



Instructional Leadership as a Vehicle for Teacher Collaboration and Student Achievement. What the German PISA 2015 Sample Tells Us

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We investigated the effects of principal instructional leadership (IL) on the frequency of two forms of teacher collaboration (TC) namely exchange and coordination of teaching (EXCHT) and professional collaboration (PROFCOLT) and their influence on student achievement (SA). Using data from the representative German PISA 2015 sample, we carry out structural equation modeling analysis to estimate the direct effects of IL on TC and of TC on SA, as well as the indirect effects of IL on SA. The analyses were conducted at the school level and only teachers belonging to the non-science group in PISA 2015 were included. After testing for the factorial validity of the instrument, only the collaboration form (EXCHT) could be retained. Our analysis suggests that principal instructional leadership can positively influence teachers' collaboration frequency and that the remaining form of teacher collaboration is not positively related to student achievement. Our study builds on and extends research on student achievement by adding evidence about the relations between principal leadership and teacher collaboration in Germany.

Keywords: instructional leadership, teacher collaboration, student achievement, Germany, PISA 2015, structural equation modeling, mathematics, reading

1 INTRODUCTION

School reforms around the world have historically placed student achievement at their core. Consequently, principals in their roles as schools' leaders and teachers who ultimately are responsible for instruction are expected to develop practices that lead to increased student performance (Hess and Kelly, 2007; Glanz and Zepeda, 2016). This has led to greater accountability for principals to focus on instructional leadership and for teachers to collaborate (Hallinger, 2005) as these two aspects are fundamental characteristics of effective schools (Scheerens 1990; Scheerens and Bosker, 1997; Teddlie and Reynolds, 2000). Research has shown on the one hand that leadership can positively influence teachers' commitment (Devos et al., 2014), teachers' professional learning (Liu and Hallinger, 2018), teachers' job satisfaction (Leithwood et al., 2008; Cogaltay et al., 2016; Schwartz, 2017) and teacher self-efficacy (Fackler and Malmberg, 2016). Additionally, empirical studies in the past years have shown indirect effects of principal leadership on student achievement which ultimately is mediated through teachers (c. f. Chang, 2011; Hallinger and Heck, 1998; Mascall, Leithwood, Straus, and Sacks, 2008). On the other hand, teacher collaboration has been consistently shown in the literature as a fundamental factor for the improvement of student achievement (cf. Louis et al., 2010a; Goddard et al., 2010; Dumay et al., 2013). Professional learning

communities (PLCs) provide a platform, where these two aspects can be accomplished as they provide their members with opportunities to develop themselves professionally in a climate of collaboration, allowing teachers to learn mutually by sharing their knowledge (Hord and Hirsch, 2008) which in turn can lead to increased student achievement (cf. Resnick, 2010; The Wallace Foundation, 2013).

In Germany the relevance of school leadership has gradually increased in the past years (Huber, 2016). Yet, studies concerning the role of principal instructional leadership as a main focal point or as part of a bigger construct tend to be scarce (cf. Huber et al., 2013; Brauckmann et al., 2016; Klein, 2016). Additionally, Brauckmann et al. (2014) state that there is “an overall level of uncertainty concerning the tasks and the emerging role of school management” (p. 52). However, literature consistently identifies principals as one of the main sources for the successful implementation of change in schools (Leithwood and Day, 2007; Carrier, 2011) and teachers as “the major players in the education process” (Hattie, 2012, p. 25) making further research of paramount importance. Consequently, in this paper, by using the German sample of the representative data from PISA 2015 (Reiss et al., 2019) we investigate the relationship between principals’ instructional leadership and two forms of teacher collaboration namely exchange and coordination of teaching and professional collaboration. From the wide range of identified forms of principal leadership, our focus lies on the instructional approach because the primary focus of this style is the improvement of teaching and learning, in other words the improvement of teachers’ qualities and student achievement. Additionally, we would like to test the influence that these forms of collaboration have on student achievement measured in the subjects of mathematics and reading as well as the indirect effects of instructional leadership on student achievement.

2 THEORETICAL BACKGROUND

The role that school principals play in schools is a determinant factor for the development of all its members. They are largely responsible for creating the necessary conditions that support both teaching and learning (Hallinger, 2018), thus they must establish, adapt and encourage instructional quality (OECD, 2016a). McHenry (2009) states: “although teachers are the key players in the act of collaboration, school leaders have an important responsibility to foster an environment in which collaboration can be successful” (p. 95). Their leadership role is a fundamental element of schools wanting to be more effective in educating its students, as through their leadership, teachers’ motivations and abilities are positively influenced, which ultimately will result in improved school outcomes (Pont et al., 2008). It is expected that principals are leaders of instruction (Zepeda et al., 2017). It must be stressed, however, that this is not an easy feat to accomplish, given that by shifting to an instructional model, principals have to take more responsibilities to improve instruction and still stay in a managing role capacity, which will put inevitably more pressure on them (Timperley, 2005). Furthermore, in the

current school reform climate a tension between principals’ autonomy and accountability arises with a tendency to have more of the latter (Steinberg, 2013), which may be an obstacle for principals to reach their goals, since schools which have a mixture of both of them have been identified to have better student performance (OECD, 2011). For the German context it cannot be go unnoticed that principals’ “influence is restricted as teachers are quite free to make didactical and methodical decisions in their own right” (Huber, 2016, p. 376) and because of the enormous influence that the “Lehrerkonferenz” (staff conference) on matter of decision-making has, principals’ authority is even more limited (ibid).

A growing body of research suggests that student achievement can be substantially influenced by principals and school leadership (cf. Marzano et al., 2005; Dhuey and Smith, 2014). However, a direct influence is rather unlikely. For instance, Gaziel (2007), in a study conducted in 32 secondary schools in Israel, came to the conclusion that IL influences teachers and school culture directly but its impact upon student achievement is indirect. Goddard et al. (2010) came to a similar conclusion as they found significant direct effects of leadership on teacher collaboration and of teacher collaboration on student achievement. These conclusions are complemented by Bush and Glover (2002) as they state that student learning is accomplished through teachers and also by Leithwood et al. (2008) who write: “school leaders improve teaching and learning indirectly” (p. 32). However, the influence that principals have depends largely on the style of leadership adopted; furthermore, the context determines to a great extent how good it can be (Hallinger, 2003).

Although several forms of leadership have been identified (cf. Bush, 1995; Leithwood et al., 1999; Bush and Glover, 2002), the literature differentiates between two major, predominant forms namely: instructional and transformational leadership (Hattie, 2008; Robinson et al., 2008). From these two forms, according to Bush (2013), instructional is “the longest established concept linking leadership and learning” (p. 6). The main difference between these two forms is that principals who exercise a transformational style do not guide curriculum and instruction, and student learning is not supervised, whereas principals with an instructional style take care that student learning is supervised, and additionally enforce professional development activities as well as coordination and accomplishment of instructional goals (Hallinger, 2003). Even though there is no single leadership model that guarantees success (Day et al., 2016) and effective principals use a mixture of them, as they depend on context (Belchetz and Leithwood, 2007), research has identified instructional leadership (IL) as the form with more influence on student achievement. For instance, Robinson et al. (2008), in their meta-analysis comparing transformational and instructional leaders, found that the influence of the latter was four times larger than the former. Hallinger (2011) expands these findings and considers instructional leadership to be a development building block of effective schools, while UNESCO (2016) recommends that the promotion of “a common understanding and interpretation of the concept of school leadership, particularly instructional leadership, among

all education stakeholders is necessary” (p. 210). Teachers’ motivation, loyalty and satisfaction are among the factors that are influenced by principals that use IL (Blase and Kirby, 2009; Thoonen et al., 2012).

The results from TALIS 2008 and 2013 show that in several countries where principals use IL as a management style, teachers are more likely to work together in forms that vary from cooperation activities such as administrative tasks to more complex forms of collaboration such as reciprocal peer observation of instruction or team teaching (OECD, 2009a; OECD, 2016b). Throughout the years, research on teacher collaboration has identified various forms and levels of collaboration which vary from exchange of materials and ideas to mutual preparation of lessons or joint teaching (cf. Little, 1990; Gräsel et al., 2006; Steinert et al., 2006; Frey et al., 2009). For our study, we will investigate the two forms of collaboration proposed by PISA 2015, namely Exchange and Coordination of Teaching (EXCHT) which refers to elements that promotes the common development of didactical skills such as the exchange of materials and/or how to assess student performance, and Professional Collaboration (PROFCOLT) which include aspects related to joint teaching, observation of teaching and providing feedback to colleagues.

The term IL encompasses practices related to the planning, evaluation and co-ordination of instruction and is characterized by the collegial practice of collaboration in order to improve the quality of teaching and learning (Hopkins, 2001; OECD, 2016b). Furthermore, Southworth (2009) states that principals can also influence student achievement through three processes: modeling, monitoring and dialogue. Day et al. (2016) argues that establishing clear educational goals, planning the curriculum, and evaluating teachers and teaching are primary components of instructional leadership. Another complementing view on these characteristics is seen, for example, in an instructional leadership program offered for public schools in Nova Scotia, where the core content focuses on increasing knowledge, skills, and competencies around the seven standards namely: vision for instruction, leading and managing change, collaborative learning culture, professional learning, high quality instruction, understanding and using data to improve instruction and a positive learning environment (NSILA, 2018).

In one of the first frameworks of IL, Hallinger and Murphy (1985) define and propose three major leadership functions for principals: 1) define the school mission, 2) manage the instructional program and 3) create a positive school climate. These functions are accomplished by the following processes: 1) the establishment and communication of goals, 2) the evaluation of instruction, coordination and supervision of curriculum, and 3) the promotion of professional development activities for teachers as well as protection of the instructional time. Following this line, a more recent framework of school leadership by Marzano et al. (2015) emphasizes the importance of IL for the development of schools and as a vehicle to support student achievement. He proposed a five-domain School Leader Evaluation including: 1) a data-driven focus on student achievement; 2) continuous improvement of instruction; 3) a guaranteed and viable curriculum; 4)

cooperation and collaboration; and 5) school climate. In this work, the core and non-negotiable focus and goal is the improvement of student learning which as stated by Louis et al. (2010b) is significantly but indirectly influenced from principal leadership, given that leadership first support professional [learning] communities (PLC) which in turn creates a “school climate that encourages levels of student effort above and beyond the levels encouraged in individual classrooms” (p. 37), while nurturing professional and instructional practices, such as teacher collaboration which is directly related to student achievement (cf. Goddard et al., 2007; Lara-Alecio et al., 2012; Ronfeldt et al., 2015). These are among the reasons why research consistently, on the one hand endorses PLCs as a fundamental element for the further development of the school and the improvement of student achievement (cf. Saphier, 2005; Vescio et al., 2008; Farbmán et al., 2014), and on the other hand identifies leadership as a building block of such communities, as a lack of it usually leads to its collapse (DuFour et al., 2016). For instance, DuFour and Marzano (2011) argue that “creating a PLC will always require a collective effort, but the fate of that effort will depend to a large extent on the leadership capabilities of the principal” (p. 37).

A PLC as defined by DuFour et al. (2016) is “an ongoing process in which educators work collaboratively in recurring cycles of collective inquiry and action research to achieve better results for the students they serve” (p. 5). That is, the central idea behind PLCs is that students learn more and perform better when their teachers work together. As García-Martínez et al. (2018) put it, “authentic professional learning communities in schools [...] will involve the recompositing of the dynamics centered in the institutional bureaucracy, toward an instructional model” (p. 10). Embedded in a PLC lies, therefore, a focus on IL as it provides structures that support school’s improvement efforts (DuFour and Fullan, 2013) which are mainly focused on improving student learning through professional development activities for teachers such as teacher collaboration.

DuFour et al. (2016) define teacher collaboration as a standardized and structured process that allows teachers to work by relying upon each other to positively influence their classroom practice, which will have benefits for themselves, their students and their schools. It plays a major role for teachers in their professional lives by providing opportunities to reflect on their teaching practice as well as to improve it (OECD, 2016a; de Jong et al., 2019), and is a decisive element to support the improvement in student learning (Poulos et al., 2014). For instance, Griffin et al. (2010) found that when teachers focus on student development rather than resources or skills, they were able to positively influence students’ reading comprehension. Furthermore, teachers’ effectiveness can be significantly raised over time (Kraft and Papay, 2014) as well as teachers’ self-efficacy and collective efficacy (Durksen et al. (2017) and improvement of instructional quality (cf. Hochweber et al., 2012). It must be noticed that not all forms of collaboration are necessarily positively related on every aspect of the school. For instance, Mora-Ruano et al. (2019) showed a negative relationship between

the exchange form of collaboration and student achievement. Therefore, enhancing such types of collaboration may fail to increase student achievement.

Although literature on principal leadership in Germany can be found already in the 80s, most of it comes from the 90s and the 00s (see Huber, S. G., 2016 for a detailed review), making further research on the topic of critical importance. We could not find any studies in this decade that have investigated the links between instructional leadership, teacher collaboration and student achievement in Germany. Consequently, our study could shed some light on a topic where research seems to be scarce.

3 RESEARCH QUESTION AND HYPOTHESIS

Through our literature review, we identified specific factors that are influenced by principal instructional leadership, PLCs and teacher collaboration. In this study we would like to assess: 1) to what extent does instructional leadership influence teacher collaboration (measured in the form “exchange and coordination of teaching” EXCHT), 2) to what extent does instructional leadership influence teacher collaboration (measured in the form “professional collaboration” PROFCOLT) and 3) to what extent does these forms of teacher collaboration influence student achievement (measured in the scores of mathematics and reading from PISA 2015). We hypothesize that 1) instructional leadership has a significant effect on teacher collaboration regardless of the form; and 2) none of the investigated forms of collaboration has an effect on student achievement, because these forms are not specifically aimed at student achievement, so it may be positively related to other aspects.

4 METHODS

4.1 Design

PISA uses a multi-layered (stratified) probability sample from a list of all schools provided by the 14 Länder’s Statistical Offices in Germany. This stratified sample design follows two stages where first, schools are randomly selected, and then within each selected school, classes, students or teachers are randomly selected (Sälzer and Reiss, 2016). For a detailed report of the design used in PISA 2015 (see *ibid*; OECD, 2017).

4.2 Participants

In Germany a total of 6,504 students and 5600 teachers (2031 science (16.5%), 3569 non-science (29%)) and 253 principals (which represent the total schools surveyed) took part in PISA 2015. These samples cover both the lower secondary level (Sekundarstufe I) as well as vocational and schools for students with special needs. For a detailed report of the participating schools in PISA 2015 in Germany, see Heine et al. (2016). Given a) the focus of our study and b) the nature of our research questions, for our analyses we a) matched the three datasets (school, teacher and student) into a

single one, where the data was aggregated at the school level and b) we selected only teachers who belong to the non-science group because it has a larger sample size than the teachers’ science group, which allows us to better interpret the results and additionally because this group of teachers were asked originally two rate two forms of collaboration. These two procedures resulted in a final sample of 185 schools (including all school forms). As we are working with aggregated data at the school level, it must not go unnoticed that both the teacher sample (3569 non-science teachers, 67.2% female, 31.3% male, 1.5% no answer, with a mean age of 44.9); and the student sample (6,504 students) are effectively averaged.

4.3 Measures

Principal Leadership

In PISA 2015 principal leadership is measured in the school questionnaire through scale SC009 (Tables A1, A2), which consists of 13 items where principals should indicate the frequency of leadership activities and behaviors during the last academic year. From the items, four indices were constructed by PISA, namely: curricular development (LEADCOM, four items), instructional leadership (LEADINST, three items), professional development (LEADPD, three items), and teachers’ participation (LEADTCH, three items). Given that our interest lies in instructional leadership, the index LEADTCH was excluded from the analyses because this index is related to distributed leadership. A WLE-Score for each of the scales was provided. PISA provides weighted likelihood estimates (WLE) for contextual indices, which are constructed from the questionnaires. This estimate is preferred for the estimation of an individual’s ability as it corrects the inherent small bias that MLE provides (OECD, 2009b). Although PISA 2015 treats LEADINST as the only index for instructional leadership, the wording of the items belonging to LEADCOM and LEADPD as well as the descriptions of these indices, are actually defined in the literature as instructional leadership. For this reason we keep these variables as measures of instructional leadership for the analyses.

Teacher Collaboration

The frequency of collaboration among teachers belonging to the non-science group is measured in the teachers’ questionnaire through scale TC0046. This question is comprised of eight items (Tables B1, B2), from which two indices were constructed by PISA namely: exchange and coordination of teaching (EXCHT, four items) and professional collaboration (PROFCOLT, four items). As opposed to the scales of the school questionnaire where a WLE for every scale was provided, in this section only a WLE for the EXCHT scale was available.

Student Achievement

Given that one of our aims is to identify the effect of teacher collaboration on student achievement, this dependent variable is represented by student test scores in the domains of mathematics and reading, as assessed in the PISA 2015 test. “The [...] assessment of mathematics focuses on measuring students’ capacity to formulate, use and interpret mathematics in a

variety of contexts [whereas] the assessment of reading focuses on students' ability to use written information in real-life situations" (OECD, 2016c, p. 146, 176). The student dataset contains 10 plausible values (PVs) depicting the children's ability in these two competences. For our analysis we used only the first PV provided because in large samples "using one [...] or five plausible values does not make any substantial difference in the [...] mean estimates [...] as well as in the [...] standard error estimates" (OECD, 2009b, p. 44). "PVs are multiple imputations drawn from a posterior distribution by combining the IRT scaling of the test items with a latent regression model using information from the student context questionnaire in a population model" (OECD, 2017, p. 128) this methodology "aims to increase the accuracy of the estimates of the multivariate proficiency distributions for various subpopulations and the population as a whole" (ibid p. 145).

4.4 Analysis

In order to answer our research questions, we carry out a secondary analysis of the representative German PISA 2015 data (Reiss et al., 2019). All analyses were conducted using the software package Mplus 7.2 (Muthén and Muthén, 1998-2017). Given that we would like to investigate the direct effects of principal instructional leadership (IL) on teacher collaboration (TC), and of TC on student achievement (SA), as well as the indirect effects of IL on SA, our primary data analysis method is structural equation modeling (SEM). This technique allows us to test the structural relationship between measured variables and latent constructs, by running simultaneous analyses such as confirmatory factor analysis, linear regression and path estimates (cf. Bentler, 1988; Bollen, 1989; Byrne, 2016). This model is comprised of a measurement model, defining the latent constructs and a structural model, defining the relationships among the latent variables (Bollen, 1989). In order to assess model fit, following Brown (2006) and Kline (2016) recommendations, four fit indices were used: the Tucker-Lewis Index (TLI; Tucker and Lewis, 1973), the comparative fit index (CFI; Bentler, 1988), the root mean-square error of approximation (RMSEA; Steiger and Lind, 1980), and the standardized root mean square (SRMR). We considered values of CFI > 0.95, TLI < 0.95, RMSEA < 0.08, and SRMR < 0.08 to be a good fit, whereas values of CFI > 0.90, TLI < 0.90, RMSEA < 0.10, and SRMR < 0.10 are considered an acceptable fit (Hu and Bentler, 1999; Hair et al., 2014; Kline, 2016).

Given that we wanted to conduct our analyses at the school level, also integrating variables from the teacher questionnaire, an intraclass correlation analysis was carried out in order to establish whether a model at this level made sense. By using the school variable as cluster, the results of this analysis revealed high correlations levels among the teacher's variables, ranging from 4.6 to 28.6% suggesting the appropriateness of modeling at the school level. Additionally, following Anderson and Gerbing's (1988) suggestion, before modeling the structural model, we conducted separate confirmatory analyses for the constructs IL and TC, in order to ensure that these latent variables were adequately measured. We used the MLR-Estimator because it provides robust statistics in the presence of incomplete and/or

TABLE 1 | Results of CFAs of measurement models of IL and TC (separated and together).

	χ^2	Df	p	CFI	TLI	RMSEA	RMSEA CI ₉₀	SRMR
IL	2.988	2	0.224	0.996	0.987	0.050 ^a	0.000–0.159	0.021
TC	83.662	19	0.000	0.822	0.738	0.117 ^b	0.092–0.143	0.071
IL and TC	9.739	8	0.283	0.995	0.991	0.029 ^c	0.000–0.083	0.035

^ap = 0.379.

^bp < 0.05.

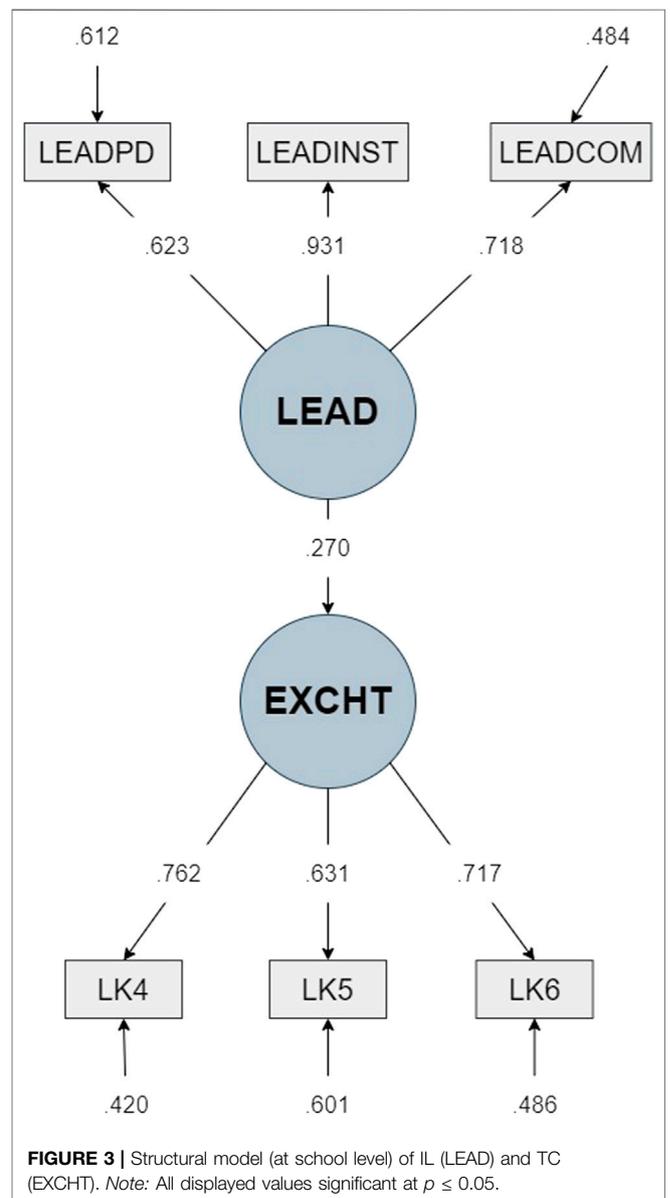
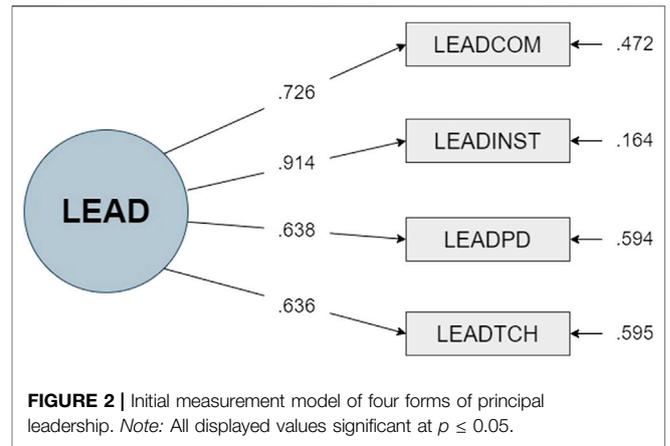
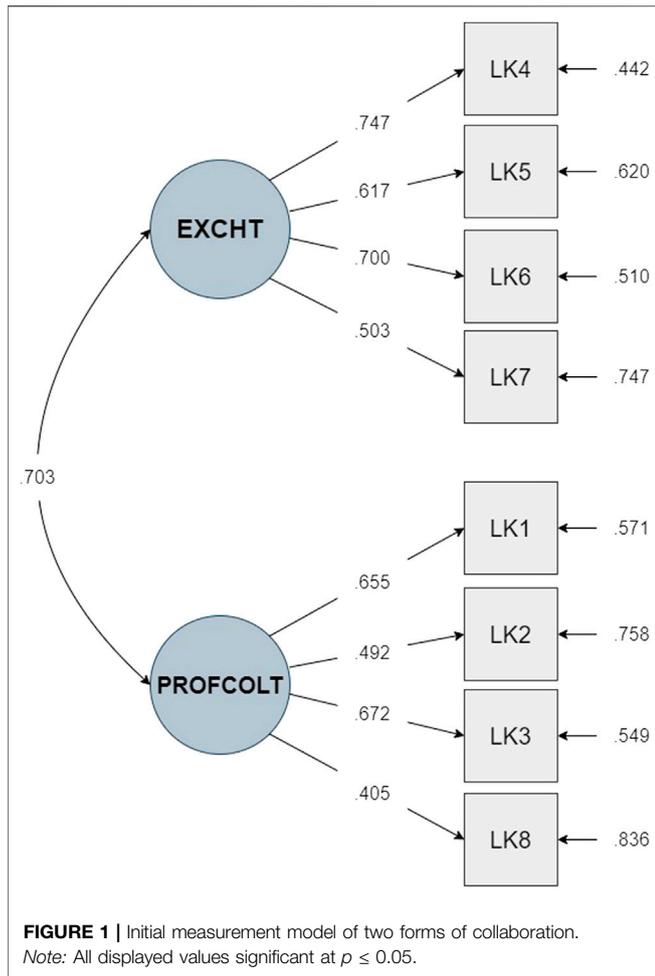
^cp = 0.677.

non-normal data (Lei and Shiverdecker, 2019). Hypothesis testing was conducted at significance level of $p < 0.05$. **Table 1** shows the results of the final measurement model of both IL and TC as well as the separated CFAs of the constructs IL and TC which revealed that the construct TC was not adequately measured, consequently a re-specification was needed.

As already mentioned, PISA provides WLEs for all measured constructs such as principal leadership, its separated forms (instructional, distributed, etc.) and teacher collaboration. Although in PISA 2015 two forms of collaboration were collected, only one WLE was provided, namely EXCHT (exchange and coordination of teaching). For this reason, the CFA on TC was conducted using the items that measured each form whereas principal leadership was measured (in this first confirmatory step) by using all the four WLEs provided by PISA, although the final model will only contain the three forms belonging to our interest, namely LEADCOM, LEADINST, LEADPD. As can be seen in **Figure 1**, the factor loadings of items belonging to EXCHT loaded reasonably well with the exception of item LK7, while the construct PROFCOLT had two items which because their low factor loadings warranted deletion. However, given that latent variables should be represented by a minimum of three observed variables (Brown, 2006) and faced with the fact that no WLE for this construct was provided, we exclude it from our analyses. We also excluded the item LK7 of the EXCHT construct because it contributed to a misspecification of the model. CFA of the measurement model belonging to principal leadership (**Figure 2**) yielded good and acceptable factor loadings. As already mentioned, given that LEADTCH does not belong to the construct IL, it was excluded from the final analyses. **Figure 3** shows the final structural model of IL and TC.

5 RESULTS

We tested the extent to which teacher collaboration and instructional leadership mediated by collaboration influence student achievement, measured using the PISA-2015 scores in math and reading. Our analyses yielded statistically positive direct links between instructional leadership and collaboration (standardized coefficient = 0.273), but negative significant effects from collaboration and math (standardized coefficient = -0.429)



and collaboration to reading (standardized coefficient = -0.397) scores; this is the case also for the indirect effects from instructional leadership to math (standardized coefficient = -0.117) and reading (standardized coefficient = -0.108). All of these effects were significant. A detailed report of both direct and indirect effects can be seen in **Table 2**. Overall, the model (**Figure 4**) produced a good fit of the data, $\chi^2 = 35.596$ ($p < 0.05$), $df = 16$, $CFI = 0.980$, $TLI = 0.965$, $RMSEA = 0.069$ (90% CI = $0.038-0.100$) $PCLOSE = 0.138$, $SRMR = 0.061$.

6 DISCUSSION

Our findings contribute to a growing body of literature that supports the notion that principals play a positive significant role with regard to the collaboration practices of teachers and that specific forms of teacher collaboration are not necessarily positively related with student achievement. This becomes apparent given the negative relationship we found between the exchange and coordination of teaching and the mathematic and reading proficiencies in Germany.

On the one hand, our results are in line with previous studies which investigated the link between instructional leadership and

TABLE 2 | Standardized factor loadings and significance values of the final model.

	Std. β	S.E.	β	p-value
EXCHT by				
LK4	0.774	0.052	14.761	*
LK5	0.620	0.052	11.832	*
LK6	0.714	0.058	12.268	*
LEAD by				
LEADCOM	0.718	0.050	14.283	*
LEADINST	0.935	0.044	21.022	*
LEADPD	0.618	0.055	11.191	*
EXCHT on				
LEAD	0.273	0.082	3.338	*
MATH on				
EXCHT	-0.429	0.064	-6.742	*
LEAD	0.108	0.077	1.410	0.159
LEAD ^a	-0.117	0.042	-2.819	**
READ on				
EXCHT	-0.397	0.067	-5.955	*
LEAD	0.111	0.077	1.442	0.149
LEAD ^a	-0.108	0.040	-2.742	**
READ with				
MATH	0.951	0.006	156.540	*

EXCHT, Teacher Collaboration (Exchange and Coordination); LEAD, Instructional Leadership; LEADCOM, curricular development; LEADINST, instructional development; LEADPD, professional development.

*Significant at $p < 0.001$; ** significant at $p < 0.01$.

^aIndirect effect mediated by Collaboration.

teacher collaboration (cf. Robinson et al., 2008; Goddard et al., 2010), which demonstrated a positive connection between these two variables. On the other hand, our results remain consistent with the results from Mora-Ruano et al. (2019), who, by analyzing

the PISA 2012 data, showed that exchange of materials was not positively related with student achievement. Because of nature of the data we worked with (cross sectional), no causal relationships can be drawn and therefore, the direct negative effects from teacher collaboration to student achievement we found do not necessarily mean that the higher the frequency of teacher collaboration, the lower the scores in mathematics and reading will be. These results point out that this specific form of collaboration is not related to student achievement. However, it might be of critical importance that when both principals and teachers want to have a positive influence on student achievement, the focus must be shifted to other forms of teacher collaboration that deal specifically with student achievement. The negative indirect effect from instructional leadership to student achievement mediated through teacher collaboration also supports this interpretation.

A major limitation of our study warrants attention. Although in PISA 2015 two forms of teacher collaboration were measured, one of the investigated forms proved to be problematic for the specification of the instrument and could not be retained, meaning that some information was lost and therefore we could not test our hypothesis regarding the rejected form of collaboration. By only retaining one form, we were able to deliver a valid model to investigate direct effects of IL to TC, of TC to SA and indirect effects of IL to SA. Future studies should make sure that the forms of teacher collaboration that are formulated and investigated in a questionnaire, can be fully included in more complex statistical models given that collaboration comprises several complex forms of interactions from which different aspects of the school can be influenced and therefore by

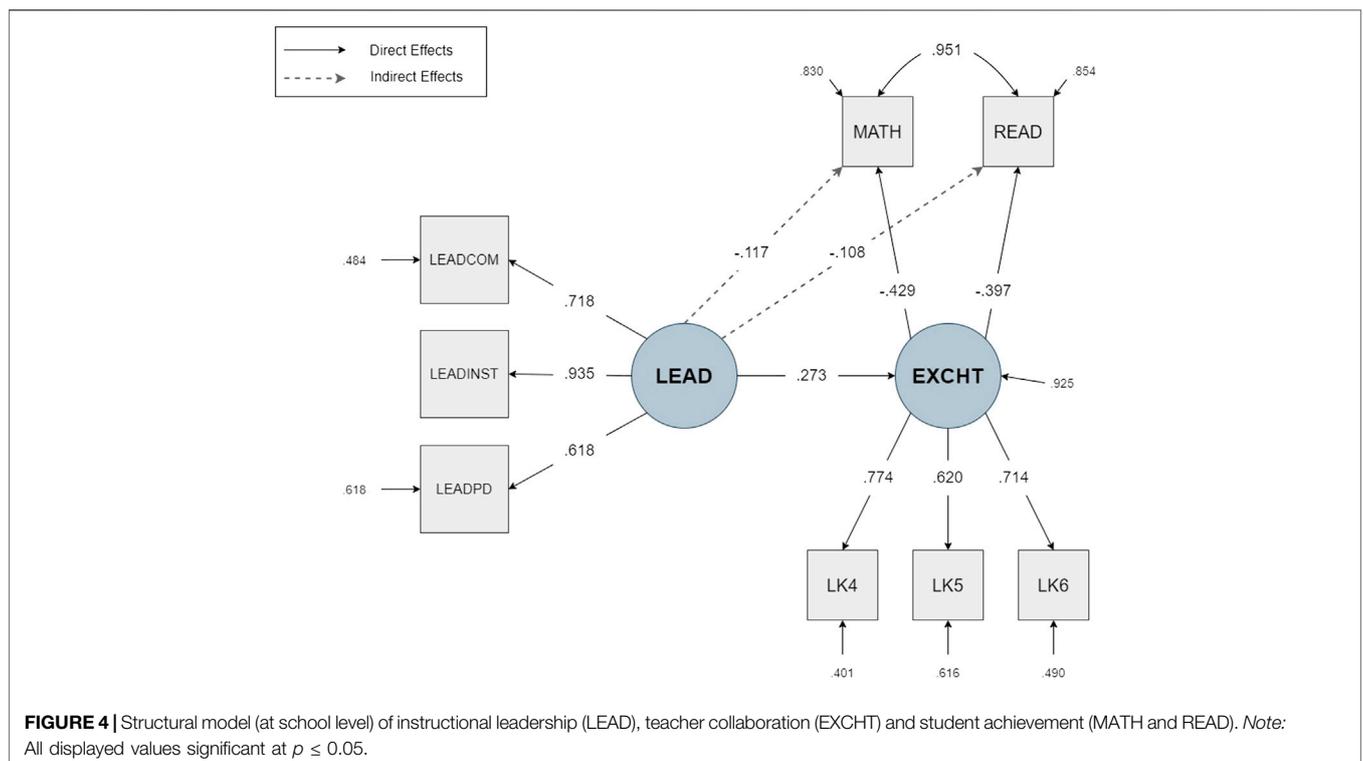


FIGURE 4 | Structural model (at school level) of instructional leadership (LEAD), teacher collaboration (EXCHT) and student achievement (MATH and READ). Note: All displayed values significant at $p \leq 0.05$.

investigating only one form valuable information will be lost. For practitioners, specifically for the German context where the pedagogical freedom that teachers possess must be taken into account, our findings suggest that principals' influence in matters of instruction should not be hampered because of this freedom. Furthermore, our results indicate that by reinforcing the focus on instruction, principals can boost teachers' collaborative practices, which depending on its form will have an impact in their teaching practice, student achievement and other aspects.

7 CONCLUSION

The aim of this study was to investigate the links between instructional leadership, teacher collaboration and student achievement by analyzing the representative PISA 2015 data in Germany. Although some part of the data proved to be problematic and only one form of collaboration could be retained in our final model, we could establish a positive relationship between instructional leadership and teacher collaboration and that the teacher collaboration form we were able to investigate is not positively related to student achievement. These results could and should be expanded in future studies by the inclusion of more forms of collaboration as well as more forms of leadership styles.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: A written permission to access and use the data for scientific purposes was necessary through the German Research Data Center (FDZ) at the Institute for Educational Quality

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- Improvement (IQB). Requests to access these datasets should be directed to <https://www.iqb.hu-berlin.de/fdz>.

ETHICS STATEMENT

Ethical approval was not provided for this study on human participants because as per OECD guidelines and German national regulations (KMK) no new ethics approval was required. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JM: Drafted the manuscript, wrote the literature background, performed and interpreted the statistical analyses. MS: Provided expertise on data analysis and performed some of these analyses (i.e., aggregation of data). EW: Provided input on the conception of the study and contributed to manuscript revision.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX A

TABLE A1 | Instructional leadership questionnaire information.

Construct	Instructional leadership
Item text	Below are statements about your management of this school. Please indicate the frequency of the following activities and behaviors in your school during <the last academic year>
Data source	School questionnaire
Answer format	Rating scale
Literature/remarks	Scale parameters here refer to KTT. The index in the dataset was based on the IRT (see OECD, 2017)
Number of items	13
Categories	1 = did not occur 2 = 1–2 times during the year 3 = 3–4 times during the year 4 = once a month 5 = once a week 6 = more than once a week

TABLE A2 | Instructional leadership questionnaire items.

Item ID	Item text
Q01 ^a	I use student performance results to develop the school's educational goals
Q02 ^a	I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school
Q03 ^a	I ensure that teachers work according to the school's educational goals
Q04 ^b	I promote teaching practices based on recent educational research
Q05 ^b	I praise teachers whose students are actively participating in learning
Q06 ^c	When a teacher has problems in his/her classroom, I take the initiative to discuss matters
Q07 ^b	I draw teachers' attention to the importance of pupils' development of critical and social capacities
Q08 ^c	I pay attention to disruptive behavior in classrooms
Q09 ^d	I provide staff with opportunities to participate in school decision-making
Q10 ^d	I engage teachers to help build a school culture of continuous improvement
Q11 ^d	I ask teachers to participate in reviewing management practices
Q12 ^c	When a teacher brings up a classroom problem, we solve the problem together
Q13 ^a	I discuss the school's academic goals with teachers at faculty meetings

^aDimension "curricular development".

^bDimension "instructional development".

^cDimension "professional development".

^dDimension "teachers' participation".

APPENDIX B

TABLE B1 | Teacher collaboration questionnaire information.

Construct	Teacher collaboration (forms)
Item text	On average, how often do you do the following in this school?
Data source	International questionnaire for teachers
Answer format	Rating scale
Literature/Remarks	Klingebliel and Klieme (2016). Scale parameters here refer to KTT. The index in the dataset was based on the IRT (see OECD, 2017)
Number of items	8
Categories	1 = Never 2 = once a year or less 3 = 2–4 times a year 4 = 5–10 times a year 5 = 1–3 times a month 6 = once a week or more

TABLE B2 | Teacher collaboration questionnaire items.

Item ID	Item text
LK1 ^a	Teach jointly as a team in the same class
LK2 ^a	Observe other teachers' classes and provide feedback
LK3 ^a	Engage in joint activities across different classes and age groups (e.g., projects)
LK4 ^b	Exchange teaching materials with colleagues
LK5 ^b	Engage in discussions about the learning development of specific students
LK6 ^b	Work with other teachers in my school to ensure common standards in evaluations for assessing student progress
LK7 ^b	Attend team conferences
LK8 ^a	Take part in collaborative professional learning

^aDimension "professional collaboration".

^bDimension "exchange and coordination of teaching".