Teacher support in learning: Instrumental and appraisal support in relation to math achievement

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This study explored the extent to which teachers' instrumental (i.e., tangible aid to promote learning) and appraisal support (i.e., teacher feedback) enhanced students' achievement in mathematics. Participants included 13,950 fifteen-year-old Canadian students who participated in the 2012 Programme for International Student Assessment. Based on students' reports, results from hierarchical regression analyses showed that instrumental support and teacher feedback respectively positively and negatively predicted math achievement. Further, teacher feedback made an additional contribution to math achievement over and above instrumental support. Findings suggest that different types of teacher support might differ in their efficacy in promoting math achievement.

Introduction

There is little doubt that teacher support is conducive to student outcomes, such as academic achievement (e.g., Niehaus, Rudasill & Rakes, 2012; Sakiz, Pape & Hoy, 2011), task persistence (Pakarinen et al., 2014), attendance (Klem & Connell, 2004), and learning motivation (e.g., Ahmed, Minnaert, van der Werf & Kuyper, 2010). According to Tardy's (1985) hierarchical model of social support that was developed based on previous literature (e.g., House, 1981), support comes from an intricate network that encompasses multiple sources (e.g., parents and the community), and can be distinguished into four major types, including emotional, informational, instrumental, and appraisal. Linking this model to the context of teaching and learning means that teachers can also provide different forms of social support to students, with each uniquely influencing students' attitude and behaviours (Tennant et al., 2015). Emotional support reflects the perception that teachers are approachable, warm and encouraging (Malecki & Demaray, 2003), such as when students feel that they are cared for by their teachers (Malecki, Demaray & Elliott, 2000). Informational or instructional support refers to the offering of guidance or information that can be used to solve a given problem (Malecki et al., 2000; Suldo et al., 2009). Instrumental support can be regarded as the provision of tangible support that aims to enhance learning (Suldo et al., 2009; Tennant et al., 2015), such as when teachers dedicate time to explain unknown concepts to students. Lastly, appraisal support involves the provision of evaluative feedback, such as constructive criticism or suggestions for improvements (Malecki & Demaray, 2003; Suldo et al., 2009). In other words, teacher support is multidimensional (Anderman, Andrzejewski & Allen, 2011; Suldo et al., 2009; Tennant et al., 2015).

Despite the comprehensive nature of teacher support, research to date has focused mainly on instructional (Hamre & Pianta, 2005; Hübner, Nückles & Renkl, 2010; Kikas & Mägi, 2016; Kiuru et al., 2015) and emotional support (Kikas & Mägi, 2016; Ruzek et al., 2016; Wentzel, Russell & Baker, 2016) in relation to academic-related outcomes. Accordingly,

recent studies have contended a need to examine other types of teacher support essential to student outcomes (Suldo et al., 2009; Tennant et al., 2015). The primary objective of the present study was thus to respond to this call within the context of mathematics achievement. On the basis that math is a subject that requires a cumulative understanding and the provision of feedback (Kikas & Mägi, 2016), this study considered two relevant, but distinctive, forms of teaching support, including instrumental and appraisal support (i.e., the use of feedback). Not only would this consideration provide extensions to the limited literature that primarily has explored math achievement primarily in relation to teachers' instructional and emotional support (Ottmar, Decker, Cameron, Curby & Rimm-Kaufman, 2014; Wagner et al., 2016), but it would also provide suggestions to educators in terms of which type(s) of support might play a more integral role in math outcomes.

Instrumental support

Instrumental support is typically characterised by teachers' provision of tangible resources that serve to facilitate students' learning (e.g., spending time to ensure learning, providing enrichment activities or opportunities for student collaboration) (Perry, VandeKamp, Mercer & Nordby, 2002; Suldo et al., 2009). When students perceive a sense of instrumental support from their teachers, they are more likely to engage with assigned tasks (Strati, Schmidt & Maier, 2017), and to value them (Assor, Kaplan & Roth, 2002). These students are also likely to demonstrate self-regulated learning (Perry et al., 2002). In corroboration, a one-year longitudinal study examining students' perception on different aspects of the school environment found a link between teachers' behaviours (e.g., instrumental support and clarity of expectations) and students' achievement motivation and school engagement (Wang & Eccles, 2013). In addition to academic benefits, instrumental support also promotes better students' well-being (Suldo et al., 2009). The link between instrumental support and various learning components (e.g., achievement motivation) thus entails a potential relationship between instrumental support and academic achievement.

Instrumental support in the math classroom

To date, the extent to which instrumental support contributes positively to learning performance in the math classroom remains unclear due to the paucity of relevant studies. Amongst the few studies that have explored this relationship, instrumental support has been positively associated with math achievement, including higher scores for girls (Tennant et al., 2015), as well as higher levels of intrinsic motivation and help-seeking behaviours in the math classroom (Federici & Skaalvik, 2014a). In support of these positive linkages, Federici and Skaalvik (2014b) found that perceived instrumental support from math teachers was positively associated with students' perception of utility and intrinsic value of math, suggesting that students who perceived higher levels of instrumental support were also more likely to perceive math as useful and enjoy it. Albeit the lack of relevant studies, the available findings nonetheless imply a relationship between instrumental support and math achievement.

Appraisal support as teacher feedback

Appraisal support can be offered in the form of feedback, social comparison and affirmation (House, 1981). Within the learning environment, one of the most salient indicators of such support is when teachers provide students with feedback (Kelly & Antonio, 2016). Fundamentally, feedback provides students with information with regard to their performance or understanding on a given topic (Andersson & Palm, 2017; Gielen, Peeters, Dochy, Onghena & Struyven, 2010). It is practised with the goal of empowering students to become self-regulated learners, in which they would be able to monitor and regulate their present learning in relation to their learning goals through interpreting external feedback (e.g., from teachers) and generating internal feedback (Nicol & Macfarlane-Dick, 2006). On the basis that teacher feedback is evaluative, such that it encompasses comments and suggestions about a student's current and intended levels of understanding or performance (Hattie & Timperley, 2007; Nicol & Macfarlane-Dick, 2006; Voerman, Korthagen, Meijer & Simons, 2014), the current study regards it as a proxy for appraisal support.

Despite being fundamental to teaching, (Voerman et al., 2014), there have been disagreements among extant studies about the extent to which teacher feedback is effective in promoting academic success. To elucidate, although the seminal review of Black and Wiliam (1998) and related studies (e.g., Nyquist, 2003; Rodriguez, 2004) illustrated a positive relationship between feedback and achievement gains, they have been challenged because the apparent magnitude of effects were derived from unclear or even flawed sources (Bennett, 2011). Further, a recent meta-analysis by Kingston and Nash (2011) demonstrated that the mean effect size for the provision of feedback to students was a small 0.03. Further, evidence of learning improvements in response to feedback has been inconsistent (Shute, 2008). For instance, Kluger and DeNisi's (1996) pivotal meta-analysis (607 effect sizes; 23,633 observations) indicated that while teacher feedback had an effect size of 0.41, performance unexpectedly declined in one-third of the studies after the provision of feedback. A recent study (Förster & Souvignier, 2014) also demonstrated that students, who were asked to monitor and reflect on their learning goals in reading based on the feedback that they received, did not achieve better than those in a controlled group and a comparable group whose teachers received information on their learning progress. These inconsistent findings therefore highlight a need for further investigation.

Teacher feedback in the math classroom

The effectiveness of feedback also appears to be dependent on the properties of the given task (Kluger & DeNisi, 1998). With respect to the school, this means that the impact of feedback on achievement could be either positive or negative depending on the nature of the subject. Indeed, different types of formative assessment, such as the use of feedback, tends to have smaller mean effect sizes in math (d = 0.17) and science (d = 0.09) as compared to English (d = 0.32) (Kingston & Nash, 2011). The seemingly small impact of feedback on math is also evident in Cadima, Leal and Burchinal's (2010) study, which demonstrated that whereas higher quality instruction (e.g., provision of feedback) was associated with greater gains in first grade language-related achievement (e.g., vocabulary),

it was not associated with global math achievement. In corroboration, another study involving middle-school students found that although the total effects of process-oriented feedback (i.e., feedback that focuses on the process or strategy employed on a given task) on math achievement and math interest was positive, they did not reach statistical significance (Rakoczy, Harks, Klieme, Blum & Hochweber, 2013). While recent studies (e.g., Havnes, Smith, Dysthe & Ludvigsen, 2012) attempted to attribute the lack of effect size to practices common to the math classroom, such as how students tend to receive less and shorter feedback because they focus more on correcting mistakes, the conflicting findings point to a need for further exploration on the relationship between teacher feedback and math achievement.

Math achievement

Perhaps not immediately apparent to math learners, but math skills are associated with a plethora of developmental outcomes that span across different life domains. Academically, a meta-analysis of six longitudinal studies (e.g., the National Longitudinal Survey of Youth) found that early math achievement (e.g., numerical knowledge) was the strongest predictor of later academic achievement, as compared to language, reading, and attention skills, for both children and adolescents (Duncan et al., 2007). Recent studies conducted in Australia also demonstrated positive associations between secondary school performance in advanced math classes and university performance in health-related and science-related courses (Anderton, Joyce & Hine, 2017; Joyce, Hine & Anderton, 2017). Socio-emotionally, a recent study that used a national-wide survey in Canada found that math skills in kindergarten were significantly associated with later social-emotional behaviours (Romano, Babchishin, Pagani & Kohen, 2010). Specifically, better math skills in kindergarten predicted lower levels of physical aggression, anxiety, depression, hyperactivity and impulsivity, as well as higher attentiveness in Grade 3 (Romano et al., 2010). Considering the importance of math skills, as reflected through math achievement, it is imperative to explore the role of teacher support in impacting students' math achievement. In doing so, educational implications could be derived to assist educators in the implementation of effective reforms in math teaching.

The present study

The present study sought to contribute to the limited literature on teacher support in the math classroom by exploring the extent to which instrumental support and teacher feedback promote math achievement. With references to previous studies (e.g., Federici & Skaalvik, 2014a; Tennant et al., 2015), instrumental support was regarded as teachers' provision of guidance and help that are instrumental to students' understanding and learning. Appraisal support was considered through feedback because teachers' appraisal denotes the provision of evaluative information regarding students' performances (Malecki et al., 2000; Kelly & Antonio, 2016). Specifically, given that feedback results from performance (Hattie & Timperley, 2007), teacher feedback was treated as an outcome that follows instrumental support. In this contention, it is important for teachers to first foster students' understanding through guidance and help before raising their awareness of

learning (e.g., what they know or do not know) through the provision of appropriate tasks and accompanying feedback (Prawat, 1989; Schelfhout, Dochy, Janssens, Struyven & Gielen, 2006). By examining the relative strength of teacher feedback in making additional contribution to math achievement beyond that of instrumental support, the present study could also provide insights to the inconclusive literature regarding the relationship between teacher feedback and math achievement.

Taken together, this study was guided by two main research questions: (1) To what extent do instrumental support and feedback predict math achievement?; (2) Given that feedback is assumed to follow teaching and learning, would feedback make additional contribution to math achievement over and above instrumental support? To obtain a more elucidating illustration on these relationships, gender differences were taken into account because previous studies have consistently found higher math scores among boys in comparison to girls (e.g., Mann & DiPrete, 2016; Voyer & Voyer, 2014). Based on previous literature (e.g., Federici & Skaalvik, 2014a), it was hypothesised that there would be a positive association between instrumental support and math achievement. No hypothesis could be made regarding the relationship between feedback and math achievement due to the inconsistent results in previous studies. Finally, it was hypothesised that feedback would explain additional variances in math achievement.

Method

Data source and participants

This study employed the 2012 *Program of International Student Assessment* (PISA) student database that was collected by the Organization for Economic Co-operation and Development (OECD) from 15-year-old students across 34 OECD countries and 31 partner countries/ economies (OECD, 2014). The main goal of PISA is to ascertain the quality, equity and efficiency of education in equipping students with the knowledge and skills that are critical in modern societies. Participating students are assessed in different areas, including math, reading, science, problem-solving abilities, with financial literacy as an extra option. In addition to these subject areas, PISA provides data on various aspects related to teaching and learning (e.g., teacher feedback) from the perspectives of educators and students. All measures were developed through an intensive process involving local and international item panelling, pilot testing, and reviews to ensure that they are internationally comparable. To maintain the scientific rigor of PISA, the reliability and construct validity of all measures have been evaluated across participating countries; items pertinent to each measure have also been scaled across these countries to create a composite score for each participant.

For the purpose of this study, only the responses from Canadian students were used. The Canadian context was chosen because results from the 2012 PISA depicted a decline in math achievement among Canadian students, albeit its average remained above the OECD average (Stokke, 2015). To illustrate, an analysis by Richards (2014) revealed that all but two Canadian provinces (namely, Quebec and Saskatchewan) experienced significant declines in math achievement between 2003 and 2012; in particular, Manitoba

and Alberta respectively declined by 36 and 32 points. Similarly, in another international assessment (*2011 Trends in International Mathematics and Science Study, TIMSS*) that focused on specific math skills (e.g., algebra), participating Canadian provinces also experienced a decline (Stokke, 2015). Based on this context, the present study utilised the Canadian data source, including 15-year-old students from across 10 provinces in Canada (N = 13,950; 7,106 girls).

Measures

Math achievement

Math achievement was represented by participants' standardised score in the math portion of the assessment, which was either in paper-pencil or computerised format. The test, consisting of a mixture of multiple-choice items and open-ended questions, evaluated students' ability to reason mathematically and their understanding on four content categories, including quantity, uncertainty and data, change and relationships, and space and shape (OECD, 2013).

Instrumental support

Instrumental support was measured from students' perspective using five items that were rated on a 4-point Likert-type response, ranging from 1 = *every lesson* to 4 = *never or hardly ever*. All items (see Appendix) were reverse scored (e.g., a score of 4 = a score of 0), meaning that higher scores indicated higher levels of support. In this study, these items had a reliability of $\alpha = .88$.

Appraisal support

Appraisal support was evaluated by students' perceived frequency of teacher feedback, which was measured with four items that were rated on a 4-point Likert-type response of 1 = *every lesson* to 4 = *never or hardly ever*. All items (see Appendix) were reverse scored (e.g., a score of 4 = a score of 0), in which higher scores denoted higher prevalence of feedback. The reliability of these items in the present study was also good ($\alpha = .78$).

Results

Preliminary analyses

As depicted in Table 1, correlational analyses indicated that all variables of interest were significantly related. With the exclusion of teacher feedback, which yielded negative correlations, $r(13948) = -.08$, $p < .001$, all variables were positively correlated with math achievement. The strongest correlation was found between instrumental support and teacher feedback $r(13948) = .52$. Gender was also weakly correlated with instrumental support and teacher feedback, respectively rs(13948) = .02, and .12, ps < .001.

Table 1: Means, standard deviations, and intercorrelations among gender, math achievement, instrumental support and teacher feedback

Variable	1	2	3	4
1. Math achievement	1.00			
2. Gender	.06***	1.00		
3. Instrumental support	.09***	.02*	1.00	
4. Teacher feedback	-.08***	.12***	.52***	1.00
M	511.81	1.49	.27	.27
SD	83.31	.500	.99	1.00

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

Regression analyses

Hierarchical regression analyses were conducted to evaluate the research questions while holding gender differences constant. Furthermore, R-square change (ΔR^2) was computed to assess whether the increment of variance put forward by the additional predictor (i.e., teacher feedback) was statistically significant, as denoted by ΔF (i.e., F change) (Pedhazur, 1997).

Results from hierarchical regression analyses with gender (first step), instrumental support (second step), teacher feedback (third step), as predictor variables revealed a model that accounted for 3.4% of variance in math achievement, $F(3, 13946) = 164.29$, $p < .001$. The ΔR^2 showed that instrumental support accounted for an additional 0.7% over and above gender, $\Delta F (1, 13947) = 103.81$, $p < .001$. In extension, teacher feedback made additional variances, $\Delta R^2 = .02$, $\Delta F (1, 13946) = 327.99$, $p < .001$, over and above gender and instrumental support.

Table 2: Summary of hierarchical regression analysis for gender, instrumental support and teacher feedback

Predictor	β	R^2	ΔR^2	ΔF
Step 1		.004***		
Gender	.06***			
Step 2		.011***	.007***	103.81***
Gender	.06***			
Instrumental support	.09***			
Step 3		.034***	.023***	327.99***
Gender	.08***			
Instrumental support	.18***			
Teacher feedback	-.18***		.	

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

Examinations of the beta weights in the final model revealed that gender, instrumental support, and teacher feedback significantly predicted math achievement (see Table 2). Specifically, based on the coding of 1 = girls and 2 = boys, results indicated that boys (M = 517.22, SD = 86.36) had higher math achievement as compared to girls (M = 506.60,

SD = 79.93), B = 13.74, $p < .001$. Controlling for gender differences and teacher feedback, results indicated a positive association between instrumental support and math achievement, B = 15.02, $p < .001$. By contrast, teacher feedback was negatively associated with math achievement, B = -14.82, $p < .001$, with gender and instrumental support held constant. In other words, instrumental support and teacher feedback respectively enhanced and hindered math achievement.

Discussion

The purpose of the present study was to explore the extent to which instrumental and appraisal support (i.e., teacher feedback) promoted math achievement while accounting for gender differences. Consistent with previous studies (e.g., Ganley & Vasilyeva, 2011; Wach, Spengler, Gottschling & Spinath, 2015), correlational and regression analyses indicated significant gender differences, whereby boys demonstrated higher math achievement than girls. Furthermore, in support of the notion that teacher support is distinct yet related (Anderman et al., 2011; Tennant et al., 2015), results indicated a moderate correlation between instrumental support and teacher feedback.

Interestingly, results of regression analyses suggest that instrumental support and teacher feedback might have differential impact on math achievement. In line with the findings of Tennant and colleagues (2015), instrumental support predicted better math achievement, thus suggesting that students tend to have better math achievement when teachers focus on helping and guiding them in understanding mathematical concepts and solving questions. By contrast, although teacher feedback explained additional variances in math achievement over and above instrumental support, it predicted lower math achievement. These findings therefore imply that while teacher feedback adds to instrumental support, it nonetheless hinders students' learning. On the one hand, this negative association contradicts extant studies (Carrillo-de-la-Peña et al., 2009; van den Berg, Harskamp & Suhre, 2016) that demonstrated the effectiveness of feedback in enhancing learning outcomes. On the other hand, these results reflect the handful of studies (e.g., Kluger & DeNisi, 1996) that found an association between teacher feedback and detrimental learning outcomes. Nonetheless, it is important to note that due to the correlational nature of this study, these results might also imply that teachers are providing more feedback to those who are struggling with their maths. Hence, longitudinal studies are needed to determine the effects of feedback on math achievement.

There are a few plausible explanations for the negative association between teacher feedback and math achievement. The first explanation concerns students' responses to the given feedback. For example, it is reasonable to assume that enhanced achievement would be less likely to occur if students have failed to modify their learning on the basis of teacher feedback (Havnes et al., 2012; Nicol & Macfarlane-Dick, 2006), or if they have interpreted teacher feedback in a way that deviates from the original meaning (Hattie & Timperley, 2007; Kulhavy (1977). However, given that the secondary data source does not provide information regarding students' responses to teacher feedback, this explanation is tentative and additional research is warranted.

While the aforementioned speculation might explain why students did not experience enhanced achievement in response to greater provision of teacher feedback, they do not fully explain why there was a decrease in achievement. To explain these findings, this study proposes a need to consider the achievement goal theory (Dweck, 1986; Harackiewicz, Barron & Elliot, 1998; Pintrich, 2000). According to this theory, there are two main learning goals that motivate students in their intention to become involved and to persist in a learning task (Meece, Anderman & Anderman, 2006). Students with a mastery goal orientation focus on understanding and achieving competence in the learning activity; by contrast, those with a performance goal orientation focus on exhibiting high ability as compared to others (Meece et al., 2006). Extensive research evidence indicates that while mastery goal orientation is associated with more positive learning outcomes, such as higher levels of task persistence and effort, a performance goal is associated with poorer performance among students (e.g., Grant & Dweck, 2003). Given that teacher feedback is performance-based on the surface (i.e. it is only when students effectively use them to guide their learning that achievement is observed) (Brookhart, 2003), teachers might inadvertently communicate to students that they value their performance more so than their understanding when they provide such appraisal support.

In support of this, a recent study found that students' achievement goals mediated the association between achievement feedback and achievement emotions (Pekrun, Cusack, Murayama, Elliot & Thomas, 2014), which have been proposed to influence achievement (Hattie & Timperley, 2007). In other words, a possible reason why students of the current study had lower math achievement is that the teachers' feedback might have focused mainly on their performance, as opposed to their mastery goals, thereby affecting their learning. Likewise, students' perception of what teacher feedback entails might also bring negative consequences to their learning outcomes. For example, Van-Dijk and Kluger (2000, 2001) found that teacher feedback negatively predicted students' academic performance when students perceived them as tasks that must be done, but that they were not committed to do. Nevertheless, these explanations are speculative, and thus it would be necessary for future studies to account for students' perception on the meaning of teacher feedback.

Limitations, strengths, and future directions

The present study has several limitations that need to be considered. First, it explored the relationship between teacher support and math achievement among a group of fifteen-year-old Canadian students, which limits the generalisability of the results. Therefore, it would be important to extend this research to other countries, and to different age groups. For instance, given that certain degrees of cognitive skills must be involved in the interpretation of teacher feedback, students who are cognitively more advanced (e.g., older students) might be more likely to benefit or suffer from teacher feedback. Hence, it would be of interest for future studies to investigate the relative contributions of instrumental support and teacher feedback on math achievement simultaneously across different age groups. Second, appraisal support was evaluated by proxy with teacher feedback, which might not necessarily have captured this type of support in its entirety. Relatedly, the manner by which teacher feedback was evaluated also needs to be noted,

given that its effectiveness on learning might depend more than its frequency in that it is the *type* of feedback that is paramount to learning (Hattie & Timperley, 2007; Voerman, Meijer, Korthagen & Simons, 2012). For example, van den Bergh, Ros and Beijaard (2013) found that a combination of confirmative, critical and constructive feedback was the most effective type of feedback in enhancing learning achievements. Accordingly, it would be important for future studies to evaluate the extent to which teacher feedback serves as an appropriate indicator of appraisal support within the learning environment so as to ensure its construct validity. Third, the correlational nature of the present study precludes interpretations about possible causal relationships of instrumental support and teacher feedback on math achievement. Longitudinal studies are needed to elucidate the effectiveness of instrumental support and teacher feedback on students' math achievement among different age groups. Lastly, given that students' math scores on the PISA might not be reflective of their actual math achievement, thus mitigating its relationship with the type of support that is provided in the math classroom, math achievement should be measured by school-based examination or assessment whenever possible.

Notwithstanding these limitations, the current study has several strengths. First, by considering the importance of instrumental support and teacher feedback in academic achievement, this study addressed the need to examine the effectiveness of different forms of teacher support on student outcomes. Second, with a focus on math achievement, this study contributed to the current lack of understanding on how teacher support might facilitate or hinder math learning outcomes. The large sample size also adds to the significance of these findings. Third, instrumental and appraisal support were measured from the perspective of students, which is important not only because there could be discrepancies between teacher and student perceptions towards school and learning (Henry, Mashburn & Konold, 2007), but also because students' learning behaviours are guided by their perception and interpretation of teacher support (Kikas & Mägi, 2016). Most importantly, this study challenged the view that teacher feedback would promote overall academic achievement by illustrating that it could potentially lead to lower math achievement. To the extent that instrumental support and teacher feedback only explained a small percentage of variance in math achievement, future studies would benefit from attending to other types of teacher support that are relevant to math. Further, given that there is an established literature on the importance of instructional/informational and emotional support in the math classroom, it would be interesting for future studies to consider them in addition to instrumental and appraisal support.

Current findings propose several directions for future research. First, because students' abilities and characteristics cannot be ignored within the context of teacher support (Byrnes & Miller, 2007; Jonassen & Grabowski, 1993), future studies could account for possible individual differences that might moderate the effects of teacher support on academic achievement. For instance, given that academic self-concept is strongly related to academic performance and learning goals (Prince & Nurius, 2014), examining students' math self-concept in the association between teacher support and math achievement might offer a more nuanced picture on how teacher and student variables interact to

enrich or thwart learning. As another example, because there are gender differences concerning how students receive teacher support (Tennant et al., 2015) and teaching practices (Geist & King, 2008), it is necessary for future studies to investigate whether these differences contribute to differences in the effectiveness of teacher support on subsequent achievement, especially within the math classroom. In addition to considering potential moderators, future studies could extend this line of research by noting possible mediators that serve to strengthen or weaken the relationship between teacher support and math achievement. For example, because instrumental support is associated with lower math anxiety (Federici & Skaalvik, 2014a), which has been emphasised by previous studies to have detrimental impacts on math achievement (Maloney & Beilock, 2012; Wu, Amin, Barth, Malcarne & Menon, 2012), especially among girls (Beilock, Gunderson, Ramirez & Levine, 2010), math anxiety might mediate the link between instrumental support and math achievement. Specifically, instrumental support might reduce math anxiety, which in turn, might promote better learning outcomes. A consideration of possible moderators and mediators is therefore warranted.

Conclusion and implications

By underscoring the conducive role of instrumental support in promoting math achievement while at the same time questioning the effectiveness of teacher feedback, the present study highlights a need for teachers to be cautious in terms of the kind of support that they provide in the math classroom. Specifically, findings of the present study illustrate a need for math teachers to offer a generous amount of instrumental support to help students succeed. By contrast, it would be imperative for schools to first evaluate the extent to which feedback encourages student success. Moreover, teachers need to be knowledgeable in terms of the type and amount of feedback that they provide. For instance, Voerman and colleagues (2012) suggested that specific feedback (e.g., progress feedback) is more likely to promote learning as compared to those that are non-specific; moreover, specific feedback should be given with references to the recommended positive to negative ratio of 3:1. Furthermore, given that students might be uncertain in terms of how they should interpret and use teacher feedback to guide their subsequent learning, appropriate support (e.g., instrumental support) should be given so that the intended outcome (i.e., enhanced learning) could be achieved. Finally, to the extent that teacher support is highly important for learning, school psychologists could inform teachers regarding relevant support strategies through professional development opportunities.

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http://www.cpa.ca/docs/File/Convention/2017/2017%20CPA%20Convention%20Program_Abstract%20Book_V-6-6-2017-sm2.pdf

References

Ahmed, W., Minnaert, A., van der Werf, G. & Kuyper, H. (2010). Perceived social support and early adolescents' achievement: The mediational roles of motivational beliefs and emotions. *Journal of Youth and Adolescence*, 39(1), 36-46. https://doi.org/10.1007/s10964-008-9367-7

Anderman, L. H., Andrzejewski, C. E. & Allen, J. (2011). How do teachers support students' motivation and learning in their classrooms? *Teachers College Record*, *113(5),* 969-1003. http://www.tcrecord.org/Content.asp?ContentId=16085

Andersson, C. & Palm, T. (2017). The impact of formative assessment on student achievement: A study of the effects of changes to classroom practice after a comprehensive professional development programme. *Learning and Instruction*, 49, 92-102. https://doi.org/10.1016/j.learninstruc.2016.12.006

Anderton, R., Joyce, C. & Hine, G. (2017). Secondary school mathematics and science matters: Academic performance for secondary students transitioning into university allied health and science courses. *International Journal of Innovation in Science and Mathematics Education,* 25(1), 34-47. https://openjournals.library.sydney.edu.au/index.php/CAL/article/view/11317

Assor, A., Kaplan, H. & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal of Educational Psychology*, 72(2), 261-278. https://doi.org/10.1348/000709902158883

Beilock, S. L., Gunderson, E. A., Ramirez, G. & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, 107(5), 1860-1863. https://doi.org/10.1073/pnas.0910967107

Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice,* 18(1), 5-25. https://doi.org/10.1080/0969594X.2010.513678

Black, P. & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice,* 5(1)*,* 7-74. https://doi.org/10.1080/0969595980050102

Brookhart, S. M. (2003). Developing measurement theory for classroom assessment purposes and uses. *Educational Measurement: Issues and Practice*, 22(4), 5-12. https://doi.org/10.1111/j.1745-3992.2003.tb00139.x

Byrnes, J. P. & Miller, D. C. (2007). The relative importance of predictors of math and science achievement: An opportunity-propensity analysis. *Contemporary Educational Psychology*, 32(4), 599-629. https://doi.org/10.1016/j.cedpsych.2006.09.002

Cadima, J., Leal, T. & Burchinal, M. (2010). The quality of teacher-student interactions: Associations with first graders' academic and behavioral outcomes. *Journal of School Psychology*, 48(6), 457-482. https://doi.org/10.1016/j.jsp.2010.09.001

Carrillo-de-la-Peña, M. T., Bailláes, E., Caseras, X., Martínez, À., Ortet, G. & Pérez, J. (2009). Formative assessment and academic achievement in pre-graduate students of health sciences. *Advances in Health Sciences Education,* 14(1), 61-67. https://doi.org/10.1007/s10459-007-9086-y

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K. & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, 43(6), 1428-46. https://doi.org/10.1037/0012-1649.43.6.1428

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, 41(10), 1040-1048. https://doi.org/10.1037/0003-066X.41.10.1040

Federici, R. A. & Skaalvik, E. M. (2014a). Students' perceptions of emotional and instrumental teacher support: Relations with motivational and emotional responses. *International Education Studies,* 7(1), 21-36. http://dx.doi.org/10.5539/ies.v7n1p21

Federici, R. A. & Skaalvik, E. M. (2014b). Students' perception of instrumental support and effort in mathematics: The mediating role of subjective task values. *Social Psychology of Education*, 17(3), 527-540. https://doi.org/10.1007/s11218-014-9264-8

Förster, N. & Souvignier, E. (2014). Learning progress assessment and goal setting: Effects on reading achievement, reading motivation and reading self-concept. *Learning and Instruction*, 32(1), 91-100. https://doi.org/10.1016/j.learninstruc.2014.02.002

Ganley, C. M. & Vasilyeva, M. (2011). Sex differences in the relation between math performance, spatial skills, and attitudes. *Journal of Applied Developmental Psychology,* 32(4), 235-242. https://doi.org/10.1016/j.appdev.2011.04.001

Geist, E. A. & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology*, 35(1), 43-53. https://www.questia.com/library/journal/1G1-178218787/different-not-better-gender-differences-in-mathematics

Gielen, S., Peeters, E., Dochy, F., Onghena, P. & Struyven, K. (2010). Improving the effectiveness of peer feedback for learning. *Learning and Instruction,* 20(4), 304-315. https://doi.org/10.1016/j.learninstruc.2009.08.007

Grant, H. & Dweck, C. S. (2003). Clarifying achievement goals and their impact. *Journal of Personality and Social Psychology*, 85(3), 541-553. https://doi.org/10.1037/0022-3514.85.3.541

Hamre, B. K. & Pianta, R. C. (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development*, 76(5), 949-967. https://doi.org/10.1111/j.1467-8624.2005.00889.x

Harackiewicz, J. M., Barron, K. E. & Elliot, A. J. (1998). Rethinking achievement goals: When are they adaptive for college students and why? *Educational Psychologist*, 33(1), 1-21. https://doi.org/10.1207/s15326985ep3301_1

Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112. https://doi.org/10.3102/003465430298487

Havnes, A., Smith, K., Dysthe, O. & Ludvigsen, K. (2012). Formative assessment and feedback: Making learning visible. *Studies in Educational Evaluation,* 38(1), 21-27. https://doi.org/10.1016/j.stueduc.2012.04.001

Henry, G. T., Mashburn, A. J. & Konold, T. (2007). Developing and evaluating a measure of young children's attitudes toward school and learning. *Journal of Psychoeducational Assessment*, 25(3), 271-284. https://doi.org/10.1177/0734282906297531

House, J. (1981). *Work stress and social support.* Reading, MA: Addison-Wesley.

Hübner, S., Nückles, M. & Renkl, A. (2010). Writing learning journals: Instructional support to overcome learning-strategy deficits. *Learning and Instruction*, 20(1), 18-29. https://doi.org/10.1016/j.learninstruc.2008.12.001

Jonassen, D. H. & Grabowski, B. L. (1993). *Handbook of individual differences, learning, and instruction.* New Jersey: Lawrence Erlbaum Associates.

Joyce, C., Hine, G. & Anderton, R. (2017). The association between secondary mathematics and first year university performance in health science. *Issues in Educational Research,* 27(4), 770-783. http://www.iier.org.au/iier27/joyce.pdf

Kelly, N. & Antonio, A. (2016). Teacher peer support in social network sites. *Teaching and Teacher Education*, 56, 138-149. https://doi.org/10.1016/j.tate.2016.02.007

Kikas, E., & Mägi, K. (2016). Does self-efficacy mediate the effect of primary school teachers' emotional support on learning behavior and academic skills? *The Journal of Early Adolescence,* 36*,* 1-35. https://doi.org/10.1177/0272431615624567

Kingston, N. & Nash, B. (2011). Formative assessment: A meta-analysis and a call for research. *Educational Measurement: Issues and Practice,* 30(4), 28-37. https://doi.org/10.1111/j.1745-3992.2011.00220.x

Kiuru, N., Nurmi, J. E., Leskinen, E., Torppa, M., Poikkeus, A. M., Lerkkanen, M. K. & Niemi, P. (2015). Elementary school teachers adapt their instructional support according to students' academic skills; A variable and person-oriented approach. *International Journal of Behavioral Development*, 39(5), 391-401. https://doi.org/10.1177/0165025415575764

Klem, A. M. & Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health*, 74(7), 262-273. https://doi.org/10.1111/j.1746-1561.2004.tb08283.x

Kluger, A. N. & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin,* 119(2), 254-284. https://doi.org/10.1037/0033-2909.119.2.254

Kluger, A. N. & DeNisi, A. (1998). Feedback interventions: Toward the understanding of a double-edged sword. *Current Directions in Psychological Science*, 7(3), 67-72. https://doi.org/10.1111/1467-8721.ep10772989

Kulhavy, R. W. (1977). Feedback in written instruction. *Review of Educational Research*, 47(1), 211-232. https://doi.org/10.3102/00346543047002211

Malecki, C. K. & Demaray, M. K. (2003). What type of support do they need? Investigating student adjustment as related to emotional, informational, appraisal, and instrumental support. *School Psychology Quarterly,* 18(3), 231-252. https://doi.org/10.1521/scpq.18.3.231.22576

Malecki, C. K., Demaray, M. K. & Elliott, S. N. (2000). *The child and adolescent social support scale*. DeKalb, IL: Northern Illinois University.

Maloney, E. A. & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences*, 16(8), 404-406. https://doi.org/10.1016/j.tics.2012.06.008

Mann, A. & DiPrete, T. A. (2016). The consequences of the national math and science performance environment for gender differences in STEM aspiration. *Sociological Science*, 3, 568-603. https://doi.org/10.15195/v3.a25

Meece, J. L., Anderman, E. M. & Anderman, L. H. (2006). Classroom goal structure, student motivation, and academic achievement. *Annual Review of Psychology,* 57(1), 487-503. https://doi.org/10.1146/annurev.psych.56.091103.070258

Nicol, D. J. & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199-218. https://doi.org/10.1080/03075070600572090

Niehaus, K., Rudasill, K. M. & Rakes, C. R. (2012). A longitudinal study of school connectedness and academic outcomes across sixth grade. *Journal of School Psychology*, 50(4), 443-460. https://doi.org/10.1016/j.jsp.2012.03.002

Nyquist, J. B. (2003). *The benefits of reconstructing feedback as a larger system of formative assessment: A meta-analysis*. Master's thesis, Vanderbilt University, Nashville, TN.

OECD [The Organization for Economic Cooperation and Development] (2013). *Programme for international student assessment (PISA): The PISA approach to assessing student performance in mathematics: Annex A1*. http://www.oecd.org/pisa/keyfindings/pisa2012-us-annexa1.pdf

OECD (2014). *Programme for international student assessment (PISA): PISA 2012 Technical Report,* Retrieved on 10 January, 2017 from https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

Ottmar, E. R., Decker, L. E., Cameron, C. E., Curby, T. W. & Rimm-Kaufman, S. E. (2014). Classroom instructional quality, exposure to mathematics instruction and mathematics achievement in fifth grade. *Learning Environments Research*, 17(2), 243-262. https://doi.org/10.1007/s10984-013-9146-6

Pakarinen, E., Aunola, K., Kiuru, N., Lerkkanen, M. K., Poikkeus, A. M., Siekkinen, M. & Nurmi, J. E. (2014). The cross-lagged associations between classroom interactions and children's achievement behaviors. *Contemporary Educational Psychology*, 39(3), 248-261. https://doi.org/10.1016/j.cedpsych.2014.06.001

Pedhazur, E. J. (1997). *Multiple regression in behavioral research* (3rd ed.). Orlando, FL: Harcourt Brace.

Pekrun, R., Cusack, A., Murayama, K., Elliot, A. J. & Thomas, K. (2014). The power of anticipated feedback: Effects on students' achievement goals and achievement emotions. *Learning and Instruction*, 29, 115-124. https://doi.org/10.1016/j.learninstruc.2013.09.002

Perry, N. E., VandeKamp, K. O., Mercer, L. K. & Nordby, C. J. (2002). Investigating teacher-student interactions that foster self-regulated learning, *Educational Psychologist*, 37(1), 5-15. https://doi.org/10.1207/S15326985EP3701_2

Pintrich, P. R. (2000). An achievement goal theory perspective on issues in motivation terminology, theory, and research. *Contemporary Educational Psychology*, 25(1), 92-104. https://doi.org/10.1006/ceps.1999.1017

Prawat, R. S. (1989). Promoting access to knowledge, strategy, and disposition in students: A research synthesis. *Review of Educational Research,* 59(1), 1-41. https://doi.org/10.3102/00346543059001001

Prince, D. & Nurius, P. S. (2014). The role of positive academic self-concept in promoting school success. *Children and Youth Services Review*, 43, 145-152. https://doi.org/10.1016/j.childyouth.2014.05.003

Rakoczy, K., Harks, B., Klieme, E., Blum, W. & Hochweber, J. (2013). Written feedback in mathematics: Mediated by students' perception, moderated by goal orientation. *Learning and Instruction*, 27, 63-73. https://doi.org/10.1016/j.learninstruc.2013.03.002

Richards, J. (2014, June). *Warning signs for Canadian Educators: The bad news in Canada's PISA results*. C.D. Howe Institute e-brief No. 176. https://ssrn.com/abstract=2457229

Rodriguez, M. C. (2004). The role of classroom assessment in student performance on TIMSS. *Applied Measurement in Education,* 17(1), 1-24. https://doi.org/10.1207/s15324818ame1701_1

Romano, E., Babchishin, L., Pagani, L. S. & Kohen, D. (2010). School readiness and later achievement: Replication and extension using a nationwide Canadian survey. *Developmental Psychology,* 46(5), 995-1007. https://doi.org/10.1037/a0018880

Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y. & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. *Learning and Instruction*, 42, 95-103. https://doi.org/10.1016/j.learninstruc.2016.01.004

Sakiz, G., Pape, S. J. & Hoy, A. W. (2012). Does perceived teacher affective support matter for middle school students in mathematics classrooms? *Journal of School Psychology*, 50(2), 235-255. https://doi.org/10.1016/j.jsp.2011.10.005

Schelfhout, W., Dochy, F., Janssens, S., Struyven, K. & Gielen, S. (2006). Towards an equilibrium model for creating powerful learning environments: Validation of a questionnaire on creating powerful learning environments during teacher training internships. *European Journal of Teacher Education,* 29(4) 471-503. https://doi.org/10.1080/02619760600944787

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, 78(1), 153-189. https://doi.org/10.3102/0034654307313795

Stokke, A. (2015, May). *What to do about Canada's declining math scores*. Commentary No. 427, C.D. Howe Institute. http://www.cdhowe.org/sites/default/files/attachments/research_papers/mixed/commentary_427.pdf

Strati, A. D., Schmidt, J. A. & Maier, K. S. (2017). Perceived challenge, teacher support, and teacher obstruction as predictors of student engagement. *Journal of Educational Psychology*, 109(1), 131-147. http://psycnet.apa.org/buy/2016-10825-001

Suldo, S. M., Friedrich, A. A., White, T., Farmer, J., Minch, D. & Michalowski, J. (2009). Teacher support and adolescents' subjective well-being: A mixed-methods investigation. *School Psychology Review,* 38(1), 67-85. http://www.nasponline.org/publications/periodicals/spr/volume-38/volume-38-issue-1/teacher-support-and-adolescents-subjective-well-being-a-mixed-methods-investigation

Tardy, C. H. (1985). Social support measurement. *American Journal of Community Psychology*, 13(2), 187-202. https://doi.org/10.1007/BF00905728

Tennant, J. E., Demaray, M. K., Malecki, C. K., Terry, M. N., Clary, M. & Elzinga, N. (2015). Students' ratings of teacher support and academic and social-emotional well-being. *School Psychology Quarterly*, 30(4), 494-512. https://doi.org/10.1037/spq0000106

Van den Bergh, L., Ros, A. & Beijaard, D. (2013). Teacher feedback during active learning: Current practices in primary schools. *British Journal of Educational Psychology,* 83(2)*,* 341-362. https://doi.org/10.1111/j.2044-8279.2012.02073.x

Van den Berg, M., Harskamp, E. G. & Suhre, C. J. M. (2016). Developing classroom formative assessment in Dutch primary mathematics education. *Educational Studies,* 42(4)*,* 305-322. https://doi.org/10.1080/03055698.2016.1193475

Van-Dijk, D. & Kluger, A. N. (2000, April). Positive (negative) feedback: Encouragement or discouragement? Paper presented at the 15th annual convention for the Society for Industrial and Organizational Psychology, New Orleans, Louisiana.

Van-Dijk, D. & Kluger, A.N. (2001, April). Goal orientation versus self-regulation: Different labels or different constructs? Paper presented at the 16th annual convention of the Society for Industrial and Organizational Psychology, San Diego, CA.

Voerman, L., Meijer, P. C., Korthagen, F. A. & Simons, R. J. (2012). Types and frequencies of feedback interventions in classroom interaction in secondary education. *Teaching and Teacher Education*, 28(8), 1107-1115. https://doi.org/10.1016/j.tate.2012.06.006

Voerman, L., Korthagen, F. A., Meijer, P. C. & Simons, R. J. (2014). Feedback revisited: Adding perspectives based on positive psychology. Implications for theory and classroom practice. *Teaching and Teacher Education*, 43, 91-98. https://doi.org/10.1016/j.tate.2014.06.005

Voyer, D. & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin*, 140(4), 1174-1204. https://doi.org/10.1037/a0036620

Wach, F.-S., Spengler, M., Gottschling, J. & Spinath, F. M. (2015). Sex differences in secondary school achievement – The contribution of self-perceived abilities and fear of failure. *Learning and Instruction,* 36*,* 104-112. https://doi.org/10.1016/j.learninstruc.2015.01.005

Wagner, W., Göllner, R., Werth, S., Voss, T., Schmitz, B. & Trautwein, U. (2016). Student and teacher ratings of instructional quality: Consistency of ratings over time, agreement, and predictive power. *Journal of Educational Psychology*, 108(5), 705-721. https://doi.org/10.1037/edu0000075

Wang, M. T. & Eccles, J. S. (2013). School context, achievement motivation, and academic engagement: A longitudinal study of school engagement using a multidimensional perspective. *Learning and Instruction*, 28, 12-23. https://doi.org/10.1016/j.learninstruc.2013.04.002

Wentzel, K. R., Russell, S. & Baker, S. (2016). Emotional support and expectations from parents, teachers, and peers predict adolescent competence at school. *Journal of Educational Psychology*, 108(2), 242-255. https://doi.org/10.1037/edu0000049

Wu, S. S., Barth, M., Amin, H., Malcarne, V. & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in Psychology*, 3, 1-11. https://doi.org/10.3389/fpsyg.2012.00162

Appendix: Measurement items

Items for instrumental support

1. The teacher shows an interest in every student's learning.
2. The teacher gives extra help when students need it.
3. The teacher helps students with their learning.
4. The teacher continues teaching until the students understand.
5. The teacher gives students an opportunity to express opinions.

Measurement items for appraisal support (teacher feedback)

1. The teacher tells me about how well I am doing in my mathematics class.
2. The teacher gives me feedback on my strengths and weaknesses in mathematics.
3. The teacher tells us what is expected of us when we get a test, quiz or assignment.
4. The teacher tells me what I need to do to become better in mathematics.

Note. Items are from OECD (2013). Students were asked to consider each item in terms of how often they occurred in their math class.

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