

Who benefits the most? Teacher expectations and their relation with students' achievement in mathematics in primary school

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Funding information

Swiss National Science Foundation, Grant/Award Number: 100019_146172

Abstract

Over the past 50 years, many studies have investigated the impact of teacher expectations on student achievement and indicated small to moderate effects. Currently, it is still unclear which student-related factors (e.g. socioeconomic status, or gender) moderate the expectation effect. There is still a need to gain a better understanding of the relation between teacher expectations and students' characteristics. The present study aims to examine the accuracy of teacher expectations as well as student-related moderators of the expectation effects on students' achievement. The analyses are based on data from a longitudinal study including 28 primary school teachers and their students ($N = 509$). The results show that high expectations of teachers correlated positively with student achievement in mathematics, although no significant moderating effects were found. These findings strengthen the importance of ensuring high teacher expectations for all students.

KEYWORDS

longitudinal study, mathematics achievement, primary school, teacher expectations

1 | INTRODUCTION

The first investigation into teacher expectations, an experimental study entitled *Pygmalion in the Classroom* by Rosenthal and Jacobson (1968), demonstrated that students whose teachers had high expectations of them, tended to confirm those expectations (*Pygmalion effect*). Teacher expectations on student achievement can be viewed as beliefs that teachers form in relation to their students' present and future performance (Dusek & Joseph, 1983; Friedrich et al., 2015; Good & Brophy, 1997; Rubie-Davies, 2004).

Since the study by Rosenthal and Jacobson (1968), many other studies have been conducted on the subject. In the beginning, these were mainly replication studies, some of which were not able to show a replication of the Pygmalion effect (Claiborn, 1969; Humphreys & Stubbs, 1977; Snow, 1969). At present, there is broad consensus that teacher expectations influence student achievement (for an

overview, see the reviews by Jussim & Harber, 2005 and Wang et al., 2018)—both positively and negatively. Low expectations seem to be harmful in the same way that high expectations are beneficial (De Boer et al., 2010). Correlation studies in the school have reported relatively small expectation effects. Nevertheless, Hollenstein et al. (2019) and Muntoni et al. (2020) found that teacher expectations related positively to student achievement, despite controlling for teachers' professional knowledge. This means, teachers with the same professional knowledge (i.e. content knowledge, pedagogical-psychological knowledge) foster higher gains in students' achievement with high expectations as compared to low expectations. In addition, a number of intervention studies have highlighted teachers' expectation effects (e.g. De Boer et al., 2018; Neuenschwander et al., 2021; Rubie-Davies et al., 2015). Neuenschwander et al. (2021) found that fourth- and sixth-grade students' migration background and socioeconomic status (SES) cause a bias regarding teacher expectations on student

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achievement in mathematics and German. For example, teachers form low expectations towards students from minority groups or with low SES. Nevertheless, after the intervention, teachers' expectations in the intervention group on student achievement in mathematics were not biased by students' migration background, in contrast to those of the control group (Neuenschwander et al., 2021).

Regarding which student characteristics influence teacher expectations, findings are consistent for SES, where teacher expectations appear to be low for students with lower SES (Wang et al., 2018). However, other student characteristics that can affect teacher expectations or moderate the effects of teacher expectation bias on achievement are rare and sometimes inconsistent (Wang et al., 2018). For example, findings for minority groups have been inconsistent. While a number of studies have found that teacher expectations appear to be low for minority groups (Fox, 2015; Neuenschwander et al., 2021; Rubie-Davies et al., 2006), other studies found no difference tied to minority groups and instead found negative correlations with SES (Timmermans et al., 2015; Van den Bergh et al., 2010). Furthermore, it remains unclear whether low-achieving students benefit more from high teacher expectations than high-achieving students (De Boer et al., 2010; Madon et al., 1997).

Following the lack of consistent research on student characteristics and their moderating effect on teachers' expectation bias regarding student achievement, the present study aims to examine (1) how student characteristics (SES and gender) influence teacher expectations and (2) which student characteristics (prior achievement, SES, or gender) moderate the magnitude of teacher expectation effects on students' mathematics achievement. The study draws on the example of primary school mathematics teachers and their students in German-speaking Switzerland.

1.1 | Teacher expectations and its bias based on student characteristics

If teacher expectations are accurate, they are likely to be a good predictor of student achievement. However, when teacher expectations are inaccurate, they can lead to self-fulfilling prophecy effects (Jussim, 1989). Assessment tendencies and errors can lead to distorted or inaccurate teacher expectations, which can result in a self-fulfilling prophecy (Gentrup & Rjosk, 2018; Jussim et al., 2009; Merton, 1948). Zhu et al. (2018) argued that an estimation of students' current achievements can be used as an indicator of their expected achievements. The residual approach by Madon et al. (1997) determined the inaccuracy level within this estimation in the sense of a self-fulfilling prophecy. This approach represents the basis of the present study (see the *Measures* section).

From a pedagogical perspective, a slight overestimation of student achievement is viewed as more favourable in fostering achievement, than a correct estimation or even an underestimation (Timmermans et al., 2015). An overestimation of achievement, which equates high expectations with achievement, has been shown to positively affect students' achievement development (Rubie-Davies, 2007, 2010;

Rubie-Davies et al., 2015; Rubie-Davies et al., 2006). The effect of teacher expectations becomes problematic when the achievement gap between students increases due to self-fulfilling prophecies (in the sense of the Matthew effect, cf. Merton, 1968). Thus, high achievers progressed more because teachers overestimated their success and low-achieving students progressed less because of lower teacher expectations (Babad, 1993). Therefore, it is important that teachers form high expectations for all their students (Rubie-Davies et al., 2018).

Rubie-Davies (2014) found that some teachers have high expectations for low-achieving students, leading to higher achievement. Teacher expectations do not always result in self-fulfilling prophecies, but student characteristics also influence the effect of the teacher expectations on students' achievement (e.g. Brophy, 1983; Gentrup & Rjosk, 2018; Good, 1987; McKown & Weinstein, 2002; Rubie-Davies, 2009). For example, student SES correlated positively with high teacher expectations (De Boer et al., 2010; Ready & Wright, 2011; Timmermans et al., 2015), which may be discussed critically in terms of equal opportunities (Gentrup et al., 2018). This finding was supported in a number of studies, with very few determining a negative correlation between high teacher expectations and SES (Wang et al., 2018). With regard to SES, the positive correlation between teacher expectations and SES appears clear. Consequently, SES should be considered for all analyses investigating expectancy effects. Regarding other student characteristics, for example, gender, findings have been less consistent. While some studies reported on mathematics teachers having higher expectations for their male students than for their female students (Hermann & Vollmeyer, 2016; Lazarides & Watt, 2015; Lorenz et al., 2016; Ready & Wright, 2011), some studies made opposite findings: teachers formed higher expectations for their female students (e.g. Hinnant et al., 2009; Timmermans et al., 2015).

1.2 | The student-related moderation effect of teacher expectations

Certain studies have indicated that student's characteristics may affect their susceptibility to teacher expectations. Jussim and Harber (2005) argued that the effect of teacher expectations was greater for certain groups of students than others. Young students, for example, primary students (or other students who rely more on teacher support), were more responsive to teacher expectations (Good & Nichols, 2001; Hinnant et al., 2009). Jussim et al. (1996) found that teachers' expectations effects in the mathematics context were more powerful for girls and low-SES students. However, a study by De Boer et al. (2010) did not find a clear interaction effect between gender and expectations.

Results have been inconsistent with regard to students' previous achievement levels. Some studies indicated that low achievers, particularly low achievers with minimal learning support at home, were significantly affected by teacher expectations—both positively and negatively (Good & Nichols, 2001; Hattie, 2013; Jussim et al., 1998; McKown & Weinstein, 2008). Other findings showed that high achievers benefitted the most from high expectations (De Boer et al., 2010;

Pesu et al., 2016). Either way, high achievers are far more likely to receive high expectations than low achievers.

1.3 | The present study and its purpose

Although findings regarding the influence of student-related factors on teacher expectations have been inconsistent, there seems to be consensus among researchers that teacher expectations affect student achievement. It remains unclear to what degree student characteristics relate to high and low teacher expectations and how they moderate the magnitude of teacher expectation effects. The focus of the presented study is twofold: We aim to investigate (1) the relation between student characteristics (SES and gender) and teacher expectations, and (2) the relation of student characteristics (prior achievement, SES, or gender) on the magnitude of teacher expectation effects on student achievement in mathematics. We formulated the following hypotheses based on our current knowledge. First, we assume the existence of a positive relation between teacher expectations and student SES, as well as higher teacher expectations for male students (H1) (Gentrup et al., 2018; Hermann & Vollmeyer, 2016). Second, we posit that low-achieving students benefit more from high expectations in mathematics than high-achieving students (H2a) (Madon et al., 1997). Furthermore, we expect teacher expectations to play a significant role for female students' achievement in mathematics (H2b), as well as for low-SES students (H2c) (Jussim et al., 1996).

2 | Methods

2.1 | Sample and research design

The present study's database was obtained from 'Outcomes of Teacher Education' (*Wirkungen der Lehrerbildung* (WiL) in German), a longitudinal study supported by the Swiss National Science Foundation. The analyses were based on the beginning and end of teachers' third year in the profession. At both measurement time points (beginning and end of the third year on the job), data were available from 28 primary teachers and their classes, totalling in 509 students (3rd grade: $n = 130$; 4th grade: $n = 71$; 5th grade: $n = 134$; 6th grade: $n = 174$). Written informed consent was obtained from students' parents and the teachers for data collection. On the day of the survey, the children decided independently whether they wanted to participate in the study, work on another task in another room, or join another class. At the time of the survey, the students had been taught mathematics for 1 year (34.4%), 2 years (31.0%), or 3 years (34.6%) by the same teacher.¹ As the teachers in the present study had already known the students for at least a year, they had formed less prejudiced expectations (Hattie, 2013). Research confirms, teacher expectations become more accurate, the longer a teacher has known their students

and has been able to gather information about them (Dusek & Joseph, 1983).

The teachers were, on average, $m = 25$ years old (min = 23; max = 34). The proportion of women in the teacher sample was 86.1%, corresponding to the average proportion of women teaching at the primary level in Switzerland (Federal Statistical Office (FSO), 2018). On average, each teacher taught a class of 18 students. All students of all classes participated in the study. The students were $m = 11$ years old (min = 8; max = 14) on average. The gender ratio among the students was balanced (49.7% male; 50.3% female).

The data set contained missing values relating to student achievement at the beginning (1.2%) and end (4.9%) of the school year, as well as teacher expectations (10.8%) and student SES (16.7%). No missing values were detected in relation to students' gender. Little's Missing Completely at Random (MCAR) test (Li, 2013; Little, 1988) demonstrated a statistically significant distribution of missing values ($\chi^2 = 40.65$, $df = 13$; $p < .001$), meaning the missing values were not distributed randomly. Therefore, we estimated a logistic regression regarding mathematics achievement (t1 and t2), with SES/teacher expectations as predictors and a binary-coded missing variable of teacher expectations/SES as dependent variables. This allowed us to check whether at least part of the MCAR assumptions, namely the independence of the probability of missing values from influences of other model variables, was fulfilled. If no significant predictor effect was shown in a logistic regression with the missing variable as a binary dependent variable, the missing values' MCAR property was proven. Table 1 demonstrates the results of the logistic regression. As is visible on the right, the logistic regressions revealed no significant effects on the missing values of teacher expectations and SES.

2.2 | Variables and instruments

All the variables that we used to test H1 and H2a–c are presented in Table 2, including their descriptive statistics.

2.2.1 | Student mathematics achievement

Students' mathematics achievement was measured at the beginning and end of the school year using elements of a standardised mathematics test from Switzerland (Lehrmittelverlag, 2020; Moser, 2003). The four tests related to each grade level's corresponding curriculum and covered 30–70 mathematical tasks in arithmetic, geometry, algebra and stochastic algebra. The tests were designed specifically for each grade level from third to sixth., thus containing age-appropriate tasks for all students. Consequently, in this study, the risk of tasks being left unanswered or answered incorrectly due to low reading competence was kept as low as possible. However, one disadvantage was that the four level-specific tests have their own metrics. At the time of the survey, no test procedure had been identified that could be used from third to sixth grade with a common metric. Due to the lack of anchor items and the small sample size within the grade levels, item-response-theory

¹ How long the teacher had been teaching the class prior, that is, whether the teacher had already taught the class 1 or 2 or 3 years, was not relevant to the analysis.

TABLE 1 Logistic regression to test the distribution of missing values.

| | DV: Teacher expectations (binary-coded missing variable) | | | | DV: SES (binary-coded missing variable) | | | |
|------------------------------------|--|-----|-----|---------|---|-----|-----|---------|
| | B | SE | p | Exp (B) | B | SE | p | Exp (B) |
| Student mathematics achievement t1 | -.59 | .65 | .36 | .55 | -.24 | .28 | .38 | .79 |
| Student mathematics achievement t2 | -.78 | .51 | .13 | .46 | .03 | .27 | .92 | 1.03 |
| Teacher expectations | - | - | - | - | -.32 | .16 | .05 | .73 |
| Student SES | -.32 | .36 | .37 | .73 | - | - | - | - |
| Constant | -3.97 | .45 | .00 | .02 | -2.15 | .16 | .00 | .12 |

Abbreviation: DV, dependent variable.

TABLE 2 Descriptive statistics on the variables used in the analysis.

| | <i>m</i> | <i>SD</i> | Min | Max | <i>ICC</i> ₁ | <i>ICC</i> ₂ | % |
|--------------------------------|----------|-----------|-------|------|-------------------------|-------------------------|------|
| Student test and questionnaire | | | | | | | |
| Mathematics achievement t1 | 500 | 100 | 358 | 825 | .10 | .66 | - |
| Mathematics achievement t2 | 608 | 123 | 350 | 892 | .15 | .75 | - |
| SES | .12 | .81 | -1.96 | 1.60 | - | - | - |
| Male | | | | | | | 49.7 |
| Teacher questionnaire | | | | | | | |
| Teacher expectations | .00 | .10 | -3.19 | 2.49 | .27 | - | - |

Note: Mathematics achievement: The mean value at the beginning of the school year was transformed to $m = 500$ and $SD = 100$; SES: z-standardised for all participants in the study ($N = 50$); teacher expectations: standardised residual score.

TABLE 3 Descriptive statistics on student start-of-year mathematics achievement split into three achievement groups.

| Achievement group | % | <i>n</i> | <i>m</i> | <i>SE</i> | <i>SD</i> | Min | Max |
|-------------------|------|----------|----------|-----------|-----------|-----|-----|
| Low achievers | 16.5 | 83 | 383 | 1.48 | 13.46 | 358 | 399 |
| Average achievers | 66.7 | 335 | 485 | 2.89 | 52.88 | 404 | 599 |
| High achievers | 16.7 | 84 | 673 | 6.54 | 59.91 | 601 | 825 |
| Total | 100 | 502 | 500 | 4.45 | 100 | 358 | 825 |

Note: High achievers: students with a test score of more than a standard deviation above the mean at the beginning of the school year ($m > 600$); average achievers: students with a mean between $m = 400$ and $m = 600$; low achievers: students with more than a standard deviation below the mean ($m < 400$).

(IRT) scaling was not possible. Nevertheless, to create a common metric, the test values were z-standardised within each grade level and then merged across grade levels. The standardised variable indicated students' achievement in relation to the achievement of other students in the same grade (e.g. third grade).

Table 6 and Figures 1–3 indicate whether teachers form high expectations for low-achieving students. To investigate this relation, students were split into three achievement groups based on the start-of-year test scores (De Boer et al., 2010). Table 3 presents the descriptive statistics on student start-of-year mathematics achievement, split into three achievement groups.²

² Based on the assumption that mathematics achievement and self-concept correlate, the differences in students' mathematics self-concept between the achievement groups were tested for significance with one-sample independent *t*-tests. These tests were done to validate the achievement groups. The differences between the three achievement groups' means were found to be statistically significant ($p < .001$).

2.2.2 | Teacher expectations and teacher expectation bias

As an initial step, teachers were asked to predict the expected mathematics score for each student at the end of the school year ('Please indicate what score you expect from students in the mathematics test'). Teacher expectations were recorded at the end of the school year (Good & Brophy, 1997; Rubie-Davies, 2004) prior to the students taking the test. Hence, teachers were not aware of the test results and their expectations were viewed as beliefs relating to the future. According to Roese and Sherman (2007), the time reference can be short-term, as in this study (e.g. the expected achievement of the result of a test that has just been completed) or long-term (e.g. the expected performance of a student 1 year later). An example of the mathematics test used in this study (see description above) was available to the teachers throughout their making estimations.

TABLE 4 Descriptive statistics on teacher expectations (end of school year).

| Teacher expectations | % | <i>n</i> | <i>m</i> | <i>SE</i> | <i>SD</i> | Min | Max |
|-----------------------|------|----------|----------|-----------|-----------|-------|------|
| Low expectations | 30.0 | 136 | −1.19 | .04 | .48 | −3.19 | −.51 |
| Accurate expectations | 38.0 | 172 | .01 | .02 | .29 | −.50 | .50 |
| High expectations | 32.0 | 145 | 1.10 | .04 | .49 | .51 | 2.49 |
| Total | 100 | 453 | .00 | .05 | .10 | −3.19 | 2.49 |

The second step was to ascertain the inaccuracy level in the teachers' predictions (Gentrup & Rjosk, 2018; Jussim et al., 2009). The inaccuracy level in each expected score was determined by the residual approach of Madon et al. (1997) in accordance with Hinnant et al. (2009) and Rubie-Davies and Peterson (2016). In line with Gentrup et al. (2020), the present paper defines inaccuracy as the deviation from the students' characteristics (intrinsic motivation, self-concept in terms of mathematics, and mathematics achievement at the beginning of the school year). These students' characteristics influence students' achievement; therefore, they could be used as legitimate indicators for teachers to estimate their students' achievement, but contain no information relating to teacher expectations.

The standardised residuals from the multiple regression between teachers' expected scores and student characteristics resulted in an indicator of teachers' expectations in the sense of a self-fulfilling prophecy (*teacher expectation bias*). These student characteristics explained 57% of the variance in the teachers' expected scores compared with the students' actual mathematics test scores. The standardised residuals indicated the proportion of teachers' estimations that could not be explained by the aforementioned student characteristics. Positive residuals indicated that teachers in the sample expected a higher achievement level from their students than could be predicted by student characteristics (*high expectations*). Negative residuals indicated that teachers expected less of their students than what the student characteristics predicted (*low expectations*).

The residual score (*teacher expectation bias*) was split into three groups (for analyses of H2, see Table 4). Following the assumption that a misjudgement was psychologically relevant only if teacher estimations and effective student achievement differed to a certain degree, a standard deviation of more than half is classified as a moderate expectation bias (De Boer et al., 2010; Rubie-Davies & Peterson, 2016; Urhahne et al., 2010). A positive standardised residual score greater than 0.5 corresponded with high expectations. A negative residual score smaller than −0.5 indicated low expectations. A standardised residual score around zero ± 0.5 signified accurate expectations.

2.2.3 | Student characteristics as control variables

In this study, we controlled for the variables gender and SES (in the analyses for H2).³ Students' *gender* was ascertained using the student questionnaire (female students were the reference category). The *SES*

³ We also examined the influence of students' ages, but this was not significant. Therefore, in favour of the number of parameters that could be estimated freely, age was not considered further in the analyses.

represented a z-value derived from students' data of their parents' highest educational attainment and the number of books at home. This understanding of SES is a short form of economic, social and cultural status (ESCS), widely used in PISA. The SES value correlated significantly with ESCS (at least in terms of the Swiss data; $r > .90$).

2.3 | Statistical analyses

First, a zero-order correlation table was obtained to assess the significance of the associations between teacher expectations and student characteristics. Second, the data were analysed using multilevel regression models in Mplus 8.2 (Muthén & Muthén, 2017). Variance between the classes exceeded the critical value of 10% for the dependent variables (teacher expectation bias and student achievement; see Table 2), so it was necessary to consider the hierarchical data structure (students nested in classes) in our analyses (Lüdtke et al., 2009). To test H1, we specified a model with student characteristics (SES and gender) as predictors of teacher expectation bias. In this way, it was possible to test whether or not teacher expectations were systematically biased in terms of SES or gender. We tested H2a–c with at least 10 different multilevel regression models. In Model 1, we included students' mathematics achievement at the beginning of the school year as a continuous variable. Based on this, it was possible to see how many variances in student achievement (continuous variable) could be explained by their prior achievement. In Model 2, other student characteristics were included, for example, SES and gender, to examine their relevance in relation to students' mathematics achievement. To test teacher expectations (low vs. high) as a predictor (aside from students' mathematics achievement at the beginning of the year), we specified Model 3 (M3), which was used to estimate the categorical variable teacher expectation effect. In this case, teacher expectations were dummy-coded, with the accurate expectation serving as the reference category. The advantage of using the categorical variable is that possible differential effects resulting from differences in the extent of teacher expectation bias (low vs. high) could be presented more clearly (De Boer et al., 2010). The effects of teacher expectation bias and student characteristics were analysed simultaneously in Model 4 (M4). In this way, it was possible to establish the importance of teacher expectations regarding student characteristics. In Models 5–10, we examined student-related moderating effects: high or low teacher expectations regarding (1) students' mathematics achievement, (2) SES and (3) gender.

In all models tested in this study, the predictor variables pertained to the student level and were viewed as having the same effect in each class (a fixed effect). However, the intercept was modelled randomly at

TABLE 5 Zero-order correlations between all variables in the present study.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|------------------------------|---------|---------|---------|-------|------|---|
| 1 Mathematics achievement t1 | 1 | | | | | |
| 2 Mathematics achievement t2 | .78*** | 1 | | | | |
| 3 Low expectations | -.12(*) | -.29*** | 1 | | | |
| 4 High expectations | .08 | .15* | -.45*** | 1 | | |
| 5 SES | .25*** | .31*** | -.23*** | .25** | 1 | |
| 6 Male | .12** | .08(*) | .12* | -.10* | -.03 | 1 |

Note: Pearson correlation coefficient.

(*) $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

TABLE 6 Cross-table student achievement/teacher expectations (end of school year).

| | | Teacher expectation bias | | | |
|---------------------------|------------------|--------------------------|-----------------------|-------------------|-------------|
| | | Low expectations | Accurate expectations | High expectations | Total |
| Student achievement group | Low achiever | 27 (5.9%) | 18 (4.0%) | 20 (4.4%) | 65 (14.3%) |
| | Average achiever | 87 (19.3%) | 113 (24.9%) | 107 (23.6%) | 307 (67.8%) |
| | High achiever | 22 (4.8%) | 41 (9.1%) | 18 (4.0%) | 81 (17.9%) |
| | Total | 136 (30.0%) | 172 (38.0%) | 145 (32.0%) | 453 (100%) |

Note: Valid N = 453 (89%); missing N = 56 (11%); total N = 509 (100%).

the grade level, that is, classes could differ in their average score on the criterion variable (Heck & Thomas, 2015).

The missing values on student characteristics were supplemented by *full information maximum likelihood* (FIML) estimations. All skewness and kurtosis values were found to be less than 2.58, falling within the acceptable range (Field, 2000).

3 | RESULTS

3.1 | Descriptive statistics

Before the results from the multilevel regression models are presented (H1 and H2a–c), we, first considered the relations between all variables used in the present study. Table 5 presents the zero-order correlations for all the variables used.

Table 6 provides an overview of the distribution of teacher expectations and student achievement, indicating that teachers also had high expectations of low achievers.

3.2 | Teacher expectation bias and its relation to student characteristics

To test H1, we examined the relation between teacher expectation bias and student characteristics, using a multilevel regression model with random intercept. For this analysis, the continuous version of the teacher expectation bias variable was used as the dependent variable.

The results from the analysis are presented in Table 7. Model 0 (M0) was the empty model, excluding the effects of predictors. The results

TABLE 7 Student characteristics and their effect on teacher expectation bias.

| | M0 β (SE) | M1 β (SE) |
|-----------------------|--------------------|--------------------|
| Intercept | -.025 (.11) | -.12 (.14) |
| SES | | .23 (.05)*** |
| Male | | -.21 (.05)*** |
| R^2_{within} | | .098 |

Note: Random intercept models with teacher expectation bias (continuous variable) as the dependent variable.

*** $p < .001$.

from Model 1 provided information on the relation between teacher expectation bias and student characteristics. SES ($\beta = .23$; $p < .001$) and gender ($\beta = -.21$; $p < .001$) were found to be significant predictors of teacher expectation bias. Teacher expectations were higher in the case of girls and students from a higher SES. These student characteristics accounted for 10% of the variance in teacher expectation bias (Cohen's $f^2 = 0.11$).

3.3 | Student mathematics achievement and the relation to teacher expectations

To test the relation between teacher expectations and student mathematics achievement (H2a–c), 10 random intercept multilevel regression models were estimated. The results from these models are presented in Table 8.

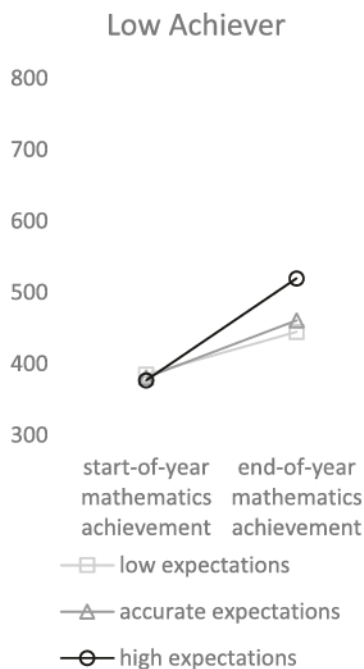
TABLE 8 Effect of student characteristics and teacher expectations on student achievement.

| | M0 | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 |
|---|--------------|--------------|--------------|---------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|
| | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) |
| Intercept | .01 (.22) | .02 (.20) | .03 (.20) | .01 (.20) | .02 (.20) | .06 (.08) | .06 (.08) | .09 (.09) | .05 (.08) | .05 (.08) | .06 (.08) |
| Mathematics achievement t1 | .76 (.02)*** | .73 (.02)*** | .73 (.02)*** | .73 (.02)*** | .73 (.02)*** | .69 (.03)*** | .71 (.02)*** | .71 (.02)*** | .72 (.03)*** | .71 (.02)*** | .71 (.02)*** |
| Low expectations | | | | -.16 (.03)*** | -.17 (.03)*** | -.17 (.03)*** | -.16 (.03)*** | -.12 (.05)** | -.17 (.03)*** | -.17 (.03)*** | -.17 (.03)*** |
| High expectations | | | | .19 (.03)*** | .19 (.02)*** | .18 (.02)*** | .19 (.02)*** | .19 (.02)*** | .19 (.02)*** | .19 (.03)*** | .19 (.04)*** |
| SES | | .08 (.03)** | | .02 (.03) | .02 (.03) | -.01 (.03) | .01 (.04) | .00 (.03) | -.01 (.03) | .00 (.04) | -.01 (.03) |
| Male | | -.02 (.03) | | .04 (.03) | .04 (.03) | .03 (.03) | .03 (.03) | .06 (.03) | .03 (.03) | .03 (.03) | .04 (.03) |
| Low expectations* mathematics achievement t1 | | | | | | .05 (.04) | | | | | |
| Low expectations* | | | | | | | | | | | |
| SES | | | | | | | | | | | |
| Low expectation* male | | | | | | | | | | | |
| High expectations* mathematics achievement t1 | | | | | | | | | | | |
| High expectations* SES | | | | | | | | | | | |
| High expectations* | | | | | | | | | | | |
| male | | | | | | | | | | | |
| R^2_{within} | .57 | .59 | .59 | .65 | .65 | .65 | .65 | .65 | .65 | .65 | .65 |

Note: Random intercept models with student mathematics achievement at the end of the school year (continuous variable) as the dependent variable.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Low achievers' mathematics development during one school year in relation to teacher expectations

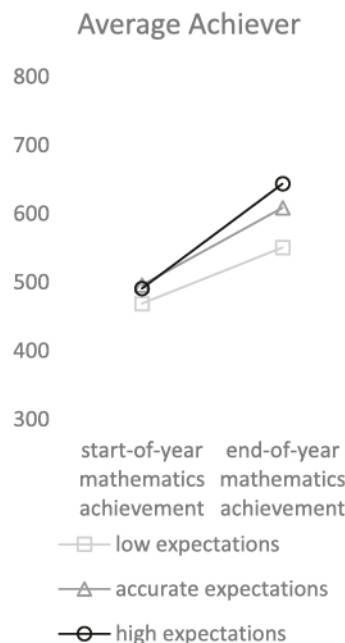


Note: $n_{low} = 27$; $n_{accurate} = 18$; $n_{high} = 20$.

FIGURE 1 Low achievers' mathematics development during one school year in relation to teacher expectations. $n_{low} = 27$; $n_{accurate} = 18$; $n_{high} = 20$.

The model on the left is the empty model (M0). Model 1 demonstrated that considering the prior achievement covariate resulted in a substantial decrease in variance. The covariate accounted for 57.1% of the variance in student achievement. Prior achievement was found to be a significant predictor of mathematics achievement at the end of the school year ($\beta = .76$; $p < .001$). Model 2 indicated that student achievement improved as SES ($\beta = .08$; $p = .003$) increased. Achievement was not found to be related significantly to gender. Nevertheless, compared with the covariate-only model, student characteristics accounted for only 0.2% additional variance in achievement (Cohen's $f^2 = 0.036$). The effects presented in Model 3 showed a clear relation between the inaccuracy level in teacher expectations and student achievement. Achievement development correlated negatively with low expectations ($\beta = -.16$; $p < .001$) and correlated positively with high expectations ($\beta = .19$; $p < .001$). This suggests that achievement development was lowest for students with low expectations and increased with higher expectations. Compared with the covariate-only model (M1), this model accounted for 8.2% extra variance (Cohen's

Average achievers' mathematics development during one school year in relation to teacher expectations



Note: $n_{low} = 87$; $n_{accurate} = 113$; $n_{high} = 107$.

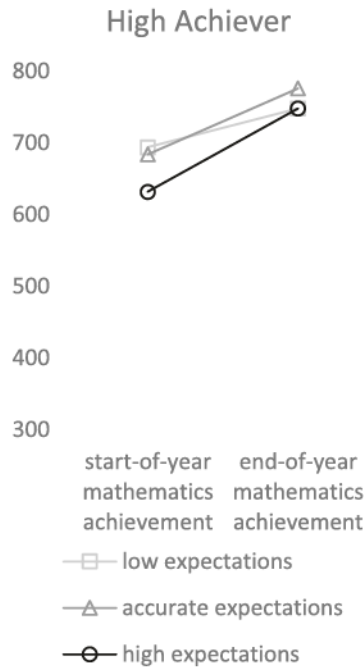
FIGURE 2 Average achievers' mathematics development during one school year in relation to teacher expectations. $n_{low} = 87$; $n_{accurate} = 113$; $n_{high} = 107$.

$f^2 = 0.24$). Model 4 indicated the effects of both student characteristics and teacher expectations on student achievement. Compared with Model 1 (M1), this model accounted for 8.1% additional variance (Cohen's $f^2 = 0.23$).

The results showed that low expectations are as harmful as high expectations are beneficial for student achievement. No significant interaction effect was found between student prior achievement and teacher expectations (H2a), as well as between student characteristics (SES and gender; H2b-c) and teacher expectations (M5-M10).

Figures 1-3 give insight into the relation between teacher expectations and student achievement when considering student achievement at the beginning of the school year. The slope corresponding to high expectations was almost the same in each achievement group. Furthermore, Figures 1-3 indicate that over a 1-year period, high expectations led to an increase in achievement, which was around twice as high as the effect associated with low expectations, a difference of more than half the standard deviation in achievement. This means an advantage of one semester for students taught by a teacher with high expectations, compared with students taught by a teacher with low expectations.

High achievers' mathematics development during one school year in relation to teacher expectations



Note: $n_{low} = 22$; $n_{accurate} = 41$;
 $n_{high} = 18$.

FIGURE 3 High achievers' mathematics development during one school year in relation to teacher expectations. $n_{low} = 22$; $n_{accurate} = 41$; $n_{high} = 18$.

4 | DISCUSSION

This study aimed to provide deeper insights into the relation between teacher expectation (bias) and students' mathematics achievement in primary school. The analyses indicated that teacher expectations correlated with student characteristics. Teachers form higher expectations for girls and high SES students. This result indicated the existence of a systematic bias in teacher expectations, in line with Gentrup and Rjosk (2018). The key finding from this study was that high expectations corresponded with improved progress in mathematics achievement, across all levels of mathematical ability (low, average and high achievers).

4.1 | Teacher expectation bias and its relation to student characteristics

First, the results indicated that the teachers in the sample had high expectations not only for high achievers, but also for low-achieving students (see Table 6), in line with Rubie-Davies (2004).

To gain more insight, we then examined the relation between teacher expectations and student characteristics (H1). Student SES had a positive relation with teacher expectations in line with Gentrup and Rjosk (2018), Lorenz et al. (2016), McKown and Weinstein (2008), Ready and Wright (2011) and Rubie-Davies et al. (2006). Furthermore, mathematics teachers' expectations were higher for female students than male students. This result was in line with Hinnant et al. (2009) and Timmermans et al. (2015), who also found a positive relation between expectations and female mathematics students, contrary to other studies that focussed on mathematics (Hermann & Vollmeyer, 2016; Lazarides & Watt, 2015; Lorenz et al., 2016; Ready & Wright, 2011). Notably, student characteristics explained little variance in expectations, as, for example, compared with De Boer et al.'s (2010) findings ($R^2 = .254$). Thus, other factors (e.g. student effort or teacher-related factors, such as teacher beliefs) could influence teacher expectations significantly (Brophy & Good, 1974; Wang et al., 2018). Regarding equality of opportunity, it might seem promising that student characteristics, (gender or SES) explain only 10% of the variance in teacher expectation bias. Nevertheless, 10% is sufficient to explain a certain degree of variance in teacher expectations. On the positive side, it should be noted that, SES does not correlate positively with students' end of year achievements if teacher expectations are taking into account (M3-M10). This means, SES is less important than teacher expectations for students' achievement.

4.2 | Student mathematics achievement and its relation to teacher expectations

The analyses indicated that high expectations have a positive relation with mathematics achievement. Low expectations inhibited achievement to the same extent that high expectations promoted achievement. This was in line with De Boer et al. (2010), Rubie-Davies et al. (2018) and Wang et al. (2018) who found that maximising expectations helps to fully develop students' talent. As shown in the results, students taught by teachers with high expectations were a whole semester ahead in terms of achievement as compared to students taught by teachers with low expectations. This is an important finding for teacher influence and their behaviour during lessons. Unlike in De Boer et al.'s (2010) study, no moderator effect was found in the current study, which again underlines the importance of ensuring high teacher expectations for all students, not just a specific (performance) group.

5 | STRENGTHS AND LIMITATIONS

A particular strength of this study was the emphasis on teacher expectation effect as a result of expectation levels and testing of student-related moderating effects. Student characteristics were taken into account to ensure that the expectation effect was not overestimated erroneously. Unlike reading and language learning, student learning in mathematics is more dependent on formal learning opportunities in school (Rubie-Davies et al., 2015). Therefore, student achievement

in mathematics is linked substantially with mathematics teaching, increasing the importance of the present study.

When interpreting the results, it should be noted that the analyses of the present contribution are based on the last two (of four) measurement time points of a sample within a longitudinal study. As a consequence, we cannot rule out a positive selection.

Further limitations which must be considered: The results relate to mathematics achievement among (Swiss) primary school students, so the findings may not be generalisable to other subjects, grades, or cultural backgrounds. Nevertheless, the results correspond with other research undertaken in other cultural contexts (e.g. Rubie-Davies et al., 2015), suggesting that the outcomes may be similar in other countries. There are two further limitations regarding the operationalisation of teacher expectations and student mathematics achievement. The end-of-year estimations made by teachers did not provide any information on causality between expectations and achievement. One advantage of assessing expectations at the end of the school year is that the teachers had at least 1 year to get to know their students (De Boer et al., 2010). According to Raudenbush (1984), this leads to more precise and possibly more sustainable expectations of student future performance. This particularly applies to the teachers in our sample, who were teaching their students for 1, 2, or 3 years. Therefore, they had known their students over the course of at least 1 year. Their expectations became increasingly less reliant on assumptions compared with initial estimations made when they had only known the students for a few weeks. The second limitation of operationalisation concerns the mathematical achievement tests that have no common metric across time points, due to the lack of anchor items. Although the data could be merged into one variable via z-standardisation (see the *Student mathematics achievement* section), future research projects should use the same test or a test design that allows common (IRT) scaling using anchor items. Key advantages of level-specific tests include curriculum-specific links to respective grade levels, broad content coverage and formulation of tasks adapted to grades.

6 | PRACTICAL IMPLICATIONS AND FUTURE RESEARCH

The results indicated that student prior achievement is an important predictor of primary student achievement in mathematics ($R^2_{\text{within}} = .57$). Factors such as SES are less important, particularly in relation to teacher expectations. This finding not only emphasises the importance of teacher expectations for students' learning at school, but may also provide a possible starting point for decoupling the connection between SES and learner success, thereby counteracting the consolidation of educational inequities.

Furthermore, it is notable that the variance between classes in terms of teacher expectation bias (27%) indicated that expectations vary between teachers. To counteract this variance, the positive influence of expectations on student achievement should be addressed in teacher training and in further education. For example, to enable teachers to reflect on their own expectations and gain awareness of possible expectation effects. Nevertheless, to implement the teacher

expectation effect in teacher training and further education, empirical evidence is needed with regard to how teacher behaviour in the classroom mediates high expectations. Rubie-Davies et al. (2015), for example, demonstrated that a warm classroom climate, clear goals and mixed or flexible groups mediate high expectations. Previous studies did not find evidence for the role of feedback or cognitive activation as a mediator for high expectations (Gentrup et al., 2020; Hollenstein, 2020). More research is needed to gain a better understanding of how teachers' behaviour can mediate high expectations.

More research is needed to examine the expectation effect in more detail. Intervention studies, for example, Rubie-Davies et al. (2015), De Boer et al. (2018) and Neuenschwander et al. (2021) showed that it is possible to learn the behaviour of high expectation teachers. In many studies of teacher expectations (including the current one) where SES is included, expectations are lower for those students from low SES. SES should be considered, especially with regard to the relation with teacher expectations. Future research could focus on ways to intervene in teachers' low expectations for low SES students. The present study's results correspond with Rubie-Davies et al. (2018) and Wang et al.'s (2018) assertion that all teachers should strive to maximise all students' achievement. The results show that all students (regardless of their SES and gender) can benefit from teachers who have high expectations of them. They could be up to a whole semester further in terms of achievement. Therefore, the consequences are substantial, and all teachers should have high expectations to all of their students.

ACKNOWLEDGEMENTS

The project was funded by Swiss National Science Foundation (Project Number: 100019_146172). The Open Access publication of this article was funded by the Open Access Publication Fund of the St. Gallen University of Teacher Education (PHSG). The authors thank Dr. Catherine Ferris for proofreading the article.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

Written informed consent was obtained from the parents and the teachers for the data collection. On the day of the survey, the children could decide independently whether they wanted to participate or solve another task in another room or in another class. All subjects gave their informed consent for inclusion before they participated in the study. The consent was approved by the legal office of the St. Gallen University of Teacher Education. There is no ethics committee established at the St. Gallen University of Teacher Education, therefore no approval could be obtained. The St. Gallen University of Teacher Education upholds the regulations of the Swiss Academies; these were followed throughout.

TRANSPARENCY STATEMENT

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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How to cite this article: Hollenstein, L., Brühwiler, C., & König, J. (2024). Who benefits the most? Teacher expectations and their relation with students' achievement in mathematics in primary school. *European Journal of Social Psychology*, 54, 658–669. <https://doi.org/10.1002/ejsp.3035>