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Student Boredom in the Adolescent Years

Vorgelegt von

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Zusammenfassung

Aktuelle Forschung zeigt, dass Langeweile eine der am häufigsten erlebten negativen Emotionen in der Schule ist. Sie wird als äußerst unangenehme Emotion beschrieben, die unter anderem mit Aufmerksamkeitsproblemen, geringerer Anstrengungsbereitschaft und Motivation, Schwierigkeiten bei der Selbstregulation, der Nutzung weniger effektiver Lernstrategien, schlechteren Leistungen bis hin zu Schulabbruch und Jugendkriminalität in Zusammenhang steht. Obwohl Langeweile in der Regel negativ mit Leistung korreliert, gibt Hinweise darauf, dass sowohl Über- als auch Unterforderung zu Langeweile führen können. Es ist jedoch unklar, ob Langeweile durch Überforderung mit denselben negativen Korrelaten einhergeht wie Langeweile durch Unterforderung. Darüber hinaus wird Langeweile in verschiedenen Kontexten mit gesundheitlichen Problemen wie Depressionen, somatischen Beschwerden, Fettleibigkeit und Essstörungen sowie Drogenmissbrauch in Verbindung gebracht. Über mögliche negative physische und psychische Auswirkungen schulischer Langeweile ist jedoch bisher wenig bekannt. Zusammengenommen deuten diese Ergebnisse darauf hin, dass Langeweile uns davon abhält, unser volles Potenzial auszuschöpfen, und sich nachteilig auf unsere Gesundheit auswirken kann. Folglich wurde Langeweile unter anderem als Plage der heutigen Zeit beschrieben, die es weiter zu erforschen und zu reduzieren gilt. Das Ziel der vorliegenden Dissertation war es deshalb schulische Langeweile durch Über- und Unterforderung, sowie deren Auswirkungen auf gesundheitsbezogene Lebensqualität im Mathematikunterricht der Sekundarstufe 1 zu erforschen. Dafür wurden in Studie 1 systematisch Verhaltens- und Persönlichkeitsvariablen von Schülerinnen und Schülern verglichen, die stark gelangweilt und leistungsschwach sind (also wahrscheinlich überfordert, basierend auf

der Mathematiknote) und stark gelangweilt, aber leistungsstark (also wahrscheinlich unterfordert). Die Ergebnisse zeigen, dass Langeweile durch Über- und Unterforderung mit ähnlichen nachteiligen Verhaltens- und Persönlichkeitsvariablen einhergeht. Anknüpfend an Studie 1 wurde die Thematik der Langeweile durch Über- und Unterforderung in Studie 3 erneut aufgegriffen, um empirische Evidenz für das Vorhandensein und die Prävalenz von Langeweile durch Über- und Unterforderung zu erforschen. Mithilfe eines standardisierten Mathematiktests und latenter Profilanalyse konnte gezeigt werden, dass Langeweile in Mathematik sowohl durch Über- als auch durch Unterforderung auftreten kann und dass Geschlecht und Schulform dabei eine Rolle spielen können. Studie 2 untersuchte den Zusammenhang zwischen Langeweile und gesundheitsbezogener Lebensqualität. Die Ergebnisse zeigen, dass Langeweile signifikant negativ mit gesundheitsbezogener Lebensqualität zusammenhängt und eine stärkere Zunahme von Langeweile im Laufe eines Schuljahres mit niedrigeren Werten gesundheitsbezogener Lebensqualität einhergeht. Zusammenfassend und im Einklang mit bisheriger Forschung verdeutlicht die vorliegende Dissertation die Relevanz der Langeweileforschung. Sie zeigt, dass Langeweile in der Schule allgegenwärtig ist (Studie 3) und im Laufe eines Schuljahres zunimmt (Studie 2). Es wurde empirisch belegt, dass hohe Langeweile sowohl bei leistungsschwachen als auch bei leistungsstarken Schülerinnen und Schülern auftreten kann (Studien 1 und 3) und mit zahlreichen problematischen Korrelaten sowohl bei leistungsschwachen als auch bei leistungsstarken Schülern (Studie 1) sowie gesundheitlichen Problemen (Studie 2) einhergeht. Die Ergebnisse verdeutlichen, dass Langeweile in der Schule ein ernstzunehmendes Problem darstellt, mit dem Schülerinnen und Schüler nicht allein gelassen werden sollten.

To my mother

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General Introduction

Boredom: An Important but Unpleasant and Neglected Emotion

The origins of contemporary emotion research can be traced back to Darwin's comparative studies of animals and humans (1859; 1872), which subsequently sparked advancements in various fields such as psychology and physiology (Ludwig & Welch, 2019). Based on Darwin's work, evolutionary theories suggest that emotions are a result of human evolution and help us survive, reproduce, and flourish by adapting to nature and society (e.g., Al-Shawaf et al., 2016). For example, the function of fear is to protect living beings against dangerous, threatening, and aversive situations (Misslin, 2003). Like fear, boredom is considered to hold significant implications for human functioning, as it signals the absence of meaningful engagement with the environment (Bench & Lench, 2013). In other words, boredom serves as a valuable source of information about our lives, leading us toward engaging and meaningful activities while deterring us from pursuits that are not adequately challenging or purposeful (Lin & Westgate, 2021).

Since the ancient Greeks, boredom has been a topic of interest in philosophy, religion, and science (Kuhn, 1976). At the beginning of the 20th century, German psychologist Theodor Lipps described boredom as a feeling of displeasure that arises out of a conflict between the need for activity and the lack of stimulation or the inability to be stimulated (cited in Fenichel, 1951, p. 349; Lipps, 1903). Decades later, boring and monotonous working conditions were linked to numerous health issues such as asthma, hand tremors, regular drinking, and excessive smoking (Ferguson, 1973), visual, musculoskeletal, and emotional health problems (M. J. Smith et al., 1981), as well as stress-related health issues and cardiovascular diseases (Fisher, 1993). Moreover, boredom proneness and leisure boredom were linked to borderline personality disorder diagnosis (Masland et al., 2020), depression (e.g., Fahlman et al.,

2009), obesity and eating disorders (e.g., Ganley, 1989), somatic complaints (Sommers & Vodanovich, 2000), and substance abuse (e.g., Weybright et al., 2015). Furthermore, in school, boredom was linked to higher levels of achievement-related anger, anxiety, and shame (e.g., Pekrun et al., 2011), procrastination (e.g., Blunt & Pychyl, 1998) and reduced motivation (e.g., Pekrun et al., 2010), as well as school drop-out (e.g., Farrell et al., 1988) and lower academic achievement (e.g., Camacho-Morles et al., 2021) and career aspirations (Krannich et al., 2019). Taken together, these findings suggest that boredom keeps us from reaching our full potential and might be detrimental for our health. Consequently, boredom has been described as the plague of modern society (Goetz et al., 2014; Pekrun et al., 2010; Spacks, 1996) and achievement-oriented societies should make every effort to investigate and reduce boredom, given the growing competition in a hyper-globalized economy. Surprisingly though, while studies on boredom have increased steadily over the past years, boredom can still be considered a neglected emotion in psychological research compared to fear, anger, shame, and anxiety (Elpidorou, 2020).

Adolescent Boredom in Mathematics Due to Over- vs. Under-Challenge

While several different definitions of boredom exist, there is no universally accepted coherent definition of boredom (Vodanovich, 2003). Nevertheless, most definitions agree that the experience of boredom is typically characterized by negative valence and attentional issues, the perception of time passing slowly, and insufficient dissatisfactory stimulation, challenge, and meaning (Goetz et al., 2014). In terms of a multi-component definition of emotional experiences (Scherer, 1984, 2000), boredom is defined as an unpleasant and aversive state (affective component) with an altered perception of time (cognitive component) and a desire to leave or change the situation

(motivational component; Krannich et al., 2019; Nett et al., 2011). Achievement emotions are considered relatively unexplored (Goetz et al., 2006) even though they are ever-present (Pekrun, 2007). In achievement settings, boredom is one of the most commonly experienced emotions (Healy, 1984; Pekrun & Linnenbrink-Garcia, 2014). For example, Goetz et al. (2007) found that ninth graders are bored, on average, almost half of the time they spend in class.

In line with Csikszentmihalyi's (1975) concept of flow, it has long been argued that boredom arises in under-challenging situations when someone's skills are higher than the situational demands (i.e., the "understimulation model"; R. P. Smith, 1981). However, for example, in the context of his control-value theory, Pekrun (2006) argued that boredom can also arise in over-challenging situations when someone's skills are lower than the situational demands. Combining both lines of reasoning, there is a whole body of literature addressing boredom due to over- vs. under-challenge, consistently demonstrating that boredom is experienced in both over- and under-challenging situations (e.g., Acee et al., 2010; Daschmann et al., 2011; Goetz & Frenzel, 2010; Krannich et al., 2019; Kügow et al., 2009; Preckel et al., 2010).

Academic boredom has been shown to be highly domain-specific (Goetz, Frenzel, Pekrun, et al., 2007) and particularly pertinent in mathematics (e.g., Preckel et al., 2010). As a core school subject, mathematics has importance for a wide range of professions (e.g., Bieg et al., 2014) and is a predictor of participation in secondary education as well as expected future salary (Organization for Economic Cooperation and Development, 2014). Accordingly, boredom in mathematics has been addressed in several recent studies, for example, exploring control-value appraisals as antecedents of boredom (Putwain et al., 2018) or links between boredom and achievement (Tze et al.,

2015). With an often more negative motivation towards school, adolescents are believed to be particularly prone to experience boredom (e.g., Larson & Richards, 1991). A recent longitudinal study by Weybright et al. (2020) showed in a representative sample of U.S. 8th, 10th, and 12th graders that boredom increased steadily across and within grades from 2008 to 2017, with a greater increase for girls. In sum, adolescent boredom in mathematics deserves more attention, particularly considering its prevalence and consequences.

The Present Dissertation

The present dissertation seeks to add to this literature by investigating scholastic boredom due to over- vs. under-challenge of adolescents and its undesirable correlates in three quantitative studies by assessing boredom in a domain-specific way, focusing on the subject of mathematics. The data employed in all three studies was collected as part of a longitudinal field study during the semester 2018/19 and consisted of 1.485 secondary school students from the Free State of Bavaria, Germany. All findings can be fully reproduced using analysis scripts that are publicly available from the Open Science Framework (osf.io/tbqk8).

Study 1

Recent research linked boredom in school to attention problems, reduced effort, self-regulation, and motivation (e.g., Eren & Coskun, 2016), the use of less effective learning strategies (e.g., Pekrun et al., 2010), the avoidance of schoolwork (e.g., Culp, 2006), and consequently with lower academic achievement (e.g., Daniels et al., 2009; Niculescu et al., 2015; Pekrun et al., 2011). Nevertheless, while scholastic boredom is typically reported to correlate negatively with achievement (e.g., Pekrun et al., 2014), there is substantial evidence that it can be triggered by both over- and under-challenge

(e.g., Krannich et al., 2019). Experiencing high boredom implies undesirable correlates, as boredom in general has been associated with numerous serious problems like dropping out of school (Farrell et al., 1988; Robinson, 1975) or juvenile delinquency (Newberry & Duncan, 2001; Spaeth et al., 2015). However, it is unclear whether the experience of boredom is similarly severe when students are low-achieving and when students are high-achieving. On the one hand, undesirable correlates of boredom could augment particularly for poorly performing students, while high-performing students do not suffer as much. On the other hand, excessive boredom per se could covary with problematic behavior and personality—irrespective of whether students perform well (thus, likely tend to be under-challenged) or poorly (thus likely tend to be over-challenged). Study 1 of the present dissertation addressed this question by systematically comparing behaviors (social and emotional problems, positive/negative affect, cognitive reappraisal, and expressive suppression) and personality traits (neuroticism and conscientiousness) of students who are highly bored (more than one *SD* above *M*, $n = 258$) and low-achieving (thus, likely over-challenged, as indicated by teacher-assigned math grades, $n = 125$) and highly bored yet high-achieving (thus, likely under-challenged, $n = 119$) in the subject of mathematics.

The selection of behaviors and personality traits investigated in Study 1 was guided by correlative findings of previous studies investigating general boredom proneness, namely links with enhanced negative emotions (Rupp & Vodanovich, 1997), conduct problems (Dahlen et al., 2004; Leong & Schneller, 1993; Spaeth et al., 2015), hyperactivity (Gerritsen et al., 2014), peer problems (Tolor, 1989), negative affect (Alda et al., 2015), expressive suppression (Vierhaus et al., 2016), neuroticism (Mercer-Lynn et al., 2013), and negatively with prosocial behavior (Leong & Schneller, 1993),

positive affect (Alda et al., 2015), cognitive reappraisal (Vierhaus et al., 2016), and conscientiousness (Culp, 2006). As a preliminary step, study 1 attempted to replicate these findings while assessing student boredom in mathematics.

Study 2

While boredom in school has been shown to have adverse academic consequences like lower achievement (e.g., Pekrun et al., 2014) and achievement-related anger, anxiety, and shame (e.g., Putwain et al., 2018), comparatively little is known about potential psychological and physical health-related correlates of scholastic boredom. Based on empirical evidence on links between boredom proneness and leisure boredom with adverse health effects, such as depression (e.g., Fahlman et al., 2009; Sommers & Vodanovich, 2000), somatic complaints (Sommers & Vodanovich, 2000), substance abuse (e.g., Iso-Ahola & Crowley, 1991; Weybright et al., 2015), and eating disorders (e.g., Abramson & Stinson, 1977; Ganley, 1989), Study 2 sought to explore psychological and physical health correlates of scholastic boredom.

The longitudinal study investigated latent correlations of mathematics boredom at three time points during a semester in 2018/19 and Rasch scaled health-related quality of life (HRQoL; i.e., physical well-being, psychological well-being, autonomy and parent relation, social support and peers, school environment, and general HRQoL) employing a sample of 1.484 adolescents. Furthermore, to explore if changes in mathematics boredom across the semester were linked with HRQoL, boredom trajectories were estimated using latent growth curve modeling. The relationship between latent growth parameters of student boredom and HRQoL dimensions was explored in bivariate correlation analyses.

Study 3

Following the previously mentioned literature addressing boredom due to over- vs. under-challenge, study 3 strived to provide stronger evidence for the existence and prevalence of boredom due to over- vs. under-challenge in mathematics because empirical evidence is still largely lacking. Instead of teacher-assigned grades (see Study 1), the mathematics achievement of students was measured with a reliable index of mathematical abilities, arguing that this provides stronger evidence of boredom due to over- vs. under-challenge in mathematics among secondary school students. A standardized mathematics test was used to measure the fraction of students who experience high boredom in math classes while having a high mathematical potential (hence, are likely under-challenged) and the faction of students who experience boredom while having a low mathematical potential (hence, are likely over-challenged). Using latent profile analysis, it was hypothesized to find at least four distinct boredom profiles. Two of those profiles should consist of students that show either high boredom and low achievement (i.e., an over-challenged group) or high boredom and high achievement (i.e., an under-challenged group). As suggested by negative correlations between boredom and achievement (e.g., Camacho-Morles et al., 2021), one profile should consist of students that show low boredom and high achievement (i.e., a well-off group). Eventually, a fourth profile should consist of students demonstrating average levels of all variables included in the profile analysis (i.e., an indifferent group).

Above and beyond identifying the existence and sizes of qualitatively different boredom/mathematics achievement groups, gender, and school type were used as latent class predictors to explore the role of both variables.

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Study 1: Excessive Boredom Among Adolescents: A Comparison Between Low and High Achievers

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Abstract

Existing research shows that high achievement boredom is correlated with a range of undesirable behavioral and personality variables and that the main antecedents of boredom are being over- or under-challenged. However, merely knowing that students are highly bored, without taking their achievement level into account, might be insufficient for drawing conclusions about students' behavior and personality. We, therefore, investigated if low- vs. high-achieving students who experience strong mathematics boredom show different behaviors and personality traits. The sample consisted of 1.404 German secondary school students (fifth to 10th grade, mean age 12.83 years, 52% female). We used self-report instruments to assess boredom in mathematics, behavioral (social and emotional problems, positive/negative affect, cognitive reappraisal, and expressive suppression), and personality variables (neuroticism and conscientiousness). In comparing highly bored students (more than one *SD* above *M*, $n = 258$) who were low vs. high achievers (as indicated by the math grade, $n = 125$ / $n = 119$), results showed that there were no mean level differences across those groups for all variables. In conclusion, our results suggest that high boredom can occur in both low- and high-achieving students and that bored low- and high-achievers show similar behaviors and personality profiles.

Keywords: boredom, emotions, personality, achievement, adolescents

Excessive Boredom Among Adolescents: A Comparison Between Low and High Achievers

Boredom is one of the most commonly experienced emotions in educational settings (Healy, 1984; Pekrun & Linnenbrink-Garcia, 2014). Adolescents report being bored 30–40% of the time in school (Barnett, 2012; Farrell et al., 1988), but also in their spare time (Larson & Richards, 1991). Highly bored students were shown to avoid schoolwork (Culp, 2006), to have attention problems, and reduced effort, self-regulation, and motivation (Eren & Coskun, 2016; Pekrun et al., 2010, 2002). They were also shown to use less effective learning strategies (Pekrun et al., 2010; Pekrun & Linnenbrink-Garcia, 2014). As a consequence, there is consistent evidence that boredom correlates negatively with academic achievement (Ahmed et al., 2013; Daniels et al., 2009; Goetz et al., 2010; Goetz, Frenzel, Pekrun, et al., 2007; Niculescu et al., 2015; Pekrun et al., 2010, 2011, 2014; Putwain et al., 2013). More generally, high boredom among adolescents has been associated with numerous serious problems like dropping out of school (Farrell et al., 1988; Robinson, 1975) or juvenile delinquency (Newberry & Duncan, 2001; Spaeth et al., 2015). An important and well-documented characteristic of boredom is that it can be triggered by both over- and under-challenge (Krannich et al., 2019). However, it is unclear whether boredom is similarly severe when students are bored due to over-challenge and when they are bored due to under-challenge. In other words: Are undesirable correlates of boredom worse in the case of over-challenge, and may under-challenged students not suffer as much? Or is it the excessive boredom per se that covaries with problematic behavior and personality? To address this question, we systematically compared students who are highly bored and low-achieving, that is, likely over-challenged, and highly bored yet high-achieving, that

is, likely under-challenged, in the subject of mathematics. The present study thus seeks to enrich the literature by enhancing our understanding of achievement boredom. Specifically, we add further knowledge about a potential differentiation between boredom due to being over- vs. under-challenged and offer practical implications for teachers, students, and parents.

Boredom as an Unpleasant Emotion With Undesirable Correlates

Boredom, most generally, is described as an unpleasant and distressing experience (Martin et al., 2006). There are two widely used scales to measure general trait boredom: The Boredom Proneness Scale (BPS; Farmer & Sundberg, 1986) and the Boredom Susceptibility Scale (BSS; Zuckerman, 1979). Research on the BPS has revealed that boredom proneness has multiple undesirable correlates, including alexithymia (Eastwood et al., 2007), alienation (Tolor, 1989), anger and aggression (Dahlen et al., 2004; Mercer-Lynn, Hunter, et al., 2013; Rupp & Vodanovich, 1997), impulsiveness (Dahlen et al., 2005; Leong & Schneller, 1993; Mercer-Lynn, Hunter, et al., 2013; Watt & Vodanovich, 1992), loneliness (Farmer & Sundberg, 1986), narcissism (Wink & Donahue, 1997), negative affect (Vodanovich et al., 1991), neuroticism (Barnett & Klitzing, 2006; Mercer-Lynn, Flora, et al., 2013; Mercer-Lynn, Hunter, et al., 2013) procrastination (Blunt & Pychyl, 1998; Vodanovich & Rupp, 1999), and unsociability (Leong & Schneller, 1993). In turn, low levels of boredom proneness have been shown to be linked with higher levels of conscientiousness, openness to experience (Culp, 2006), and life satisfaction (Farmer & Sundberg, 1986). High scores on the BSS have been reported to be associated with higher levels of motor impulsivity, sensitivity to reward, gambling, alcohol, and smoking (Martínez-Vispo et al., 2019; Mercer-Lynn, Flora, et al., 2013). Going beyond such general, context-

transcending findings, the present study specifically addresses boredom at school, and even more specifically, student experiences of boredom in the subject of mathematics. We thus assess boredom as a trait construct in a domain-specific way.

While mathematics boredom has been studied in several recent studies addressing, for example, the control- and value-appraisal antecedents of mathematics boredom (Pekrun et al., 2010; Putwain et al., 2018), or boredom-achievement links (Tze et al., 2015), no study to date seems to have explored whether such domain-specific boredom is also linked with person-level behavioral and personality variables. In other words, it remains open to question if those students who report to experience intense boredom in mathematics only show undesirable levels of structs related to the domain of mathematics (e.g., poor study habits), or if they also show problematic behavior patterns beyond this context (e.g., lower sociability). In line with Bronfenbrenner's (1992) ecological systems theory, we suggest that domain-specific boredom and more general behavioral and personal variables inevitably interact with each other. Thus, the first aim of this study was to replicate prior correlational findings as demonstrated using more general instruments for the assessment of boredom in the subject of mathematics.

Boredom Due to Being Over- vs. Under-Challenged

The idea of boredom being caused by under-challenge has already been brought forward by Csikszentmihalyi in 1975. In this work, he argued that boredom supposedly arises in situations in which someone's competencies are higher than the situational opportunities or, in other words, in situations that are under-challenging. However, boredom can also be prompted when task demands are too high and cannot be interpreted in a meaningful way, implying over-challenge. Integrating across both perspectives, Pekrun's (2006, 2018) control-value theory of achievement emotions

proposes that boredom should be linked with either low or high control. In other words, according to this theory, students should experience boredom when they appraise that success is either quite easily or only barely attainable for them (Putwain et al., 2018). This implies that both low and high achievers may experience high levels of boredom. Over the past years, these theoretical propositions have been addressed by a large body of empirical research which has consistently demonstrated that boredom is, indeed, experienced in both over- and under-challenging situations (Acee et al., 2010; Goetz & Frenzel, 2010; Krannich et al., 2019; Kügow et al., 2009; Preckel et al., 2010; Westgate & Wilson, 2018).

Despite this compelling evidence on the meaning of differentiating between boredom due to being over- vs. under-challenged, what still seems open to question is whether experiencing intense boredom is similarly severe when students are low-achieving and thus likely over-challenged, or when students are high-achieving and thus likely under-challenged. On the one hand, the undesirable correlates of boredom may arise only for poorly performing students, while high performing students may not suffer as much from undesirable correlates of boredom. Such reasoning would be supported by the fact that high academic achievement typically is associated with conscientiousness (Chamorro-Premuzic & Furnham, 2003; De Feyter et al., 2012) and high self-esteem (Booth & Gerard, 2011). Those factors could protect against the potential undesirable correlates of boredom. From another perspective, experiencing intense levels of boredom at school may imply undesirable correlates, irrespective of levels of challenge, and scholastic performance. Such reasoning is supported by Krannich's (2019) study which showed both being over- or under-challenged resulted in a decrease in career aspirations.

The Present Study

The present study addresses a gap in research on achievement boredom by systematically comparing students who are highly bored and low-achieving – thus, likely over-challenged, and highly bored yet high-achieving – thus, likely under-challenged. As potential undesirable correlates, we took into account both behavioral and personality variables. As achievement boredom has been shown to be highly domain-specific (Goetz, Frenzel, Pekrun, et al., 2007) and particularly salient in mathematics (Preckel et al., 2010) we decided to focus on this domain. The present study takes a trait perspective (Pekrun, 2006), proposing that individuals systematically differ in their tendency to experience boredom.

The choice of constructs addressed in the present study was guided by the aim to address the central negative aspects mentioned in the general boredom proneness literature, in as much as they seemed relevant in our context. We thus aimed at replicating prior findings on a broad range of correlates of boredom as demonstrated using more general instruments for the assessment of boredom proneness, while assessing boredom specifically with respect to the subject of mathematics. Previous research has shown that boredom is linked with enhanced negative emotions (Rupp & Vodanovich, 1997), conduct problems (Dahlen et al., 2004; Leong & Schneller, 1993; Spaeth et al., 2015), hyperactivity (Gerritsen et al., 2014), peer problems (Tolor, 1989), and lack of prosocial behavior (Leong & Schneller, 1993). Therefore, to explore potential undesirable correlates of boredom, we took all subscales of the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997) into account. Furthermore, boredom has been shown to be positively linked with negative affect (Alda et al., 2015), expressive suppression (Vierhaus et al., 2016), and neuroticism (Mercer-Lynn, Flora, et

al., 2013) as well as negatively with positive affect (Alda et al., 2015), cognitive reappraisal (Vierhaus et al., 2016), and conscientiousness (Culp, 2006). We therefore additionally considered general affect as measured with the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), cognitive reappraisal and expressive suppression as measured with the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) and finally, neuroticism and conscientiousness as measured with the Big Five Inventory-2 (BFI-2; Soto & John, 2017).

Despite the extensive body of research examining achievement boredom in adolescents, it is still open to question whether experiencing intense boredom is similarly severe when students are low-achieving and when they are high-achieving. Therefore, we formulated the following exploratory research question: Do low-achieving students with high boredom systematically differ in their self-reported behaviors and personality traits from high-achieving students with high boredom? We propose that an answer to this question enhances the scientific understanding of achievement boredom and offers practical implications, especially with respect to potentially dealing differentially with students who are bored due to being over- vs. under-challenged.

Method

Sample

The sample consisted of N = 1.404 secondary school students from 103 classrooms of 25 schools (52% girls [n = 731], 47% boys [n = 661], 1% not indicated [n=12]) from the Free State of Bavaria, Germany. Students were from all three tracks of the Bavarian three-track general secondary school system, with 47% (n = 662 students) from the upper (Gymnasium), 28% (n = 390) the middle (Realschule), and 25% (n =

349) the lower track (Mittelschule). This distribution across tracks is equivalent with the Bavarian secondary student statistics, with a slight overrepresentation of Gymnasium student population (LfStat, 2018). The students were in the fifth (n = 172), sixth (n = 197), seventh (n = 582), eighth (n = 291), ninth (n = 134), and 10th grade (n = 24) and were 9 to 17 years old, with a mean age of M_{age} = 12.83 years (SD_{age} = 1.29). The vast majority of the students (92%, n = 1.287) was born in Germany while 18% of them had at least one foreign-born parent (n_{mother} = 181, n_{father} = 177, n_{both} = 118).

The research was approved by Ludwig Maximilian University of Munich's Ethics Review Board of the Faculty of Psychology and Education. Participation in the study was voluntary, written informed consent was obtained from all participants, parents or guardians respectively, and no identifiers that could link individual participants to their results were obtained.

Measures

The data reported here were assessed as part of a longer questionnaire which in total consisted of ten pages with open-ended and multiple-choice questions. External trained testing personnel brought the questionnaires to the schools and collected them a few weeks later. The questionnaire was filled out at home by the students and collected, inside sealed envelopes, in class by their mathematics teachers.

Boredom

Students' class-related, habitual, trait-like boredom in mathematics was accessed using six items of the course-specific boredom scale of the Achievement Emotions Questionnaire–Mathematics (AEQ-M; Frenzel et al., 2007; Pekrun et al., 2011). In the AEQ, students are prompted to "Please indicate how you feel, typically, during math class"; a sample item is "I am so bored that I can't stay awake" (see Table 1 for the full

set of items used in this study in original German, and their English translation). Students responded using a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Table 1

Boredom Items of the Achievement Emotions Questionnaire–Mathematics (AEQ–M)

Items German	Items English translation
Ich finde den Unterricht langweilig.	I think the mathematics class is boring.
Vor Langeweile schalte ich ab.	I can't concentrate because I am so bored.
Vor Langeweile kann ich mich kaum wach halten.	I am so bored that I can't stay awake.
Vor Langeweile gehen mir immer wieder Gedanken durch den Kopf, die mit Mathe nichts zu tun haben.	I think about what else I might be doing rather than sitting in this boring class.
Ich schaue ständig auf die Uhr, weil die Zeit nicht vergeht.	Because of time drags I frequently look at my watch.
Ich werde unruhig, weil ich nur darauf warte, dass die Mathestunde endlich vorüber ist.	I get restless because I can't wait for the class to end.

Note. Asking students to judge "Please indicate how you feel, typically, during math class."

Achievement

Self-reported math grades from students' last final report card were used as an indicator of achievement. The grades are summative scores based on multiple evaluations over the course of a school year and range from 6 (*poor*) to 1 (*excellent*).

Emotional and Behavioral Problems

The German version (SDQ–Deu–S; Lohbeck et al., 2015) of the one-sided self-report version (see Goodman et al., 2003) of the Strengths and Difficulties Questionnaire for 11-17-year-olds by Goodman (1997) was used to measure emotional and behavioral problems. The items comprised of five subscales of five items each for emotional symptoms (e.g., "I worry a lot"), conduct problems ("I get very angry and often lose my temper"), hyperactivity ("I am restless, I cannot stay still for long"), peer problems ("I would rather be alone than with people of my age"), and prosocial behavior ("I am helpful if someone is hurt, upset or feeling ill"). Students were asked to judge these items on a scale from 1, *not true,* 2, *somewhat true,* to 3, *certainly true*.

Positive and Negative Affect

The German version by Krohne, Egloff, Kohlmann, and Tausch of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) was used to determine students' general affective states. This self-report scale consists of 10 positive (e.g., "excited") and 10 negative adjectives (e.g., "upset"). Participants responded on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*) to describe their "general emotional state."

Cognitive Reappraisal and Expressive Suppression

The German version of the Emotion Regulation Questionnaire (ERQ; Abler & Kessler, 2009; see Gross & John, 2003 for the English version) was used to measure the tendency to regulate emotions by cognitive reappraisal or expressive suppression. Participants had to rate four items on cognitive reappraisal (e.g., "When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm") and

expressive suppression (e.g., "I keep my emotions to myself") on a scale from 1 (*not at all true*) to 7 (*completely true*).

Conscientiousness and Neuroticism

We considered two of the big five personality traits which have been reported to be systematically linked with boredom, namely conscientiousness, and neuroticism. While conscientiousness (e.g., "I am someone who is systematic, likes to keep things in order") measures differences in organization, productiveness, and responsibility, neuroticism (e.g., "I am someone who tends to feel depressed, blue") measures differences in the frequency and intensity of negative emotions (Soto, 2018). We used the German version of the Big Five Inventory-2 for their assessment (BFI–2; Danner et al., 2019; see Soto & John, 2017 for the English version). Students were asked to rate 12 items for each construct on a 5-point rating scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Data Analyses

All analyses were conducted using R 3.6.1 (R Core Team, 2019). The full analysis code is available from the Open Science Framework database (https://osf.io/zypae). To assess the internal consistency of the scales, the reliability coefficient Cronbach's alpha (α) was calculated. As outlined in Table 2, AEQ–M boredom, PANAS positive and negative affect, and BFI–2 neuroticism and conscientiousness showed good reliabilities (α between .81 and .86). SDQ hyperactivity and prosocial behavior, ERQ cognitive reappraisal, and expressive suppression showed borderline-acceptable reliabilities, but SDQ conduct and peer problems showed low reliabilities (α between .47 and .53). However, earlier studies also documented comparably low internal consistencies for those SDQ subscales when using student

ratings (Goodman, 2001). Therefore, this was not a peculiarity of our sample. To circumvent biased results due to scale unreliability, we chose to model all variables as latent constructs using the Lavaan 0.6-5 package (Rosseel & Jorgensen, 2019) employing the full information likelihood method (FIML; Enders, 2010) for treating missing data, and the MLR estimator (maximum likelihood estimation with robust [Huber-White] standard errors and a scaled test statistic that is [asymptotically] equal to the Yuan-Bentler test statistic).

Table 2

Means, Standard Deviations, and Cronbach's Alpha for the Study Scales

Scale	Construct	*M* (*SD*)	Min. – Max.	α
AEQ-M	Boredom	2.39 (0.95)	1.00 – 5.00	.86
SDQ	Emotional symptoms	1.58 (.48)	1.00 – 3.00	.71
	Conduct problems	1.36 (.31)	1.00 – 3.00	.47
	Hyperactivity	1.73 (.45)	1.00 – 3.00	.68
	Peer problems	1.42 (.34)	1.00 – 3.00	.53
	Prosocial behavior	2.61 (.36)	1.00 – 3.00	.65
PANAS	Positive affect	3.53 (.62)	1.00 – 5.00	.80
	Negative affect	2.00 (.68)	1.00 – 4.80	.84
ERQ	Cognitive reappraisal	3.93 (1.25)	1.00 – 7.00	.68
	Expressive suppression	3.70 (1.25)	1.00 – 7.00	.60
BFI-2	Neuroticism	2.65 (.66)	1.00 – 5.00	.81
	Conscientiousness	3.40 (.67)	1.25 – 5.00	.82

Note. $1390 \leq n \leq 1404$ due to missing values. α = Cronbach's alpha.

We thus obtained latent correlations between boredom, emotional and behavioral problems, positive and negative affect, cognitive reappraisal, and expressive suppression, as well as neuroticism and conscientiousness based on structural equation modeling (SEM). To identify highly bored students, we obtained latent factor scores for each student for the six items of the AEQ-M boredom scale. In this context, we defined

the high boredom group to include all students who scored higher than one standard deviation (*SD* = .7) above the standardized sample mean of zero on the AEQ-M boredom scale (*n* = 258). To compare across low- vs. high-achievers among these highly bored students, we used the final math grade of the previous school year as an indicator of achievement in math class. In this analysis, students with missing grades (*n* = 14) were excluded. Grades from 4 to 6 (4 = sufficient, 5 = poor, 6 = insufficient) were coded as 0 = low achievement and grades from 1 to 3 (1 = excellent, 2 = good, 3 = satisfactory) as 1 = high achievement (*M* = 3, *SD* = 0.9, *Mdn* = 4). As a result, there were 125 students in the low achievement group (boredom *M* = 3.98, *SD* = .53), and 119 students in the high achievement group (boredom *M* = 3.80, *SD* = .42). To account for multiple testing, we used the Bonferroni method to adjust the alpha level to .005.

Results

Preliminary Analysis

Table 3 shows the latent correlations between students' mathematics boredom and all other affective and behavioral constructs considered in this study, across the full sample. Boredom correlated significantly with all other constructs assessed. Strong relations were found for conduct problems and hyperactivity (r between .52 and .56), and medium-sized relations were found for emotional symptoms, positive and negative affect, and neuroticism and conscientiousness (r between −.45 and .45). Peer problems and prosocial behavior, as well as cognitive reappraisal and expressive suppression, showed small-sized links with mathematics boredom (r between −.29 and .13). The overall pattern of relationships was consistent with previous studies on boredom proneness in that higher levels of boredom in mathematics class were associated with

higher levels of undesired behavioral and personality variables, and lower levels of desirable behavioral and personality variables.

Table 3

Behavior and Personality: Latent Correlations with Boredom and Comparison Between Bored Low and High Achievers

				Manifest means				
		Latent correlation with boredom		Low achievers	High achievers	Comparison of latent means		
Scale	Construct	*r*	*p*	*M* (*SD*)	*M* (*SD*)	β	*p*	R^2
SDQ	Emotional symptoms	.42	< .001	.90 (.52)	.79 (.53)	−.14	.067	.02
	Conduct problems	.52	< .001	.61 (.43)	.46 (.35)	−.23	.005	.05
	Hyperactivity	.56	< .001	1.07 (.46)	.99 (.49)	−.04	.555	< .00
	Peer problems	.25	< .001	.56 (.40)	.47 (.35)	−.17	.091	.03
	Prosocial behavior	−.29	< .001	1.48 (.42)	1.50 (.40)	.01	.874	< .00
PANAS	Positive affect	−.45	< .001	3.16 (.71)	3.40 (.62)	.20	.009	.04
	Negative affect	.40	< .001	2.40 (.67)	2.28 (.67)	−.12	.110	.01
ERQ	Cognitive reappraisal	−.12	.002	3.69 (1.35)	3.85 (1.16)	.12	.162	.01
	Expressive suppression	.13	.001	4.09 (1.32)	3.63 (1.26)	−.19	.041	.04
BFI-2	Neuroticism	.45	< .001	3.06 (.71)	2.91 (.64)	−.11	.199	.01
	Conscientiousness	−.44	< .001	3.02 (.67)	3.06 (.65)	−.02	.774	< .00

Note. Bonferroni adjusted *p*-value < .005. R^2 = coefficient of determination.

Group Differences Between Low and High Performers

Before comparing latent mean differences between low- and high-achieving students, we tested for measurement invariance of each of the latent constructs addressed in this study, using the SemTools 0.5-2 package (Jorgensen et al., 2019). This was to make sure that the latent scores used in the analysis were comparable across both groups. We sequentially tested for equivalence of model form (configural), equivalence of factor loadings (metric), and equivalence of item intercepts or thresholds (scalar; Meredith, 1993). For comparing latent means across groups, scalar invariance is necessary (Vandenberg & Lance, 2000). We refrained from additionally testing for residual invariance, which is nugatory to the interpretation of latent mean differences (Vandenberg & Lance, 2000). As can be seen from S1 Table, scalar factorial invariance could indeed be accepted for all constructs except SDQ hyperactivity and peer problems. While hyperactivity showed metric invariance, peer problems only showed configural invariance, implying considerably different item functioning of those items for the low- as opposed to high-achieving bored students.

To investigate differences in behavioral and personality variables of highly bored students who are performing poorly vs. well in mathematics, we regressed the dichotomous variable achievement in mathematics (low vs. high) on all other constructs considered in this study, modeled as latent variables. The results (Table 3) revealed no group differences for any of the constructs. It is worth noting that those results proved to be fully robust when entering school type as dummy-coded control variables. In interpreting these results, differential item functioning for hyperactivity and peer problems must be taken into account.

Discussion

In the present study, we aimed to systematically compare students who are highly bored and low-achieving, i.e., likely over-challenged, with students who are highly bored and high-achievement, i.e., likely over-challenged. We argued that it remains open to question whether experiencing intense boredom is associated with similarly severe levels of undesirable correlates when students are low- vs. high-achieving. To this end, within the group of highly bored students in our sample, we compared across low-achieving and thus likely over-challenged, and high-achieving and thus likely under-challenged students.

As a preliminary analysis step, we examined correlates of students' boredom in the context of mathematics, following up on previous research which has consistently reported that boredom has multiple undesirable correlates. Our results fully replicated earlier-reported patterns of relationships with undesirable boredom correlates. Specifically, we found again that student-reported experiences of boredom during mathematics classes is positively correlated with emotional and behavioral problems, negative affectivity, the use of expressive suppression to regulate emotions, and neuroticism. In contrast, students' mathematics boredom proved to be negatively correlated with levels of prosocial behavior, positive affectivity, cognitive reappraisal, and conscientiousness.

Moreover, and most importantly, our results suggest that high boredom is associated with similar levels of problematic correlates in low- and high-achieving students. The two groups did not significantly differ in emotional symptoms, conduct problems, hyperactivity, peer problems, prosocial behavior, positive and negative affect, neuroticism, cognitive reappraisal and expressive suppression, neuroticism, and

conscientiousness. In line with Pekrun's (2006, 2018) control-value theory of achievement emotions which posits that boredom can occur either when control is particularly high, or when it is particularly low, we find that both over- and under-challenge can lead to high boredom. Furthermore, irrespective of student's performance, and hence irrespective of their subjective control in a certain domain, our study demonstrates that high boredom itself is associated with many of these problems. In sum, we propose that one important implication from our findings is that boredom is boredom — irrespective of its antecedents.

Limitations, Suggestions for Future Research, and Implications

By showing that bored low- and high-achievers show similar patterns in behavioral and personality variables, this study addresses a gap in boredom research and contributes to a better understanding of achievement boredom. However, the following limitations should be taken into account when interpreting our results and could be considered as directions for future research.

First of all, the present study relies on the reasoning that the combination of high boredom with good grades in mathematics implies that those students tend to be bored due to being under-challenged, while the combination of high boredom with poor grades implies that they tend to be over-challenged. It is important to note that this is an assumption, and the classification as over- vs. under-challenge may not have been fully valid for each individual student in the two groups. However, we deliberately chose to assess domain-specific boredom and domain-specific achievement separately, to first identify students with very high boredom, and then classify boredom as likely being due to over- vs. under-challenge based on students' achievement. While this indirect approach to assess over- and under-challenge may be a point of debate, we also deem

more direct self-report assessments (e.g., ‘I am bored because it's too easy’) as psychometrically problematic. Items combining reports of boredom with attributions of boredom are double-barreled and thus ambiguous — it is unclear if students who endorse those items do so because they are bored, or because they find the material easy vs. hard, or because they attribute boredom to over- or under-challenge.

Moreover, our study was conducted in math class at secondary schools in Germany. To generalize our findings, future research should consider problematic correlates of intense boredom in high- and low-achievers in other relevant contexts like elementary schools, universities, or the workplace; in domains other than mathematics; and in other cultures.

With almost 20% (n = 256) of the students in our sample indicated to be severely bored in math class, this study suggests again that no student should be left alone to endure the “torments of boredom” (Berlyne, 1960, p. 192). Given that students almost exclusively use avoidance-oriented coping strategies to deal with their boredom (Goetz, Frenzel, & Pekrun, 2007), boredom should be openly discussed in class, and more promising coping strategies such as cognitive- and behavioral-approach strategies should be addressed (Nett et al., 2010).

One of the most reported reasons for boredom is low-quality instructional design (Goetz & Frenzel, 2006). An adaptive and individualized learning environment might, therefore, contribute to preventing boredom due to being both over- or under-challenged. Most importantly, teachers, parents, and students should be aware that boredom in school needs to be taken seriously. Boredom can indicate severe problems not just in the sense of a student being lazy, too bright, over-challenged, or under-challenged, but can constitute a debilitating personality trait.

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Supporting Information

S1 Table

Chi-Squared Difference Test for the Nested Model Comparison

Model	χ2 (df)	CFI	RMSEA (90% CI)	SRMR	Model comp	Δχ2 (Δdf)	ΔCFI	ΔRMSEA	ΔSRMR	Decision
SDQ Emotional Symptoms										
M1	12.6 (10)	.985	.048	.038†	-	-	-	-	-	-
M2	14.8 (14)	.995	.022	.046	M1	2.21 (4)	.010	−.03	.008	Accept
M3	16.5 (18)	1.000	.000†	.049	M2	1.73 (4)	.005	−.02	.003	Accept
SDQ Conduct Problems										
M1	16.9 (10)	.926†	.077	.049†	-	-	-	-	-	-
M2	24.6 (14)	.886	.081	.065	M1	7.68 (4)	–.04	.004	.015	Accept
M3	25.9 (18)	.915	.062†	.065	M2	1.32 (4)	.03	.019	.001	Accept
SDQ Hyperactivity										
M1	22.3 (10)	.933	.101	.055†	-	-	-	-	-	-
M2	25.1 (14)	.939†	.081†	.063	M1	2.86 (4)	.006	−.020	.008	Accept
M3	40.4 (18)**	.877	.102	.083	M2	15.25 (4)**	−.62	.020	.020	Reject

S1 Table (continued)

Model	χ2 (df)	CFI	RMSEA (90% CI)	SRMR	Model comp	Δχ2 (Δdf)	ΔCFI	ΔRMSEA	ΔSRMR	Decision
SDQ Peer Problems										
M1	12.2 (10)	.970†	.043†	.041†	-	-	-	-	-	-
M2	26.1 (14**	.830	.086	.068	M1	13.97 (4)**	−.140	.043	.027	Reject
M3	27.7 (18)	.864	.068	.070	M2	1.54 (4)	.034	−.018	.002	Accept
SDQ Prosocial Behavior										
M1	13.6 (10)	.977	.055	.038†	-	-	-	-	-	-
M2	17.9 (14)	.975	.048	.055	M1	4.23 (4)	−.001	−.007	.016	Accept
M3	21.3 (18)	.979	.039	.059	M2	3.46 (4)	.003	−.009	.005	Accept
PANAS Positive Affect										
M1	129 (70)	.883	.086	.066†	-	-	-	-	-	-
M2	136 (79)	.887†	.080	.075	M1	7.00 (9)	.004	−.006	.009	Accept
M3	147 (88)	.882	.077†	.078	M2	11.35 (9)	.005	−.003	.004	Accept
PANAS Negative Affect										
M1	175 (70)	.784†	.114	.082†	-	-	-	-	-	-
M2	217 (79)	.773	.110	.096	M1	16.03 (10)	−.012	−.004	.014	Accept
M3	198 (88)	.774	.104	.098	M2	8.20 (9)	.002	−.006	.002	Accept

S1 Table (continued)

Model	$\chi2$ (df)	CFI	RMSEA (90% CI)	SRMR	Model comp	$\Delta\chi2$ (Δdf)	ΔCFI	ΔRMSEA	ΔSRMR	Decision
ERQ Cognitive Reappraisal										
M1	6.82 (4)	.982†	.079	.035†	-	-	-	-	-	-
M2	10.68 (7)	.977	.068†	.057	M1	3.86 (3)	−.005	−.011	.022	Accept
M3	18.49 (10)	.947	.086	.070	M2	7.81 (3)	−.030	.018	.012	Accept
ERQ Expressive Suppression										
M1	9.77 (4)	.933†	.112	.043†	-	-	-	-	-	-
M2	13.56 (7)	.924	.090†	.053	M1	3.79 (3)	−.009	−.022	.01	Accept
M3	19.57 (10)	.890	.091	.068	M2	6.01 (3)	−.035	.001	.01	Accept
BFI-2 Neuroticism										
M1	278 (108)	.694	.119	.099†	-	-	-	-	-	-
M2	287 (119)	.697†	.113	.105	M1	8.98 (11)	.004	−.006	.006	Accept
M3	299 (130)	.696	.108	.107	M2	11.78 (11)	−.001	−.005	.002	Accept
BFI-2 Conscientiousness										
M1	242 (108)	.765	.108	.094†	-	-	-	-	-	-
M2	251 (119)	.769	.102	.099	M1	8.86 (11)	.004	−.006	.005	Accept
M3	268 (130)	.758	.100	.102	M2	17.23 (11)	.011	−.002	.004	Accept

Note. Total $N = 244$; group 1 $n = 125$; group 2 $n = 119$. M1: Configural invariance. M2: Metric invariance. M3: Scalar invariance. ** $p \leq .01$.

Study 2: Boredom Makes Me Sick: Adolescents' Boredom Trajectories and Their Health-Related Quality of Life

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Abstract

Existing research shows consistent links between boredom and depression, somatic complaints, substance abuse, or obesity and eating disorders. However, comparatively little is known about potential psychological and physical health-related correlates of academic boredom. Evidence for such a relationship can be derived from the literature, as boredom has adverse consequences in both work and achievement-related settings. The present study investigates latent correlations of 1.484 adolescents' (Mage = 13.23) mathematics boredom scores at three time points during a semester in 2018/19 and their Rasch scaled health-related quality of life (HRQoL). Moreover, we applied latent growth curve modeling to estimate boredom trajectories across the semester and determined the relationship between the latent growth parameters of student boredom and HRQoL in bivariate correlation analyses. Our results show that boredom is significantly negatively linked with all HRQoL dimensions (physical well-being, psychological well-being, autonomy and parent relation, social support and peers, school environment [SCH], and general HRQoL [GH]). Furthermore, stronger increases in boredom across the semester were negatively associated with SCH scores and GH. In conclusion, given that boredom is negatively linked with HRQoL and that stronger boredom growth is linked with more severe health-related problems, signs of academic boredom could be an early warning signal for adolescents' potentially severe problems.

Keywords: achievement emotions, boredom, adolescents, health-related quality of life

Boredom Makes Me Sick: Adolescents' Boredom Trajectories and Their Health-Related Quality of Life

While there are several different definitions of boredom, most of them agree that boredom experiences are typically characterized by a certain degree of negative valence, coupled with attentional issues, the perception of time passing slowly, and insufficient and dissatisfactory stimulation, challenge and meaning (Goetz et al., 2014). Boredom is one of the most commonly experienced emotions in educational settings (Healy, 1984; Pekrun & Linnenbrink-Garcia, 2014). Particularly during the adolescent years, students report elevated levels of academic boredom (Larson & Richards, 1991), and among U.S. adolescents, the overall experience of boredom increased steadily from 2008 to 2017 (Weybright et al., 2020). Some philosophical notions of boredom emphasized its benefits (Goetz, Frenzel, & Pekrun, 2007; Vodanovich, 2003) and also in the psychological literature, it has been argued that boredom can be considered functional, for example, in the context of willpower (Bieleke & Wolff, 2021). However, academic boredom in particular, has been shown to be a largely adverse emotional experience (Goetz, Frenzel, & Pekrun, 2007) and there is consistent empirical evidence that academic boredom is linked with a multitude of problematic academic outcomes, including higher levels of achievement-related anger, anxiety, and shame (Pekrun et al., 2011; Putwain, Becker, et al., 2018), reduced motivation and effort (Eren & Coskun, 2016; Pekrun et al., 2010, 2002), lower academic achievement (Camacho-Morles et al., 2021; Kügow et al., 2009; Pekrun et al., 2017; Putwain, Becker, et al., 2018; Tze et al., 2015), and dropping out of school (Farrell et al., 1988; Robinson, 1975).

Similarly, in the context of work, there is evidence that boring, monotonous working conditions are associated with emotional health complaints (Smith et al., 1981)

and physical health problems, such as visual and musculoskeletal complaints, asthma, bronchitis, and hand tremors (Ferguson, 1973; Smith et al., 1981), as well as stress-related health issues such as cardiovascular diseases (Fisher, 1993). Furthermore, there is ample empirical evidence that general boredom proneness and leisure boredom are linked with depression (Fahlman et al., 2009; Farmer & Sundberg, 1986; Mercer-Lynn et al., 2013; Sommers & Vodanovich, 2000; Vodanovich et al., 1991), somatic complaints (Sommers & Vodanovich, 2000), substance abuse (Iso-Ahola & Crowley, 1991; Orcutt, 1984; Samuels & Samuels, 1974; Weybright et al., 2015), obesity, eating disorders (Abramson & Stinson, 1977; Ganley, 1989), and borderline personality disorder diagnosis (James et al., 1996; Masland et al., 2020).

However, for educational settings, evidence on psychological and physical health correlates of boredom is largely lacking. Hypotheses on such correlates can be derived from the above-mentioned literature as boredom is likely to have similar adverse consequences in work and education. Within this literature, it is discussed that boredom may exacerbate health problems, such as increased food consumption in obese individuals (Abramson & Stinson, 1977). Conversely, it can also be the case that unhealthy behaviors such as substance abuse intensify experiences of boredom (Iso-Ahola & Crowley, 1991). It is therefore conceivable that boredom and health are linked through reciprocal effects. Furthermore, the boredom cascade model suggests that boredom results in frustration and maladaptive escape behaviors (such as impulsive behavior induced by identity disturbance) that fuel chronic feelings of emptiness, which, in turn, generate boredom (Goetz, Frenzel, Pekrun, et al., 2007).

Given the lack of studies on health correlates of boredom in education, we aimed to explore whether academic boredom is linked with general psychological and physical

health problems. If academic boredom is linked with psychological and physical health-related variables, then students' boredom experienced in school could be interpreted as an early warning signal for potentially severe health problems in adolescence. With over 1.3 billion primary and secondary school students worldwide (UIS, 2017), schools play a crucial role in determining not only educational outcomes but also health (Kolbe, 2019), thus making them primary agents to protect and improve public health.

Boredom in school has been shown to be highly domain-specific (Goetz, Frenzel, Pekrun, et al., 2007). Many recent studies on academic boredom focused on the subject of mathematics, as this subject takes an outstanding role in modern societies. Scholastic success in mathematics is important for a wide range of professions (Bieg et al., 2014) and a predictor of participation in secondary education and expected future salary (Organization for Economic Cooperation and Development, 2014). For example, research on mathematics boredom addressed the antecedents of boredom, such as control-value appraisals (Pekrun et al., 2010; Putwain, Pekrun, et al., 2018), links between boredom and achievement (Putwain, Becker, et al., 2018), and behavioral and personality correlates among highly bored low and high achievers (Schwartze et al., 2020). In line with these studies, we operationalize academic boredom in a domain-specific way, focusing on the domain of mathematics. We conceptualized mathematics boredom as an individual differences construct (Pekrun, 2006), proposing that individuals systematically differ in their tendency to experience boredom in mathematics. We asked secondary school students about their habitual tendencies to experience mathematics boredom three times across a semester, as we aimed to assess a construct that is between trait and state dimensions, albeit more on the trait side.

The key goal of the present longitudinal study was to expand our knowledge on the relevance of mathematics boredom, by investigating whether such domain-specific boredom was linked with students' health-related quality of life (HRQoL), as measured with the KIDSCREEN at the end of the semester (Ravens-Sieberer et al., 2005). Here, HRQoL is described as a multidimensional construct covering physical, emotional, mental, social, and behavioral components of well-being, functioning as perceived by the individual (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006). Developed simultaneously in several countries and validated in a large representative sample across 13 European countries, the KIDSCREEN is considered a valid measure of HRQoL and can be used to identify children and adolescents who are at increased risk of developing health problems (Ravens-Sieberer et al., 2007). We based our first hypothesis on this literature.

Hypothesis 1: Trait mathematics boredom is negatively linked with HRQoL.

In addition to exploring concurrent links of boredom and HRQoL, a second important goal of the present study was to explore if changes in boredom across a semester were linked with HRQoL. Scattered prior research has shown that trajectories of academic boredom show an upward trend over time (Barkoukis et al., 2010; Raccanello et al., 2019; Tze et al., 2014), with substantial changes between grades 5 and 7 (Vierhaus et al., 2016), which is also in line with the decline in students' interest in mathematics during adolescence (Frenzel et al., 2010). We expected to replicate those findings.

Hypothesis 2: Boredom increases across a semester for secondary school students.

Additionally, prior research has shown that there is variance in adolescents' boredom growth trajectories. Changes in boredom were linked with contextual and individual factors such as task value, learning style, effort regulation, and academic engagement (Pawlak et al., 2020; Tze et al., 2014). No study to date seems to have explored whether changes in academic boredom are related to psychological and physical health symptoms. However, based on the existing evidence on concurrent psychological and physiological correlates of boredom, it is conceivable that stronger increases in boredom are linked with lower HRQoL in adolescents, hence our third hypothesis.

Hypothesis 3: A greater increase in boredom across a semester is associated with lower subsequent HRQoL.

Materials and Methods

Study Design and Procedure

To test our hypotheses that levels and growth trajectories of boredom are linked with HRQoL, we employed data collected in the context of a longitudinal field study in the subject of mathematics. The study included three assessments (T_1–T_3) which took place at the beginning of the semester (September 2018, T_1), in November (T_2), and in February 2019 (T_3). Boredom was assessed at all three time points and HRQoL was measured at T_3. As such, boredom and health outcomes were linked through a prospective design. At T_1, the questionnaires were handed out in class, filled out at home by the students, and collected again inside sealed envelopes. At T_2 and T_3, the data collection was administered by undergraduate research assistants and all questionnaires were filled out in class.

Sample

The overall sample consisted of N = 1.484 (n_{T1} = 1.400, n_{T2} = 1.262, n_{T3} = 1.260) secondary school students from 99 classes in 30 schools in Bavaria, Germany. Due to being absent from class, missing consent forms, or a belated decision to participate in the study, 84 participants were missing at T_1, 222 at T_2, and 224 at T_3. Ten participants were missing at both T_1 and T_2, 6 at T_1 and T_3, and 68 at T_2 and T_3. Missing data were handled by using the full information likelihood method (FIML; Enders, 2010). At T_1, students were 9 to 18 years old, with a mean age of 13.23 years (SD_{age} = 1.32; 52% girls, n = 770; 48% boys, n = 714). All tracks of the Bavarian three-track general secondary school system were represented, with 48% (n = 708 students) from the upper (Gymnasium), 27% (n = 397) from the middle (Realschule), and 26% (n = 379) from the lower track (Mittelschule). This distribution across tracks is equivalent with the Bavarian secondary student statistics, with a slight overrepresentation of the Gymnasium student population (LfStat, 2018). The students were in the fifth (n = 194), sixth (n = 204), seventh (n = 613), eighth (n = 305), ninth (n = 143), and 10th grade (n = 25). The majority of the students (86%, n = 1.275) were born in Germany, while 26% of them had at least one foreign-born parent (n_{mother} = 195, n_{father} = 188, n_{both} = 256).

Measures

The measures were assessed as part of a more comprehensive self-report survey, assessing behavioral and personality variables.

Boredom

Students' class-related, habitual (i.e., trait-like) boredom was assessed using the six-item class-related boredom scale of the Achievement Emotions Questionnaire-Mathematics (AEQ-M; Frenzel et al., 2007; Pekrun et al., 2011). For this subscale of the

AEQ-M, instructions prompt students to "Please indicate how you feel, typically, during math class." A sample item is "I am so bored that I can't stay awake" (see Table A1 in the Appendix for the full set of items used in this study, in the original German and the English versions). Students responded using a 5-point Likert scale ranging from 1 (*not at all true*) to 5 (*completely true*). The scale showed good internal consistency for all time points, with Cronbach's α coefficients greater than 86 (see Table A2).

Health-Related Quality of Life

The German version of the KIDSCREEN-27 for children and adolescents was used to measure HRQoL (Ravens-Sieberer et al., 2005). Students were asked "How are you? How do you feel? This is what we would like you to tell us. Please read every question carefully. What answer comes to your mind first? Choose the box that fits your answer best and cross it. Please try to remember the last week, i.e., the last seven days." The items comprised of five dimensions: physical well-being (PH, 5 items, e.g., "Have you felt fit and well?"), psychological well-being (PW, 7 items, e.g., "Have you felt sad?"), autonomy and parent relation (PAR, 7 items, e.g., "Have you had enough time for yourself?"), social support and peers (SOC, 4 items, e.g., "Have you been able to rely on your friends?"), and school environment (SCH, 4 items, e.g., "Have you got on well at school?"). Participants responded to all items on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*), except for the first item of PH ("In general, how would you say your health is?") which was scored from 1 (*excellent*) to 5 (*poor*). Negatively worded items were reverse-coded, so that higher scores depict better HRQoL. The scale showed adequate internal consistency for all five dimensions; Cronbach's α coefficients were all greater than 80 (see Table A2). In addition, we also obtained a general HRQoL score from the ten KIDSCREEN-27 items that constitute the

KIDSCREEN-10, as suggested by the authors (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006). The development of the KIDSCREEN was based on the probabilistic partial credit model (PCM), from the Rasch family of models (Bond & Fox, 2001). Both the subscale scores and the general HRQoL score have been confirmed to be valid measures of HRQoL across 13 European countries (Ravens-Sieberer et al., 2007). Accordingly, we also submitted our data to the probabilistic partial credit model, applying an SPSS syntax provided by the KIDSCREEN authors (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006). Next, we translated the obtained Rasch scores into *T*-values, using the norms provided by the KIDSCREEN authors (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006). Comparing our sample with the KIDSCREEN reference population (12 to 18-year-old adolescents), the students in our sample showed average scores within the suggested thresholds for classifying test-values as "normal" or "noticeable" (±½ *SD*—i.e., 5—around the mean T scores of 50) on all scales (see Table A2). As such, our sample can be considered to demonstrate "normal" physical and psychological health on average (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006).

Statistical Analysis

We used R 3.6.1 (R Core Team, 2019), except for the Rasch scale score and norm-related T-score calculation for the KIDSCREEN dimensions for which we used SPSS 26 (IBM Corp, 2019). The full R code of our analyses is available in the OSF (see data availability statement). The KIDSCREEN score calculation syntaxes can be obtained from the KIDSCREEN authors (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006).

Boredom was modeled as a latent construct using the Lavaan package in R (Rosseel & Jorgensen, 2019). We applied the full information likelihood method (FIML; Enders, 2010) to deal with missing data. The MLR estimator (maximum likelihood estimation with robust (Huber-White) standard errors and a scaled test statistic that is (asymptotically) equal to the Yuan-Bentler test statistic), was used to account for non-normal distributions of the data. As a preliminary analysis step, we tested for measurement invariance using the SemTools R package, to make sure that the latent boredom scores were comparable over time (Jorgensen et al., 2019). Since χ^2, and correspondingly also delta χ^2, are overly sensitive to sample size, we evaluated differences in practical fit indices (Putnick & Bornstein, 2016; Rutkowski & Svetina, 2014; Van De Schoot et al., 2012; Widaman et al., 2010). We sequentially tested increasingly constrained longitudinal measurement models, namely equivalence of model form (configural), equivalence of factor loadings (metric), and equivalence of item intercepts or thresholds (scalar; Meredith, 1993). The differences in CFI (−002), RMSEA (−001), and SRMR (001 to 004) were clearly below commonly recommended thresholds (Chen, 2007), indicating scalar equivalence. This implies that the latent boredom construct was equally represented by the scale items across the three time points used in the present analyses (Isiordia & Ferrer, 2018). In other words, changes in the factor level can be interpreted as reflecting actual differences in the students' reported experiences of boredom.

To test hypothesis 1, we obtained latent correlations between the boredom scores at T_1, T_2, and T_3 and the HRQoL scores. Concerning hypothesis 2, we applied doubly latent growth curve modeling to estimate boredom trajectories across the semester by using a stepwise confirmatory approach comparing an intercept only (non-growth) with

a linear growth model (Bollen & Curran, 2016). It is worth noting that our 3-wave-repeated measures design allowed for meaningfully estimating only linear, but not nonlinear (e.g., quadratic) growth (Whittaker & Khojasteh, 2017). To test hypothesis 3, we determined the relationship between the latent growth parameters of boredom and the HRQoL dimensions, using the growth parameters of boredom (intercept and slope) in bivariate correlation analyses. To account for multiple testing, we adjusted *p*-values using Holm's method (1979), a procedure that has been shown to be more powerful than the original Bonferroni method (Wright, 1992).

Students who did not participate at T_3 (n = 224) and therefore, have no HRQoL data did not differ from the overall sample in terms of gender, (t294.73) = 85, p_{Holm} = 1.; age, t(298.84) = −2.68, p_{Holm} = .055; school type, t(300.19) = 2.53, p_{Holm} = .072; math grade, t(301.08) = −2.05, p_{Holm} = .204; country of birth, t(256.78) = −.07, p_{Holm} = 1.; boredom T_1, t(287.49) = −.72, p_{Holm} = 1.; and boredom T_2, t(192.37) = −1.04, p_{Holm} = 1. As such, missingness at T_3 was not systematically related with any of those variables.

Results

Table 1 shows the bivariate correlations between boredom and the HRQoL dimensions. It is worth noting that the correlations between the boredom scores across time were relatively large (rs > .61), indicating that boredom showed considerable stability over time. Furthermore, confirming hypothesis 1, boredom was significantly negatively linked with all HRQoL dimensions, with the strongest correlations observed for school environment and general HRQoL (rs = −.319 to −.487). All correlations remained virtually the same when including age and gender as covariates. The correlations imply that boredom was negatively associated with physical well-being (feeling physically exhausted, physically unwell, unfit, having low energy),

psychological well-being (having no pleasure in life, feeling depressed, feeling unhappy, having low self-esteem), autonomy and parent relation (feeling restricted, feeling overlooked, not appreciated, feeling finances are restricting life style), social support and peers (feeling excluded, not accepted by peers), school environment (disliking school, negative feelings about school, not doing well at school), and general HRQoL (feeling unhappy, unfit and dissatisfied with regard to family life, peers and school life; (Ravens-Sieberer & The KIDSCREEN Group Europe, 2006).

Table 1

Latent Bivariate Correlation Coefficients (r) Between Boredom and HRQoL Dimensions

	Bo T_1	Bo T_2	Bo T_3	PH	PW	PAR	SOC	SCH	GH
Boredom T_1 (Bo T_1)	-								
Boredom T_2 (Bo T2)	.69	-							
Boredom T_3 (Bo T3)	.62	.72	-						
Physical well-being (PH)	−.24	−.18	−.26	-					
Psychological well-being (PW)	−.28	−.28	−.32	.55	-				
Autonomy and parent relation (PAR)	−.18	−.20	−.23	.38	.52	-			
Social support and peers (SOC)	−.13	−.09	−.10	.36	.42	.40	-		
School environment (SCH)	−.40	−.42	−.49	.44	.58	.48	.35	-	
General HRQoL (GH)	−.33	−.33	−.39	.69	.81	.69	.51	.72	-

Note. $p < .001$ for all coefficients with the exceptions of *r*(Bo T1/SOC): $p = .002$; *r*(Bo T2/SOC) and *r*(Bo T3/SOC): $p = .013$.

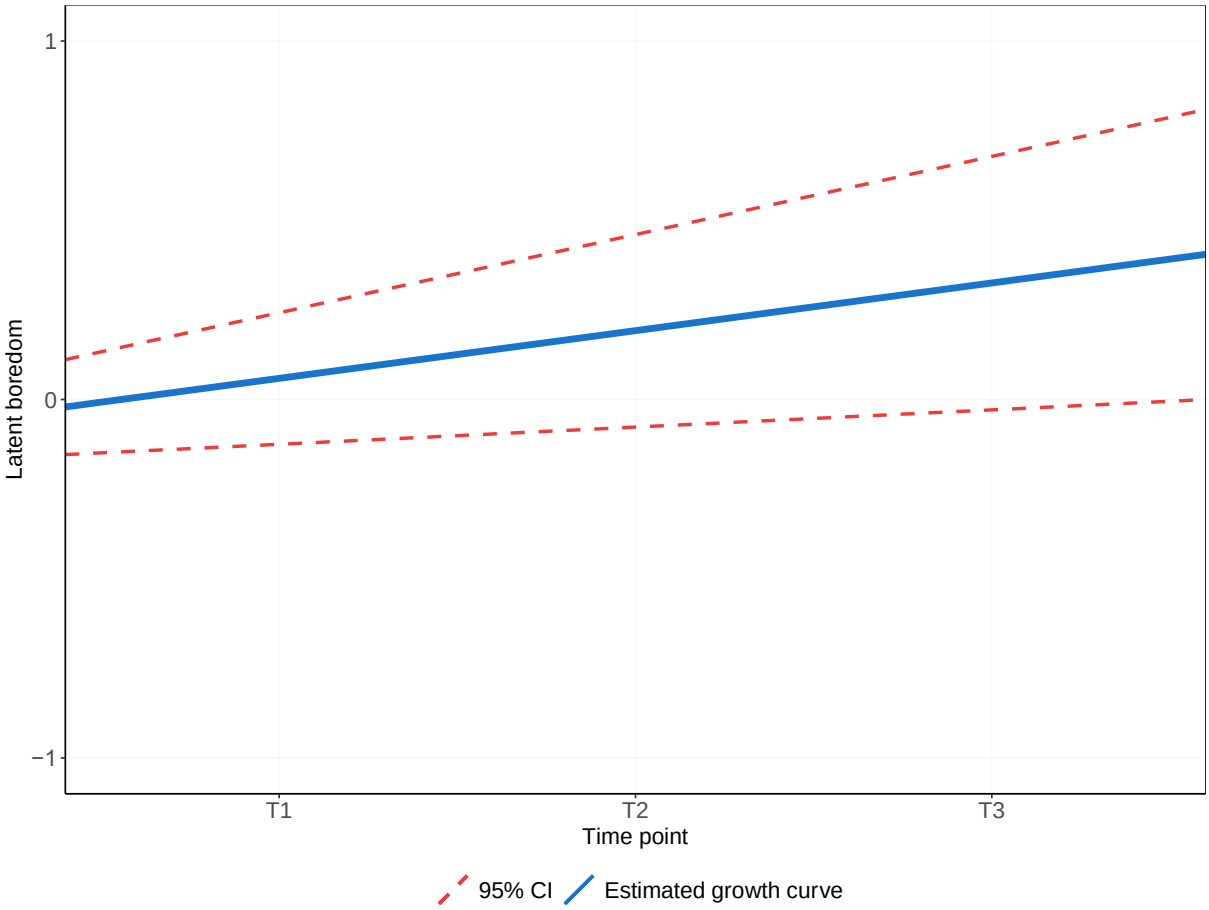
Concerning the growth trajectory of boredom across the semester (hypothesis 2), we used latent growth curve analysis to compare intercept-only ($\chi^2 = 860.39$, $df = 137$, AIC = 64,693, BIC = 64,968, RMSEA = .058) and linear growth models ($\chi^2 = 815.53$, $df = 134$, AIC = 64,654, BIC = 64,945, RMSEA = .057). We settled for the linear growth model as it showed a significantly better fit to the data ($\chi^2_{diff} = 38.739$, $df_{diff} = 3$, $p < .001$). This linear growth model implied that there was a significant, yet small-sized

increase in boredom over the three time points (slope = .15, 95% CI [.05, .22], *SE* = .04, $p = .002$, see Figure 1). The variance of this slope also proved to be significantly different from zero ($\tau^2 = .76$, $p = .049$). In fact, while the overall latent slope parameter estimate was small and positive, the individual estimates ranged from −2.17 to 2.71. Slope and intercept were negatively correlated ($r = -.38$, $p < .001$).

Having established growth curve parameters of the development of boredom over time, we explored the correlative links between the latent intercept and growth parameters and the HRQoL dimensions next (see Figure A1). In line with the results from the concurrent correlation analyses reported above, the intercept (given our model specification interpretable as students' levels of boredom at the first measurement T_1) was significantly negatively correlated with all HRQoL dimensions, indicating that higher boredom levels were linked with lower values on all HRQoL dimensions. Furthermore, and partially in line with hypothesis 3, the slope was significantly linked with the school environment and general HRQoL scores (rs = −.15 and −.11, respectively). By implication, stronger increases in boredom across the semester were associated with more negative feelings about school and lower general HRQoL (see Table 2). In line with previous studies that showed gender universality of achievement emotion-outcome links (Pekrun, 2018; Pekrun & Stephens, 2010), these relationships proved to be equivalent across genders (see Figure S1).

Figure 1

Latent Growth Trajectory of Boredom Across the Semester



Note. Y-axis truncated for an optimal graphical representation of the overall growth trajectory, depicted boredom values extrapolated beyond the observed time points.

Table 2

Latent Bivariate Correlations Between Boredom Growth Parameters and HRQoL Dimensions

	Growth Parameter			
	Intercept		Slope	
	r	*p*	*r*	*p*
Physical well-being	−.24	<.001	−.04	.771
Psychological well-being	−.28	<.001	−.07	.251
Autonomy and parent relation	−.18	<.001	−.08	.156
Social support and peers	−.12	.005	.03	.771
School environment	−.40	<.001	−.15	<.001
General HRQoL	−.33	<.001	−.11	.008

Discussion

The present study raised two important questions as to whether levels and change of mathematics boredom across a semester are linked with HRQoL. Confirming our first hypothesis, we provided empirical evidence that high levels of boredom were negatively associated with poorer self-reported physical well-being, psychological well-being, autonomy, parent relations, social support and peer relations, school environment, and general HRQoL, which supports and extends earlier findings on adverse consequences of academic boredom (Eren & Coskun, 2016; Farrell et al., 1988; Goetz, Frenzel, Pekrun, et al., 2007; Kügow et al., 2009; Niculescu et al., 2015; Pekrun et al., 2010, 2011, 2002, 2014; Putwain, Becker, et al., 2018; Robinson, 1975; Tze et al., 2015). Remarkably, context-specifically experienced boredom in mathematics demonstrated substantial negative links with context-transcending health indicators.

Specifically, high boredom in mathematics was substantially associated with lack of pleasure in life, feeling depressed, feeling unhappy, having low self-esteem (PW), disliking school, negative feelings about school, not doing well (SCH), and feeling unhappy, unfit, and generally dissatisfied with regard to family life, peers, and school life (GH). Following Brunswik's symmetry principles, it is likely that correlations are attenuated if constructs are operationalized at different levels of domain specificity (Wittmann, 1988). The pattern of our findings supports the notion of stronger links between contextually closer concepts, as mathematics boredom was most closely linked with the school-related HRQoL dimension (SCH). Furthermore, above and beyond concurrent links, this study also sought to explore the links between trajectories of mathematics boredom and HRQoL. Confirming our second hypothesis and in line with previous research on academic boredom (Barkoukis et al. 2010; Tze et al. 2014; Vierhaus et al. 2016), we observed an increase in boredom during the semester. Boredom intercept and slope proved to be negatively correlated, implying that students who started the schoolyear on higher levels tended to show smaller increases in boredom and vice versa. Confirming hypothesis 3, the dynamics of boredom across the semester were linked with students' HRQoL. Stronger increases in boredom were linked with more severe health-related problems, specifically with the dimension of school environment (disliking school, negative feelings about school, not doing well), but also with general HRQoL.

Given that our findings are correlational, the mechanisms generating the observed correlations remain open to discussion. On the one hand, boredom and particularly, an increase in boredom across a semester, could be drivers of an adverse health development. It has been shown that boredom during math class occurs when

lessons are experienced as either over- or under-challenging and thus, lack meaningful opportunities for engagement (Csikszentmihalyi, 1975). If students repeatedly experience such lessons across the semester and their boredom levels increase over time, they then may withdraw from classes and start to engage in maladaptive escape behaviors. Based on the above-mentioned boredom cascade model, the experience of boredom can then lead to such maladaptive escapes, prompting issues regarding individuals' mental and physical health (Masland et al., 2020). More specifically, repeated and increasingly intense experiences of boredom in mathematics, a subject typically judged as highly important by relevant others (e.g., parents, teachers, society), are likely to increase the use of avoidant and anger-related or acting-out strategies of emotion regulation (Vierhaus et al., 2016). Such maladaptive coping and emotion regulation strategies, in turn, are likely to fuel more general psychological and physical health issues, such as vulnerability to infection or cardiovascular disease (Carver & Vargas, 2011; DeSteno et al., 2013).

In contrast to other emotions, where intensity is associated with high value (importance) of the events triggering emotion, boredom is linked to lack of meaning and value—exemplified in the question, "What is it all for?" (Goetz, Frenzel, & Pekrun, 2007; Pekrun, 2006; Pekrun et al., 2007). This quest for value expresses an individuals' lack of purpose or perspective and resembles the core position of meaning in Frankl's (1959) work on depression and suicide prevention. It is a fundamental human need to want one's life to be meaningful. Lack of meaning and value, as implied by boredom, thwart this need, thus contributing to health problems (Fahlman et al., 2009). While the emotional experience of boredom has been shown to be psychometrically distinct from depression (Fahlman et al., 2009; Goldberg et al., 2011; van Tilburg & Igou, 2017), the

correlative link between boredom and psychological well-being (assessed with items such as “Have you felt sad”) as demonstrated again in our study can be interpreted in that strong experiences of boredom might make students vulnerable to depression.

On the other hand, adverse health conditions could be a driver of boredom experiences in achievement contexts. For example, health conditions such as obesity could lead to a lack of energy, social isolation, and lack of popularity with other students as well as teachers, leading to more boredom in class. Finally, there may also be third variables that can generate both maladaptive levels and trajectories of boredom, and poor health among adolescents, such as extraordinary unfortunate environmental circumstances—the current pandemic-implied school lockdowns being a palpable example (e.g., Martarelli et al., 2021; Ravens-Sieberer et al., 2021).

Limitations

The present study used a robust latent growth curve modeling approach and yielded consistent findings that supported our hypotheses. Nevertheless, the study has limitations that should be considered in interpreting the findings and can be used to derive directions for future research. As noted, the analysis was correlational; future research should replicate the current findings using predictive models and longitudinal designs involving repeated measures of both boredom and health indicators to model their co-development over time. Given that our design only involved three measurement points, we could meaningfully estimate only an intercept-only against a linear growth model, while it is conceivable that the boredom trajectory over time also forms nonlinear trends, e.g., initially strong increases followed by a flattening of the curve; such quadratic trends have, for example, been found for adolescents’ interest loss trajectories during adolescence. Future research could explore corresponding nonlinear

growth also for boredom, but a larger number of measurement time points (at least four) would be necessary to meaningfully estimate such nonlinear trend models (Whittaker & Khojasteh, 2017). Self-report was used to assess both boredom and health problems; future studies should complement this approach by using other data sources as well, such as physiological and behavioral data to assess boredom and medical records to assess health problems. Furthermore, this study focused on boredom in the domain of mathematics and it was conducted using a sample of German secondary school students. As such, it remains to be explored if the present findings generalize to other cultural and school contexts. Limited research points to cultural differences in the experience of boredom between Irish and U.S. citizens (Vodanovich & Watt, 1999) or European Canadians and Chinese (Ng et al., 2015). In exploring whether our findings also extend to younger age groups, the elementary school version of the AEQ (Lichtenfeld et al., 2012) could be used. Further, given the outstanding societal role of the domain of mathematics, we focused our study on this subject domain, expecting that boredom in mathematics would demonstrate substantial links with students' more general HRQoL. However, the degree to which boredom in other subject domains is linked with HRQoL, too, remains to be explored. Just as the question of whether domain plays a moderating role for student boredom-health outcome links seems to be an intriguing avenue for future research. Finally, we did not take teaching method or parental expectations into account. Instructional design is one of the most reported reasons for boredom (Goetz et al., 2006) and parental expectations can be positively linked with student academic performance but also their depression (Ma et al., 2018). Future research could address the role of teaching methods and parental expectations for boredom-HRQoL links.

Conclusions

In conclusion, the present study provided empirical evidence that boredom is negatively linked with HRQoL and that stronger boredom growth within a semester is linked with lower self-reported health-related quality of life. Teachers, parents, and students should pay attention to boredom as a potential early warning signal for potentially severe, context-specific as well as context-transcending health problems.

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Appendix

Table A1

Class-Related Boredom Items of the Achievement Emotions Questionnaire-Mathematics (AEQ-M)

Items German	Items English translation
Ich finde den Unterricht langweilig.	I think the mathematics class is boring.
Vor Langeweile schalte ich ab.	I can't concentrate because I am so bored.
Vor Langeweile kann ich mich kaum wach halten.	I am so bored that I can't stay awake.
Vor Langeweile gehen mir immer wieder Gedanken durch den Kopf, die mit Mathe nichts zu tun haben.	I think about what else I might be doing rather than sitting in this boring class.
Ich schaue ständig auf die Uhr, weil die Zeit nicht vergeht.	Because of time drags I frequently look at my watch.
Ich werde unruhig, weil ich nur darauf warte, dass die Mathestunde endlich vorüber ist.	I get restless because I can't wait for the class to end.

Note. Asking students to judge "Please indicate how you feel, typically, during math class."

Table A2

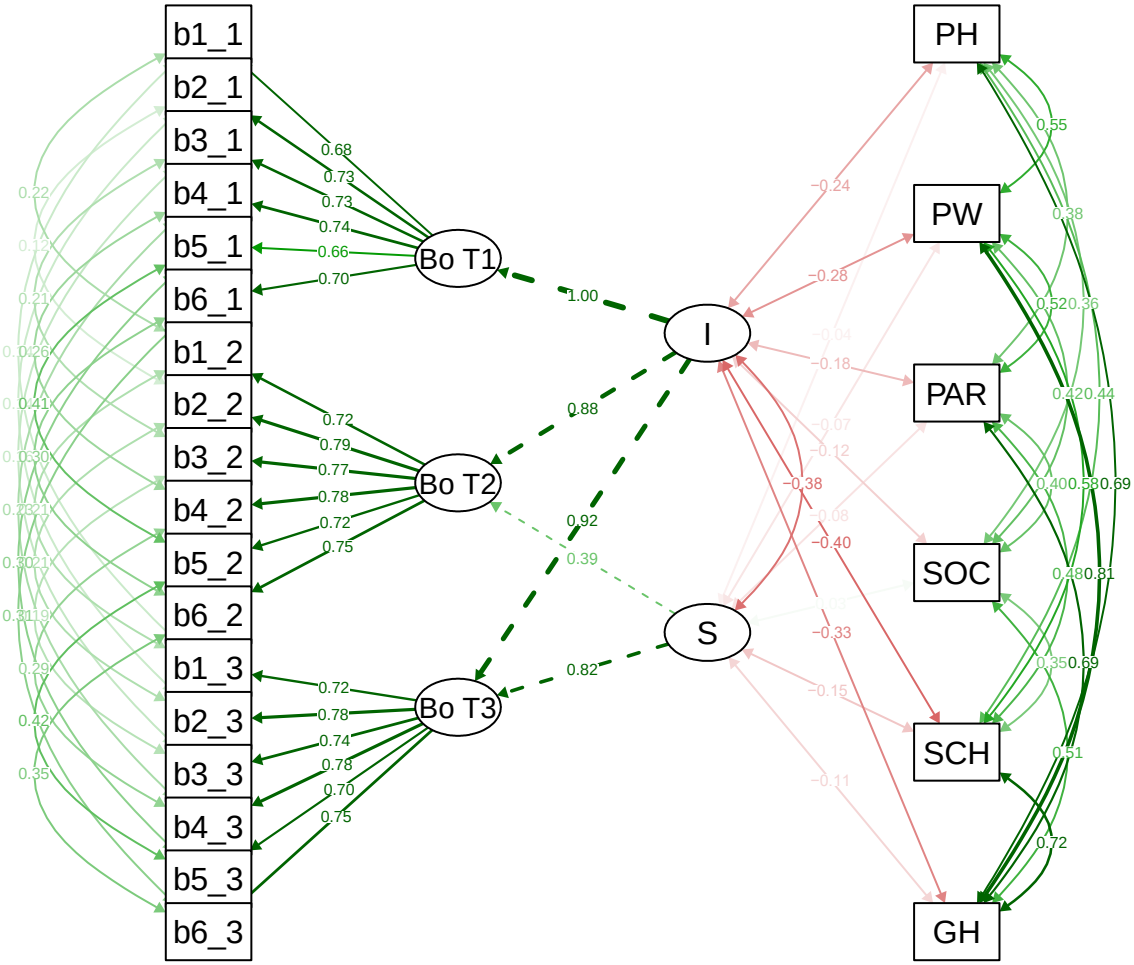
Manifest Means, Their Standard Deviations and Confidence Intervals, Skewness, Kurtosis, and Cronbach's α Coefficients for the Study Variables

	M	*SD*	95% CI		Skew	Kurt	*α*
			LL	*UL*			
Boredom T_1	2.39	.95	2.34	2.44	.51	−.38	.86
Boredom T_2	2.46	1.01	2.40	2.51	.53	−.49	.88
Boredom T_3	2.48	1.01	2.42	2.53	.49	−.57	.88
Physical well-being	48.50	11.86	47.84	49.16	.07	.06	.82
Psychological well-being	48.69	12.79	47.98	49.40	.11	.01	.87
Autonomy and parent relation	53.67	11.35	53.03	54.30	.14	.48	.80
Social support and peers	52.26	11.63	51.61	52.90	−.58	.20	.83
School environment	49.69	10.58	49.10	50.28	.09	.47	.83
General HRQoL	49.59	11.11	48.98	50.21	.72	.99	.81

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Figure A1

Path Diagram of Boredom Growth Parameters and HRQoL Dimensions



Note. b1_1 to b6_3 = items indicating boredom (first number indicating scale item index, second number indicating measurement time point), Bo T1/2/3 = boredom as measured at time points 1/2/3 (early/mid/end of semester), I = intercept, S = slope, PH = physical well-being, PW = psychological well-being, PAR = autonomy and parent relation, SOC = social support and peers, SCH = school environment, GH = general HRQoL.

Study 3: Boredom Due to Being Over- or Under-Challenged in Mathematics: A Latent Profile Analysis

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Abstract

Recent research on boredom suggests that it can emerge in situations characterized by over- and under-challenge. In learning contexts, this implies that high boredom may be experienced both by low- and high-achieving students. This research aimed to explore the existence and prevalence of boredom due to being over- and under-challenged in mathematics, for which empirical evidence is lacking. We employed a sample of 1.407 students (5th to 9th graders) from all three secondary school tracks (lower, middle, and upper) in Bavaria (Germany). Boredom was assessed via self-report and achievement via a standardized mathematics test. We used latent profile analysis to identify groups characterized by different levels of boredom and achievement and additionally examined gender and school track as group membership predictors. Results revealed four distinct groups, of which two showed considerably high boredom. One was coupled with low achievement on the test (i.e., "over-challenged group", 13% of the total sample), and one was coupled with high achievement (i.e., "under-challenged group," 21%). Furthermore, we found a low boredom and high achievement (i.e., "well-off group," 27%) and a relatively low boredom low achievement group (i.e., "indifferent group," 39%). Girls were overrepresented in the over-challenged group, and students from the upper school track were underrepresented in the under-challenged group. CONCLUSION: Our research emphasizes the need to openly discuss and further investigate boredom due to being over- and under-challenged.

Keywords: boredom; mathematics achievement; achievement emotions

Boredom Due to Being Over- or Under-Challenged in Mathematics: A Latent Profile Analysis

In the tradition of Csikszentmihalyi (1975), it has long been argued that boredom arises when someone's skills are greater than the situational demands—thus, in under-challenging situations (e.g., Larson & Richards, 1991). However, Pekrun et al. (2002) argued that boredom can also arise when task demands are too high, implying over-challenge. Accordingly, a differentiation between boredom due to over-challenge vs. boredom due to under-challenge has been used in recent research on academic boredom (e.g., Acee et al., 2010). Empirical research shows that indeed, strong boredom experiences can be initiated both through highly challenging and poorly challenging situations (Daschmann et al., 2011). However, to date, there is scarce empirical evidence for the existence and prevalence of boredom due to over- and under-challenge among learners. We seek to add to this literature (e.g., Acee et al., 2010; Daschmann et al., 2011) by selecting school mathematics as an applied learning domain. We chose mathematics because it is a core school subject and is frequently studied in STEM education research (i.e., science, technology, engineering, and mathematics; e.g., Li et al., 2020). We propose that students who show high abilities in mathematics and report high levels of mathematics boredom can be classified as bored due to under-challenge, while students who show poor abilities in mathematics and report high mathematics boredom can be classified as bored due to over-challenge.

Existing research linking boredom and performance in the academic domain typically followed variable-centered approaches, reporting small-sized negative correlations between boredom and performance (e.g., Pekrun et al., 2010). This negative correlation implies that with performance, students tend to report less boredom, but this

does not preclude, that there are also students with high content matter competencies who still do experience elevated levels of boredom, most likely due to under-challenge (see also Schwartze et al., 2020). We used latent profile analysis (LPA) for our analyses and additionally examined gender and school track as predictors. LPA is a categorical latent variable modeling approach that aims to identify subpopulations within a population based on certain variables (Spurk et al., 2020). It assumes that people can be categorized by different attributes with a certain probability. Our study findings are of high practical relevance as they provide teachers with empirical evidence of the expected prevalence of students in their classes who likely are bored due to over- vs. under-challenge.

The key goal of the present study was to adopt a person-centred approach in exploring possible combinations of self-reported boredom and competence among learners of mathematics. To gain insight into the existence and prevalence of correspondingly differing subpopulations within learners of mathematics, we assessed students' mathematics abilities using a standardized mathematics test. Based on the assumption about the existence of boredom due to over- and under-challenge (Daschmann et al., 2011), we expected to find at least four distinct boredom profiles. A profile that is characterized by high boredom and low achievement (i.e., an over-challenged group) and one characterized by high boredom and high achievement (i.e., an under-challenged group). In addition, as implied by the overall negative correlation between boredom and performance (e.g., Camacho-Morles et al., 2021), we expected to find a profile characterized by low boredom and high achievement (i.e., a well-off group). Finally, we expected an "indifferent group" demonstrating average levels of all variables included in the profile analysis.

Additionally, we sought to explore the role of gender and school track. Mathematics is a strongly gender-stereotyped domain (e.g., Keller, 2001) and girls have been shown to report more boredom due to over-challenge, while boys report more boredom due to under-challenge when asked directly about those challenge-implied boredom experiences (Daschmann et al., 2011). Accordingly, we assume that girls could be overrepresented in the low achievement/high boredom group (i.e., over-challenged), while boys could be overrepresented in the high achievement/high boredom group (i.e., under-challenged). Furthermore, the German three-tiered tracking system is designed to provide a match between students' intellectual potential and the cognitive demand of their school track. Therefore, we had no a priori expectations as to certain school tracks being more prevalent in any of the boredom groups. Nevertheless, it seemed relevant to explore if boredom due to over- or under-challenge is more prevalent at the lower, middle, or upper track of the German secondary school system.

Materials & Methods

Participants

To test our hypotheses, we used data collected in the context of a longitudinal field study in the subject of mathematics. The sample consisted of N = 1.407 (51% girls, n = 717; 49% boys, n = 690) secondary school students from 91 classes in 30 schools in Bavaria, Germany. Due to being absent from class, missing consent forms, or a belated decision to participate in the study, 165 participants were missing at T_1, and 136 at T_2. At T_1, students were between 9 and 17 years old, with a mean age of 12.89 years (SD_{age} = 1.27). All tracks of the Bavarian three-tiered secondary education system were represented, with 25% (n = 354) from the lower track, 27% (n = 375) from the middle track, and 48% (n = 678) from the upper track. This distribution across tracks is

equivalent to the Bavarian secondary student statistics (LfStat, 2018). The students were in the fifth (n = 185), sixth (n = 203), seventh (n = 577), eighth (n = 301), and ninth grade (n = 141). Most of the students (81%, n = 1.205) were born in Germany. Twenty-six percent of the students had at least one foreign-born parent (n_{mother} = 186, n_{father} = 184, n_{both} = 123).

Procedure

The data collection took place in the school year of 2018/2019 in September (T_1) and February (T_2). At both time points, boredom and mathematics achievement were measured. The data collection was administered by trained research assistants and both the boredom questionnaire and mathematics achievement test were filled out during the regular class time.

Measures

Mathematics Achievement

Mathematics achievement was measured using the Bielefeld Math Achievement Test for Secondary Education (BMATS), which is an extension of the PALMA Mathematics Achievement Test (e.g., Murayama et al., 2013). This test measures mathematical skills (declarative, procedural, and conceptual) with complex multiple-choice, single-choice items, and short text responses, which are scored based on a fully standardized rubric. The test is linked with anchoring items throughout grades 5 to 9 and across both measurement time points. It consisted of 15 to 17 items for grades 5 to 9 that cover the mathematics curriculum, such as algebra, functions, and geometry. All items combined represent a highly reliable composite mathematics achievement score for the overall mathematics achievement in form of a Rasch-scaled person parameter (test-retest reliability across T1 and T2 = .78).

Mathematics Boredom

Class-related mathematics boredom was measured through students' self-reports with six items of the Achievement Emotions Questionnaire - Mathematics (e.g., "I can't concentrate because I am so bored."; AEQ-M, Pekrun et al., 2011). Students responded to all items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Across our sample, students reported medium levels of boredom at T_1 (M = 2.45, SD = 1.01) and T_2 (M = 2.63, SD = 1.06). Cronbach's alpha and test-retest reliability estimates were satisfactory (α_{T1} = .88 and α_{T2} = .89, r = .60 for the test-retest reliability).

Analyses

We used Mplus 8.6 (Muthén & Muthén, 1998–2017) and LPA taking clustering into account to identify categorical latent variables that represent classes of students who share similar combinations of boredom and mathematics achievement level profiles across both time points. We used both time points to obtain more robust cluster solutions, given that both variables were highly stable across the two timepoints which were only a few months apart (see Schwartze et al., 2021 for measurement invariance of boredom across time). We standardized the mathematics achievement scores based on the school track and class levels, as we intended to consider student ability relative to their age- and school-based reference group. Boredom was standardized for the whole sample.

To determine the most appropriate number of groups, we iteratively tested the fit of 1 to 5 groups, using Akaike's (1987) Information Criterion (AIC), Schwarz's (1978) Bayesian Information Criterion (BIC), and the corrected Akaike's information criterion (AICC, Hurvich & Tsai, 1989), where lower values indicate a better fit of the data. We

also used the Lo-Mendell-Rubin adjusted likelihood ratio test (LMRT) and Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), which compare whether a *k*-class solution fits better than a *k*-1 class solution (Tein et al., 2013). We furthermore examined entropy, a standardized index of model-based classification accuracy, where high values of entropy indicate better classification (Wang et al., 2017). Additionally, to explore whether gender and school track were linked with class membership, we tested our final class solution for both variables separately as latent class predictors using the 3-step method (R3STEP; Asparouhov & Muthén, 2014).

Results

As indicated by lower AIC, BIC, and AICC values, the 4-class solution fitted the data better than the 1 to 3-class solutions. Even though it had lower AIC, BIC, and AICC values, a better entropy, and (barely) not statistically significant LMRT and VLMR p-values (see Table 1), the 5-class model was rejected because it did not reveal another qualitatively distinct group. The entropy of the selected 4-class solution (.63) suggests at least a 20% error rate but it should be noted that entropy values decrease and the classification error rates increase as sample size increases, and entropy can get volatile under large sample sizes (Wang et al., 2017).

Table 1

LPA results

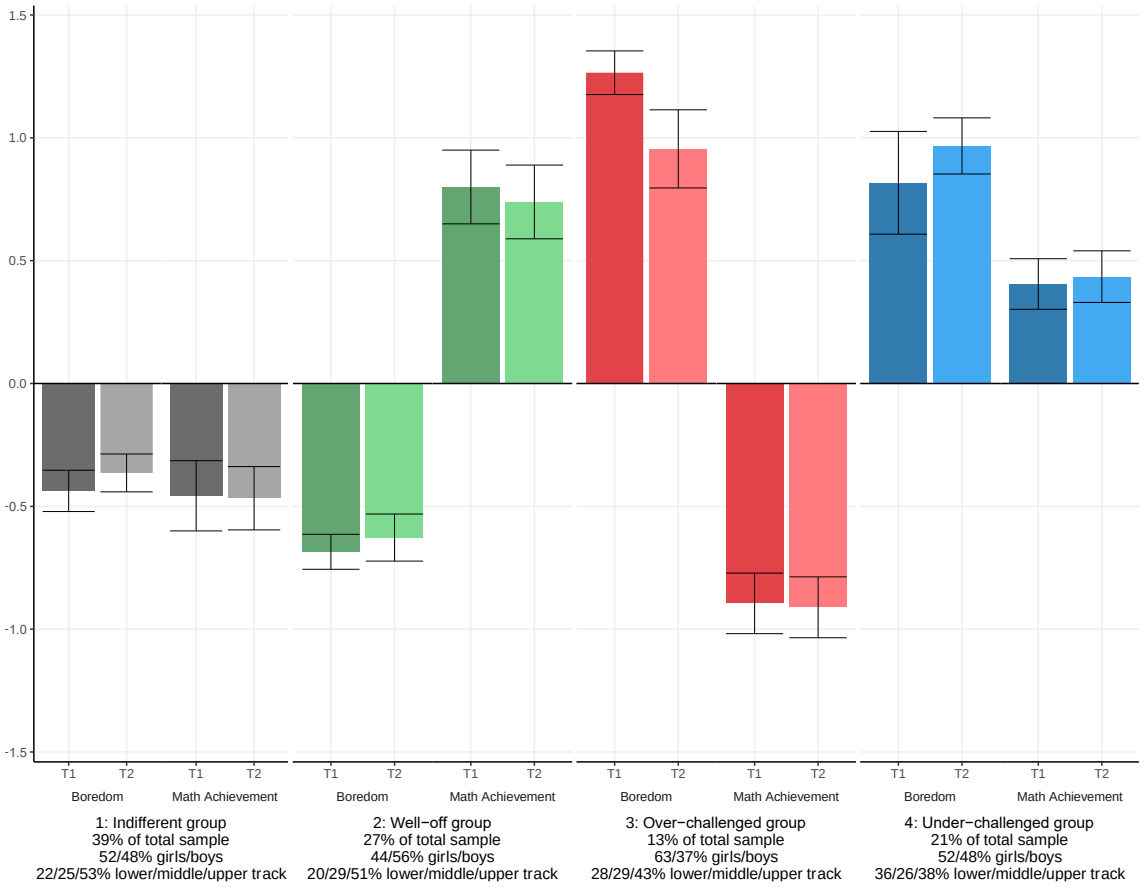
N latent classes	AIC	BIC	AICC	VLMR *p*-value	LMRT *p*-value	Entropy	Class size: *n* (%)
1	14285.09	14327.08	14285.19	-	-	-	Class 1: 1.407 (100%)
2	13721.44	13789.68	13721.70	0	0	.715	Class 1: 944 (67%) Class 2: 463 (33%)
3	13586.96	13681.44	13587.45	.0884	.0946	.571	Class 1: 445 (32%) Class 2: 512 (36%) Class 3: 450 (32%)
4	**13447.28**	**13568.01**	**13448.08**	**.0525**	**.0556**	**.627**	**Class 1: 554 (39%, 52% girls)** **Class 2: 375 (27%, 44% girls)** **Class 3: 184 (13%, 63% girls)** **Class 4: 294 (21%, 52% girls)**
5	13375.06	13522.04	13376.24	.1412	.1465	.669	Class 1: 221 (16%) Class 2: 112 (8%) Class 3: 718 (51%) Class 4: 234 (17%) Class 5: 122 (8%)

Note. The selected model is printed in boldface. AIC: Akaike information criterion; BIC: Bayesian information criterion; AICC: corrected Akaike's information criterion; VLMR: Vuong-Lo-Mendell-Rubin likelihood ratio test; LMRT: Lo-Mendell-Rubin adjusted likelihood ratio test.

Accordingly, in line with our expectations, we found four distinct and theoretically meaningful classes which showed qualitatively varying profiles of boredom and mathematics achievement levels. In line with our expectations, we found one group in which students showed high boredom and low mathematics achievement at both time points (class 1, the "over-challenged group"). Additionally, we found one group with students who showed high boredom and high mathematics achievement (class 4, the "under-challenged group"). Moreover, we found a group in which students showed low boredom and high mathematics achievement (class 2, the "well-off group"). Lastly, the data revealed one group with relatively low boredom and low mathematics achievement (class 3, which we labeled "indifferent group"; see Figure 1). Importantly, since mathematics achievement values were standardized based on the school track and class levels, students' levels of mathematics achievement in said groups are low or high relative to their same-grade and same-track peers.

Figure 1

Estimated boredom and mathematics achievement means and standard errors of the four boredom profiles at both time points



Using gender as a latent class predictor showed that the likelihood to be in the over-challenged group relative to the indifferent or well-off group was significantly higher for girls (class 3 relative to class 1; p = .046, b = -.561, OR = .571 and class 3 relative to class 2; p = .001, b = -1.015, OR = .362).

Using school track as a latent class predictor showed that the likelihood to be in the under-challenged group relative to the indifferent or well-off group was significantly lower for students from the upper school track (class 1 relative to class 4; p = .002, b = -1.165, OR = .312 and class 2 relative to class 4; p = .002, b = -1.124, OR = .325).

Discussion

This study is the first to explore the prevalence of qualitatively different boredom types in terms of over- vs. under-challenge in learning contexts. The goal of the present study was to explore students' profiles of boredom in mathematics classes in conjunction with their mathematic ability, as measured by a standardized test, using LPA. To approach the question of boredom due to over-challenge vs. boredom due to under-challenge empirically, our central aim was to explore the prevalence of high boredom among students who scored low vs. high on a standardized mathematics achievement test.

In line with our expectations, we found two distinct profiles that showed considerably high levels of boredom, but at varying mathematics achievement levels; high boredom coupled with low achievement ("over-challenged group") as well as high boredom coupled with relatively high achievement ("under-challenged group"). The "over-challenged group" consisted of students who were considerably low performing (almost -1 *SD* relative to their age and school track comparison group) while showing considerably high levels of boredom (around +1 *SD* relative to the other students). At the same time, the "under-challenged group" consists of students who were considerably high performing (around +.5 *SD*) while showing considerably high levels of boredom (almost +1 *SD*). Based on this, we assume that the high levels of boredom reported by these students are mostly due to the—for them—either excessive or too low demands in mathematics lessons.

Furthermore, two groups with relatively low boredom emerged, one of which was characterized by low boredom and high ability, which we propose to be a "well-off group". These students demonstrated high performance in the standardized test (equally

well as the under-challenged group) yet seem to be successful at finding value and challenge in mathematics, and thus respond with low mathematics boredom. Lastly, we observed a group with low boredom and low achievement, which we propose to be seen as an "indifferent group". Those students performed relatively poorly on the standardized test (-0.5 *SD*), but they do not seem to react to this with experiences of over-challenge during their mathematics classes, as they did not report elevated levels of boredom relative to their peers.

Regarding the prevalence of boredom due to over- vs. under-challenge, our key finding is that as many as 21% (n = 294) of the students in our sample were identified as the "under-challenged group", and as many as 13% (n = 184) constituted the "over-challenged group". As such, a third of the students were classified as highly bored, coupled with either low or high mathematics achievement scores. We assume that this is potentially caused by the German school system where teachers must follow a strict curriculum and the implementation of techniques such as individualization, differentiated teaching, grouping of students by ability or utility-value interventions are rare, resulting in a considerably high fraction of students being confronted with a poor balance of challenge given their skill level in mathematics. Overall, considering the growing shortage of STEM professionals (Anger et al., 2021), the potential waste of resources and missing opportunities to promote the talent of many students who most likely withdraw from mathematics as it seems overly boring to them seems unfortunate.

In line with girls being more likely to be bored due to over-challenge (e.g., Daschmann et al., 2011), our findings confirmed that girls were overrepresented in the "over-challenged group" (63%). While girls underperforming in mathematics is one of the most resistant gender gaps in modern societies, a large part of the gender gap is due

to social stereotypes and it is expected that institutions can durably modify these stereotypes (Lippmann & Senik, 2018). This gender stereotype apparently also leads to experiences of being over-challenged, to which quite some girls seem to react with feelings of boredom.

There were only a few effects of school track on class membership probability. Thus, our findings indicate that the German three-tiered tracking system is sufficiently functional in terms of matching students' intellectual potential and the cognitive demand of their school track. One exception was that students from the upper school track were underrepresented in the under-challenged group. The main reason for that might be a more demanding curriculum in the upper school track that is less likely to under-challenge its students.

It is important to note that our results are clearly sample-dependent, and replication is needed with different samples, to substantiate these findings. Also, future research could explore the prevalence of boredom due to over- vs. under-challenge in other achievement settings like elementary schools, other domains like languages, and among different ethnicities with different cultural backgrounds.

Conclusion

Our findings emphasize the need to openly discuss boredom in learning contexts, and address coping strategies such as cognitive- and behavioral-approach strategies (Nett et al., 2010). This seems particularly relevant given that boredom coping strategies have been shown to be significantly related to graded high school performance (Eren & Coskun, 2016). Beyond education, the differentiation and prevalence between "boredom due to over-challenge" vs. "boredom due to under-challenge" could also be investigated in other domains, such as work.

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General Discussion

Boredom is Boredom Irrespective of its Antecedents

The overarching goal of the present dissertation was to investigate adolescent boredom in mathematics due to over- vs. under-challenge and its undesirable correlates. The key goal of Study 1 was to systematically compare students who are highly bored and low-achieving (thus, likely over-challenged) with students who are highly bored and high-achieving (thus, likely under-challenged). As a preliminary step, Study 1 replicated undesirable boredom correlates by showing that student-reported experiences of boredom during mathematics classes go along with higher levels of emotional and behavioral problems, negative affectivity, the use of expressive suppression to regulate emotions and neuroticism. Student mathematics boredom also proved to be accompanied by lower levels of prosocial behavior, positive affectivity, cognitive reappraisal, and conscientiousness. Study 1 thus provides evidence that students' mathematics boredom, as measured with a well-established domain-specific instrument, the AEQ-M (Pekrun & Goetz, 2005), goes along with an increase of undesirable correlates of boredom similar to general boredom proneness. The results thus underline the importance that the experience of boredom in school should not be accepted as a part of the class but should be perceived as an emotion that can go hand in hand with severe problems.

Furthermore, and in line with Pekrun's (2006) control-value theory of achievement emotions the results of Study 1 suggest that high boredom can occur both in low- and high-achieving students and is accompanied by similar levels of problematic correlates in both groups. Low- and high-achieving students did not differ significantly in their behaviors and personality traits (i.e., emotional symptoms, conduct problems, hyperactivity, peer problems, prosocial behavior, positive and negative affect, neuroticism, cognitive reappraisal and expressive suppression, neuroticism, and

conscientiousness). Thus, boredom itself seems to be associated with these problems and good scholastic performance and the experienced level of subjective control in a domain are neither protective nor vulnerability factors.

Boredom as an Early Warning Sign for Health-Related Problems

There are several studies demonstrating that general boredom, boredom proneness, boredom at work, and leisure boredom are linked with psychological and physical health problems (e.g., Fisher, 1993; Masland et al., 2020; Smith et al., 1981; Sommers & Vodanovich, 2000; Weybright et al., 2015). However, while boredom in school has been shown to be linked to a multitude of problematic academic outcomes (e.g., Eren & Coskun, 2016; Pekrun et al., 2011; Putwain et al., 2018; Tze et al., 2015), evidence on psychological and physical health correlates of scholastic boredom is mostly lacking, as of yet. Supporting and extending earlier findings on adverse academic consequences of scholastic boredom (see also Study 1), Study 2 showed that mathematics boredom is substantially linked with with lack of pleasure in life, feeling depressed, feeling unhappy, having low self-esteem, disliking school, negative feelings about school, not doing well, and feeling unhappy, unfit, and generally dissatisfied with regard to family life, peers, and school life. While context-specific mathematics boredom was most closely associated with the school-related HRQoL dimension, even the associations with rather context-transcending health indicators, such as general HRQoL, were substantial. The results of Study 2 thus add even more weight to the implications of Study 1. Boredom in school should not only be perceived as an emotion that can go hand in hand with severe problems like conduct and peer problems or emotional symptoms but also more general psychological and physical health issues.

In line with previous findings on academic boredom (e.g., Tze et al., 2014; Vierhaus et al., 2016), Study 2 observed an increase in boredom during the semester, with stronger increases in boredom being linked with more severe health-related problems. Particularly since both teachers and parents proved to be a valuable source of judging boredom in students (Daschmann et al., 2014; Nett et al., 2016), scholastic boredom—as judged by parents or teachers—could be used as an early warning sign of potential severe psychological and physiological health impairments.

Both Over- and Under-Challenged Students Experience Boredom

In the academic boredom literature, it has been claimed repeatedly that boredom at school can occur either due to over- or due to under-challenge. This differentiation is also common among practicing mathematics teachers who often observe that some students seem to roll their eyes when teachers try to come up with alternative explanations of a to-be-learned topic or principle, while others seem to tune out as if they had given up on ever grasping the topic. However, empirical evidence for the existence and prevalence of boredom due to over- and under-challenge among students is still largely lacking. To approach the question of "boredom due to over-challenge" vs. "boredom due to under-challenge" empirically, the aim of Study 3 was to explore the prevalence of high boredom in mathematics classes among students who scored low vs. high on a standardized math achievement test.

Confirming the hypothesis, four distinct profiles of boredom and math achievement were found using LPA. Students in the "over-challenged group" showed high levels of boredom (around +1 *SD* relative to all other students) coupled with low achievement (almost -1 *SD* relative to students in their age and school track). Students in the "under-challenged group" showed high levels of boredom (almost +1 *SD*)

coupled with relatively high achievement (around +.5 *SD*). It can be assumed that the high levels of boredom reported by students in the "over-challenged group" can be attributed to frequently being over-challenged during their mathematics classes, as their math achievement was clearly below their peers. In contrast, students in the "under-challenged group" most likely experience boredom during mathematics classes due to under-challenge, as their math achievement is well above their peers. Two groups showed relatively low boredom, indicating that those students do neither react with experiences of over- nor under-challenge. Students in the "well-off group" showed low boredom and high achievement (similar to the under-challenged group) while students in the "indifferent group" showed low boredom and low achievement (-0.5 *SD*).

Overall, 34% of the students showed high boredom due to being either over- or under-challenged in mathematics. Considering the growing shortage of STEM professionals (e.g., Anger et al., 2021) as well as the previously reported undesirable correlates of boredom (see Study 1) and links between boredom and health-related problems (see Study 2), the potential misfit between students' skill levels and the challenge they experience in their mathematics classes seems worrying. Exploring the role of gender and school type, using both variables as latent class predictors, it was affirmed that girls experience boredom due to over-challenge more often than boys (see also Daschmann et al., 2011). It has been shown that institutions can durably modify social stereotypes that lead to gender gaps, such as girls underperforming in mathematics (Lippmann & Senik, 2018). Moreover, other than an underrepresentation of students from the upper school track in the under-challenged group, no effects of school track were found. Therefore, the three tracks of the German tracking system seem to provide an adequate match between the student's skill level and the cognitive

demand of their school track, while students from the upper school track are less likely to be under-challenged.

Limitations and Suggestions for Future Research

Overall, the present dissertation addresses several gaps in boredom research and contributes to a better understanding of achievement boredom. However, the following limiting aspects should be taken into account when interpreting the results and could be considered as directions for future research. First, all three studies investigated a large representative sample of German secondary school students in the subject of mathematics. To generalize the results, the findings should be replicated with different samples in different domains and achievement settings. As there is evidence for cultural differences in the experience of boredom (e.g., Ng et al., 2015; Vodanovich & Watt, 1999), the findings should be replicated in other cultures as well. Second, the studies in this dissertation relied on self-report data. Future research should include other data sources as well, such as physiological and behavioral data. Third, the attribution of boredom due to over- vs. under-challenge in Study 1 was based on teacher-assigned math grades. Since academic knowledge is only a minor part of what grades are assessing (e.g., Bowers, 2011), the proposition of Study 1, that those students indeed suffered from boredom due to under- vs. over-challenge was uncertain. However, Study 3 measured the mathematics achievement of students with a reliable index of mathematical abilities (instead of teacher-assigned grades), arguing that this provides stronger evidence of boredom due to over- vs. under-challenge in mathematics among secondary school students. Still, the results are sample-dependent and should be replicated with different samples. Last, considering the correlational results of Studies 1 and 2, it remains open to discuss what underlies the observed correlational patterns.

Future research should replicate the findings using predictive models. While a robust latent growth curve modeling approach was used in Study 2, future research should investigate nonlinear boredom trajectories and longitudinal designs involving repeated measures of both boredom and health indicators to model their co-development over time.

Implications for Practice

Summarizing the most important implications from all three studies, the following practical implications can be derived for classroom teaching. First, any student—regardless of their achievement—may experience high levels of boredom that are accompanied by undesirable correlates (Studies 1 and 3). This may be counterintuitive to the belief that better-performing students are better off and should be beard in mind. Second, there are more students bored due to under- than over-challenge and girls are more often bored due to over-challenge in German secondary mathematics education (Study 3). This result emphasizes the need to modify social stereotypes (e.g., Lippmann & Senik, 2018) and for example, offer differentiated and individualized teaching (e.g., Landrum & McDuffie, 2010) or grouping students by ability (e.g., Feuchter & Preckel, 2022) to provide adequately challenging learning opportunities and promote talent regardless of gender. Moreover, deviating from teacher-centered instruction and the strict curriculum of the German school system by opening up learning environments could give students more control and autonomy over their learning (e.g., Deci & Ryan, 1985). With low-quality instructional design being one of the most reported reasons for boredom in class (Goetz & Frenzel, 2006), a variety of teaching methods should be offered. Third, boredom in school is ubiquitous (Study 3), increasing during a school year (Study 2), and goes hand in hand with undesirable

correlates (Study 1) and serious context transcending health-related problems (Study 2). Therefore, boredom needs to be taken seriously, and students should not be left alone to deal with it. Boredom should be discussed openly in class regularly, and prevention and intervention programs are needed. Since students use almost exclusively avoidance-oriented strategies to cope with boredom (Goetz et al., 2007), more promising coping strategies, such as cognitive- and behavioral-approach strategies, should be addressed (Nett et al., 2010).

Conclusion

In conclusion and in line with previous studies, the present dissertation underlined the importance of boredom research and showed that boredom in school is omnipresent (Study 3) and increases during a school year (Study 2). In three studies, empirical evidence was provided that high boredom can occur both in low- and high-achieving students (Studies 1 and 3) and is linked with serious health issues (Study 2) and numerous problematic correlates for both low- and high-achievers (Study 1). Boredom is an important emotion, that should lead us toward engaging and meaningful activities (e.g., Lin & Westgate, 2021) and, thus, could be facilitated to maximize opportunities for learning. However, with only few opportunities to respond constructively to boredom in school, students find other—more dysfunctional—alternatives such as sadistic and aggressive behavior (e.g., Li & Chu, 2022; Pfattheicher et al., 2023). It seems harder than ever for teachers to keep up with todays' always-connected and fast paced world, where social media provides constant notifications to an endless stream of content that is precisely selected by machine learning algorithms to hold our attention and keep us engaged as long as possible (e.g., Metzler & Garcia, 2023). But teaching is arguably one of the most important tasks in our society and

enabling students to reach their full potential by providing optimally challenging and meaningful learning activities should be of the upmost importance particularly in achievement-oriented societies.

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