to the research questions 1a and 1b, we formulated two hypotheses. First, we hypothesized that students' metacognitive knowledge affects teacher judgments of mathematical and written language skills, after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender (*Hypothesis 1a*). Second, we hypothesized that students' metacognitive knowledge affects school track recommendations (*Hypothesis 1b*). With regard to research questions 2a and 2b, we also formulated two hypotheses. First, we hypothesized that teacher judgments of mathematical and written language skills mediate the effect of students' metacognitive knowledge on teachers' school track recommendations, after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender (*Hypothesis 2a*). Second, we hypothesized that both teacher judgments and school track recommendations mediate the effect of students' metacognitive knowledge on their transition to gymnasium, after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender (*Hypothesis 2b*).

2. Method

2.1. Sample

To test the hypotheses, we used data from the German National Educational Panel Study (NEPS[1]; NEPS Network, 2021; Blossfeld & Roßbach, 2019), which follows multiple cohorts of children, adolescents, and adults across their life course. This study focuses on the representatively drawn kindergarten cohort of the NEPS (for more information on sampling strategy, see Steinhauer et al., 2016). The analytical sample for this study consists of children from Starting Cohort 2 who participated in competence testing in second grade, which is the first measurement point included in this study. Since our main interest is students' transition to tracked secondary school, which mostly takes place after fourth grade in Germany, we excluded children from two federal states in Germany (Berlin and Brandenburg) where students' transition to secondary school only occurs after sixth grade. Furthermore, we excluded children who did not attend fourth grade (e.g., due to repeating or skipping a grade) at the time when the majority of the sample was tested in Grade 4. This resulted in a sample size of $N = 5870$ children (51.4 % of whom were girls) who attended 890 different primary school classes. The mean age of the children at the measurement point in Grade 4 was 9 years and 9 months ($SD = 4.6$ months), and around 32 % of them had a migration background. Families' highest international socio-economic status (HISEI; see Ganzeboom et al., 1992; Ganzeboom, 2010) was 58.42 ($SD = 19.05$) on average. According to Nold (2010), the mean HISEI of students in Germany in 2008 was 47.6. Thus, this indicates that a comparatively higher proportion of highly educated parents participated in our study. Furthermore, $N = 554$ teachers participated in the study.

2.2. Measures

The NEPS includes large, representatively drawn samples and aims to perform longitudinal measurements of various areas of competence that are considered to be important for educational trajectories. Due to the large number of constructs measured, it was not possible to survey every construct on an annual basis. Therefore, not all variables of interest were assessed at the same measurement point. Our analyses drew on four measurement points for Starting Cohort 2. The cognitive competence measures were assessed in Grades 2, 3, and 4. The assessments took place in schools during the first half of each academic year between November and January. To obtain information on teacher judgments and teachers' school recommendations, we used data from a questionnaire completed by teachers when the children were in Grade 4 (i.e., a few months before they provided official school transition recommendations for secondary school). On average, teachers provided judgments for six students ($M = 6$, $SD = 3.6$, min = 1, max = 19). Finally, we drew on data from telephone interviews with parents to obtain information on family background variables and actual school transitions once children attended Grade 5. More information about the procedures and test and survey instruments used in Starting Cohort 2 is available online (https://www.neps-data.de/sc2).

2.2.1. Cognitive competence measures

The competence tests were administered in small groups by trained test administrators at the respective schools. All test administrators underwent extensive training, which was designed in cooperation with the relevant NEPS units and conducted by employees of the survey institute. Students' cognitive abilities were measured in Grade 2, their metacognitive knowledge was measured in Grade 3, and their reading and mathematical competencies were measured in Grade 4. All cognitive competence measures were assessed using paper-based achievement tests that were specifically designed for administration in the NEPS. Furthermore, except for the test of cognitive abilities, a comparable scaling procedure was adopted for all tests (see Pohl & Carstensen, 2012), which provided unidimensional proficiency scores.

2.2.1.1. Cognitive abilities. The test of cognitive abilities (reasoning) was administered in Grade 2 and included 12 matrix items. Each item consisted of several horizontally and vertically arranged fields, in which different geometrical elements were shown; only one field remained free. Students were required to identify the figural element that logically completed the stimulus set (Lang et al., 2014). The matrix items were presented in two sets of six items each, with a testing time of 3 min. The

[1] The NEPS study is conducted under the supervision of the German Federal Commissioner for Data Protection and Freedom of Information (BfDI) and in coordination with the German Standing Conference of the Ministers of Education and Cultural Affairs (KMK) and the Educational Ministries of the respective Federal States. All data collection procedures, instruments, and documents were checked by the data protection unit of the Leibniz Institute for Educational Trajectories (LIfBi). The necessary steps are taken to protect participants' confidentiality according to national and international regulations of data security. Participation in the NEPS study is voluntary and based on the informed consent of participants. This consent to participate in the NEPS study can be revoked at any time. All analyses were conducted using data from starting cohort 2 of the National Educational Panel Study (NEPS; https://doi.org/10.5157/NEPS:SC2:10.0.0). All participants of this study or their parents gave informed consent to participate in the study.

items were scored dichotomously, with 0 indicating an incorrect response and 1 indicating a correct response. In the analyses, the sum score (with a maximum score of 12 points) was used. The reliability of the test was good (Cronbach's $\alpha = 0.74$).

2.2.1.2. Metacognitive knowledge. In Grade 3, students' metacognitive knowledge was measured through a scenario-based competence test that primarily focused on different aspects of strategy knowledge, which can be seen as a prerequisite for actual strategy use (Schneider et al., 2022). The test was based on the general rationale of tests used with secondary school children (e.g., the metacognitive strategy knowledge test concerning reading strategies implemented in several languages within the OECD states participating in the Programme for International Student Assessment; Artelt et al., 2009). These tests provide clear standards against which students' responses can be evaluated and have been shown to be reliable and economical in use (Artelt & Schneider, 2015). The test used in the present study was used to assess metacognitive knowledge in a broad and domain-general way and consisted of 10 scenarios that referred to conditional metacognitive knowledge (i.e., knowledge about the appropriateness of different strategies in diverse situations). The test was used to assess knowledge about solving cognitive tasks, such as remembering or organizing information, or knowledge about metacognitive strategies, such as planning and regulating (see Fig. 1 for an example of a scenario). Six of the scenarios were related to a school or learning context, while the remaining scenarios were embedded in out-of-school contexts. For each scenario, three strategies of differing quality were presented, and children had to rate the usefulness of each strategy on a three-point Likert scale (for more information about the test, see Lockl, 2017; Lockl et al., 2018). The testing time was 15 min. To score the test, pair comparisons (Option X is more or less useful than Option Y) were made with reference to experts' judgments of the relative usefulness of the presented strategies. These pair comparisons were scored as dichotomous variables, with 1 indicating a correct response (judgment of a strategy pair that aligned with the experts' ratings) and 0 indicating an incorrect response (judgment of a strategy pair that was contrary to the experts' ratings or the two strategies in a pair were considered equal). On average, children correctly solved slightly more than half of the 20 valid pair comparisons ($M = 11.7$, $SD = 3.5$). Scores for each child were calculated as weighted maximum likelihood estimates (Warm, 1989). The reliability was close to the threshold that can be considered acceptable (Expected-A-Posteriori (EAP) / Plausible Values (PV) reliability = 0.67; Nunnally & Bernstein, 1994).

2.2.1.3. Reading competence. The reading competence test was administered in Grade 4 and lasted 28 min. The test included five texts that referred to different everyday situations and 31 multiple-choice items that referred to these texts. Gehrer et al. (2013) provided further details on the theoretical framework that guided the construction of the test, while Rohm et al. (2017) summarized its psychometric properties. Responses were scaled using a one-parametric item response model (Rasch, 1960), which resulted in good reliability (EAP/PV reliability = 0.82). Reading proficiency for each respondent was estimated as a weighted maximum likelihood estimate (Warm, 1989).

2.2.1.4. Mathematical competence. As for reading, the mathematics test was administered in Grade 4. Again, the mean test duration was 28 min. The mathematics test included 24 items that represented different content areas (e.g., quantity, change and relationship, space and shape, and data and chance) and cognitive components (for more information on the theoretical framework, see Neumann et al., 2013). The items required either multiple-choice or short-constructed responses. Mathematical competencies were modeled using item response theory (Pohl & Carstensen, 2012), and the test demonstrated good item fit and reliability (EAP/PV reliability = 0.75; Schnittjer et al., 2020).

2.2.2. Teacher judgments and school recommendations

The survey items were integrated into a paper-based teacher questionnaire that classroom teachers were asked to complete when the children were in Grade 4.

2.2.2.1. Teacher judgments. Teachers were asked to assess the child's written language skills (reading and writing) and mathematical skills (e.g., handling numbers and quantities). In the process, they were instructed to provide their assessment of each child in comparison to other children of the same age. Teacher judgments of students' written language skills and mathematics were assessed on a five-point Likert scale that ranged from 1 (much worse) to 5 (much better). In the analyses, each item was treated as a distinct variable.

2.2.2.2. Teacher school recommendations. Teachers were asked to answer the following question: "From today's perspective, what school type would you recommend for this child?" They could select the following school types: schools with a basic academic track (*Hauptschule*), schools with an intermediate academic track (*Realschule*), schools with a high academic track (gymnasium), schools with several courses of education (e.g., comprehensive school), and schools for students with special needs. For the reasons described in chapter 1.4, we differentiated between upper secondary school (gymnasium) and other school types. Thus, teachers' school recommendations were scored as a dichotomous variable, with 1 for upper secondary school (gymnasium) and 0 for all other school types.

2.2.3. Additional variables

2.2.3.1. Actual school transition. Information on actual school transitions was obtained by asking parents about the type of school that their children attended in Grade 5. Again, answers were coded as a dichotomous variable, with 1 for upper secondary school (gymnasium) and 0 for all other school types.

2.2.3.2. SES. Children's SES was indicated by their parents' occupations as reflected in the International Socio-economic Index of Occupational Status (ISEI-08; Ganzeboom, 2010). In case a score of the ISEI-08 was available for both parents, the highest ISEI-08 value (HISEI) was selected. The HISEI has a theoretical range of 12 to 99, with larger values indicating a higher status.

2.3. Analyses

To investigate our research questions, we applied a path analysis. During the analysis, cognitive competencies (metacognitive knowledge, reading, mathematics, and cognitive abilities) and background variables were treated as predictive (exogenous) variables. Teacher judgments, teacher school recommendations, and actual school transitions were treated as mediating or outcome (endogenous) variables (see Fig. 2). Furthermore, a continuous outcome variable and dichotomous outcome variables were included in the analysis. Thus, the path analysis combined linear and probit regression. To account for the fact that teachers made judgments and recommendations for all children in their respective classes, a multilevel analysis was performed, in which the teacher (or class) level was entered at Level 2 and the individual student level was entered as Level 1.

The path analysis was conducted using MPlus Version 7.4 (Muthén & Muthén, 2015). To address missing data, we applied the full information maximum likelihood (FIML) approach (e.g., Arbuckle, 1996) in MPlus. The FIML approach uses valid information from all observations for model estimation. It has been shown to be superior to other missing data strategies (e.g., listwise deletion or mean replacement) and provide more accurate estimates of regression coefficients and variance accounted (Enders, 2001). To support the FIML approach and offer a

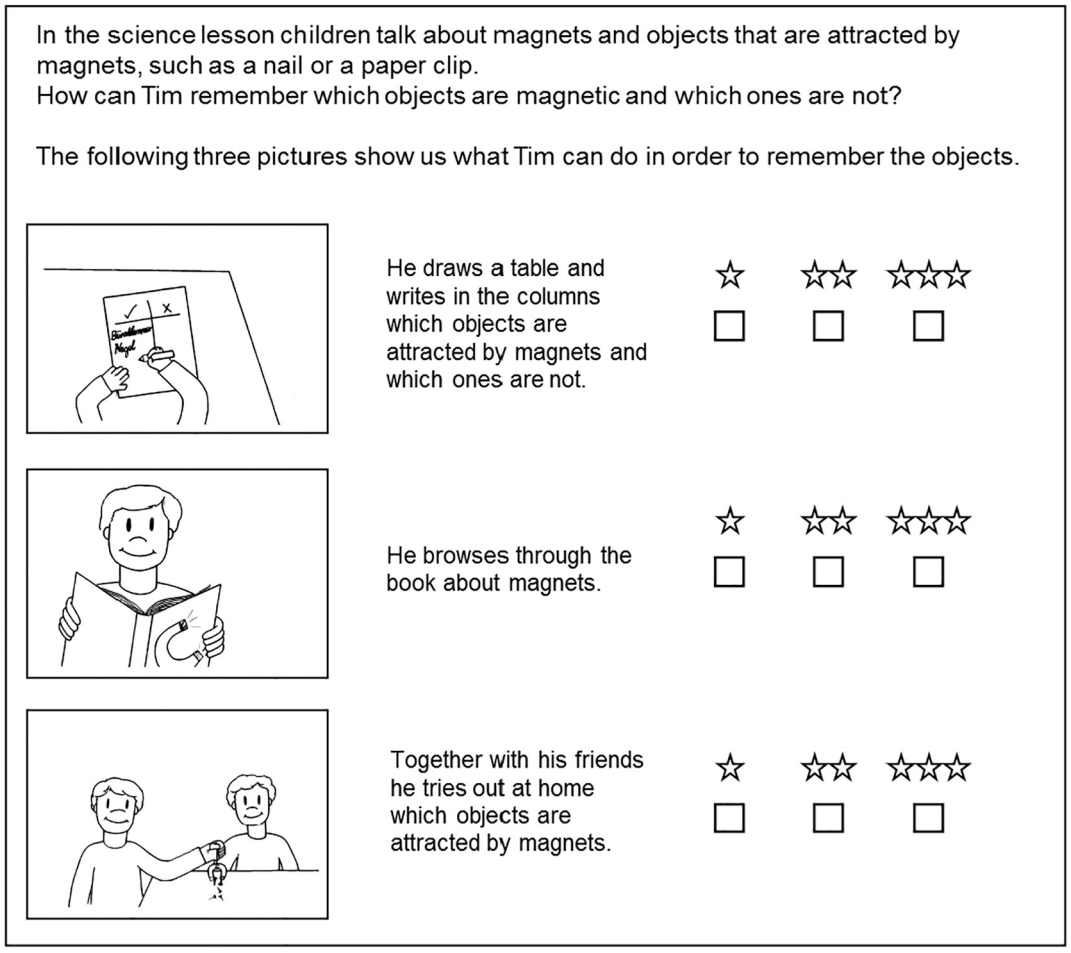


Fig. 1. Example of a Scenario in the Metacognitive Knowledge Test.

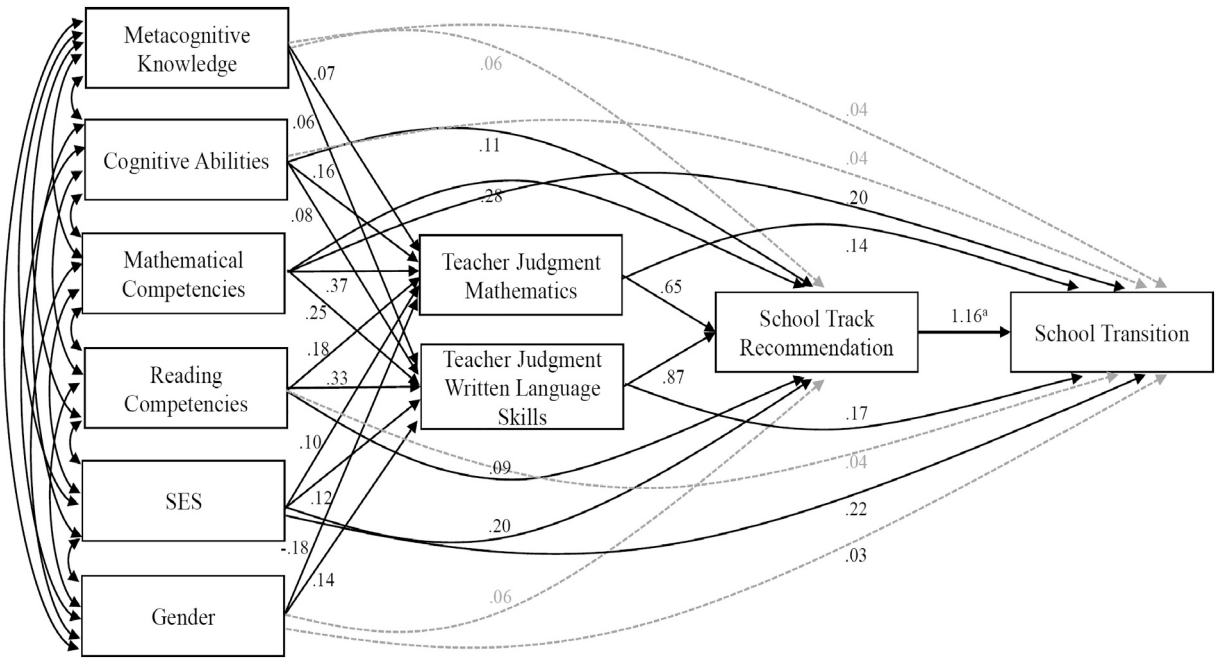


Fig. 2. Results of the Path Model Predicting Teacher Judgments, Teachers' School Track Recommendation and School Transition.
Note: For reasons of clarity the intercorrelations between the predictor variables are not displayed in the figure. Non-significant paths ($p > .05$) are shown in dashed grey lines. [a] This effect is not standardized (due to the categorical independent variable). Socio-economic status (SES) was measured by HISEI.

broader data basis for dealing with missing data, we included children's reading and mathematical competencies and teacher judgments of mathematics and written language skills (all of which were assessed in Grade 2) and migration background as auxiliary variables. These auxiliary variables were selected based on the results of an attrition analysis (see supplement in Appendix A). As described in detail in Appendix A, the attrition analyses showed only minor sample selection bias across the different measurement points due to nonresponse. Nevertheless, as argued by Graham (2009), including auxiliary variables in the missing data model is a useful way of reducing estimation bias due to attrition and missingness not at random. Finally, all continuous variables were *z*-standardized before being entered into the analysis. Thus, the respective effects can be interpreted as standardized regression weights.[2]

3. Results

In the following sections, we first report descriptive statistics for the variables included in the analysis and present intercorrelations between them. Then, we present the main results of the path analysis (see Fig. 2).

3.1. Descriptive statistics

Table 1 provides a summary of descriptive statistics for the children's cognitive competencies, teacher judgments, teacher school recommendations, and students' transition to gymnasium. With regard to cognitive abilities, on average, children solved around half of the 12 items correctly ($M = 6.83$, $SD = 2.59$). Metacognitive knowledge, mathematical competencies, and reading competencies were estimated as weighted maximum likelihood estimates (WLEs, Pohl & Carstensen, 2012). As a result of the scaling, mean scores for metacognitive knowledge and mathematical competencies were approximately zero, whereas the mean score for reading competencies was negative ($M = -0.55$, $SD = 1.28$). This is because these WLEs were linked to the scale of the same reading competencies test administered in Grade 5 of Starting Cohort 3 of the NEPS (Rohm et al., 2017). Regarding metacognitive knowledge, there were no significant differences between boys ($M = 0.03$, $SD = 0.93$) and girls ($M = 0.01$, $SD = 0.87$), $t(5{,}108) = 0.68$, $p = .50$. Teacher judgments were $M = 3.45$ ($SD = 1.06$) for mathematics and $M = 3.33$ ($SD = 1.13$) for written language skills. Thus, they were somewhat higher than the expected value of 3, which would mean that the children's skills were estimated to be as good as those of other children of the same age. Furthermore, 45 % of children received a teacher recommendation for the highest school track (gymnasium). Finally, among the children who remained in the study in Grade 5, 64 % attended the highest school track. As described in the attrition analyses, this high percentage may be because information about children's school attendance in Grade 5 is more likely to be available to children from higher-status households (see Appendix A).

Table 1
Descriptive Statistics.

	N	*Min*	*Max*	*M*	*SD*
Grade 2: Cognitive abilities	5658	0	12	6.83	2.59
Grade 3: Metacognitive knowledge	5114	−4.60	3.58	0.02	0.90
Grade 4: Mathematical competence	5083	−4.91	4.88	0.04	1.11
Grade 4: Reading competence	5081	−4.32	3.84	−0.55	1.28
Grade 4: Teacher judgment: Mathematics	3879	1	5	3.45	1.06
Grade 4: Teacher judgment: Written language skills	3900	1	5	3.33	1.13
Grade 4: Teacher school recommendation[a]	3799	0	1	0.45	0.50
Grade 5: School transition[a]	2969	0	1	0.64	0.48

[a] School type: 1 = gymnasium (higher secondary school track), 0 = other school types.

3.2. Intercorrelations

Table 2 shows intercorrelations between the variables included in the study. First, metacognitive knowledge was positively associated with all indicators of children's cognitive competencies, teacher judgments, teacher school recommendations, and the transition to gymnasium ($r = 0.22$ to $r = 38$, all $p < .001$). As expected, positive correlations were also found between the other cognitive competencies (i.e., between cognitive abilities, reading competencies, and mathematical competencies; $r = 0.32$ to $r = 0.65$; all $p < .001$). Moreover, teacher judgments about mathematics and written language skills were positively associated with each other ($r = 0.61$, $p < .001$) and teachers' school recommendations ($r = 0.60$ and $r = 0.65$ for mathematics and written language skills, respectively; $p < .001$). In addition, somewhat weaker but still significant correlations emerged between children's socio-economic background (HISEI) and all indicators of children's cognitive competencies, teacher judgments, teacher recommendations, and the transition to gymnasium ($r = 0.15$ to $r = 33$, all $p < .001$). Finally, significant correlations were found between teacher judgments and gender ($r = 0.16$ and $r = -0.16$ for written language skills and mathematics, respectively; $p < .001$). This indicates that girls, on average, received higher judgments in written language skills, whereas boys obtained higher judgments in mathematics. Although the corresponding correlations with the test scores point in a similar direction, the correlation coefficients were lower ($r = 0.09$ and $r = -0.05$ for written language skills and mathematics, respectively; $p < .001$).

3.3. Path model

To test our hypotheses, we applied a path analysis. Table 3 shows the standardized regression weights obtained in the model, as specified in Fig. 2. This model assumes direct and indirect paths and is a saturated model that allows all variables to be intercorrelated (AIC: 185741.092; BIC: 186555.073).[3]

With regard to *Hypothesis 1a*, the results showed that metacognitive knowledge significantly contributed to predicting teacher judgments of written language skills ($\beta = 0.06$, $p < .001$) and mathematics ($\beta = 0.07$, $p < .001$) after accounting for students' mathematical and reading competencies, cognitive abilities, SES, and gender. Thus, *Hypothesis 1a* was supported by the data, but the effect was rather small with regard to teacher judgments in both competency domains. As shown in Table 3 and Fig. 2, all of the other variables entered into the regression analyses were also found to be significant predictors of teacher judgments of written language skills and mathematics, which underlines the importance of including and controlling for them in analyses.

To investigate whether metacognitive knowledge affects school track recommendations (*Hypothesis 1b*), we calculated the total effect of metacognitive knowledge on school track recommendations, which, in

[2] The criteria for using FIML are multivariate normal distribution which is very difficult to test in practice and a missing (completely) at random mechanism. Although we cannot completely rule out "missing not at random" we have shown on the basis of the attrition analyses that only minor sample selection bias across the different measurement points occurred due to nonresponse. In addition, we included a large number of auxiliary variables in the analyses, which makes a possible bias unlikely.

[3] We compared this saturated model with other models with a reduced number of paths. That is, in these models, we systematically left out different paths (e.g., the direct paths from teacher judgments to school transition). However, the model fit of all other models was worse in comparison to the model fit of the saturated model.

Table 2
Pearson Correlations.

	1	2	3	4	5	6	7	8	9	10
1. Metacognitive knowledge	–	0.23***	0.38***	0.37***	0.30***	0.31***	0.29***	0.22***	0.22***	−0.01
2. Cognitive abilities		–	0.32***	0.37***	0.28***	0.33***	0.28***	0.24***	0.15***	0.07***
3. Reading competence			–	0.65***	0.55***	0.47***	0.48***	0.37***	0.31***	0.09***
4. Mathematical competence				–	0.50***	0.57***	0.50***	0.42***	0.33***	−0.05***
5. Teacher judgment: written language skills					–	0.61***	0.65***	0.48***	0.29***	0.16***
6. Teacher judgment: mathematics						–	0.60***	0.46***	0.28***	−0.16***
7. Teacher: school recommendation							–	0.61***	0.31***	0.05**
8. School transition[a]								–	0.29***	0.03
9. HISEI									–	−0.01
10. Gender[b]										–

[a] School type: 1 = gymnasium, 0 = other school types.
[b] Gender: 1 = female, 0 = male.
** $p < .01$.
*** $p < .001$.

Table 3
Standardized Regression Weights Obtained in Model 1 (Full Model).

	Teacher judgment: written language skills	Teacher judgment: mathematics	School recommendation (teacher)	School transition
Cognitive competencies				
Metacognitive knowledge	0.064**	0.070**	0.058	0.044
Reading competence	0.327**	0.177**	0.088*	0.038
Mathematical competence	0.245**	0.367**	0.280**	0.198**
Cognitive abilities	0.076**	0.160**	0.110**	0.040
Background variables				
HISEI	0.117**	0.103**	0.197**	0.216**
Gender (1 = female; 0 = male)	0.140**	−0.175**	0.062	0.027
Teacher judgments				
Written language skills			0.874**	0.167**
Mathematics			0.645**	0.143**
School recommendation (teacher)				1.164**,[a]

* $p < .05$.
** $p < .01$.
[a] This effect is not standardized (due to the categorical independent variable).

turn, is composed of a direct and an indirect effect via teacher judgments (see Fig. 2). As shown in Table 4, the total effect of metacognitive knowledge on school recommendations was significant ($\beta = 0.16$, $p < .001$), which supports *Hypothesis 1b* and underlines the relevance of metacognitive knowledge for teachers' school track recommendations.

To examine how metacognitive knowledge affects school track recommendations in greater depth, we assessed whether teacher judgments of mathematical and written language skills mediated the effect of students' metacognitive knowledge on teachers' school track recommendations, after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender (*Hypothesis 2a*). The results of the path analysis confirmed *Hypothesis 2a* and showed that metacognitive knowledge indirectly predicted teachers' school recommendations ($\beta_{Ind} = 0.10$, $p < .001$) via its direct effect on teacher judgments of written language skills and mathematics. The findings also demonstrated that teachers' school track recommendations were largely based on their perceptions of students' skills—that is, their judgments of written language ($\beta = 0.87$, $p < .001$) and mathematics skills ($\beta = 0.65$, $p < .001$). In addition to these indirect effects, which are mediated via teacher judgments, there were direct effects of children's mathematical competencies ($\beta = 0.28$, $p < .001$) on school track recommendations as well as, to a smaller degree, effects of socio-economic background ($\beta = 0.20$, $p < .001$), cognitive abilities ($\beta = 0.11$, $p = .001$), and reading competencies ($\beta = 0.09$; $p = .033$). Gender ($\beta = 0.06$; $p = .052$) did not directly predict school track recommendations when the indirect path via teacher judgments was considered simultaneously. Likewise, the direct effect of metacognitive knowledge on school track recommendations ($\beta = 0.06$, $p = .086$) was not found to be significant.

Table 4
Estimates of Indirect and Total Effects of Metacognitive Knowledge.

	Unstandardized Coefficients
School recommendation[a]	
Mediated via teacher judgments	0.101**
Total	0.159**
School transition[a]	
Mediated via school recommendation and teacher judgments	0.206**[b]
Total	0.250**[b]

[a] School type: 1 = gymnasium, 0 = other school types.
[b] These effects are not standardized (due to the categorical independent variable).
** $p < .01$.

Finally, with regard to *Hypothesis 2b*, the results demonstrated that metacognitive knowledge also contributed to predicting students' transition to gymnasium, as mediated through teacher judgments and teacher school recommendations ($b_{Ind} = 0.21$, $p < .001$). Thus, the results support the hypothesis that metacognitive knowledge indirectly affects students' transition to gymnasium via teacher judgments of their mathematical and literacy skills and teachers, school track recommendations, after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender (indirect effect). The total effect of metacognitive knowledge on school transition was $b = 0.50$ ($p < .001$). The results showed that the school track that children actually attended in Grade 5 was significantly predicted by teachers' school track recommendations in Grade 4 ($b = 1.16$, $p < .001$). However, other smaller direct effects on students' transition to the gymnasium emerged; these were not mediated by teachers' school track recommendations. Specifically, students' transition to gymnasium was significantly

predicted by teacher judgments of mathematical ($\beta = 0.14$, $p = .006$) and written language skills ($\beta = 0.17$, $p = .001$) and children's mathematical competencies ($\beta = 0.20$, $p < .001$) and SES ($\beta = 0.22$, $p < .001$). Metacognitive knowledge, reading competencies, cognitive abilities, and gender were not found to have significant direct effects on students' transition to gymnasium (all $p > .05$) when the indirect effect via teacher-school track recommendations was considered simultaneously.

4. Discussion

In the present study, we investigated the effects of students' metacognitive knowledge on teacher judgments of student achievement, school track recommendations, and students' actual transitions to gymnasium using a representative sample of 5870 elementary school students drawn from German NEPS data. We analyzed the total and indirect effects of students' metacognitive knowledge in a multilevel path model. With regard to total effects, we found that students' metacognitive knowledge significantly predicted teacher judgments of their mathematics and written language skills (*Research Question 1a*) and school track recommendations (*Research Question 1b*), after controlling for students' mathematical and reading competencies, cognitive abilities, SES, and gender. The total effects were small but significant. With regard to the indirect effect of metacognitive knowledge on school track recommendations (*Research Question 2a*), we found that students' metacognitive knowledge indirectly affected teachers' school track recommendations via teacher judgments of mathematical and written language skills, after controlling for the included covariates. Moreover, we showed that students' metacognitive knowledge indirectly affected their transition to gymnasium via teacher judgments and school track recommendations, after controlling for the included covariates (*Research Question 2b*). Both indirect effects of students' metacognitive knowledge were significant but relatively small.

Our results are in line with correlational findings that suggest that teacher evaluations of student academic abilities are associated with teachers' perceptions of student metacognitive knowledge, especially with regard to strategy use (Carr & Kurtz, 1991; Urhahne & Wijnia, 2021). The findings of our study also contribute to the large body of literature on teacher judgments of student achievement (Südkamp et al., 2012; Urhahne & Wijnia, 2021). In accordance with earlier studies, which suggested that teachers use a comprehensive achievement evaluation based on different students' characteristics, achievement, and behaviors (Bonefeld et al., 2020; Kriegbaum et al., 2019), we showed that students' metacognitive knowledge directly affects teacher judgments of their mathematical and written language skills. Moreover, the teachers in our study appeared to include some aspects of metacognitive knowledge related learning strategies in their judgments of domain-specific skills, which may indicate a holistic perspective that includes different student competencies (Weinert, 2001) in the assessment of their academic abilities (Carr & Kurtz, 1991). This is also in line with the halo effect assumption with regard to teacher judgments: teacher judgments of student achievement and aptitudes are positively correlated with teacher judgments of student motivation (Kaiser et al., 2013; Kriegbaum et al., 2019) or classroom behavior (Batruch et al., 2023). Thus, teachers who perceive one positive aspect of a student, such as metacognitive knowledge-related learning strategies, are likely to judge their achievement or aptitude in a similarly positive manner. Interestingly, we found that students' metacognitive knowledge affects teacher judgments of student achievement despite controlling for students' actual competencies in mathematics and reading in our analyses. Moreover, we supplement previous findings about the relation between student planning and teacher judgments as a basis for school track recommendations (Boone & Van Houtte, 2013; Sneyers et al., 2018) by showing that students' metacognitive knowledge, which is an indicator for students' metacognitive knowledge-related learning strategies, affects teachers' school track recommendations. However, in our study, the effect of students' metacognitive knowledge on teachers' school track recommendations was mediated by teacher judgments of student achievement. We also contribute to the research on school transitions by showing that students' metacognitive knowledge had an indirect effect (beyond students' mathematical and reading skills) on their transition to gymnasium via teacher judgments of student achievement and school track recommendations (Maaz & Nagy, 2010). This indirect effect demonstrates the long-term impact of elementary school students' metacognitive knowledge on their actual transition to gymnasium. Hence, this stresses the relevance of students' metacognitive knowledge for teachers' school track recommendations and the school transition process, in addition to students' domain-specific achievement.

In our study, we used a standardized scenario-based test to assess students' metacognitive knowledge-related learning strategies (Lockl, 2017; Lockl et al., 2018). In comparison to other measures described in the literature (e.g., self-reports on strategy use, interviews, or questionnaires), our measure has several advantages. First, it can be considered more objective and valid than student self-reports, as it includes a clear benchmark of evaluation (see Händel et al., 2013). Second, how the items are presented (i.e., scenarios and suggested strategies through pictures) does not place high demands on children's language skills or working memory capacity, as would likely be the case with interviews or questionnaires; therefore, their presentation can be considered appropriate for elementary school children (Lockl et al., 2016; see also Schneider et al., 2022). By showing an indirect effect of students' metacognitive knowledge based on a scenario-based test, our finding that students' metacognitive knowledge has an indirect effect on teachers' school track recommendations complements previous studies that have reported that teachers' subjective perception of some students' metacognitive knowledge-related learning strategies (e.g., planning skills) are important for school track recommendations (Boone & Van Houtte, 2013; Gil-Hernández, 2021; Sneyers et al., 2018).

In our study, we discovered rather small but significant indirect effects of metacognitive knowledge on teachers' school track recommendations and students' actual transition to gymnasium, after controlling for students' mathematical and reading skills, SES, gender, and cognitive abilities. Nevertheless, we detected these small but significant effects even when we controlled for several covariates, such as students' mathematical and reading skills and cognitive abilities, which are highly predictive of school track recommendations and the transition to gymnasium (Brandt et al., 2020; Gnas et al., 2022; Maaz & Nagy, 2010; Sneyers et al., 2018). Although they are small, the indirect effects discovered in our study are important for various reasons. First, the small effects of metacognitive knowledge can still make a difference by accumulating into a larger effect for students' outcomes during an academic year (Funder & Ozer, 2019). Second, the small effect sizes identified in the current study are consistent with previous research findings from psychological studies that showed small effects on average (Gignac & Szodorai, 2016). With our large NEPS dataset, we were able to demonstrate that metacognitive knowledge had small indirect effects on teachers' school recommendations and students' transition to gymnasium, which affected over 5000 elementary school students in Germany. Due to the NEPS sampling strategy, our findings are representative of the German school system, which allows us to draw important conclusions for teacher education and in-service teachers across Germany and countries with similar school tracking systems.

4.1. Practical implications

The indirect effects uncovered in this study support the relevance of teaching metacognitive strategies in schools because students' metacognitive knowledge has an impact on teacher judgments of student achievement and thus on students' school careers. Our findings are particularly important because interdisciplinary learning skills such as self-regulation, which includes metacognitive knowledge, have been recommended for teaching elementary school students for many years (Randi & Corno, 2000). Some countries, such as Switzerland, have

already integrated self-regulation skills into their teaching curricula as interdisciplinary learning skills (Högger, 2018; Karlen et al., 2022), but this is not yet the case in Germany. Furthermore, recent studies have found that German teachers still lack knowledge about metacognitive knowledge and are less willing to foster students' metacognitive knowledge in their lessons (Dignath & Büttner, 2018). Other teacher characteristics, such as teaching experience, might also play a role in whether teachers are able to teach metacognitive knowledge to their students. More teaching experience benefits the teaching of metacognitive knowledge (van Velzen, 2012).

These results suggest that German teachers, especially novice teachers, require support to learn about and teach metacognitive knowledge to students. One implication of our results is that pre-service teacher education and professional development programs should include discussions of the impact of students' metacognitive knowledge on the teacher. Another implication is that instruction on how to develop and use metacognitive skills should be integrated into teacher education as a means of enhancing teachers' limited knowledge about metacognitive knowledge in general (Dignath & Büttner, 2018). This would also improve students' metacognitive knowledge and foster their successful transition to gymnasium in the long term.

4.2. Limitations

Our study has three limitations. First, the reliability of the test on metacognitive knowledge was only near the threshold of what was considered acceptable. The rationale for the test was guided by similar tests for secondary school children (e.g., Artelt et al., 2009; Schlagmüller & Schneider, 2007). However, some of its characteristics had to be modified for use with elementary school children. For instance, the number of alternatives presented per scenario was reduced to ensure that demands on the children's working memory capacity remained low. This resulted in a relatively low number of available pair comparisons, with possible impairments to reliability. The relatively low number of items in the test was due to the fact that longer test times were not possible in a large representative study with many measured constructs such as NEPS. In an earlier pilot study, which allowed for more time and served as the basis for selecting items for the main study, reliability of the metacognitive knowledge items was higher ($\alpha = 0.76$; Lockl et al., 2018), which suggests that the items were suitable in principle for adequately capturing students' metacognitive knowledge. Furthermore, the test covered a broad construct of metacognitive knowledge; thus, a very high consistency was not expected for the items. Second, in our study, we assumed that metacognitive knowledge was an indicator of students' metacognitive knowledge-related learning strategies, such as planning or strategy use. However, we did not measure metacognitive knowledge-related learning strategies. Thus, we cannot confirm whether students exhibited such strategies. Accordingly, future studies should extend our research by examining the relation between metacognitive knowledge and observed metacognitive knowledge-related learning strategies in classrooms within the path model. Third, some student measures were assessed at different time points, which was attributable to the research design of the preschool (*Kindergarten*) cohort in the NEPS. In particular, students' cognitive abilities were measured in Grade 2, their metacognitive knowledge was measured in Grade 3, and their reading and mathematical competencies were measured in Grade 4. Metacognitive knowledge has been shown a moderate stability over time (Artelt et al., 2012). Therefore, we assumed that it was reflected in children's learning strategies even after a time lag. However, it is also possible that the effect of metacognitive knowledge was underestimated because it was not measured at the same time as achievements. Metacognitive knowledge in Grade 3 could have influenced reading and mathematics in Grade 4, and the shared variance of the different constructs might be attributed to reading and mathematical competencies in the path analysis. Ideally, students' mathematical and reading skills and cognitive abilities would have all been assessed at the same point, such as in Grade 3, when their metacognitive knowledge was measured. Thus, future studies should assess these predictors at the same time point. Despite these limitations, we believe that the large, representative sample used in our study provides strong support for the generalization of our findings and allows us to make a pivotal contribution to the study of teacher judgments of student achievement and school transitions.

4.3. Conclusions

The indirect effects of students' metacognitive knowledge on teacher school track recommendations and students' transition to a higher secondary school track (i.e., gymnasium) emphasize the pivotal role of metacognitive knowledge in students' educational trajectories. The indirect effects of metacognitive knowledge are important because students' metacognitive knowledge cannot be directly judged by teachers but affects teacher judgments in different domains. Metacognitive knowledge is not an official criterion for students in the selection process for gymnasium in Germany, but it influences teachers' school track recommendations nevertheless. Consequently, metacognitive knowledge is not only important in fostering high achievement (Desoete et al., 2001), but it also plays a role in the transition process from elementary school to a higher secondary school track. Thus, the impact of students' metacognitive knowledge on teacher judgments of student achievement should be discussed in pre-preservice teacher education and teacher professional development programs to increase awareness of this topic and its consequences for students' school careers.

CRediT authorship contribution statement

Sog Yee Mok: Conceptualization, Writing – original draft, Writing – review & editing. **Kathrin Lockl:** Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – review & editing. **Markus P. Neuenschwander:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

None

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.lindif.2024.102456.

References

Arbuckle, J. L. (1996). Full information estimation in the presence of incomplete data. In G. A. Marcoulides, & R. E. Schumacker (Eds.), *Advanced structural equation modeling: Issues and techniques* (pp. 243–277). Erlbaum.

Artelt, C., Beinicke, A., Schlagmüller, M., & Schneider, W. (2009). Diagnose von Strategie-Wissen beim Textverstehen [diagnosis of strategic knowledge in text comprehension]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 41*(2), 96–103. https://doi.org/10.1026/0049-8637.41.2.96

Artelt, C., Neuenhaus, N., Lingel, K., & Schneider, W. (2012). Entwicklung und wechselseitige Effekte von metakognitiven und bereichsspezifischen Wissenskomponenten in der Sekundarstufe. *Psychologische Rundschau, 63*(1), 18–25.

Artelt, C., & Schneider, W. (2015). Cross-country generalizability of the role of metacognitive knowledge in students' strategy use and reading competence [development and mutual effects of metacognitive and domain-specific knowledge components in secondary school]. *Teachers College Record, 117*, 1–32. http://www.tcrecord.org/Content.asp?ContentId=17695.

Batruch, A., Geven, S., Kessenich, E., & van de Werfhorst, H. G. (2023). Are tracking recommendations biased? A review of teachers' role in the creation of inequalities in tracking decisions. *Teaching and Teacher Education, 123*, Article 103985. https://doi.org/10.1016/j.tate.2022.103985

Baudson, T. G., Fischbach, A., & Preckel, F. (2016). Teacher judgments as measures of children's cognitive ability: A multilevel analysis. *Learning and Individual Differences, 52*, 148–156. https://doi.org/10.1016/j.lindif.2014.06.001

Education as a lifelong process. In Blossfeld, H.-P., & Roßbach, H.-G. (Eds.), *The German National Educational Panel Study (NEPS). Edition ZfE* (2nd ed.), (2019). Springer VS.

Bonefeld, M., Dickhäuser, O., & Karst, K. (2020). Do preservice teachers' judgments and judgment accuracy depend on students' characteristics? The effect of gender and

immigration background. *Social Psychology of Education, 23*(1), 189–216. https://doi.org/10.1007/s11218-019-09533-2
Boone, S., & Van Houtte, M. (2013). Why are teacher recommendations at the transition from primary to secondary education socially biased? A mixed-methods research. *British Journal of Sociology of Education, 34*(1), 20–38. https://doi.org/10.1080/01425692.2012.704720
Boudon, R. (1974). *Education, opportunity, and social inequality: Changing prospects in Western society*. Wiley.
Brandmiller, C., Dumont, H., & Becker, M. (2020). Teacher perceptions of learning motivation and classroom behavior: The role of student characteristics. *Contemporary Educational Psychology, 63*, Article 101893.
Brandt, N. D., Lechner, C. M., Tetzner, J., & Rammstedt, B. (2020). Personality, cognitive ability, and academic performance: Differential associations across school subjects and school tracks. *Journal of Personality, 88*(2), 249–265. https://doi.org/10.1111/jopy.12482
Brookhart, S. M., Guskey, T. R., Bowers, A. J., McMillan, J. H., Smith, J. K., Smith, L. F., … Welsh, M. E. (2016). A century of grading research: Meaning and value in the most common educational measure. *Review of Educational Research, 86*(4), 803–848. https://doi.org/10.3102/0034654316672069
Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. Weinert, & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65–116). Erlbaum.
Carr, M., & Kurtz, B. E. (1991). Teachers' perceptions of their students' metacognition, attributions, and self-concept. *British Journal of Educational Psychology, 61*(2), 197–206. https://doi.org/10.1111/j.2044-8279.1991.tb00975.x
Carr, M., & Kurtz-Costes, B. E. (1994). Is being smart everything? The influence of student achievement on teachers' perceptions. *British Journal of Educational Psychology, 64*(2), 263–276. https://doi.org/10.1111/j.2044-8279.1994.tb01101.x
Desoete, A. (2008). Multi-method assessment of metacognitive skills in elementary school children: How you test is what you get. *Metacognition and Learning, 3*(3), 189–206.
Desoete, A., Roeyers, H., & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities, 34*(5), 435–447. https://doi.org/10.1177/002221940103400505
Dignath, C., & Büttner, G. (2018). Teachers' direct and indirect promotion of self-regulated learning in primary and secondary school mathematics classes – Insights from video-based classroom observations and teacher interviews. *Metacognition and Learning, 13*(2), 127–157. https://doi.org/10.1007/s11409-018-9181-x
Ditton, H., & Krüsken, J. (2006). Der Übergang von der Grundschule in die Sekundarstufe I [transition from elementary school to lower secondary school]. *Zeitschrift für Erziehungswissenschaft, 9*(3), 348–372.
Ditton, H., Krüsken, J., & Schauenberg, M. (2005). Bildungsungleichheit — der Beitrag von Familie und Schule [Educational inequality - the contribution of family and school]. *Zeitschrift für Erziehungswissenschaft, 8*(2), 285–304. https://doi.org/10.1007/s11618-005-0138-x
Dumont, H., Klinge, D., & Maaz, K. (2019). The many (subtle) ways parents game the system: Mixed-method evidence on the transition into secondary-school tracks in Germany. *Sociology of Education, 92*(2), 199–228. https://doi.org/10.1177/0038040719838223
Efklides, A. (2006). Metacognition and affect: What can metacognitive experiences tell us about the learning process? *Educational Research Review, 1*(1), 3–14. https://doi.org/10.1016/j.edurev.2005.11.001
Enders, C. K. (2001). The performance of the full information maximum likelihood estimator in multiple regression models with missing data. *Journal of Educational and Psychological Measurement, 61*, 713–740. https://doi.org/10.1177/00131644021615 00
Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906
Flavell, J. H., Miller, P. H., & Miller, S. A. (1993). *Cognitive development*. Pearson Education Inc.
Funder, D. C., & Ozer, D. J. (2019). Evaluating effect size in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science, 2*(2), 156–168. https://doi.org/10.1177/2515245919847202
Ganzeboom, H. B. G. (2010). A new international socio-economic index (ISEI) of occupational status for the international standard classification of occupation 2008 (ISCO-08) constructed with data from the ISSP 2002-2007. In *Paper presented at the annual conference of international social survey programme, Lisbon*.
Ganzeboom, H. B. G., De Graaf, P. M., & Treiman, D. J. (1992). A standard international socio-economic index of occupational status. *Social Science Research, 21*(1), 1–56.
Gehrer, K., Zimmermann, S., Artelt, C., & Weinert, S. (2013). NEPS framework for assessing reading competence and results from an adult pilot study. *Journal for Educational Research Online, 5*(2), 50–79.
Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences, 102*, 74–78. https://doi.org/10.1016/j.paid.2016.06.069
Gil-Hernández, C. J. (2021). The (unequal) interplay between cognitive and noncognitive skills in early educational attainment. *American Behavioral Scientist, 65*(11), 1577–1598. https://doi.org/10.1177/0002764221996764
Glock, S., Krolak-Schwerdt, S., Klapproth, F., & Böhmer, M. (2013). Beyond judgment bias: How students' ethnicity and academic profile consistency influence teachers' tracking judgments. *Social Psychology of Education, 16*(4), 555–573. https://doi.org/10.1007/s11218-013-9227-5
Gnas, J., Mack, E., & Preckel, F. (2022). When classmates influence teacher judgment accuracy of students' cognitive ability: Studying frame-of-reference effects in primary school. *Contemporary Educational Psychology, 69*, Article 102070. https://doi.org/10.1016/j.cedpsych.2022.102070
Graham, J. W. (2009). Missing data analysis: Making It Work in the real world. *Annual Review of Psychology, 60*, 549–576. https://doi.org/10.1146/annurev.psych.58.110405.085530
Grammer, J. K., Purtell, K. M., Coffman, J. L., & Ornstein, P. A. (2011). Relations between children's metamemory and strategic performance: Time-varying covariates in early elementary school. *Journal of Experimental Child Psychology, 108*, 139–155. https://doi.org/10.1016/j.jecp.2010.08.001
Händel, M., Artelt, C., & Weinert, S. (2013). Assessing metacognitive knowledge: Development and evaluation of a test instrument. *Journal for Educational Research Online, 5*(2), 162–188.
Henninges, M., Traini, C., & Kleinert, C. (2019). *Tracking and sorting in the German educational system (LIfBi working paper No. 83)*. Bamberg, Germany: Leibniz Institute for Educational Trajectories.
Högger, D. (2018). Förderung von Lebenskompetenzen in der Schule [Fostering life competencies at school]. *Suchtmagazin, 2018*(4), 29–32. http://hdl.handle.net/11654/26552.
Kaiser, J., Retelsdorf, J., Südkamp, A., & Möller, J. (2013). Achievement and engagement: How student characteristics influence teacher judgments. *Learning and Instruction, 28*, 73–84. https://doi.org/10.1016/j.learninstruc.2013.06.001
Karlen, Y., Bühlmann, F., Compagnoni, M., Pfaffhauser, R., Schuler, N., & Zimmerli, C. (2022). *Überfachliche Kompetenzen stärken. Anregungen für die Planung, Förderung und Einschätzung überfachlicher Kompetenzen [Strengthening interdisciplinary competences. Suggestions for planning, promoting and assessing interdisciplinary competences]*. FHNW: Pädagogische Hochschule. https://doi.org/10.26041/fhnw-4237
Kriegbaum, K., Steinmayr, R., & Spinath, B. (2019). Longitudinal reciprocal effects between teachers' judgments of students' aptitude, students' motivation, and grades in math. *Contemporary Educational Psychology, 59*, Article 101807. https://doi.org/10.1016/j.cedpsych.2019.101807
Lang, F. R., Kamin, S., Rohr, M., Stünkel, C., & Willinger, B. (2014). Erfassung der fluiden kognitiven Leistungsfähigkeit über die Lebensspanne im Rahmen des Nationalen Bildungspanels: Abschlussbericht zu einer NEPS-Ergänzungsstudie (NEPS Working Paper No. 43). In *Bamberg, Germany: Leibniz Institute for Educational Trajectories, National Educational Panel Study*. https://doi.org/10.5157/NEPS:WP43:1.0
Lockl, K. (2017). *Assessment of declarative metacognition: Starting cohort 2–grade 3*. Bamberg: Leibniz Institute for Educational Trajectories, National Educational Panel Study.
Lockl, K., Händel, M., & Artelt, C. (2018). Kompetenztestung bei Grundschulkindern: Differenzielle Effekte unterschiedlicher Testbedingungen [Competence testing in primary school children: Differential effects of different test administration modes]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 50*(1), 33–43. https://doi.org/10.1026/0049-8637/a000183
Lockl, K., Händel, M., Haberkorn, K., & Weinert, S. (2016). Metacognitive knowledge in young children: Development of a new test procedure for first graders. In H.-P. Blossfeld, J. von Maurice, M. Bayer, & J. Skopek (Eds.), *Methodological issues of longitudinal surveys: The example of the national educational panel study* (pp. 465–484). Springer Fachmedien.
Maaz, K., & Nagy, G. (2010). Der Übergang von der Grundschule in die weiterführenden Schulen des Sekundarschulsystems: Definition, Spezifikation und Quantifizierung primärer und sekundärer Herkunftseffekte [the transition from elementary to high school of the secondary school system: Definition, specification, and quantification of primary and secondary effects of social background]. In J. Baumert, K. Maaz, & U. Trautwein (Eds.), *Zeitschrift für Erziehungswissenschaft Sonderheft 12 | 2009* (pp. 153–182). VS Verlag für Sozialwissenschaften.
Maaz, K., Trautwein, U., Lüdtke, O., & Baumert, J. (2008). Educational transitions and differential learning environments: How explicit between-school tracking contributes to social inequality in educational outcomes. *Child Development Perspectives, 2*(2), 99–106. https://doi.org/10.1111/j.1750-8606.2008.00048.x
Muthén, B. O., & Muthén, L. K. (2015). *Mplus (Version 7.4) 2015*. Los Angeles, CA.
NEPS Network. (2021). *National Educational Panel Study, scientific use file of starting cohort grade 5. Leibniz Institute for Educational Trajectories (LIfBi), Bamberg*. https://doi.org/10.5157/NEPS:SC3:10.0.0
Neuenschwander, M. P., Gerber, M., Frank, N., & Rottermann, B. (2012). *Schule und Beruf: Wege in die Erwerbstätigkeit [School and occupation: Ways into employment]*. VS-Verlag.
Neuenschwander, M. P., & Malti, T. (2009). Selektionsprozesse beim Übergang in die Sekundarstufe I und II [Selection processes during the transition to secondary level I and II]. *Zeitschrift für Erziehungswissenschaft, 12*(2), 216–232. https://doi.org/10.1007/s11618-009-0074-2
Neumann, I., Duchhardt, C., Grüßing, M., Heinze, A., Knopp, E., & Ehmke, T. (2013). Modeling and assessing mathematical competence over the lifespan. *Journal for Educational Research Online, 5*, 80–109. https://doi.org/10.25656/01:8426
Nold, D. (2010). Sozioökonomischer status von Schülerinnen und Schülern 2008. Ergebnisse des Mikrozensus [socioeconomic status of schoolchildren 2008. Results from the microcensus]. *Wirtschaft und Statistik, 2*, 138–149. https://www.destatis.de/DE/Methoden/WISTA-Wirtschaft-und-Statistik/2010/02/status-schueler-022010.pdf?_blob=publicationFile.
Nunnally, J. C., & Bernstein, I. H. (1994). The assessment of reliability. *Psychometric Theory, 3*, 248–292.
Pietsch, M., & Stubbe, T. C. (2007). Inequality in the transition from primary to secondary school: School choices and educational disparities in Germany. *European Educational Research Journal, 6*(4), 424–445.
Pohl, S., & Carstensen, C. H. (2012). *NEPS technical report – Scaling the data of the competence tests (NEPS working paper No. 14)*. Otto-Friedrich University, National Educational Panel Study.

Randi, J., & Corno, L. (2000). Teacher innovations in self-regulated learning. In I. M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 651–685). Academic Press.

Rasch, G. (1960). *Studies in mathematical psychology: I. Probabilistic models for some intelligence and attainment tests*. Nielsen & Lydiche.

Robinson-Cimpian, J. P., Lubienski, S. T., Ganley, C. M., & Copur-Gencturk, Y. (2014). Teachers' perceptions of students' mathematics proficiency may exacerbate early gender gaps in achievement. *Developmental Psychology, 50*, 1262–1281. https://doi.org/10.1037/a0035073

Rohm, T., Krohmer, K., & Gnambs, T. (2017). NEPS technical report for Reading. In *Scaling results of starting cohort 2 for grade 4 (NEPS survey paper No. 30). Bamberg*.

Rottermann, B., Neuenschwander, M. P., Rösselet, S., & Niederbacher, E. (2015). Bedingungen von erwartungswidrigen Schulniveauzuweisungen beim Übergang in die Sekundarstufe I [Conditions of unexpected school level assignments in the transition to lower secondary level]. *Zeitschrift für Soziologie der Erziehung und Sozialisation, 35*(4), 417–433.

Rüede, C., Mok, S. Y., & Staub, F. C. (2023). Fostering flexibility using comparing solution strategies and classroom discussion: Effects of two professional development programs. *Journal for Research in Mathematics Education, 54*(1), 43–63. https://doi.org/10.5951/jresematheduc-2020-0232

Salonen, P., Vauras, M., & Efklides, A. (2005). Social interaction-what can it tell us about metacognition and coregulation in learning? *European Psychologist, 10*(3), 199–208.

Schlagmüller, M., & Schneider, W. (2002). The development of organizational strategies in children: Evidence from a microgenetic longitudinal study. *Journal of Experimental Child Psychology, 81*, 298–319. https://doi.org/10.1006/jecp.2002.2655

Schlagmüller, M., & Schneider, W. (2007). *WLST 7–12. Würzburger Lesestrategie-Wissenstest für die Klassen 7 bis 12*. Hogrefe.

Schneider, W., & Pressley, M. (1997). *Memory development between 2 and 20*. Erlbaum.

Schneider, W., Schlagmüller, M., & Vise, M. (1998). The impact of metamemory and domain-specific knowledge on memory performance. *European Journal of Psychology of Education, 13*, 91–103. https://doi.org/10.1007/BF03172815

Schneider, W., Tibken, C., & Richter, T. (2022). The development of metacognitive knowledge from childhood to young adulthood: Major trends and educational implications. In J. J. Lockman (Ed.), *Advances in child development and behavior* (pp. 273–307). Academic Press.

Schnittjer, I., Gerken, A.-L., & Petersen, L. A. (2020). *NEPS technical report for mathematics – Scaling results of starting cohort 2 in fourth grade (NEPS survey paper no. 69). Bamberg: Leibniz Institute for Educational Trajectories, National Educational Panel Study*. https://doi.org/10.5157/NEPS:SP69:1.0

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351–371. https://doi.org/10.1007/BF02212307

Sneyers, E., Vanhoof, J., & Mahieu, P. (2018). Primary teachers' perceptions that impact upon track recommendations regarding pupils' enrolment in secondary education: A path analysis. *Social Psychology of Education, 21*(5), 1153–1173. https://doi.org/10.1007/s11218-018-9458-6

Stang, J., & Urhahne, D. (2016). Wie gut schätzen Lehrkräfte Leistung, Konzentration, Arbeits- und Sozialverhalten ihrer Schülerinnen und Schüler ein? Ein Beitrag zur diagnostischen Kompetenz von Lehrkräften [how well do teachers assess the performance, concentration, work-related and social behavior of their students? A contribution to the diagnostic competence of teachers]. *Psychologie in Erziehung und Unterricht, 63*(3), 16. https://doi.org/10.2378/peu2016.art18d

Steinhauer, H. W., Zinn, S., Gaasch, C., & Goßmann, S. (2016). *NEPS technical report for weighting: Weighting the sample of kindergarten children and grade 1 students of the National Educational Panel Study (wave 1 to 3) (NEPS working paper No. 66)*. Bamberg: Leibniz Institute for Educational Trajectories, National Educational Panel Study.

Südkamp, A., Kaiser, J., & Möller, J. (2012). Accuracy of teachers' judgments of students' academic achievement: A meta-analysis. *Journal of Educational Psychology, 104*(3), 743–762. https://doi.org/10.1037/a0027627

Timmermans, A. C., de Boer, H., Amsing, H. T. A., & van der Werf, M. P. C. (2018). Track recommendation bias: Gender, migration background and SES bias over a 20-year period in the Dutch context. *British Educational Research Journal, 44*(5), 847–874. https://doi.org/10.1002/berj.3470

Urhahne, D., & Wijnia, L. (2021). A review on the accuracy of teacher judgments. *Educational Research Review, 32*, Article 100374. https://doi.org/10.1016/j.edurev.2020.100374

van Kraayenoord, C. E., & Schneider, W. E. (1999). Reading achievement, metacognition, reading self-concept and interest: A study of German students in grades 3 and 4. *European Journal of Psychology of Education, 14*(3), 305–324. https://doi.org/10.1007/BF03173117

van Leest, A., Hornstra, L., van Tartwijk, J., & van de Pol, J. (2021). Test- or judgement-based school track recommendations: Equal opportunities for students with different socio-economic backgrounds? *British Journal of Educational Psychology, 91*(1), 193–216. https://doi.org/10.1111/bjep.12356

van Velzen, J. H. (2012). Teaching metacognitive knowledge and developing expertise. *Teachers and Teaching, 18*(3), 365–380. https://doi.org/10.1080/13540602.2012.629843

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*(1), 3–14. https://doi.org/10.1007/s11409-006-6893-0

Warm, T. A. (1989). Weighted likelihood estimation of ability in item response theory. *Psychometrika, 54*, 427–450. https://doi.org/10.1007/BF0229462

Weinert, F. E. (2001). Concepts of competence. In OECD (Ed.), *Definition and selection of competencies: Theoretical and conceptual foundations*. OECD.

Wyatt-Smith, C., Adie, L., & Harris, L. (2024). Supporting teacher judgement and decision-making: Using focused analysis to help teachers see students, learning, and quality in assessment data. *British Educational Research Journal, 0*, 1–29. https://doi.org/10.1002/berj.3984