frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 27 May 2024
DOI 10.3389/feduc.2024.1385442

OPEN ACCESS

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RECEIVED 12 February 2024
ACCEPTED 13 May 2024
PUBLISHED 27 May 2024

CITATION
Basileo LD, Otto B, Lyons M, Vannini N and Toth MD (2024) The role of self-efficacy, motivation, and perceived support of students' basic psychological needs in academic achievement. *Front. Educ.* 9:1385442. doi: 10.3389/feduc.2024.1385442

The role of self-efficacy, motivation, and perceived support of students' basic psychological needs in academic achievement

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Former research has highlighted the relevance of basic psychological need (BPN) satisfaction for students' academic motivation and achievement. However, the specific role of self-efficacy in this relationship has been neglected. Using survey response data from a sample of 2,359 German middle school students in 35 schools, we employed Hierarchical Linear Modeling to investigate the role of teacher support for students' perceived BPN, academic self-efficacy, and autonomous and controlled motivation on student achievement in two subjects (mathematics, German). We found that self-efficacy had the largest relationship with achievement and it mediated the effect of autonomous motivation on grades while controlled motivation had a small and statistically significant, negative relationship regardless of self-efficacy. Support of students' perceived BPN had a positive statistically significant association with autonomous motivation. Motivation and self-efficacy also mediated perceived BPN support and achievement. Self-efficacy had a statistically significant association and had a reciprocal relationship with both autonomous and controlled motivation. The findings indicate that self-efficacy plays a major role in the relationships among perceived BPN support, motivation, and academic achievement, and highlight the importance of supporting student self-efficacy in academic settings.

KEYWORDS

social cognitive theory, self-efficacy, self-determination theory, autonomous motivation for learning, basic psychological needs, student achievement, academic motivation

1 Introduction

The economic growth and development of nations depends upon the quality of education that their citizens receive, and countries that invest in education are more adaptive and resilient (Mazarr, 2022). Disruptions from the COVID-19 pandemic brought greater awareness of the importance of adaptiveness and resilience as all countries sought alternative means of educating their children. Some countries were able to return quickly to in-person learning, but interrupted learning impacted all students (Patrinos, 2023).

Although signs of recovery from lost learning time are appearing, student academic performance data in reading and mathematics has shown a declining trend (Mullis et al., 2023; OECD, 2023a; The Nation's Report Card, 2023). For example, a report of data from 81 countries participating in the 2022 Program for International Student Assessment (PISA) reveals that average scores dropped by 15 points in mathematics and by 10 points in reading compared to data from the 2018 PISA (OECD, 2023a). Although the COVID-19 pandemic certainly affected academic performance, the Organization for Economic Development and Cooperation (OECD) notes that this decline began between 2009 and 2012 (OECD, 2023a). Given that measures of academic performance, such as high stakes tests, are strong determinants of the trajectories of students' future personal and professional lives, these and other similar performance trends throughout the world give rise to concerns about the quality of education and what is needed to improve educational outcomes. One important approach to improving the quality of education is to examine students' experience of school. Students' attitudes and wellbeing impact how they perform in the classroom, and those who feel safe and have a sense of belonging in school are more confident as learners (OECD, 2023b).

Studies grounded in self-determination theory have found that satisfaction of students' basic psychological needs (BPN) positively influences their wellbeing and academic motivation (Reeve and Su, 2014; Ryan and Deci, 2017; Ahn et al., 2021). Particularly, the use of autonomy supportive or controlling teaching practices has been found to strongly influence student motivation to learn (Reeve and Jang, 2006; Reeve, 2009; Reeve and Cheon, 2021). Additionally, there is ample evidence from studies based on social cognitive theory (Bandura, 1986, 1997) that supports the relationship between student self-efficacy and academic achievement (Asakereh and Yousofi, 2018; Akturk and Ozturk, 2019; Olivier et al., 2019; Usher et al., 2019; Zysberg and Schwabsky, 2021; Luo et al., 2023; Salvo-Garrido et al., 2023; Al-khresheh and Alkursheh, 2024; Bozzato, 2024). These findings suggest that efforts to improve education might be supported through a better understanding of how the satisfaction of students' BPN, students' autonomous and controlled motivation in the classroom, and students perceived self-efficacy all affect academic achievement.

While prior studies have made the association between satisfaction of BPN and student motivation (Ryan and Deci, 2017, 2020; Ahn et al., 2021; Reeve and Cheon, 2021; Bureau et al., 2022; Conesa et al., 2022) or BPN and achievement (Taylor et al., 2014; Nalipay et al., 2020; Theis et al., 2020; Ahn et al., 2021; Buzzai et al., 2021; Earl et al., 2023), few have specifically made the association between student motivation, and achievement (e.g., Aydin and Michou, 2020; Ahn et al., 2021). Furthermore, studies of self-efficacy have found a strong relationship with both achievement and motivation. For example, Macakova and Wood (2022) found that satisfaction of BPN is related to self-efficacy, which mediates the relationship of BPN to achievement. Raven and Pels (2021) found that satisfaction of BPN was related to students' grades. But studies that link the three constructs of BPN, self-efficacy, and motivation (controlled and autonomous) with student achievement are few. The missing piece seems to be how motivation and self-efficacy are related to achievement.

Few studies have assessed both self-efficacy and motivation. Fokkens-Bruinsma et al. (2021) discovered that autonomous motivation in students entering university is predictive of academic achievement while self-efficacy was not. Their study did not look at controlled motivation and it also took place in a university setting which may not be applicable to students in elementary or secondary settings. A cross-lagged panel analysis by Li et al. (2024) revealed positive reciprocal relationships between self-efficacy, autonomous motivation, and academic achievement in secondary school students, but found that controlled motivation had no effect on self-efficacy. This population of younger students is particularly of interest because of the pervasive emphasis within elementary and secondary school systems on academic achievement as an accountability measure as well as on the lifelong consequences of academic school achievement for later professional career success, socioeconomic advancement, and overall wellbeing (Hanushek, 2009, 2019; Chetty et al., 2010; Carnevale et al., 2011; Oreopoulos and Salvanes, 2011; Reardon, 2011; Case and Deaton, 2021; Reber and Smith, 2023).

Additionally, while students' reading literacy and mathematics skills often influence each other in terms of student performance (TIMSS, 2019; Cooper et al., 2022; Chang, 2023), there is a lack of studies that examine motivational effects across different academic topics. Typically, empirical studies in education that investigate correlates of student achievement only do so in one subject area, such as mathematics or reading, but subjects can differ with how teachers teach them. For example, data from the National Educational Panel study of teachers in Germany spanning 2011–2014 indicated that teachers' use of differentiated instruction practices, such as tiered assignments based on student ability, homogeneous and heterogeneous ability grouping, tutoring, and project-based learning, differed by academic discipline (math and German) and by school track (Pozas et al., 2020). Given this variability, it is important to investigate whether the same patterns of motivational effects hold true across subject areas. Theoretically, we would expect to see similar effects, but we did not find one study that assessed BPN, self-efficacy, motivation (controlled and autonomous) and achievement across different academic disciplines. Furthermore, Gaspard et al. (2016) noted that empirical studies of educational interventions involving student motivation often focus on only one subject area, often without consideration of how those interventions might influence student motivation in other academic disciplines. They found that successful interventions designed to increase German students' value of math had a negative influence on their value of German language studies.

Due to the paucity of current studies examining the relationships between motivation, self-efficacy, and student achievement across different academic disciplines, the objective of this study was to conduct an in-depth investigation of these relationships. We used survey data from 35 middle schools in Germany that included 2,359 students enrolled in math and German. Students responded to questions measuring their academic self-efficacy, the degree to which their teachers supported their BPN, and their autonomous and controlled motivation to learn in both subjects. Students also provided their most recent

grades in math and German. Accordingly, our main research questions were as follows:

1. What is the role of perceived BPN satisfaction, motivation, and self-efficacy in student achievement?
2. Do the interrelations hold true across different subject areas?

The next section outlines the theoretical and empirical evidence to date. As this study incorporated two theoretical premises, it describes self-determination theory (Ryan and Deci, 2017) and then outlines social cognitive theory (Bandura, 1986, 1997). We then review studies linking self-determination theory to student motivation and achievement and the relationships between student self-efficacy, perceived BPN satisfaction, motivation and academic achievement. We follow the discussion with specific hypotheses that we investigated in the current study.

2 Theoretical background

2.1 Self-determination theory

Self-determination theory (SDT) states that all human beings have basic psychological needs (BPN) for autonomy, competence, and relatedness (Deci and Ryan, 2000; Ryan and Deci, 2017, 2020). Autonomy is volitional action toward a goal that people embrace as consistent with their sense of self and purpose in life. Competence is the feeling of being self-confident, knowledgeable, skilled, and capable of mastering challenging tasks (Di Domenico and Ryan, 2017). Relatedness is the sense of caring about others and being cared for by others. The fulfillment of these basic psychological needs positively influences motivation, psychological health, vitality, wellbeing, and quality of life (Van den Broeck et al., 2016; Avsec et al., 2021; Schutte and Malouff, 2021; Martela et al., 2023).

In education, the fulfillment of the students' BPN is essential to developing their agency and resilience as learners (Reeve et al., 2020). Studies have shown that adolescent engagement in school typically decreases over time, but satisfaction of BPN can play an important role in maintaining student engagement in learning (Earl et al., 2023). Alternatively, frustration of BPN has a negative association with student satisfaction and engagement in learning (Hughes et al., 2023).

SDT holds that human motivation is expressed along a continuum from autonomous to controlled (Deci and Ryan, 2000; Ryan and Deci, 2017). Autonomous motivation is that which individuals perceive as volitional and consistent with their sense of self, while they perceive controlled motivation as forced upon them and incongruent with their identity (Deci and Ryan, 2000; Ryan and Deci, 2017). The degree to which individuals feel that their actions are autonomous or controlled affects how they self-regulate their thoughts and actions. The highest level of autonomous motivation in education arises from learning that is inherently interesting and enjoyable (Bureau et al., 2022). Throughout the course of formal education, autonomy support by teachers predicts student autonomous motivation, engagement, conceptual understanding, academic performance, and psychological wellbeing (Reeve and Jang, 2006; Reeve, 2009; Ryan and Deci, 2017). In this context, autonomous motivation influences student academic performance through its positive impact on critical thinking, which is the only cognitive process that has a positive, significant impact on academic performance (Manganelli et al., 2019). By contrast, controlled motivation has a negative direct impact on student academic performance. It promotes the use of surface-level cognitive strategies of rehearsal and organization but has a negative influence on elaboration and critical thinking, both deep-level cognitive processes (Manganelli et al., 2019).

2.2 Social cognitive theory

Self-efficacy is a construct of social cognitive theory and its perspective on human agency (Bandura, 1986, 1997, 2001). Self-efficacy is the "metacognitive capability to reflect upon oneself and the adequacy of one's thoughts and actions" (Bandura, 2006, p. 165) and influences all other aspects of human agency. Those with more developed competencies, self-regulatory skills, and stronger self-efficacy beliefs are more successful in accomplishing desired outcomes than those whose agentic skills and beliefs are less developed (Bandura, 1986, 1997).

Within the sphere of education, self-efficacy is students' beliefs about their own ability to influence academic achievement (Bong and Skaalvik, 2002; Er et al., 2022). It has been found that students' self-efficacy beliefs influence their motivation to learn, their ability to self-regulate, and their academic performance (Usher and Pajares, 2006, 2008). Students' self-efficacy beliefs arise from four sources (Bandura, 1986, 1997): mastery experiences where students evaluate their competence from results of their own learning efforts; vicarious experiences from observing social models such as classmates who master or fail an academic task; verbal and social persuasions, such as encouragement from parents, teachers, and peers; and emotional and physiological states such as anxiety, mood, and stress.

Most important to the development of self-efficacy is students' success in academic tasks. Students with high self-efficacy beliefs have positive mastery experiences, while students with low self-efficacy beliefs have experienced failure (Yildiz and Özdemir, 2019). Although psychological states such as anxiety have the least impact, studies indicate that they can undermine self-efficacy because students interpret anxiety as evidence of low ability (Yildiz and Özdemir, 2019).

Self-efficacy changes as students have new experiences and gain new information in the transition from one grade to the next (Usher and Pajares, 2008; Kontaş and Özcan, 2022). Learning conditions that foster positive relationships and student belonging are conducive to self-efficacy (Usher and Pajares, 2008; Zysberg and Schwabsky, 2021). Students who experience their classroom environments as more supportive and caring, mastery-oriented, and challenging have higher levels of self-efficacy and competence support (Chang, 2023).

2.2.1 Sources of self-efficacy and autonomy supportive teaching

Social cognitive theory's sources of self-efficacy—mastery experiences, vicarious experiences, verbal and social persuasions, and emotional and physiological states—are also related to autonomy supportive instruction as defined by self-determination theory. With regard to mastery experiences, when teachers provide mastery goals, students focus on developing competence (Fryer et al., 2014). Teachers who provide autonomy supports for their students create learning environments that are mastery oriented (Ryan and Deci, 2017, 2020). When teachers establish mastery goals, students are more autonomously motivated and process learning at deeper levels (Fryer et al., 2014). In terms of vicarious experiences, when teachers create performance goals, students derive their sense of competence through comparisons with the competence of other students (Fryer et al., 2014). Performance goals are a source of externally regulated motivation for students that lead to surface rather than deeper learning. With regard to verbal or social persuasions, autonomy supportive teachers nurture students' internal motivational resources through words and actions that convey interest and acknowledgment of students' perspectives (Reeve and Jang, 2006; Reeve, 2009; Reeve and Su, 2014; Reeve and Cheon, 2021). Finally, as concerns students' emotional states and feelings, students of autonomy supportive teachers develop higher levels of autonomous motivation, greater use of self-regulation strategies for learning, and lower anxiety (Ryan and Deci, 2020).

2.2.2 Comparing constructs of self-efficacy and competence

Although social cognitive theory and self-determination theory are separate and distinct theories of human motivation, many researchers use constructs from both fields of inquiry to understand student motivation. Because some of the constructs share similar attributes, Rogers et al. (2014) sought to distinguish between the concepts of self-efficacy from social cognitive theory and perceived competence from self-determination theory. They found that the constructs are empirically distinct and are related differently to the idea of persistence. Under SDT, they noted that perceived competence does not lead to persistence of behavior unless the need for autonomy is also met. But in social cognitive theory, self-efficacy encourages persistence (Rogers et al., 2014). The distinction between competence and self-efficacy is that the need for competence centers on one's desire to be capable and high performing overall, while self-efficacy is an outcome-based, future-oriented focus on ability to successfully perform specific tasks (Raven and Pels, 2021; Ryan, 2024). Having reviewed the theoretical background of self-determination theory and social cognitive theory as they relate to education and student learning, the next section discusses the empirical support for these theories.

3 Prior research

This section provides an overview of the empirical evidence for associations between the BPN and student motivation, BPN and student achievement, and self-efficacy and student achievement. It also discusses the results of empirical studies that explored the relationships between the social cognitive theory construct of self-efficacy and the self-determination theory constructs of BPN and motivation.

3.1 Basic psychological needs, motivation, and academic achievement

Many studies link the satisfaction and frustration of students' BPN with academic achievement (Ahn et al., 2021; Buzzai et al., 2021; Afzal and Jami, 2023; Vijayakumaran et al., 2023; Wangchuk, 2023; Zhang and Jiang, 2023; Zupančič et al., 2024). Students' perception of satisfaction or frustration in the classroom is influenced by the teacher. Autonomy-supportive teaching practices arise from the teacher's student-focused attitude (Reeve and Jang, 2006) and include three essential instructional behaviors (Jang et al., 2010): the nurturing of students' inner motivational resources, use of non-controlling language that conveys information about the purpose of instructional activities, and overt acknowledgment of student perspective and feelings.

Autonomy supportive teachers listen more to their students, respond to their students' questions, give fewer directives, and converse with students in a way that conveys understanding of students' perspective (Ryan and Deci, 2017; Reeve and Cheon, 2021). They provide optimal learning challenges and present to students interesting and relevant learning activities aligned to meaningful goals (Jang et al., 2010). They do not give in to students but help them understand the importance and requirements of learning tasks (Reeve and Cheon, 2021). Autonomy support that teachers give to students supports students' BPN, which in turn increases student autonomous motivation and is predictive of student achievement (Jang et al., 2012; Bureau et al., 2022). Students' perceived autonomy support is positively associated with perceived competence, relatedness to teachers, vitality in school, contentment with school, and with school performance, while school-related pressure is negatively related (Howard et al., 2021; Bureau et al., 2022; Martinek et al., 2022).

Earl et al. (2023) found that BPN satisfaction is unrelated to school grades at the beginning of the school year, but as the school year progresses, students with more satisfaction of BPN show increasing and higher levels of academic achievement compared to students with less satisfaction of BPN. Fulfillment of BPN is also significantly related to grades and mastery goals (Theis et al., 2020). Support of BPN fosters student intrinsic motivation, which is positively and significantly associated with student wellbeing in learning (Ye et al., 2022) and is the only form of autonomous motivation that is positively associated with academic achievement (Taylor et al., 2014). Taylor et al. (2014) also found a reciprocal relationship between intrinsic motivation and academic achievement, with prior academic achievement also predicting later intrinsic motivation. There have been few studies that incorporate BPN, motivation and achievement besides the ones noted above. Nevertheless, motivation is the connection between students' BPN and achievement.

Overall, the impact of satisfaction of students' BPN and achievement is universally applicable across nations and cultures

(Ryan and Deci, 2017, 2020; Wang et al., 2021; Guay, 2022). Nalipay et al. (2020) found positive and significant relationships between satisfaction of student BPN and student achievement across Western and Eastern cultures, with relatedness having the largest association with achievement followed by autonomy. Despite numerous findings associated satisfaction of student BPN with achievement, one meta-analysis (Conesa et al., 2022) found support for the hypothesis that satisfaction of student BPN is associated with student motivation overall but found a lack of studies supporting the hypothesis that BPN satisfaction increases student achievement. This is interesting to note as few studies incorporate both BPN and motivation as predictors of student achievement.

3.1.1 The effect of perceived autonomy support

The current study measures students' perceptions of BPN support by their teachers through their perceived autonomy support. Perceived autonomy support is the degree to which students believe that their teachers provide encouragement and support of autonomous decisions and choice in learning (Deci and Ryan, 1985; Hu et al., 2023). Students' perceived autonomy support is positively associated with students anticipated achievement, academic self-efficacy, engagement in learning, learning motivation, academic buoyancy, and wellbeing (Deci and Ryan, 2000; Cheon and Reeve, 2013; Han and Huang, 2022; Hu et al., 2023; Kingsford-Smith et al., 2024).

With regard to perceived autonomy support and student achievement, studies have found significant effects on achievement mediated by classroom engagement and autonomy need satisfaction (Jang et al., 2012) as well as small mediating effects from students' self-regulated learning (Schuitema et al., 2016). Perceived autonomy support has also been shown to have an impact on students' use of deep learning strategies, partially mediated by self-efficacy (Zhao and Qin, 2021). A longitudinal study in Chinese elementary schools by Wei et al. (2020) also found positive relationships between students' perceived autonomy support and math achievement.

Perceived autonomy support influences student engagement and motivation for learning. Okada's (2023) meta-analysis of 43 studies involving perceived autonomy support revealed small but significant and positive associations with academic performance and behavioral engagement, as well as medium and positive associations with cognitive and emotional engagement in learning. In addition, a study of a three-year intervention designed to support the basic psychological needs, intrinsic and extrinsic motivation, and self-efficacy of 312 Swedish secondary mathematics students found significantly higher levels of intrinsic motivation and self-efficacy in the third year, but it had no impact on extrinsic motivation (Samuelsson, 2023).

Perceived autonomy support is also associated with students' overall wellbeing. In their study of adolescent German language arts students, Kleinkorres et al. (2023) found that perceived teacher autonomy support, enjoyment of school, health, and social integration had small to medium and positive relationships to each other. They also found that students perceived higher levels of autonomy support in grades five, six, and eight, but that these perceptions decreased over time along with indicators of student wellbeing.

Student perception of teachers' autonomy support also influences their perceived satisfaction of BPN which, in turn, influences autonomous motivation and a variety of educational outcomes. For example, in a study of 922 secondary physical education students in Spain, Leyton-Román et al. (2020) found that perceived autonomy support was positively and significantly predictive of satisfaction of each of the basic psychological needs. Additionally, satisfaction of these needs was significantly and positively predictive of students' autonomous motivation to be physically active. In another study of 149 university music students in Peru, Herrera et al. (2021) found that perceived autonomy support positively predicted BPN satisfaction which affected students' adaptive perfectionism as musicians and overall wellbeing.

3.2 Self-efficacy and achievement

Self-efficacy has a large effect on students' use of deeper learning strategies and their ability to transfer learning to novel contexts (Karaman et al., 2019; Schunk and DiBenedetto, 2021). It is one of several positively correlated agentic processes that are predictive of academic achievement (Code, 2020). Academic self-efficacy is associated with academic performance in reading literacy (Yang et al., 2018; Ocak and Tiraki, 2020; Zysberg and Schwabsky, 2021; Zorlu and Ünver, 2022), mathematics (Kitsantas et al., 2011; Xu and Qi, 2019; Ugwuanyi, 2020; Zysberg and Schwabsky, 2021; Er et al., 2022; Kontaş and Özcan, 2022; Muhtadi et al., 2022), and the sciences (Aurah, 2017; Oyelekan et al., 2019; Gao et al., 2020; Adjei et al., 2023; Dever, 2024) and is positively associated with overall academic achievement (Asakereh and Yousofi, 2018; Akturk and Ozturk, 2019; Olivier et al., 2019; Usher et al., 2019; Zysberg and Schwabsky, 2021; Luo et al., 2023; Salvo-Garrido et al., 2023; Al-khresheh and Alkursheh, 2024; Bozzato, 2024).

Low academic self-efficacy causes maladaptive behaviors such as procrastination (Katz et al., 2014). There is also a negative correlation between students' homework stress and their self-efficacy (Katz et al., 2012). High self-efficacy predicts perseverance through difficulties and anxieties (Usher and Pajares, 2008). Students with high self-efficacy beliefs are more likely to engage in school and persist in learning until they have achieved their learning goals (Hong et al., 2021; Zorlu and Ünver, 2022; Nong et al., 2023). It affects how students believe they can apply the skills and abilities they have to learning tasks (Bong and Skaalvik, 2002). But academic efficacy can also be negatively associated with academic achievement when students are overconfident or underconfident of their abilities (Alafgani and Purwandari, 2019). Some studies also indicate reciprocal effects between prior achievement and self-efficacy (Olivier et al., 2019), with prior achievement having a stronger effect (Talsma et al., 2018; Ansong et al., 2019; Sorjonen and Melin, 2023), and few studies have found weak effects of self-efficacy on student achievement (Ansong et al., 2019; Li et al., 2023). Recent studies have also revealed that fluctuations in students' self-efficacy and perceptions of academic

burden are negatively associated with academic achievement (Vongkulluksn et al., 2024).

There are a growing number of studies that use both social cognitive theory and self-determination theory to understand sources of academic motivation. For example, Katz et al. (2014) noted that support for students' autonomy, competence, and relatedness may reduce student procrastination by increasing autonomous motivation and self-efficacy through support of the need for competence. A study involving postsecondary students found a significant, positive relationship between self-efficacy and autonomous motivation (Azila-Gbettor et al., 2021). Another study found that autonomous motivation in prospective 1st year university students was predictive of academic achievement, but academic self-efficacy was not (Fokkens-Bruinsma et al., 2021). Raven and Pels (2021) found that self-efficacy was significantly and positively associated with satisfaction of BPN and performance. Macakova and Wood (2022) found that satisfaction of BPN of college students was positively and directly related to self-efficacy, and indirectly related to academic achievement via self-efficacy. Satisfaction of BPN has also been associated with increased academic self-efficacy of undergraduate vocational students (Chen, 2024). In their longitudinal study of Chinese secondary students studying English as a Foreign Language, Li et al. (2024) found significant reciprocal relationships between self-efficacy, autonomous motivation, and academic achievement.

In summary, we have found many studies of the relationship between student BPN and motivation, and between student BPN and achievement, with some contradictory evidence for the relationship between BPN and achievement. There are also numerous studies which support the relationship between student self-efficacy and achievement. To the best of our knowledge, however, there are few studies that investigate the associations between BPN, motivation, self-efficacy, and academic achievement and there are even fewer studies on these concepts at the middle or elementary grade levels and across academic subjects. Consequently, we put forth the following hypotheses:

H_1: Perceived BPN support will have a positive significant relationship with student achievement.

H_2: Motivation will have a significant association with achievement.

H_{2a}: Autonomous motivation will have a positive and statistically significant relationship with achievement.

H_{2b}: Controlled motivation will have a negative and statistically significant relationship with achievement.

H_3: Self-efficacy will have a positive and statistically significant relationship with achievement.

H_4: Self-efficacy will mediate the relationship between motivation and achievement.

H_5: The relationship between perceived BPN support, motivation and self-efficacy will be consistent across subject areas.

Further, we were interested in which variable would have the largest impact on student achievement and the relationship among all the variables. The next section discusses the methodology used to investigate these questions.

4 Materials and methods

Convenience sampling was used with a cross-sectional study design because simple random sampling is not feasible in school settings. To recruit the sample, we contacted middle schools in three German states by email and phone. Principals and parents both had to agree on student participation. To obtain informed consent, all parents of fifth to nineth graders received an information letter. Students whose parents signed the parental consent could voluntarily participate in the paper and pencil data survey in their classrooms. The disadvantages of this data collection mode can include clustering effects (United States Department of Education, 2022) and socially desired responses. Nevertheless, we chose paper and pencil surveys as the advantage of collecting data in this manner ensures higher response rates (Dommeyer et al., 2004; Dillman et al., 2014). College psychology and education students were trained prior to administering the questionnaires. Students received no incentives for their participation and took the survey at their school during their regular school lessons.

4.1 Participants

In total, we surveyed 35 middle schools, and 2,359 students completed the questionnaire. In Germany, students take both math and German each year. Therefore, this questionnaire consisted of three parts: demographic data, items related to math courses, and items related to German. The items in the Math and German parts were identical, but worded to be subject specific. The mean age of the students responding to the questionnaire was about 13 years of age ($SD = 1.74$) and varied between nine and 18 years old. It is possible for students in Germany to be in 9th grade and be 18 years old if they start school late and are held back a grade, but there were only two students who were 18 years of age. About 51 percent of the sample were female ($SD = 0.50$), 79 percent of the sample were living in a two-parent household ($SD = 0.40$), and 42 percent had at least one parent that was born in another country ($SD = 0.49$).

In Germany, at the end of fourth grade students are assigned to one of three school tracks based on their school performance. When students move from elementary to secondary school in the fourth grade, the teacher recommends the track in which the student should be placed. In some states, parents also have input on the track. There are three different tracks: Gymnasium (13 years of school attendance) reserved for the highest performing students headed for college, Realschule (10 years of school attendance) for the middle tier, and Hauptschule (9 years of school attendance) for the bottom tier that prepares students for vocational training.

By the age of 10 years, most students in Germany have been placed on one of the tracks. While students have their track set by fourth grade, some schools serve students from combined tracks (integrative track called Gesamtschule) where students with high, average, and low achievement levels attend school together (Lohbeck et al., 2022). Students who were on the integrative track

were excluded from the analysis ($n = 743$) which equated to 23 percent of the original sample. While we were hesitant to exclude a large percentage of students, we removed these students because we did not know the individual students' recommended track, only that they attended an integrative school. Consequently, we conducted a similar analysis on just the students who were enrolled in an integrative school. While we did not find substantive differences in the results, the findings from this study may not be generalizable to students who attend integrative track schools. The discussion section will review generalizability in more detail. The next section describes the measures and the methods used in the study.

4.2 Measures

This section describes the outcome measure, independent, and control variables. Response categories ranged from 1 to 5 on a Likert scale (1 = *not true* to 5 = *very true*) for all scales excluding the outcome measures (math and German self-reported grades). We incorporated four independent variables in the models including perceived BPN support, motivation (both autonomous and controlled), and self-efficacy. Items for each of the measures were combined into a scale and we used both Cronbach's alpha and McDonalds Omega to gauge reliability and subsequent measurement error. The reliability standard aims to set principles for maximum allowable measurement error. Cronbach's alpha of 0.6 is considered the minimum reliability threshold in education sciences (United States Department of Education, 2022). Conversely, the Omega takes into account the strength of association between items and constructs as well as item-specific measurement errors in addition to the latent factor loading to estimate reliability (Revelle and Zinbarg, 2009). An Omega of 0.7 is considered the minimum reliability threshold (Nunnally, 1978). Furthermore, Murphy and Davidshofer (1998, p. 89) state that reliability >0.6 and ≤0.7 is considered low. To this end, the minimum reliability thresholds are highly debated, often contextual, and researchers have even argued that Cronbach and Omega have the same standards (Lance et al., 2006; Dunn et al., 2014). To this end, we report both the alpha and Omega to assess reliability because, in some cases, it may provide more realistic estimates of the true reliability of a scale (Malkewitz et al., 2023).

For brevity, we provide examples of items within the following narrative. For replication, all items are reported in the Supplementary material. Next, we describe each construct in greater detail beginning with the dependent variables.

4.2.1 Student achievement

We assessed students' academic achievement in mathematics and German by using students' self-reported grades in both subject areas. Of the 2,359 students who completed the survey, 2,337 self-reported their grade in math and 2,330 did so in German. The German grading system is reversed compared to the system in the United States with one being "very good" and five being "very poor." For easier understanding, grades were reverse coded before statistical analyses to the equivalent United States letter grading scale which ranges from one being an "F" to "A" being a five. Therefore, high values indicate higher performance in this study.

4.2.2 Basic psychological need support

We measured the extent in which the mathematics and German teachers fulfilled students' basic psychological needs in their classes using a scale based on work by Katz et al. (2010). They conducted an exploratory factor analysis to assess the reliability of the scale using two samples of students ($n = 73$ and $n = 108$). They utilized maximum likelihood extraction and with an oblique rotation and found that all items loaded on a single factor, explaining 53 percent of the variance, with no apparent patterns relating to the three different needs. Reliability of the scale was also high. In the current study, the scale consisted of 15 items including items to assess teachers' autonomy support (e.g., "Our teacher provides us with different tasks to choose from"), competence support (e.g., "Our teacher matches the difficulty level of the task to each of us"), and relatedness (e.g., "Our teacher takes a personal interest in us"). We also conducted an exploratory factor analysis with oblique rotation. In line with the findings of Katz et al. (2010), we found one factor for both subjects on which all the items significantly loaded (math loadings ranged from 0.38 to 0.69; German loadings ranged from 0.52 to 0.70). Furthermore, in both subjects, the 15 items were found to be highly correlated ($r > 0.61$), and the scale comprised by the items was reliable (math $\alpha = 0.84$; $\omega = 0.84$; German $\alpha = 0.89$; $\omega = 0.88$).

4.2.3 Academic motivation

We assessed students' academic motivation for both subjects by using an adapted and shortened instrument (Ryan and Connell, 1989; Katz et al., 2008). Katz et al. (2008) validated the measures of autonomous and controlled motivation using Israeli fifth-grade students ($n = 73$). The study also showed moderate to large statistically significant correlations in the expected directions with students' positive and negative affect, mastery orientation, and task value. Our scale for each subject, which was based on the Katz et al. (2008) instrument, consisted of eleven items separated into autonomous motivation (6 items, e.g., "I study for math because I enjoy it") and controlled motivation (5 items, e.g., "I study for German because otherwise I will have problems with my parents"). The reliability for autonomous motivation in math was high ($\alpha = 0.83/\omega = 0.83$) and it was also high in German ($\alpha = 0.88/\omega = 0.88$). The reliability of controlled motivation was acceptable ($\alpha = 0.61/\omega = 0.59$ in math, $\alpha = 0.68/\omega = 0.67$ in German).

4.2.4 Self-efficacy

To measure students' self-efficacy, we created a scale based on an existing instrument from Harter (1982). Harter's instrument had a high Cronbach alpha and calculated test-retest reliability from two samples of students ($n = 208$, $n = 810$) who were retested after 3 and 9 months. For both groups, the reliability for the scale was large. We adapted self-efficacy in this study to the specific context of mathematics and German. Each of the two scales consisted of six items (e.g., "I am able to succeed in the most difficult tasks in math class if I try"; "I will succeed in German class this year"). The

TABLE 1 Sample size, means, and standard deviations of variables.

Variable	n_1	Mean	*SD*
Math grade	2,337	3.23	0.97
German grade	2,330	3.28	0.86
Track	2,361	1	3
Age	2,346	9	18
Female	2,353	0	1
Two parents	2,345	0	1
Immigrant	2,345	0	1
Perceived BPN support$_m$	2,358	2.99	0.75
Perceived BPN support$_G$	2,354	3.06	0.81
Autonomous motivation$_m$	2,358	3.28	0.97
Autonomous motivation$_G$	2,354	3.29	1.05
Controlled motivation$_m$	2,354	2.02	0.78
Controlled motivation$_G$	2,352	1.97	0.81
Self-efficacy$_m$	2,357	3.61	0.97
Self-efficacy$_G$	2,349	3.76	0.83
n_2			35

Subscripts denote the academic subject; $_m$, math; $_G$, German; n_1, students; n_2, schools.

reliability for students' self-efficacy was high, $\alpha = 0.88$ in math and $\alpha = 0.87$ for German. The Omega for math was $\omega = 0.89$ and $\omega = 0.87$ for German.

Table 1 denotes the descriptive statistics for the variables in the study, including the sample size (n), mean, and standard deviations (*SD*). The subscripts denote whether the measure was from a math or German class. All values range from one to five. The highest scale mean was seen for self-efficacy in German at 3.76 and the lowest scale mean was for controlled motivation in German at 1.97.

4.2.5 Control variables

We used several control variables to isolate the impact of perceived BPN satisfaction, motivation, and self-efficacy on academic achievement. First-level control variables included age, gender, whether the student lived in a two-parent household, and whether the student's parents were from a different country (immigrant). Hillier (2021) found that the most significant predictor of cumulative literacy was the socioeconomic status of the parents. While we did not have a measure of income for this study, we used two parent household and immigrant status as proxies. Female, Two-parents, and Immigrant were all coded dichotomously with one representing the existence of the attribute and zero representing its non-existence. We included Track as a second-level control variable.

4.3 Data analysis

We used Pearson's correlation coefficients to assess the magnitude and direction of the relationships between the dependent and independent variables. Correlation analyses were performed to assess the predictability, strength, and direction of the observational instruments and to investigate multicollinearity. Due to the nested nature of the data collection mode, we used Hierarchal Linear Modeling (HLM) to adjust for clustering of students within buildings (Raudenbush and Bryk, 2002). If we did not adjust for clustering, statistical significance could be inflated. We used SPSS version 29 with the Advanced Statistics module using the mixed methods command to calculate the estimates. We chose HLM as opposed to other methods because data were collected in clusters of schools, and data were cross-sectional, so we could not infer causality.

Variables were standardized to discern which variable had the largest impact on achievement. While standardizing dichotomous variables is problematic for linear assumptions and interpretation, we wanted to ensure all variables had the same scale to assess which variable had the largest impact on the outcome. As such, we report standardized *Beta* coefficients.

To compare measurement models and gauge model fit we used several criteria including the Conditional R-Squared (R^2c), Akaike's Information Criterion (AIC), and the Conditional Intraclass Correlation Coefficient (ICC). The Conditional R-Squared is like the R-squared in regression analysis; however, it reflects the proportion of variance explained by both fixed and random effects. In HLM, Akaike's Information Criterion can be used to compare nested models. Models with lower AIC values are considered the best-fitting model. Intraclass Correlation Coefficient is another measure of the proportion of total variance attributable to the group level. It is calculated as the ratio of the between-group variance to the total variance. It is a useful measure for assessing the impact of group-level predictors.

Equation 1 for the full model is listed below. The same model was used for both outcome variables, achievement in math and German.

Final Model

$$\begin{aligned}\mathbf{Grade_{ij}} = {} & \gamma_{00}+\gamma_{01}\mathbf{Track}+\gamma_{02}\mathbf{Age_{ij}}+\gamma_{03}\mathbf{Female_{ij}} \\ & +\gamma_{04}\mathbf{TwoParents_{ij}}+\gamma_{05}\mathbf{Immigrant_{ij}}+\gamma_{06}\mathbf{BPN_{ij}} \\ & +\gamma_{07}\mathbf{AutonomousMotivation_{ij}} \\ & +\gamma_{08}\mathbf{ControlledMotivation_{ij}}+\gamma_{09}\mathbf{SelfEfficacy_{ij}} \\ & +\mu_{0j}+\varepsilon_{ij} \qquad (1)\end{aligned}$$

5 Results

We first investigated multicollinearity. Multicollinearity occurs when two or more independent variables have a high correlation with one another, which makes it difficult to determine the individual effect of each independent variable on the dependent variable and can lead to inaccurate inferences. We combined perceived autonomy, competence, and relatedness into an overall perceived BPN satisfaction measure due to high correlations of the measures ($r > 0.6$).

Pearson correlation coefficients showed that math grades were statistically significant to all variables included in the model, and they were in the hypothesized direction. German grades had the same relationship; however, they were not related to students in

two-parent households. The highest correlation was seen between grade and self-efficacy ($r_m = 0.54$; $r_G = 0.45$) and achievement and autonomous motivation ($r_m = 0.24$; $r_G = 0.18$). Another finding worth noting was the moderate correlation between autonomous motivation and self-efficacy ($r_m = 0.43$; $r_G = 0.48$).

After investigating correlation levels, we then ran an initial model (not shown) which investigated whether there was statistically significant clustering of students within schools. In SPSS, we used the Wald Z test, and we found that both the level-one and level-two variances were statistically significant using the halved value as the threshold (p value $= 0.000$). Additionally, the Intraclass Correlation Coefficient (*ICC*) was 0.10. As such, we had evidence of significant clustering in the model. Heck et al. (2022) noted that 0.05 is often considered as a basic cutoff of evidence of substantial clustering. Nevertheless, even trivial amounts of clustering ($ICC < 0.05$) may still have substantial effects on inferences when performing single-level regression (Pituch and Stevens, 2015). This suggests the need for multilevel modeling in studies particularly when survey data are gathered in clusters.

The next step of the analysis included adding in each independent variable to assess their relationship to achievement. Table 2 shows the results of three different models in our analysis for the subject math. The first model investigated the relationship between perceived BPN support and math achievement (H_1). The second model incorporated autonomous and controlled motivation (H_2), and the last model added the impact of self-efficacy on math achievement (H_3 & H_4). Recall that coefficients were standardized to assess the magnitude of the effect. Furthermore, while adjusted standard errors were reported, unstandardized standard errors were very close to the adjusted ones except for the Intercept which had an average standard error of about 0.21 across the three models.

The findings for math are gleaned from Table 2. First, perceived BPN support (*Beta* = 0.12) had the third largest association with math achievement in the first model (behind Track and Age) and this supports the assertion put forth in H_1. In the second model, the perceived BPN shrank in magnitude but remained statistically significant. Substantively though, in smaller samples, perceived BPN support may not hold its statistical significance because the magnitude of the impact was small after motivation was introduced. The second model supported H_2 and showed that autonomous motivation (*Beta* = 0.22) had the largest association with math achievement, followed by controlled motivation (*Beta* = −0.14), with both in the expected direction. The last model included self-efficacy and supported H_3. Self-efficacy had the largest relationship (*Beta* = 0.49), with perceived BPN support and autonomous motivation falling out of statistical significance. Self-efficacy had the largest association with math achievement, and it mediated the relationship between motivation and achievement which supports H_4. The third model was the best-fitting model as it had the largest proportion of variance explained and it had the lowest AIC. The ICC remained relatively stable across models.

Further exploration was necessary to see to assess H_5 and to determine if the same pattern held true in German. Table 3 shows the exact same models but with German grades as the outcome measure. We found support for H_5 in that the interrelations between perceived BPN support, motivation and self-efficacy were consistent across subject areas. More specifically, both perceived BPN support and autonomous motivation dropped out of statistical significance, with autonomous motivation flipping signs and controlled motivation having a small and statistically significant relationship with achievement.

While the interrelations of the variables remained the same, there were some differences in the findings that should be noted. The math model explains about 9% more variation then the German one ($R^2c = 0.39$ for math; 0.30 for German). It was also superior in terms of fit as it has lower AICs. There are also some demographic differences to note. Females fell out of statistical significance in math after accounting for self-efficacy which demonstrates that they do not necessarily report lower grades in math, but they have lower levels of self-efficacy. In the German models, females remained statistically significant after accounting for self-efficacy. Finally, living in a two-parent household does not have a statistically significant relationship with self-reported grades in German, but it does so in math.

Due to the mediating findings between self-efficacy, autonomous motivation, and achievement we did some further exploration. Using HLM, we investigated the associations between perceived BPN support and autonomous and controlled motivation. We also explored perceived BPN support, and autonomous and controlled motivation with self-efficacy as the outcome variable. Figure 1 shows the findings from the exploratory models, and it also includes the findings from Tables 2, 3 to summarize all the interrelations. Standardized coefficients for math grade are reported first in the figure followed by the standardized coefficient for German grade.

Perceived BPN support had a positive and statistically significant relationship with self-efficacy ($Beta_{m/G} = 0.13/0.17$) and a positive impact on autonomous motivation ($Beta_{m/G} = 0.20/0.38$) with a smaller, but significant impact on controlled motivation ($Beta_{m/G} = 0.04/0.10$). It is interesting to note that the smaller coefficients in math and that the impact of perceived BPN on controlled motivation flipped directions once self-efficacy was included in the model. While statistically significant in this model, substantively these coefficients were small and would probably not be statistically significant in smaller scales studies. Self-efficacy had the largest impact on student achievement was noted in Tables 2, 3 in addition to a statistically significant impact on autonomous motivation ($Beta_{m/G} = 0.38/0.37$) and controlled motivation ($Beta_{m/G} = -0.22/-0.13$). Self-efficacy impacted controlled motivation more so in math than in German. When using self-efficacy as the outcome, both autonomous ($Beta_{m/G} = 0.37/0.41$) and controlled motivation ($Beta_{m/G} = -0.16/-0.12$) had a statistically significant association with self-efficacy. As such, we found support for the notion that there is a bidirectional relationship between self-efficacy and motivation. However, because these data are from a cross-sectional survey design, more analysis is needed to better understand causality and the interrelations among the variables.

6 Discussion

Our aim of the study was to examine the role of perceived BPN satisfaction, motivation, and self-efficacy in student

TABLE 2 Effect of perceived BPN support, motivation, and self-efficacy on math achievement.

	BPN			Motivation			Self-efficacy		
Variable	*Beta*	*SE*	*p value*	*Beta*	*SE*	*p value*	*Beta*	*SE*	*p value*
Intercept	−0.01	0.04	0.81	−0.01	0.05	0.86	−0.01	0.04	0.85
Track	0.14	0.03	<0.001	0.16	0.03	<0.001	0.16	0.03	<0.001
Age	−0.14	0.02	<0.001	−0.08	0.02	<0.001	−0.07	0.02	<0.001
Female	−0.09	0.02	<0.001	−0.09	0.02	<0.001	0.01	0.02	0.71
Two parents	0.05	0.02	0.01	0.03	0.02	0.08	0.03	0.02	0.04
Immigrant	−0.11	0.02	<0.001	−0.11	0.02	<0.001	−0.09	0.02	<0.001
Perceived BPN support	0.12	0.02	<0.001	0.05	0.02	0.01	−0.01	0.02	0.43
Autonomous motivation	-	-	-	0.22	0.02	<0.001	0.03	0.02	0.07
Controlled motivation	-	-	-	−0.14	0.02	<0.001	−0.06	0.02	<0.001
Self-efficacy	-	-	-	-	-	-	0.49	0.02	<0.001
R^2c			0.14			0.21			0.39
AIC			6,260.9			6,078.4			5,507.8
ICC			0.04			0.06			0.05

SE, Standard Error; R^2c, Conditional R-Squared; AIC, Akaike's Information Criterion; ICC, Conditional Intraclass Correlation Coefficient.

TABLE 3 Effects of perceived BPN, motivation, and self-efficacy on German achievement.

	BPN			Motivation			Self-efficacy		
Variable	*Beta*	*SE*	*p value*	*Beta*	*SE*	*p value*	*Beta*	*SE*	*p value*
Intercept	0.01	0.05	0.86	0.01	0.05	0.83	0.01	0.04	0.74
Track	0.17	0.04	<0.001	0.17	0.03	<0.001	0.12	0.03	<0.001
Age	−0.09	0.02	<0.001	−0.07	0.02	0.00	−0.08	0.02	<0.001
Female	0.16	0.02	<0.001	0.12	0.02	<0.001	0.11	0.02	<0.001
Two parents	0.02	0.02	0.35	0.02	0.02	0.37	0.02	0.02	0.21
Immigrant	−0.13	0.02	<0.001	−0.12	0.02	<0.001	−0.10	0.02	<0.001
Perceived BPN support	0.14	0.02	<0.001	0.09	0.02	<0.001	0.02	0.02	0.27
Autonomous motivation	-	-	-	0.14	0.02	<0.001	−0.03	0.02	0.16
Controlled motivation	-	-	-	−0.12	0.02	<0.001	−0.06	0.02	<0.001
Self-efficacy	-	-	-	-	-	-	0.40	0.02	<0.001
R^2c			0.18			0.21			0.30
AIC			6,128.3			6,049.5			5,697.01
ICC			0.07			0.07			0.05

SE, Standard Error; R^2c, Conditional R-Squared; AIC, Akaike's Information Criterion; ICC, Conditional Intraclass Correlation Coefficient.

achievement and whether the interrelations hold true across different subject areas. In summary, we confirmed our main hypotheses that perceived BPN support had a positive and significant association with achievement; that motivation had a significant relationship with achievement; that self-efficacy had a positive and statistically significant relationship with achievement; that self-efficacy mediated the relationship between motivation and achievement; and that these relationships held true regardless of subject area. However, there were slight differences to note in demographic characterisics, specfially that females fell out of statistical significance in math after accounting for self-efficacy and living in a two-parent household did not have a statistically significant relationship with self-reported grades in German. We found in our exploratory analyses that self-efficacy had a statistically significant relationship with both autonomous and controlled motivation in math and German and it had a reciprical relationship with both types of motivation. Finally, perceived BPN support and motivation had statistically significant associations with self-efficacy.

Our results are consistent with other studies that have found self-efficacy predicts achievement (Usher and Pajares, 2008; Yang et al., 2018; Yildiz and Özdemir, 2019; Ugwuanyi, 2020; Schunk

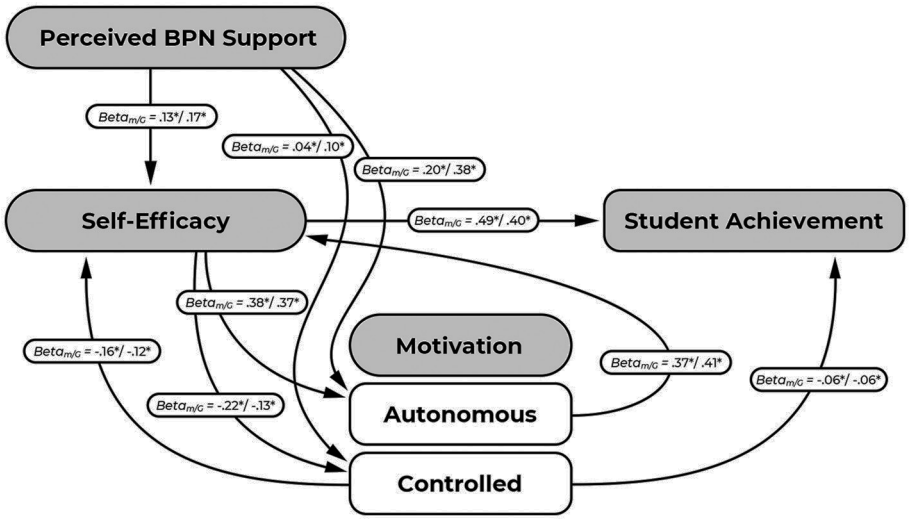

FIGURE 1
The role of self-efficacy on math and German achievement. Standardized coefficients for math grade are reported first followed by German.
* = $p < .05$.

and DiBenedetto, 2021; Zysberg and Schwabsky, 2021; Kontaş and Özcan, 2022; Muhtadi et al., 2022; Zorlu and Ünver, 2022; Luo et al., 2023; Salvo-Garrido et al., 2023; Al-khresheh and Alkursheh, 2024; Bozzato, 2024) and that BPN satisfaction predicts achievement (Taylor et al., 2014; Nalipay et al., 2020; Theis et al., 2020; Ahn et al., 2021; Buzzai et al., 2021; Afzal and Jami, 2023; Earl et al., 2023; Vijayakumaran et al., 2023; Wangchuk, 2023; Zhang and Jiang, 2023; Zupančič et al., 2024). The linkage between self-efficacy, BPN and achievement; however, has not yet been well established. Consistent with findings of Raven and Pels (2021), Macakova and Wood (2022), and Li et al. (2024), we found that self-efficacy played a major role in the relationships among perceived BPN, motivation, and academic achievement, and these relationships held true across disciplines. Self-efficacy not only had the largest relationship with math and German grades but it also mediated the relationship between academic motivation and achievement. Despite substantial empirical evidence supporting relationships between BPN satisfaction or self-efficacy and student achievement, there are few studies that also found a mediating relationship of motivation between BPN and achievement (Ahn et al., 2021; Conesa et al., 2022) and of self-efficacy between BPN and achievement (Macakova and Wood, 2022), and none that investigated the relationship of all the variables used in these models.

To this end, it is important to recall that this study examined influences on student achievement through two theoretical lenses: self-determination theory and social cognitive theory. We recognize that the two theories are based on very different assumptions, as SDT is concerned with autonomy support while social cognitive theory rejects autonomy as a meaningful construct (Ryan, 2024). Ryan (2024) further articulates that constructs from different theories cannot be fused together without consideration of their meaning within their frameworks. While the findings are not conclusive, they have important theoretical implications.

Our findings imply that SDT theorists should incorporate self-efficacy in studies that examine motivational outcomes such as student achievement. Self-efficacy accounts for a significant portion of variability in academic performance (Schunk and DiBenedetto, 2021). After accounting for self-efficacy, this study showed that the types of motivation had differential impacts on achievement with autonomous motivation no longer having a significant relationship with achievement and controlled motivation having a direct impact. Social cognitive theorists should also examine the different types of motivation. Autonomous and controlled motivation, and perceived BPN support all had statistically significant relationships with self-efficacy with autonomous motivation having the largest impact.

SDT and social cognitive theory recognize that learning involves activation of students' inner motivational resources (Reeve, 2009; Ryan, 2024). Applications of those theories seek to harness and enhance motivational resources to improve student academic achievement through different means and pathways. Our findings suggest that addressing the empirical relationships between BPN, motivation, self-efficacy and achievement provides insights for how these two theories might be combined in education policy and interventions to improve student learning. As such, further research that combines interventions grounded in the two theories may be essential to understanding the exact interrelations of constructs to improve academic achievement. As we noted in the introduction to this paper, this is a concern of global importance.

6.1 Limitations and future research

While our findings are supportive of prior research and theory, there are several limitations that should be noted. First, the outcome variable was self-reported student grades. Self-reported grades have been deemed an appropriate method of achievement and it has the benefit of not breaking ethical rules related to student record

confidentiality (Shim and Ryan, 2005; Zysberg and Schwabsky, 2021). Although self-reported grades are widely obtained as an operationalization of student achievement in educational contexts (Fryer and Dinsmore, 2020), their validity is sometimes questioned (Kuncel et al., 2005). As such, some scholars have doubted the use of self-reported grades as a valid construct. Somers et al. (2020) found that students' characteristics such as age and school performance impact the accuracy of self-reported grades. It could be that gender also played a role in reporting grades as we found that females fell out of statistical significance in math not German after accounting for self-efficacy. Therefore, future studies should examine this relationship more closely and consider more objective measures of student achievement such as assessment scale scores to confirm the patterns found. Furthermore, areas for future research include replicating the findings by linking student perceptions to assessment scores.

Additionally, teachers' instructional behavior could be assessed more objectively by observational measures instead of student perceptions. When students rate teachers' behavior there is a high variance in responses even though they are rating the same teacher (Katz, 2017). This variability represents an inconsistency among students within one class which could be interpreted as measurement error. Although this points to a more objective approach, there are also empirical findings that support the implementation of student reports when assessing BPN satisfaction in the classroom as determinant of students' motivation. For example, Katz (2017) found that the variance in students' ratings of their teacher's behavior was attributed to differences in students' perception of their teacher's behavior rather than actual differences. Therefore, she assumed that differences in students' motivation were a consequence of differences in their perceived BPN satisfaction in the classroom. Implementing more objective measures such as observations in the classroom could not mirror these important differences in students' perception. As we found students' self-efficacy to have the largest relationship with achievement in math and German, it would be interesting to investigate whether differences in students' perception of their teachers' BPN satisfying behavior similarly predict the differences in students' self-efficacy.

Another methodological limitation addresses the cross-sectional design of this study which limits our inferences on causality, as we found a reciprocal relationship between motivation and self-efficacy. While this study represents the first step of addressing the interrelations of the variables, longitudinal designs would help determine the mediating role of self-efficacy overtime. Moreover, future research should investigate how fostering self-efficacy may change student achievement. While cross-sectional designs are preferable for inquiry of interrelations, longitudinal designs are essential to cross-validate our findings. Indeed, our findings are in line with Nuutila et al. (2020) who found in their longitudinal study that situational interest as a motivational variable had a larger impact on students' self-efficacy than vice versa. However, Du et al. (2021) could not confirm reciprocity. They found that former math achievement and self-efficacy in mathematics to be predictors of later interest in mathematics. Moreover, prior math interest had no impact on students' achievement and self-efficacy.

Due to such inconsistent empirical findings, further research is needed to identify the specific underlying processes. It could be that the relationship of self-efficacy to student achievement varies cross-culturally, with a stronger relationship to achievement in Western cultures and a lesser impact in Eastern cultures (Nalipay et al., 2020). Further, it may be that the relationship between students' academic self-efficacy and student achievement is mediated by other variables such as students' perceptions of teacher support of their BPN (Katz et al., 2010), expectations, beliefs, and emotions concerning the subject area, the skills they are learning, or the value that they assign to learning tasks (Doménech-Betoret et al., 2017; Mete, 2021).

Additional studies should also further examine the impacts of tracking on students' motivation and self-efficacy. Belief in one's own competence stems from social comparisons. In other words, students build their self-efficacy by comparing their competence with other students in their class. After tracking, such social comparisons are limited to students similar in their school performance. According to the Big Fish Little Pond Effect, the assignment of students to tracks in secondary school could inadvertently lower or raise students' academic self-concept and perceived academic self-efficacy when attending schools where the average ability levels of other students are perceived as higher or lower (Marsh and Seaton, 2015; Salchegger, 2016; Basarkod et al., 2023). Furthermore, between-school tracking not only leads to social segregation of students, but also to fewer teaching resources, fewer qualified teachers, lower expectations of students, lower academic rigor of curriculum, and negatively influences learning conditions in lower track (Pomianowicz, 2023). As tracking seems to have such an immense impact on students' self-efficacy, motivation, and achievement, a similar study of integrative tracking would be helpful to determine whether our findings could be replicated. In this context, we investigated the same patterns with the integrative track students that we excluded from our sample, and we found very similar results; however, we did not have a way of determining the students' individual assigned tracks. Furthermore, Germany has one of the largest numbers of tracks within OECD and European school systems (Pomianowicz, 2023). Consequently, results should be cross validated in other countries as these findings may not be generalizable outside of educational systems that incorporate tracking.

Finally, our study included only students' perceived BPN support as relevant predictor of students' academic motivation, self-efficacy, and achievement. Recent models and research within self-determination theory highlight the independent relevance of BPN frustration (Vansteenkiste et al., 2020), assuming BPN frustration to be stronger and more perilous than the mere absence of BPN satisfaction. So far, only very few studies have considered BPN frustration as potential predictor in the educational context (Buzzai et al., 2021; Zhang and Jiang, 2023). Therefore, it would be fruitful to further examine the interplay of BPN satisfaction and frustration as determinants of students' academic motivation, self-efficacy, and achievement in future research.

While we noted several limitations and areas for future research, there are several strengths of this study. The main finding from this study was that self-efficacy had the largest relationship

with math and German grades. Furthermore, we found self-efficacy played a mediating role in achievement through perceived BPN support and motivation. Considering the findings, other studies that assess BPN, motivation and achievement that do not account for self-efficacy could have spurious relationships to student achievement. Additionally, most studies only investigated relationships using one subject area at a time. We investigated the impact of perceived BPN support, motivation, and self-efficacy on achievement using a large sample and two different academic subjects and we reached similar findings indicating a potential for generalizations to be made across subjects.

6.2 Practical implications

The results also highlight some practical implications for teachers, particularly, the importance of fostering students' self-efficacy. For example, Schunk and DiBenedetto (2021) suggest that teachers can enhance student self-efficacy through teacher or peer modeling, by providing proximal and challenging goals, and by providing feedback linking performance outcomes with student effort. In terms of self-determination theory this would represent need-supportive teaching behavior. Furthermore, this study highlights the need of principals to encourage teachers to be more supportive of students' self-efficacy in the classroom. In this context, Klassen et al. (2012) point out how satisfaction of teachers' own BPN at work supports teachers' emotions and engagement in the classroom. Moreover, it could be that teacher characteristics play a critical role in fostering self-efficacy of students and achievement. Future studies examining these relationships would help educators better understand how practices that support students' BPN, and self-efficacy can improve academic outcomes for all students.

7 Conclusion

The findings of our study underscore the importance of self-efficacy and basic psychological needs as contributing factors to student academic performance. But education builds more than just the cognitive skills associated with academics. Students' success in future careers will require them to develop interpersonal, social, and emotional competencies that prepare them to communicate and work effectively with others in increasingly globalized occupations (World Economic Forum, 2023). SDT research has shown that students in autonomy-supportive classrooms demonstrate more care for their classmates and more prosocial behavior (Reeve and Cheon, 2021). When students experience support for their basic psychological needs in school, it builds their capacity to be aware of and appreciate the diverse backgrounds and frames of reference of others, to become more empathic, and to foster good relationships (Ryan and Deci, 2020). These positive impacts are applicable to all students regardless of their nationality, individualist or collectivist culture, or any learning challenges that students may face (Ryan and Deci, 2017, 2020; Wang et al., 2021; Guay, 2022). Greater emphasis on building these skills through support of students' self-efficacy and basic psychological needs may yield long-term benefits in overall higher levels of learning as well as more productive and harmonious societies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of Fresenius University of Applied Sciences. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

LB: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. BO: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. ML: Conceptualization, Writing – original draft, Writing – review & editing. NV: Conceptualization, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing. MT: Resources, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

LB, ML, and MT were employed by Instructional Empowerment.

The remaining 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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1385442/full#supplementary-material

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