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Anna-Leena Clem

Antecedents of Mathematics and Literacy Self-concepts of Ability and Achievement Emotions in Adolescence

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF EDUCATION AND PSYCHOLOGY

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ABSTRACT

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The aim of this dissertation was to investigate antecedents of adolescents' self-concepts of ability and achievement emotions in two school subjects (mathematics and literacy). Study I examined cross-lagged longitudinal associations between self-concepts of ability and failure- and success-related causal attributions. Study II examined reciprocal developmental associations between self-concepts of ability and enjoyment, anxiety and boredom. Finally, Study III examined the role of teacher–student conflict and closeness and self-concepts of ability in achievement emotions and whether these associations are different depending on student temperament. Two longitudinal datasets were used for answering the research questions. In Study I, lower secondary school measurements (i.e., grades 7 and 9, N = 237) from the JEPS study were used. In studies II and III, the STAIRWAY dataset was used in which about 850 adolescents were followed during the transition from primary school to lower secondary school (i.e., grades 6 and 7). The results of Study I showed that self-concepts of ability predicted attributions, but not vice versa. Adolescents with higher math self-concepts of ability were subsequently using more self-serving attributions (i.e., attributions of successes to internal and failures to external factors). In both school subjects, adolescents with lower self-concepts of ability subsequently used more maladaptive attributions (i.e., attributed failures to lack of ability and successes to external factors). The results of Study II showed that in math self-concept of ability was reciprocally related to enjoyment and anxiety. Math self-concept of ability also predicted boredom but not vice versa. In literacy, no cross-lagged associations were found. Finally, the results of Study III showed that in both school subjects higher conflict in teacher–student relationship was related to lower enjoyment and higher boredom and anxiety and closer relationship was related to higher enjoyment and lower boredom. Adolescent temperament moderated some of the relations between teacher–student relationship quality, self-concept of ability and achievement emotions in literacy.

Overall, the results suggest, first, that adolescents' causal attributions related to math and literacy failures and successes are self-consistent. Second, the results suggest that, particularly in math, self-concept of ability and enjoyment of math can create a positive cycle, whereas self-concept of ability and math-related anxiety can lead to a negative cycle and higher self-concept of ability can also protect against boredom. Third, the results also highlight the role of teacher-student relationship quality and the role of student temperament in students' achievement emotions.

Keywords: self-concept of ability, achievement emotion, causal attribution, teacher–student relationship, temperament, adolescence

TIIVISTELMÄ (FINNISH ABSTRACT)

Clem, Anna-Leena
Nuorten matematiikan ja äidinkielen oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden taustalla vaikuttavat tekijät
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Tässä tutkimuksessa tarkasteltiin nuorten oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden taustalla vaikuttavia tekijöitä matematiikan ja äidinkielen oppiaineissa. Ensimmäinen tavoite oli tutkia millä tavoin epäonnistumisiin ja onnistumisiin liittyvät kausaaliattribuutiot ennustavat oppimisminäkäsityksiä ja millä tavoin oppimisminäkäsitykset ennustavat kausaaliattribuutioita. Toinen tavoite oli tutkia millä tavoin oppimisminäkäsitykset ennustavat oppimisen iloa, ahdistusta ja tylsyyttä ja millä tavoin nämä tunteet ennustavat oppimisminäkäsityksiä. Kolmas tavoite oli tarkastella opettaja-oppilassuhteen läheisyyden ja konfliktin ja oppimisminäkäsitysten yhteyksiä oppimiseen liittyviin tunteisiin sekä millä tavoin nuoren temperamentti muuntaa näitä yhteyksiä. Tutkimuksessa käytettiin kahta pitkittäisaineistoa. Ensimmäisessä tutkimuksessa käytettiin 237 nuoren 7. ja 9. luokan aineistoa (*Jyväskylä Entrance into Primary School*). Tutkimuksissa II ja III käytettiin noin 850 nuoren 6. ja 7. luokan aineistoa (*Stairway Study)*. Tulokset osoittivat, että oppimisminäkäsitykset ennustivat molemmissa oppiaineissa kausaaliattribuutioita. Molemmissa oppiaineissa heikompi oppimisminäkäsitys ennusti ei-adaptiivisten attribuutioiden käyttöä (epäonnistumisten liittämistä omaan kyvyttömyyteen ja onnistumisten liittämistä ulkoisiin tekijöihin). Lisäksi parempi matematiikan oppimisminäkäsitys ennusti minää tukevien attribuutioiden käyttöä (onnistumisten liittämistä omaan kyvykkyyteen ja epäonnistumisten liittämistä ulkoisiin tekijöihin). Parempi matematiikan oppimisminäkäsitys ennusti myös enemmän oppimisen iloa ja tämä puolestaan ennusti edelleen parempaa oppimisminäkäsitystä. Heikompi matematiikan oppimisminäkäsitys puolestaan ennusti lisääntynyttä ahdistuksen tunnetta, joka taas ennusti heikompaa oppimisminäkäsitystä. Parempi matematiikan oppimisminäkäsitys ennusti myös vähäisempää tylsyyden tunnetta, mutta ei toisinpäin. Äidinkielessä ei sen sijaan löytynyt vastavuoroisia yhteyksiä oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden välillä. Molemmissa oppiaineissa enemmän konfliktia sisältävä opettaja-oppilassuhde oli yhteydessä vähentyneeseen oppimisen iloon, lisääntyneeseen tylsyyden ja ahdistuksen tunteeseen ja läheisempi suhde oli puolestaan yhteydessä lisääntyneeseen oppimisen iloon ja vähentyneeseen tylsyyden tunteeseen. Nuoren temperamentti muunsi joitakin opettaja-oppilassuhteen, oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden välisiä yhteyksiä äidinkielessä. Tulokset antoivat viitteitä ensinnäkin siitä, että kausaaliattribuutiot ovat oppimisminäkäsitysten kanssa yhteneväisiä. Toiseksi, tulokset antoivat viitteitä siitä, että etenkin matematiikan oppimisessa oppimisminäkäsityksen ja oppimisen ilon välille voi kehittyä positiivisesti toisiaan ruokkiva yhteys, kun taas oppimisminäkäsityksen ja ahdistuksen tunteen välille voi kehittyä negatiivisesti toisiaan ruokkiva yhteys. Parempi matematiikan oppimisminäkäsitys voi myös suojata tylsyyden tunteilta. Kolmanneksi, tulokset antoivat viitteitä opettaja-oppilassuhteen laadun ja temperamentin merkityksestä oppimiseen liittyvien tunteiden synnyssä.

Avainsanat: oppimisminäkäsitys, oppimiseen liittyvä tunne, kausaaliattribuutio, opettaja-oppilassuhde, temperamentti, nuoruus

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The author of the dissertation wrote the original research plan which was reviewed by supervisors, conducted the analyses in collaboration with co-authors and wrote the reports of the three publications. The author also participated in data collection for the STAIRWAY I study.

TABLES

CONTENTS

1 INTRODUCTION

Self-concept of ability (i.e., how good students evaluate themselves in different subject domains) is central to adolescents' academic development. According to robust research evidence, higher evaluations of one's self-concept as a learner predict interest in school subjects, academic choices, success in school, and educational attainment, and can even protect against school drop-out (e.g., Durik et al., 2006; Guay et al., 2004; Marsh et al., 2005; Rumberger & Lim, 2008; Trautwein & Möller, 2016; Valentine et al., 2004). In addition, how individuals interpret reasons for their perceived successes and failures (i.e., causal attributions; Weiner, 1986, 1992) and emotions related to achievement outcomes and achievement activities (i.e., achievement emotions; Pekrun, 2017a) have been shown to play a central role in academic outcomes (e.g., Graham, 2004; Graham & Taylor, 2016; Kiuru et al., 2020; Liu et al., 2009; Pekrun, 2017a, 2017b; Perry & Hamm, 2017; Wolters et al., 2013).

Despite the importance of self-concept of ability, causal attributions, and achievement emotions in academic development, little is known about the antecedents and interplay between these factors. Increasing understanding of these dynamics is important, because it could assist in planning interventions to enhance adolescents' motivation and achievement (see also Kiuru et al., 2020; Marsh et al., 2016; Trautwein & Möller, 2016). Consequently, the present study examined domain-specific causal attributions, achievement emotions and self-concepts of ability in mathematics and literacy. Mathematics and literacy school subjects were chosen, because reading and mathematics are core contents in Finnish comprehensive school (National Core Curriculum, 2016) and literacy and math skills have been shown to have an impact on later academic success (e.g., Alexander et al., 1997; Claessens & Engel, 2013).

Theoretical models (Pekrun 2006; Weiner, 1986) as well as empirical evidence (e.g., Marsh, 1984; Marsh et al., 1984; Pekrun & Perry, 2014) suggest that self-concept of ability and causal attributions are related and that self-concept and achievement emotions are related. Thus, one of the strategies to maintain or enhance self-concepts of ability during adolescence relates to attempts to influence the way individuals interpret reasons for their perceived successes and

failures (i.e., causal attributions; Weiner, 1986, 1992; see also Perry & Hamm, 2017). Another way to enhance adolescents' self-concepts of ability and therefore their positive development is to create classroom environments and practices that boost positive emotions toward learning and mitigate negative emotions (Pekrun, 2006; Pekrun & Perry, 2014). However, the major limitation of earlier research is that it has typically used cross-sectional data, meaning little is known about the direction of the associations between self-concepts of ability and causal attributions. Similarly, only a few longitudinal studies have been conducted to test reciprocal cross-lagged associations between self-concepts of ability and achievement emotions in different achievement domains and including multiple emotions. Hence, the present dissertation aims to increase understanding of the interplay and reciprocal dynamics of domain-specific self-concept of ability, causal attributions and achievement emotions.

According to Pekrun's (2006) control-value theory of achievement emotions, not only characteristics of students, such as the self-concept of ability, affect students' emotions regarding learning, but instructional and social factors also have an impact. There is some information on how classroom practices and teacher behavior affect students' emotions but less is known about the role of the quality of teacher–student relationships in students' emotions. It has also been suggested that student temperament, that is, individual differences in responding to external and internal stimuli and in regulating these reactions (Rothbart & Bates, 2006), might affect adolescents' developmental plasticity and susceptibility to environmental influence (Belsky & Pluess, 2009). However, research of the role of adolescent temperament in the associations of the self-concept of ability and the teacher–student relationship with achievement emotions, to date, has been rare. Therefore, the present dissertation aims to increase understanding regarding the role of self-concepts of ability and teacher–student relationships in students' achievement emotions and whether these associations are different depending on adolescent temperament.

1.1 Adolescents' self-concept of ability

Students' perceptions and knowledge regarding their abilities in achievement settings have been conceptualized in various ways in the literature, such as competence beliefs (Spinath & Spinath, 2005), self-concept of ability (Wigfield & Eccles, 2000), and academic self-concept (Marsh & Seaton, 2013). These concepts can be classified based on whether they refer to students' global perceptions about themselves across achievement domains or to domain-specific perception of ability in a specific academic domain (e.g., math or verbal skills) (Bong & Skaalvik, 2003; Byrne, 1996; Marsh et al., 2017). In this study, *self-concept of ability* (Wigfield & Eccles, 2000) refers to the beliefs that a person holds about his or her current competence in a particular domain (e.g., literacy and mathematics).

Other related concepts used in the literature of self-perceptions are self-efficacy, expectancy of success and self-esteem (for reviews, see Bong & Skaalvik,

2003; Marsh et al., 2017; Schunk & Pajares, 2005; Swann et al., 2007). *Self-efficacy* is typically defined as prospective beliefs about what can be done with the skills and abilities in the future in relation to a narrowly defined task (e.g., whether a person believes they are able to throw the ball in the basket; see Bong & Skaalvik 2003; Schunk & Pajares, 2005). An important distinction between perceptions of abilities and self-efficacy is that perceptions of abilities are usually evaluated in relation to past accomplishments and in relation to social comparison, whereas self-efficacy assessment does not usually involve such evaluations (Bong & Skaalvik, 2003; Marsh et al., 2017). As a result, perception of abilities is typically measured by asking how good students evaluate their abilities/competences to be in a certain domain and how good they evaluate them to be in comparison to their peers (Trautwein & Möller, 2016). Efficacy beliefs, in turn, are usually measured by asking students to rate their confidence/probability to accomplish a specific task (Bong & Skaalvik, 2003; Marsh et al., 2017; Pajares, 1996). *Expectancy of success* is operationalized similarly to efficacy beliefs as it is defined as expectancy of success in upcoming tasks (Schunk & Pajares, 2005; Wigfield & Eccles, 2000). *Self-esteem*, in turn, typically refers to global evaluation of one's value or worth (Harter, 1999, 2003), and so it can be described as an overall feeling about the self (Leary & MacDonald, 2003).

Previously, self-concept was treated as a unidimensional constitution of global self-concept or self-esteem and it was measured by averaging scores on multiple life domains (Bong & Skaalvik, 2003; Harter, 1999). However, unidimensional models have been criticized for a tendency to mask the distinct perceptions people have toward different domains (Harter, 1999), and nowadays self is acknowledged to be multidimensional (for reviews, see Marsh & Hattie, 1996; Marsh et al., 2017; Trautwein & Möller, 2016). The realization was that people can have different perceptions of abilities in different fields. One can consider themselves good at physics but not good at English while thinking of themselves as being great at social situations. Regarding perceptions of abilities in the academic domain, Shavelson et al. (1976) proposed, in their model of self-concept, that the global self-concept is at the top of the hierarchy and it then splits into academic self-concept and non-academic self-concept. Academic self-concept further splits into different school subject self-concepts and non-academic self-concept splits into social, physical, and emotional self-concepts. However, it was later found that mathematics and verbal self-concepts were nearly uncorrelated and this finding led to Marsh and Shavelson's (1985) revised model of self-concept in which academic self-concept splits into higher order math and verbal self-concepts, while underneath these are related school subject–specific self-concepts (Marsh, 1990). Recent research has provided strong evidence for domain specificity of academic self-concepts (e.g., Arens et al., 2020; Brunner et al., 2010; Marsh & Craven, 2006; Marsh & Seaton, 2013; Valentine et al., 2004).

In general, children and adolescents use different sources for the development of their perceptions of their abilities in different school subject domains. These include other persons' perceptions of their ability, school grades,

external comparisons with their peers, and internal comparisons with their own ability areas (Bong & Skaalvik, 2003; Skaalvik & Skaalvik, 2002; Trautwein & Möller, 2016). However, it has been suggested that the construction of academic self-concept can be considered a flexible process that contains selectiveness of the various sources used for the construction of self-concept and the importance of the source used can vary depending developmental status or changes in school environment (e.g., school transitions) (Gniewosz et al., 2012). For example, in adolescence, heightened concern for other people's opinions emerges, and therefore appraisals by others (e.g., peers) about the ability of an individual can have a larger role in adolescents' self-concepts of ability than previously (Harter, 1999; Sebastian et al., 2008).

Children in the early years of primary school are able to differentiate their self-perceptions between multiple domains (Marsh et al., 1991; Wigfield & Eccles, 2000), but their self-concepts of ability are typically highly positive and even unrealistic (Wigfield et al., 1997; Wigfield & Karpanthian, 1991). In general, self-concepts tend to become less positive in middle childhood or in early adolescence (e.g., Jacobs et al., 2002; Marsh, 1989; Spinath & Spinath, 2005; Stipek & Mac Iver, 1989). However, some studies have found the decline of self-concepts to continue through middle adolescence (De Fraine et al., 2007; Nagy et al., 2010), while other studies have found that after the decline, self-concepts have a tendency to recover and then increase (Cole et al., 2001; see also Marsh, 1989). However, the changes in self-concepts might vary between domains (Cole et al., 2001; Jacobs et al., 2002), and there is also some evidence of individual differences for when and how extensively self-concepts of ability become more negative (Archambault et al., 2010). Moreover, individual differences in self-concept of ability in different subject domains tend to become more stable with increasing age (Cole et al., 2001; see also Wigfield et al., 1997). These changes in self-concepts as children get older have been related to schools using practices that give more opportunities for social comparisons of abilities, such as group activities and formal evaluation (Harter, 1999), and also the accumulation of experiences in ability domains and receiving more feedback from other people (parents, teachers, peers) for building their self-concepts (Dresel & Hall, 2013). In addition, the decline of self-concepts has also been associated with developmental changes in adolescence and changes in the social environment, as adolescents encounter school transition, which can create a mismatch between young students' needs and the school environment (Eccles et al., 1993; Eccles & Roeser, 2011).

1.2 Adolescents' causal attributions and self-concept of ability

People have a tendency to ask "why?" to look for causes behind actions, outcomes, and events, particularly when something important, negative and/or unexpected happens (Weiner, 1986, 2000; see also Stiensmeier-Pelster & Heckhausen, 2008). The perceived causes for these experiences and events are called causal attributions (Weiner, 1986, 2010). In an academic domain, students

typically search for reasons why they succeeded or failed and these interpretations, according to attributional theory of motivation and emotion, have consequences for students' future motivation, emotions, and learning behaviors (Weiner, 1986, 2010). Success and failure can be attributed to a number of different causes, such as ability or lack of it, effort or lack of it, help from others or not having enough assistance, the easiness or difficulty of a task, effective or ineffective coping strategies, or simply having luck or not being lucky (Dresel & Hall, 2013; Perry & Hamm, 2017; Weiner, 1986, 1992). However, ability and effort are typical causes individuals give for their failures and successes in achievement situations (Graham & Taylor, 2016; Weiner, 1986, 1992).

According to Weiner's (1986, 2010) attributional theory of motivation and emotion causal attributions differ from each other with respect to the following dimensions: the locus of causality (internal-external), stability (fixed-variable), and controllability (controllable-uncontrollable). *Locus* indicates the location of a cause, which can be internal or external to the actor. *Stability* refers to the temporal duration of the cause, which can be relatively constant or change over time. *Controllability* refers to the volitional alteration of the cause, which can vary from relatively controllable to uncontrollable (Weiner, 1986, 2010). For example, ability is typically considered stable, internal, and uncontrollable; effort internal, unstable, and controllable; task difficulty external, stable, and uncontrollable; and luck external, unstable, and uncontrollable (Weiner, 1986, 2010). These different attribution properties are assumed to have an impact on subsequent achievement-related thoughts, feelings, and actions and, therefore, on learning and motivation (Weiner, 1992). However, the attributions students make for their learning outcomes are subjective explanations (Weiner, 2010), so some students may, for example, see their ability and intelligence as malleable, whereas others may see these as fixed and unchangeable (Molden & Dweck, 2006; Yeager & Dweck, 2012).

In attributional theory of motivation and emotion, stability is related to expectations of future failure or success, as well as to feelings of hopelessness or hope (Weiner 1986, 1992). Attributing success or failure to stable factors (e.g., ability) leads to an expectation of the same outcomes in the future. In the case of success, it leads to feelings of hope and in the case of failure, to feelings of hopelessness. Attributing outcomes to unstable factors instead leads to uncertainty about future outcomes or the expectation that something else will happen. This means that after a failure there is not necessarily an increased expectation of future failures but also that after success there may not be improvement in future expectation of success and possibly even a decrease in expectations of future success. The dimension of controllability is linked to feelings of guilt and shame such that attributing failure to internal, uncontrollable factor (e.g., ability) elicits shame, whereas an internal controllable factor (e.g., effort) in failure elicits guilt (Weiner, 1986, 1992). Attributing success to internal features (e.g., ability or effort) creates more pride than external causes, affecting self-esteem positively, whereas attributing failure to internal causes lowers self-

esteem or self-worth (Weiner, 1986, 2010; see also Feick & Rhodewalt, 1997; McRae & Hirt, 2001).

In order to avoid threats to their ability, adolescents have been reported to use self-handicapping strategies (Berglas & Jones, 1978; Urdan & Midgley, 2001) where they create situations that actually make failure more possible, but if the failure indeed happens the student can explain it by attributing it to the handicap instead of to a lack of ability. For example, a failure in an exam can be discounted due to staying up too late before an exam. The failure is then attributed tiredness, not a lack of ability, thereby preserving self-worth. In contrast, self-worth could even have been boosted after success in such a situation. However, self-handicapping strategies can undermine achievement, and these have been related to lower school achievement (for a meta-analysis, see Schwinger et al., 2014).

Regarding the consequences of attributions to future learning and motivation in literature, individual differences in using attributions have been grouped into different attributional or explanatory styles. In general, explanatory style can be called adaptive when the causes of successes are attributed to internal, stable factors (e.g., ability), and the causes of failures are attributed to unstable or controllable causes (e.g., effort). In turn, explanatory style can be called maladaptive when the causes of successes are attributed to external, uncontrollable, unstable causes (e.g., luck) and when the causes of failures are attributed to internal, stable causes (e.g., ability). Maladaptive style can negatively affect self-concept and expectancy for future success, generates hopelessness, and reduces striving to succeed; whereas adaptive style can lead to higher self-concept and hopes and expectations for future success, and a striving to succeed in the future (Chodkiewicz & Boyle, 2014; Weiner, 1986, 2010; see also Higgins & LaPointe, 2012; Perry & Hamm, 2017). Moreover, a maladaptive attributional style can lead to a negative cycle in which maladaptive attributions lower self-esteem and motivation, which leads to lack of effort and to lower achievement (Chodkiewicz & Boyle, 2014). In an attempt to change maladaptive attributions and therefore, positively impact motivation and learning, in attribution retraining programs students are typically taught to attach poor outcomes to controllable factors (e.g., poor strategy, lack of effort), downplay uncontrollable factors (e.g., low ability, teaching quality, test difficulty) or change the dimensional features of causes (e.g., perceive ability as unstable that can be changed via effort; Perry & Hamm, 2017). The attribution retraining programs have been shown to benefit students' motivation, emotions, and achievement (Chodkiewicz & Boyle, 2014; Perry & Hamm, 2017; Weiner, 1986). Several studies of implicit theories also corroborate the benefits of using unstable, controllable attributions after failures (e.g., Dweck & Molden, 2005, 2017).

The attributions students make for their learning outcomes are subjective explanations and not necessarily realistic. Previous literature has identified self-serving attributions in students' explanations for why outcomes have occurred. In general, people have a tendency to use self-serving attributions, that is, to attribute success to internal causes and failure to external causes, and therefore

to internalize positive outcomes and deny their part in negative outcomes (Marsh, 1986a; Mezulis et al., 2004; Weiner, 1986, 1992). In the literature this type of tendency has been called self-serving bias and it has been observed among both genders and among children and adolescents (Mezulis et al., 2004), although Mezulis et al.'s meta-analysis (2004) found a decline in self-serving bias when children approach adolescence. The use of self-serving attributions can be seen as a means of enhancing one's self-esteem/self-concept or preserving it (Weiner, 1986, 1992; see also Covington, 1984; Robins & John, 1997). Thus, one of the strategies to maintain or enhance self-concepts of ability is the way individuals interpret reasons for their perceived successes and failures, that is, the causal attributions (see, e.g., Weiner, 1986, 2010).

The level of self-concept can be seen to have a motivational impact on causal attributions. Research has shown that the lower the self-concept the less attributions are used in a self-serving way and the higher the self-concept the more attributions are used to protect the self. More specifically, individuals with low self-concept do not seem to internalize success and externalize failure, whereas individuals with higher self-concept tend to do so (for an overview, see Stiensmeier-Pelster & Heckhausen, 2008; see also Möller & Köller, 2000; Campbell & Sedikides, 1999; Weiner, 1986). One way to interpret these findings is that instead of enhancing the self, people tend to perceive events in a way that is consistent with their self-view (Robins & John, 1997, Swann & Read, 1981; Weiner, 1992). Therefore, it is possible that individuals interpret their failures and successes in accordance with their self-concept of ability.

Previous literature on the relations between attributions and self-concept of ability has been mostly cross-sectional. These studies have shown that attributing success to internal causes, such as ability and effort (Marsh, 1984; Marsh et al., 1984; Platt, 1988; Zhou & Urhahne, 2013) is positively correlated with academic self-concepts. As an exception, in Nicholls' (1979) study, attributing success to effort was negatively related to academic self-concept (see also Kurtz-Costes & Schneider, 1994). Attributing failure to internal and stable causes such as to ability (Marsh, 1984; Marsh et al., 1984; Nicholls, 1979; Zhou & Urhahne, 2013) has been found to negatively correlate with academic self-concepts, whereas the results for effort attribution have been contradictory; some studies show that attributing failure to effort is negatively related with academic self-concept (Marsh, 1984; Marsh et al., 1984; Zhou & Urhahne, 2013), while other studies (Nicholls, 1979; Kurtz-Costes & Schneider, 1994) have found no associations between effort and self-concept in failure situations.

Studies concerning external causal attributions have mostly classified these attributions into the same group and are therefore unable to distinguish the role that different external attributions might have in the relationship between attributions and academic self-concepts. The results of the few studies separating different external attributions have been inconsistent. Zhou and Urhahne's (2013) study of fourth-graders showed that attributing success to task characteristics is positively related to academic self-concept. However, Platt's (1988) study of 17- to 19-year-old adolescents showed that attributing successful outcomes to task

easiness was negatively related to self-concept. In failure situations, attributions to task characteristics have been found to be negatively related to self-concept (Zhou & Urhahne, 2013). Yet, in Nicholls' (1979) study, task easiness or difficulty was not related to self-concept of ability.

The limitation of earlier studies is, however, that earlier research has mostly been cross-sectional. Only a few longitudinal studies have been conducted. One of these longitudinal studies showed that attributing success to ability at age 8 had a positive effect on domain-general self-concept of ability at age 10 via school grades, and domain-general self-concept of ability at age 8 positively predicted ability attribution in success situations at age 10 (Kurtz-Costes & Schneider, 1994). In another longitudinal study, Dresel (2001) showed that domain-general self-concept of ability negatively predicted attribution of failure by sixth- and ninth-graders to ability a year later. Neither of these studies investigated the cross-lagged associations of different domain-specific causal attributions (e.g., ability, effort, guidance, and task difficulty) and self-concepts of ability in both success and failure situations, and therefore little is known about the developmental dynamics between domain-specific self-concepts of ability and causal attributions.

1.3 Adolescents' achievement emotions

The attributional theory of motivation and emotion (Weiner, 1986, 1992) is concerned about emotions that relate to outcomes (e.g., failure or success) and links attribution dimensions to different emotional experiences. The control-value theory of achievement emotions (Pekrun, 2006; Pekrun & Perry, 2014) extends Weiner's theory by defining achievement emotions not only as emotions related to achievement outcomes but also to achievement activities (e.g., enjoyment or boredom while studying). Control-value theory also further classifies outcome-related emotions as prospective outcome emotions (e.g., anxiety linked to anticipated failing in an exam) and retrospective outcome emotions (e.g., pride after a success), and classifies achievement emotions based on whether they are positive or negative (i.e., valence) or physiologically activating or deactivating (i.e., level of physiological activation). Achievement emotions therefore evolve in relation to past, current and future successes and failures (Frenzel & Stephens, 2013). Based on control-value theory of achievement emotions (Pekrun, 2006; Pekrun & Perry, 2014) and previous research (Lichtenfeld et al., 2012), this dissertation focused on examining three achievement emotions that are of primary importance in achievement settings, namely, enjoyment, anxiety, and boredom. Enjoyment, boredom, and anxiety related to school activities are salient and frequently experienced emotions (Goetz & Hall, 2014; Pekrun et al., 2002; Raccanello, et al., 2013). The investigated emotions can be classified in the following way: enjoyment as a positive activating activity-related emotion, anxiety as a negative activating prospective outcome-related emotion, and boredom as a negative deactivating activity-

related emotion. Overall, nowadays emotions are considered not only as an outcome of learning but also as an integral part of a learning process and motivation (e.g., Meyer & Turner, 2002; see also Schutz & Lanehart, 2002).

Students experience a variety of emotions related to achievement situations (Pekrun et al., 2002) and the same student can experience anxiety while studying math but be bored while studying literacy. Like self-concepts of ability, achievement emotions are largely considered domain specific (Goetz et al., 2006, 2007, 2008; Raccanello et al., 2013). Consistent with the development of self-concept of ability, there is some evidence that mean levels of enjoyment tend to decrease in elementary and junior high school (Hagenauer & Hascher, 2010; Pekrun, von Hofe et al., 2007; see also Pekrun, 2017a; Raccanello et al., 2013), whereas anxiety mean levels have been reported to follow an opposite direction, increasing over the school years but stabilizing in adolescence (Hembree, 1990; Zeidner, 1998). Moreover, there is some evidence showing that boredom mean levels increase over the school years (Pekrun, Von Hofe et al., 2007; see also Raccanello et al., 2013). It has been suggested that adolescents start to have different interests that can be in conflict with school work and, as a result, adolescents have lower positive emotions and higher boredom regarding school. It has also been suggested that the decline of positive emotions and increase of negative emotions in adolescence can be related to the general decrease of self-concepts of ability, changes in teaching styles, greater competition in the classroom, and increase of demands (Frenzel & Stephens, 2013).

Control-value theory of achievement emotions is based on an integrative framework, and seeks to analyze the effects of achievement emotions and their antecedents in achievement and academic contexts (Pekrun, 2006). Boredom in learning is assumed to be related to off-task behaviors and ineffective learning strategies, thus undermining motivation and achievement. Similarly, anxiety is commonly thought to be related to task-irrelevant thinking and decreased intrinsic motivation. Enjoyment related to learning tasks, in turn, can facilitate learning and achievement, for example, by boosting interest and adaptive learning strategies (for reviews, see Pekrun, 2017a, 2017b; Pekrun & Perry, 2014).

According to the control-value theory of achievement emotions (Pekrun, 2006), two kinds of appraisals affect the emergence of achievement emotions (for empirical evidence, see Pekrun & Perry, 2014). First, the subjective control over the achievement activities and achievement outcomes (i.e., individual's prospective expectancies related to the achievement activities and causal attributions related to outcome of the activities) and, second, the subjective values of the achievement activity or its outcome (i.e., valence of an outcome or an activity).

The control-value theory of achievement emotions suggests that self-concept of ability affects the way one feels toward learning as it forms a basis for a person's feeling of control over achievement outcomes and activities (Pekrun & Perry, 2014). More specifically, the control-value theory assumes that when students feel they are capable of mastering the required tasks, enjoyment is likely instigated. Anxiety, in turn, is assumed to be provoked when self-concept is low

(Pekrun & Perry, 2014). Lower self-concept of ability might signal that a person is not up to the task demands and anxiety is likely to be triggered (Bandura, 1997; Csikszentmihalyi et al., 2005), particularly if the person evaluates the task as important (Pekrun & Perry, 2014). Furthermore, low ability beliefs may create attentional and interpretive biases in the processing of information. More specifically, low self-evaluations can arouse anxiety by increasing students' vigilance of threats and magnifying their evaluation of the severity of threats. In contrast, higher self-evaluations may facilitate viewing potential threats as more benign and adopting adaptive strategies to cope with threats, which decreases anxiety and results in unaffected or enhanced evaluations of self (Bandura, 1997).

The role that self-concept of ability plays in boredom with learning has been debated. Traditionally, boredom has been assumed to be triggered if ability level is high and task demands are too low (Csikszentmihalyi et al., 2005; see also van Tilburg & Igou, 2012). However, the control-value theory of achievement emotions (Pekrun, 2006) suggests that boredom is as likely to occur if subjective control over the activity is low or high. Boredom is then likely instigated if the demands of the situation exceed a person's ability to cope in the situation or if the task demands are too low in relation to ability level (see also Acee et al., 2010; Daschmann et al., 2011; Krannich et al., 2019). However, it has also been suggested that school tasks are typically designed to be difficult enough, and therefore high control situations are not common in the school environment. Thus, it is more likely that overchallenging (rather than underchallenging) situations instigate boredom in school (Pekrun et al., 2010).

The control-value theory of achievement emotions (Pekrun, 2006; Pekrun & Perry, 2014) also suggests that emotions might have an impact on self-concept of ability (see also Bandura, 1997; Marsh et al., 1999; Zeidner, 1998). Similar to associative network theory (Bower, 1981), the control-value theory of achievement emotions (Pekrun, Frenzel et al., 2007) suggests that achievement emotions can affect self-concept of ability indirectly by triggering emotion-congruent memory networks. According to associative network theory (Bower, 1981), emotions are stored in memory as nodes or units and they are linked with propositions which describe events during the time the emotion was felt. An activation of an emotion node can spread activation throughout the memory structures to which it is connected and trigger activation in those event nodes, making mood-congruent events more accessible for judging one's self-concept of ability. Thus, emotions can act as a filter through which people view information of their competence and define which information becomes accessible and salient (Kavanagh & Bower, 1985). Therefore, negative emotions may activate past failures in memory, affecting self-evaluation negatively, whereas positive emotions may activate past successes, with a positive impact on self-evaluation (see also Bandura, 1997). Another way emotions can affect self-concept is provided by feelings-as-information theory (Schwarz, 2012; see also Clore & Storbeck, 2006), which implies that emotions can affect self-evaluation directly by implicitly giving information about a person's performance and this emotionally-biased information can downgrade or upgrade beliefs (Bandura,

1997). Therefore, people are likely to make positive evaluations of themselves when they experience positive emotions and negative evaluations if they experience negative emotions. Finally, the mood-congruency hypothesis suggests that people are likely to make negative judgments of their abilities when they experience a negative mood and positive judgments when they experience a positive mood (for a review, see Sedikides, 1992).

There is evidence supporting the mood-congruency hypothesis, mainly from mood-induction studies that have investigated mood as a source of self-evaluations. According to these studies, a positive mood is positively related to subsequent self-evaluations while a negative mood has the opposite effect (for a review, see Sedikides, 1992; see also Lyubomirsky et al., 2005; Usher & Pajares, 2008), although there is also some evidence for mood-incongruency (for a review, see Sedikides & Green, 2001). Moreover, there is some evidence suggesting that mood congruency effects on self-evaluations are particularly likely with persons of low self-esteem (for a review, see Sedikides & Green, 2001).

The results from cross-sectional studies have shown that self-concepts of ability are positively related to enjoyment and negatively to boredom and anxiety in different academic domains (e.g., Goetz et al., 2008, 2010, 2013a; Gogol et al., 2017; Peixoto et al., 2017; Van der Beek et al., 2017). However, little is known about the longitudinal dynamics of these constructs. The few longitudinal studies that have investigated the associations between self-concept of ability and achievement emotions have typically examined the direction of the effect from self-concept to emotions, but not vice versa. For example, in a longitudinal study, math-related self-concept of ability was found to negatively predict math-related anxiety (Meece et al., 1990). A more recent longitudinal study by Pekrun et al. (2019) showed that math self-concept of ability negatively predicted students' math-related anxiety and positively predicted math-related enjoyment a year later. However, these studies did not examine the cross-lagged longitudinal relations between different achievement emotions and self-concepts of ability in several domains simultaneously and, therefore, they were not able to show how different achievement emotions and self-concepts of ability in different domains are developmentally related across time. To my knowledge, only a few studies have investigated reciprocal relations between achievement emotions and self-concepts of ability. Ahmed et al. (2012) showed that higher mathematics anxiety predicted lower self-concept and lower self-concept predicted higher anxiety among students in Grade 7, whereas a study from Grade 4 to Grade 7 showed that math self-concept of ability did not predict math-related enjoyment but enjoyment predicted students' math self-concept of ability (Pinxten et al., 2014). Another longitudinal study of Grade 5 students (Garn et al., 2019) also investigated enjoyment, but the focus was on physical activity enjoyment and its relations with physical self-concept and its different facets (e.g., coordination self-concept, endurance self-concept). The study found no reciprocal relations between physical self-concept and physical activity–related enjoyment, but the results showed that previous coordination self-concept predicted subsequent physical activity enjoyment and previous physical activity enjoyment predicted

future sport self-concept. In a more recent longitudinal study, Zhang (2020) examined students' self-concepts of ability and anxiety in three school subjects in grades 8 and 10 (i.e., Chinese, English and mathematics) and showed that previous self-concepts of ability negatively predicted subsequent anxiety in all three domains. However, previous anxiety predicted negatively subsequent Chinese and math self-concepts of ability but not English self-concept of ability. To my knowledge, no previous longitudinal studies have examined the reciprocal relations between self-concept of ability and multiple achievement emotions simultaneously in several school subjects.

1.4 Teacher–student relationship and achievement emotions

In the conceptualization of the teacher–student relationship quality, many models have been used, such as social support models, socialization models and developmental system models (Verschueren, 2015). In the present study, an attachment-based teacher–student relationship model was applied (see also Pianta, 2001; Verschueren, 2015). Accordingly, teachers can be seen as temporary attachment figures serving as a safe haven and a secure basis for children (Verschueren & Koomen, 2012). Stressing the affective quality of the relationship, the teacher–student relationship quality can be conceptualized as the amount of conflict and closeness in the relationship with teacher. Closeness is characterized by high levels of warmth, affection, and open communication between the teacher and the student, whereas conflict refers to perceived negativity within the teacher–student relationship (Jerome et al., 2009; Pianta, 2001).

Teacher–student relationship quality has been found to be related to many important child and adolescent outcomes. For example, it is well established in the literature that a high-quality teacher–student relationship is associated with higher school engagement and academic performance (for a meta-analysis, see Roorda et al., 2011). In addition, a positive teacher–student relationship has also been related to higher social competence (Pianta & Stuhlman, 2004) and socioemotional adjustment (Arbeau et al., 2010; Bergin & Bergin, 2009; Hughes, 2012; Myers & Morris, 2009). A positive teacher–student relationship has also been found to protect adolescents from future risk behaviors (Rudasill, Reio et al., 2010), depression and conduct disorders (Wang et al., 2013). Moreover, a positive teacher–student relationship has been found to be particularly beneficial for students who are at-risk for adjustment problems (e.g., Bergin & Bergin, 2009; Kiuru et al., 2016; Kuperminc et al., 2001; McCormick et al., 2014; Silver et al., 2005; Wang et al., 2013), and thus particularly meaningful to vulnerable children. However, less attention has been paid to the role of teacher–student relationships in students' achievement emotions.

Essentially, the control-value theory of achievement emotions suggests that not only are individual characteristics (i.e., control and value) potential sources of emotions, but the social and instructional environment is also an important antecedent of achievement emotions (Pekrun & Perry, 2014). More specifically,

the theory suggests that factors related to learning environment, such as cognitive quality of the instructions, task demands, value induction, autonomy and cooperation support, classroom goal structures, achievement expectancies of others, and achievement feedback and consequences, can have an impact on students' control and value appraisals and thereby affect achievement emotions (Dresel & Hall, 2013; Pekrun, 2006; Pekrun & Perry, 2014). Learning environment can therefore affect students' control and value appraisals and, as mentioned above, these appraisals have been found to be related to students' emotions.

Teacher–student relationship quality can be seen as a facet of the learning environment (Goetz et al., 2021) and so it can directly impact on achievement emotions. Teacher–student relationship quality can also be seen as embedded in the abovementioned factors related to the learning environment (Mainhard et al., 2018). For example, the closeness of the teacher–student relationship may help to adjust the cognitive quality of teaching to the individual needs of the students, which can further impact positively on valuing the subject and feelings of competence and in turn further affect achievement emotions (see also Aldrup et al., 2020). Furthermore, the fulfillment of basic needs of autonomy, competence and sense of relatedness can promote motivation and positive emotions and hinder negative emotions (e.g., Eccles & Roeser, 2009; Reeve, 2004; Skinner et al., 2014). For example, close and supportive teacher–student relationships can boost adolescents' sense of social relatedness and belonging within the classroom, which, in turn, may promote positive emotions toward learning and hinder negative ones (Meyer, 2014; Sakiz et al., 2012; Skinner et al., 2014). Moreover, teachers' own emotions have been found to be related to students' emotions (Becker et al., 2014).

Despite the importance of achievement emotions and teacher–student relationship quality on students' achievement, motivation, and well-being, these constructs have mainly been studied separately and research on direct and indirect relationships has mostly concentrated on teacher behavior, not on the teacher–student relationship and its relation to students' achievement emotions. There is nevertheless some evidence to suggest that learning environment such as elaborate instruction is related to more enjoyment and less boredom and anxiety in mathematics and Latin (Frenzel et al., 2007; Goetz et al., 2006). Similarly, some evidence suggests that a teacher's supportive presentation style is related to higher learning enjoyment and decreased boredom but not related to anxiety, whereas a teacher's excessive lesson demands are related to higher anxiety and boredom and lesser enjoyment (Goetz et al., 2013b; see also Lazaridez & Bucholz, 2019). Teacher behavior related to consequences of achievement, such as positive feedback of achievement, has been found to be related to higher enjoyment and lower anxiety and boredom (Frenzel et al., 2007; Goetz et al., 2006), whereas teacher punishment behavior has been found to be related to higher levels of anxiety and boredom (Frenzel et al., 2007). In addition, regarding the expectations of others, achievement pressure on behalf of the teacher, in turn, has been found to be related to increased anxiety, anger, and boredom and lower pride and enjoyment (Goetz et al., 2006). Previous empirical

studies have also shown that higher teacher support is related to lower negative and higher positive achievement emotions (for a meta-analysis, see Lei et al., 2018). Similarly, in a more recent study teacher sensitivity (e.g., teacher's awareness of learning difficulties and negative emotions) has been found to be related to lesser anxiety (Aldrup et al., 2020). Moreover, Mazer et al. (2014) found negative relations between perceived emotional support (e.g., "My teacher is willing to talk about school-related emotions with me") and negative emotions (e.g., boredom and anxiety) towards school in general. In a similar vein, in a meta-analysis of 10 studies, Hembree (1988) reported a positive relation between perceived teacher unfriendliness and test anxiety but did not find significant relation between test anxiety and teacher friendliness.

To my knowledge only one recent study has investigated associations of closeness in the teacher–student relationship with achievement emotions. In this longitudinal study of adolescents, reciprocal relations were found such that higher quality (i.e., closeness) was related to lower negative emotions and higher positive emotions, while higher positive emotions and lower negative emotions were related to higher relationship quality in the domains of math, French, English and German. Conflict, however, was not investigated (Goetz et al., 2021).

1.5 Student temperament as a moderator

It has been suggested that student temperament, that is, individual differences in responding to external and internal stimuli and in regulating these reactions (Putnam et al., 2001; Rothbart & Bates, 2006) might impact adolescents' developmental plasticity and susceptibility to environmental influence (Belsky & Pluess, 2009). Temperament traits can be defined as basic dispositions which occur early in life in the domains of activity, affectivity, self-regulation, and attention (Shiner et al., 2012). Temperament develops by a complex interplay among genes and biological and environmental factors (Shiner et al., 2012), and it is influenced by experience and maturation (Rothbart & Derryberry, 1981). Therefore, it is not inflexible to change yet it can be considered as relatively stable across time and situations and forming a basis for one's personality (Caspi & Silva, 1995; Rothbart et al., 2000; Rothbart & Bates, 2006).

In the present dissertation, the developmental model of temperament constructed by Rothbart et al. (Rothbart, 2011; Rothbart & Bates, 2006; Rothbart & Derryberry, 1981) was applied. The model suggests that there are three broad dimensions of temperament. *Extraversion/surgency* describes individual differences in approach behavior and positive affect whereas *negative affectivity* describes individual differences in proneness to distress and negative emotions. Extraversion/surgency and negative affectivity can be seen to represent reactive aspects of temperament, whereas the regulative aspect of temperament, that is, *effortful control,* refers to the ability to control behavior and regulate emotions, including attentional, inhibitory and activation control.

There is a substantial amount of research linking temperament with children's and adolescents' social, academic and emotional functioning (e.g., Al-Hendawi, 2013; Fernandez et al., 2013; Keogh, 2003; Muris & Ollendick, 2005; Rothbart, 2011; Sanson et al., 2002). For example, different temperament characteristics make individuals more vulnerable than others to certain emotional experiences (Hirvonen et al., 2013; see also Liew et al., 2014), and they also affect regulation of these emotions. More specifically, low effortful control and low extraversion/surgency and high negative affectivity have been found to be associated with internalizing problems (for a review, see Klein et al., 2012). In contrast, low effortful control and high negative affectivity have been associated with externalizing problems (for reviews, see Frick & Morris, 2004; Tacket et al., 2012). In line with the control-value theory of achievement emotions (Pekrun, 2006), there is some evidence that high effortful control, high surgency/extraversion and low negative affectivity are related to more positive and less negative achievement emotions (Lehikoinen et al., 2019). Moreover, high effortful control and low negative affectivity have been related to higher school participation and school liking, whereas shyness has been related to lower school liking (Valiente et al., 2012).

The goodness of fit model (Thomas & Chess, 1977) posits that adaptive outcome (i.e., goodness of fit) will result if the child temperament fits well with the demands and expectations of the environment. According to the model, students with different temperaments may therefore benefit from different kinds of teacher–student relationship qualities. Thus far, the most typical environment that has been studied in relation to temperament characteristics is the parent–child relationship or parenting behaviors (see Hirvonen et al., 2018; Lahdelma et al., 2021). Less is known about temperament characteristics' interactions with the teacher–student relationship quality, particularly on achievement emotions. According to the limited research on the topic, low effortful control combined with a positive relationship with a teacher has been found to be related to a decrease in problem behaviors (Wang et al., 2013) and higher achievement scores (Rudasill, Callagher et al., 2010). High emotional and instructional support from teacher in combination with difficult temperament has also found to be related to higher school achievement (Curby et al., 2011). High effortful control combined with negative teaching style, in turn, has been found to be associated with fewer anxiety symptoms compared to children with less effortful control, thus supporting the idea that effortful control may act as a buffer against negative teaching style (LaBillois & Lagace-Seguin, 2009). Also, high conflict with teacher, among children with low effortful control, has been found to be associated with emotional symptoms and peer problems (Myers & Morris, 2009). Furthermore, lower levels of closeness with teachers among shy children have been related to higher school avoidance, anxiety and social withdrawal, whereas higher closeness with teacher has been found to buffer against these effects (Arbeau et al., 2010).

In addition to environmental interaction effects, it is plausible that temperament interacts with a person's other attributes, such as self-concept of

ability. Temperament influences what kinds of learning experiences students are exposed to and how they react to and interpret these experiences (Derryberry & Rothbart, 1997; Keogh, 2003; Lonigan et al., 2004; Rothbart, 2011; Rothbart & Hwang, 2005; Rothbart & Jones, 1998; Shiner & Caspi, 2012). For example, previous research has shown that effortful control plays a role in modulating the affective consequences of threat-relevant stimuli (Lonigan et al., 2004). Higher effortful control may therefore provide protection from the detrimental effects of low self-concept on achievement emotions by allowing attention to shift from threatening stimuli and internal feelings of inadequate ability to more positive information that enables efficient coping, whereas weak effortful control, or high negative affectivity, may make students susceptible to focusing on their internal distress, thereby exacerbating the effects of low self-concept on achievement emotions (see also Derryberry & Reed, 2002; Lengua & Long, 2002; Rothbart & Jones, 1998). However, research on the interactions of self-concept of ability and temperament on achievement emotions has, to date, been rare.

1.6 Aims of the research

The main aim of this dissertation was to examine antecedents of adolescents' literacy and math self-concepts of ability and antecedents of literacy- and math-related achievement emotions. First, based on Weiner's attributional theory of motivation and emotion and Pekrun's control-value theory of achievement emotions I examined (a) to what extent students' math- and literacy-related causal attributions and achievement emotions predict their self-concepts of ability and (b) to what extent students' self-concepts of ability predict their causal attributions and achievement emotions. Second, based on Pekrun's control-value theory, I examined the relations between learning environment (i.e., teacher–student relationship quality) and achievement emotions. Third, I examined to what extent individual characteristics (i.e., student temperament) moderate the relations between (a) teacher–student relationship quality and achievement emotions and (b) self-concepts of ability and achievement emotions.

More specifically, **Study I** aimed to examine to what extent adolescents' literacy and math self-concepts of ability predict their subsequent failure- and success-related causal attributions (i.e., ability, effort, task difficulty and teacher guidance), and vice versa. **Study II**, in turn, aimed to examine to what extent adolescents' literacy and math self-concepts of ability predict their enjoyment, anxiety, and boredom regarding these school subjects, and vice versa. Finally, **Study III** examined the role of teacher–student conflict and closeness and students' self-concepts of ability in students' achievement emotions in mathematics and literacy and whether these associations are different depending on student temperament.

2 METHODS

2.1 Participants and procedure

This dissertation applied two different datasets: the Jyväskylä Entrance into Primary School (JEPS) study (Study I) and the STAIRWAY – From Primary School to Secondary School study (studies II and III). The JEPS study followed same age cohort children in Central Finland from preschool to Grade 9 in 1999 to 2009 (Nurmi & Aunola, 1999). In this dissertation, Grade 7 and Grade 9 samples of the JEPS study were used. The STAIRWAY study followed a community sample of adolescents from two municipalities in Central Finland from Grade 6 to Grade 7 in 2014 to 2016. The procedures were in accordance with the principles of the Helsinki Declaration on research with human subjects and the research plan of the broader project was approved by the Human Sciences Ethics Committee of the local university. In all of the studies, the parents of the students were asked for a written consent to allow their children to participate in the studies and students were also required to give their assent for participation.
Table 1 provides a summary of the studies I–III.

2.1.1 Study I

Study I (N = 237) used the sample of the JEPS study when the students were in Grade 7 and Grade 9. Of the students, 204 (88.3%) participated in both the seventh- and ninth-grade measurement points, 27 (11.7%) students took part in the study in only the seventh grade, and 33 (14.3%) students took part in only the ninth grade. The students completed the questionnaires concerning their math and literacy self-concepts of ability and causal attributions and students' skills in literacy and mathematics were tested in classroom group situations during normal school days. The data were collected in 2007 in the spring semester of Grade 7 and in 2009 in the spring semester of Grade 9 (see Rimkute et al., 2012).

2.1.2 Study II and III

In studies II and III, samples were part of the STAIRWAY I study which followed students from Grade 6 to Grade 7. In Study II 848 adolescents were examined twice in Grade 6 and twice in Grade 7. Out of the 848 students, a total of 841 (99%) adolescents participated in Grade 6 fall, 836 (96%) participated in Grade 6 spring, 802 (95%) participated in Grade 7 fall, and 793 (94%) participated in Grade 7 spring. In Study II, the data collection concerning students' math and literacy self-concepts of ability and achievement emotions was conducted in four waves (Grade 6 fall, Grade 6 spring, Grade 7 fall, and Grade 7 spring) between 2014 and 2016 using questionnaires. In Study III, a total of 854 students participated in the study and the data regarding students' math and literacy self-concepts of ability, achievement emotions, teacher–student relationship quality, and student temperament were collected via questionnaires in Grade 6. In Study III, information of students' task value of math and literacy was also collected in Grade 6 fall via questionnaire and in both of the studies students' math and literacy skills were tested in Grade 6 fall as well. The questionnaires were administered by trained test administrators during school hours.

2.2 Measurements

Self-concept of ability. In Study I, students' self-concepts of ability in math and literacy were assessed using a modified version of Wigfield et al.'s (1997) scale. The questionnaire included three items for both math and literacy (e.g., How good are you at math/Finnish?). The students were asked to rate these items using a 5-point Likert scale ranging from 1 (not good at all/very difficult) to 5 (very good/very easy). In studies II and III, adolescents' self-concepts of ability in math and literacy were assessed using a scale adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008). The questionnaire included three items for both math and literacy (e.g., How good are you at math calculation problems / at reading precisely and fast?) assessed on a 5-point Likert scale (1 = very poor to 5 = very good; see also Pesu et al., 2018).

Causal attributions. In Study I, adolescents' attributions for school-related success and failure outcomes were assessed using a scale developed by Rytkönen et al. (2006). Attributions for successful academic outcomes were assessed with two statements in both school subjects: "If I do well in math/Finnish tasks, it is because. . . ." and "When I succeed in math/Finnish, it is because. . . ." Similarly, attributions for failure outcomes were assessed with two statements per school subject: "If I don't do well in math/Finnish, it is because. . . ." and "When I don't succeed in math/Finnish tasks, it is because. . . ." The students were asked to answer each statement separately by ranking four options according to their importance (e.g., "most describes my thinking" and "least describes my thinking") on a 4-point scale. The four options for success situations were "I get good guidance," "I try hard," "I have the ability to succeed," and "The tasks are

easy." The answer options for failure situations were "The guidance I get is not good enough," "I don't try enough," "I'm not capable enough," and "The tasks are too difficult." Because the ranking options were negatively phrased ranging from 1 (most describes my thinking) to 4 (least describes my thinking), they were reverse scored.

Achievement emotions. In studies II and III, adolescents' enjoyment, boredom, and anxiety toward mathematics and literacy were assessed using a Finnish version of the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011; for validity, see Sainio et al., 2020). The questionnaire included three items for enjoyment (e.g., I enjoy acquiring new knowledge) and anxiety (e.g., I get tense and nervous while studying), and two items for boredom (e.g., I get bored while studying) regarding both math and literacy. The students were asked to rate the degree to which they experience these emotions toward literacy and math using a 5-point Likert scale ranging from 1 (disagree) to 5 (agree).

Teacher–student relationship. In Study III, the quality of the adolescents' relationship with their classroom teachers was assessed using a short Finnish version of the Student–Teacher Relationship Scale (STRS, short form; Pianta, 2001; see also Jerome et al., 2009). The scale was designed to measure adolescents' experience of closeness (five items, e.g., "I have a close and warm relationship with my teacher") and conflict (six items, e.g., "I often fight with my teacher") with their classroom teacher on a 5-point Likert scale ranging from 1 (I disagree) to 5 (I agree).

Temperament. In Study III, the adolescents' temperament was reported by parents using a Finnish version of the Early Adolescent Temperament Questionnaire (Revised; EATQ-R; Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001; for the validity of the Finnish sample, see Kiuru et al., 2019). The 56 statements of the questionnaire were designed to measure broader dimensions of temperament, namely, effortful control (e.g., "It is easy for me to really concentrate on homework problems"; "I have a hard time finishing things on time" (reversed)), negative affectivity (e.g., "I get sad more than other people realize"; "I get irritated when I have to stop doing something that I am enjoying"), and surgency/extraversion (e.g., I would not be afraid to try a risky sport, like deep-sea diving; I am shy (reversed). Mean scores for effortful control, negative affectivity, and surgency/extraversion were calculated.

2.2.1 Control variables

Gender. In all of the studies, students' gender was controlled for.

Literacy and math skills. In all of the studies, literacy skills were assessed using two subtests (the error-finding test and the word-chain test) from the Dyslexia Screening Methods for Adolescents and Adults by Holopainen et al. (2004; for reliability and validity, see also Savolainen et al., 2008). In Study I, reading comprehension was also assessed. The reading comprehension test included a four-page story, "Dogs of the Village," by the Finnish novelist Veikko Huovinen. In studies II and III, literacy skills were also assessed with short version of Salzburg's reading fluency test (Landerl et al., 1997). A sum score of

the three subtests was created by calculating the mean of the standardized test scores. In study I math skills were tested using a group-administered test for basic mathematical skills (Räsänen & Leino, 2005) designed for seventh to ninth graders (ages 12 to 15). In studies II and III mathematics performance was measured using the three- minute basic arithmetic test (Aunola & Räsänen, 2007; Räsänen et al., 2009).

Attainment values. In Study III, attainment values in math and literacy were assessed by two questions (e.g., "How important is it for you to be good at reading and reading comprehension/math calculation problems?") on a 5-point Likert scale ranging from 1 (not important at all) to 5 (very important) and adapted from Eccles et al. (1983).

TABLE 1 Summary of the studies I-III

Study	**Aims of the study**	**Participants**	**Main variables**	**Main measures**	**Data analysis method and measurement points**
Study I	To investigate to what extent students' self-concepts of ability predict subsequent use of causal attributions in math and literacy, and vice versa.	237 students	-Math and literacy self-concept of ability -Math and literacy success- and failure-related causal attributions (i.e., ability, effort, task difficulty, and teacher guidance)	-A modified version of Wigfield and colleagues' (1997) self-concept of ability scale -Causal attributions were measured by a scale developed by Rytkönen et al. (2006)	-Cross-lagged study with SEM -Grade 7 and Grade 9
Study II	To examine to what extent students' self-concepts of ability predict their achievement emotions in math and literacy, and vice versa.	848 students	-Math and literacy self-concept of ability -Math- and literacy-related achievement emotions (i.e., enjoyment, anxiety, and boredom)	-A self-concept of ability scale adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008) -A Finnish version of the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011)	-Random intercept cross-lagged panel model (RI-CLPM) -Twice in Grade 6 and twice in Grade 7

continues

Table 1 continues

Study	Aims of the study	Participants	Main variables	Main measures	Data analysis method and measurement points
Study III	To examine to what extent students' self-concepts of ability and teacher–student relationship quality is related to students' achievement emotions toward math and literacy and to investigate to what extent temperament moderates these relations.	854 students	-Math and literacy self-concept of ability -Math- and literacy-related achievement emotions (i.e., enjoyment, anxiety, and boredom) -Teacher–student relationship quality (i.e., closeness and conflict) -Student temperament (i.e., extraversion/surgency, negative affectivity, and effortful control)	-A self-concept of ability scale adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008) -A Finnish version of the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011) -A short Finnish version of the Student–Teacher Relationship Scale (STRS, short form; Pianta, 2001) -A Finnish version of the Early Adolescent Temperament Questionnaire (Revised; EATQ-R; Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001)	-Cross-sectional study with SEM -Grade 6

3 OVERVIEW OF THE ORIGINAL STUDIES

3.1 Study I

The aim of Study I was to (1) examine to what extent students' literacy and math self-concepts of ability in Grade 7 predict students' causal attributions related to successes and failures in literacy and math in Grade 9, and (2) examine to what extent students' causal attributions related to successes and failures in math and literacy in Grade 7 predict their Grade 9 math and literacy self-concepts of ability. Based on Weiner's (1986) attributional theory of motivation and emotion, and the assumptions drawn from self-consistency theories (e.g., Robins & John, 1997; Swann & Read, 1981), attributing success to ability was expected to positively predict subsequent self-concepts of ability, whereas attributing failure to ability was expected to negatively predict later self-concepts of ability. Moreover, adolescents with higher self-concepts of ability were assumed to be more likely to make ability attributions for successful outcomes and external attributions (i.e., lack of guidance or task difficulty) for failure outcomes. In contrast, adolescents with lower self-concepts of ability were expected to have a tendency to attribute failure to ability and success to external attributions. However, owing to the inconsistency of the empirical results regarding the relations between effort attributions and self-concept of ability (e.g., Kurtz-Costes & Schneider, 1994; Marsh, 1984; Marsh et al., 1984; Nicholls, 1979), and because empirical findings have not always been consistent with theoretical assumptions regarding these relations (e.g., Covington, 1984; Swinton et al., 2010; see also Nicholls, 1979), no specific hypotheses were set for the relations between effort and self-concept of ability.

The results showed that self-concepts of ability predicted subsequent causal attributions in both school subjects, and not vice versa. In mathematics, a higher self-concept of ability contributed to more self-enhancing and self-protective attributions. That is, the higher the students' self-concepts of ability in Grade 7

the more students attributed their math successes to their ability and their failures to getting help from a teacher. In both school subjects, a lower self-concept of ability contributed to more maladaptive attributions. That is, the lower the self-concepts of ability the students had in Grade 7, the more they attributed their failures to their lack of ability in math and literacy. Additionally, the lower the self-concepts of ability in math and literacy in Grade 7, the more students externalized their successes.

The results suggest that adolescents' causal attributions related to math and literacy failures and successes are self-consistent. That is, lower self-concept of ability can promote the use of maladaptive attributions. Higher self-concept of ability, particularly in math, can foster self-enhancing and self-protecting attributions.

3.2 Study II

The aim of Study II was (1) to investigate to what extent adolescents' literacy and math self-concepts of ability in Grade 6 predict their literacy and math related achievement emotions (i.e., enjoyment, boredom, anxiety) in Grade 7, and (2) to investigate to what extent adolescents' achievement emotions related to literacy and math in Grade 6 predict their literacy and math self-concepts of ability in Grade 7. Reciprocal relationships between prior self-concepts of ability and anxiety and between self-concepts of ability and enjoyment were expected (Pekrun, 2006; Pekrun & Perry, 2014; see also, Bandura, 1997; Zeidner, 1998). No specific hypothesis was set for boredom because theoretical assumptions and empirical results of its role have been inconsistent (e.g., Csikzentmihalyi et al., 2005; Pekrun, 2006; Pekrun et al., 2010).

The results showed that math self-concept of ability and enjoyment and anxiety were reciprocally related. More specifically, higher math self-concept of ability predicted higher enjoyment and higher enjoyment predicted higher self-concept in math. Lower self-concept of ability in math, in turn, predicted higher anxiety and higher anxiety predicted lower self-concept of ability in math. Higher math self-concept of ability also predicted lower math-related boredom but not vice versa. However, literacy self-concept of ability did not predict any of the achievement emotions and emotions did not predict literacy self-concept of ability. The results suggest that, in mathematics, enjoyment and anxiety act as sources as well as consequences of adolescents' self-concepts of ability, whereas higher self-concept of ability of math can also protect against boredom.

3.3 Study III

In Study III, the aim was (1) to examine to what extent teacher–student relationship quality (i.e., conflict and closeness) was related to math and literacy

achievement emotions (i.e., enjoyment, anxiety and boredom), and (2) to examine to what extent literacy and math self-concepts of ability were related to math and literacy achievement emotions (i.e., enjoyment, anxiety and boredom), and (3) to what extent these relations were moderated by student temperament (i.e., effortful control, negative affectivity, and surgency/extraversion). Closeness was expected to be positively related to enjoyment and negatively to boredom (cf. Frenzel et al., 2007; Goetz et al., 2006, 2013b; see also Lei et al., 2018), whereas conflict was expected to be related to higher boredom and anxiety (cf. Frenzel et al., 2007; Goetz et al., 2013b) and lower enjoyment of literacy and mathematics (cf. Goetz et al., 2013b). No specific hypotheses were set for the role of teacher–student closeness in anxiety because the related previous results have been contradictory (cf. Arbeau et al., 2010; Elmelid et al., 2015; Frenzel et al., 2007; Goetz et al., 2006, 2013b; see also Lei et al., 2018). No specific hypotheses were set for the role of temperament in the abovementioned relationship either due to a lack of research on the topic.

The results showed that in both math and literacy, self-concepts of ability were positively related to enjoyment and negatively to anxiety, whereas the self-concept of ability was negatively related to boredom but only in mathematics. Moreover, in both school subjects, teacher–student conflict was negatively related to enjoyment and positively related to anxiety and boredom, whereas teacher–student closeness was positively related to enjoyment and negatively related to boredom. Furthermore, the results illustrated that student temperament moderated some of the associations in the literacy domain. More specifically, a closer relationship with the teacher and a lower self-concept of ability in literacy were related to higher levels of anxiety, particularly among students who had lower effortful control. Lower levels of conflict in the teacher–student relationship were also related to higher levels of enjoyment in literacy, particularly among students who had lower levels of surgency/extraversion. In mathematics, domain-specific associations were not dependent on student temperament. Overall, these results suggest that not only individual factors (i.e., self-concept of ability) but also factors related to learning environment (i.e., teacher–student relationship quality) play a role in students' achievement emotions. However, particularly literacy enjoyment and anxiety were jointly dependent on the quality of teacher-student relationship and temperament of the student. The results also suggest that especially in terms of literacy-related anxiety, students' with weaker effortful control may benefit from higher self-concept of ability.

4 GENERAL DISCUSSION

The present study examined the antecedents of adolescents' math and literacy self-concepts of ability and achievement emotions. The first goal was to investigate how adolescents' domain-specific causal attributions impact their domain-specific self-concepts of ability, and vice versa (Study I). The second goal was to examine how adolescents' domain-specific achievement emotions are influenced by their domain-specific self-concepts of ability, and vice versa (Study II). The third goal was also to investigate the relationship between domain-specific self-concepts of ability and domain-specific achievement emotions but by expanding the focus by (1) examining the role of teacher–student relationship quality in students' emotions, and (2) how both of these relations were moderated by student temperament (Study III). Students' gender and math and literacy skills were controlled for in all studies and in Study III students' attainment value of math and literacy was also controlled for.

4.1 The dynamics between self-concepts of ability and causal attributions

The first aim of the dissertation (Study I) was to examine longitudinal cross-lagged relations between success- and failure-related causal attributions and self-concepts of ability separately in two subject domains (i.e., literacy and mathematics) among adolescents. First, as expected (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992) and in accordance with a previous longitudinal study (Kurtz-Costes & Schneider, 1994), the results in the domain of mathematics showed that the more positive the adolescents' math self-concepts of ability, the more they attributed successful outcomes in math to ability later on. Notable though is that literacy self-concept of ability did not predict ability attributions in success situations. Attributing successes to ability is generally considered adaptive because it can generate positive feelings and

enhance self-concept, and impact positively on achievement strivings (Schunk et al., 2014, Chapter 3, p. 91; Weiner, 1986, 2010; see also Graham, 2004).

Second, the results regarding failure situations in the math domain revealed, as expected (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992), that the higher the math self-concept of ability the more students attributed their subsequent failures to lack of guidance. The tendency to attribute successes internally and failures externally is typically called "self-serving attribution style" because it is assumed that taking credit for successes and not taking blame for failure can have beneficial effects on self-concept (Weiner, 1986, 1992). Although the tendency to internalize success and externalize failure can be considered self-protective or even enhancing (Weiner, 1986, 1992; see also Covington, 1984; Robins & John, 1997), and it has been associated with better mental health (Mezulis et al., 2004), it can also be detrimental in terms of future persistence and effort if students believe they cannot change their ability (fixed ability beliefs). More specifically, particularly in the face of failure, fixed ability beliefs have been shown to lead to goals and beliefs resulting in helpless reactions to failure and lower achievement (Dweck & Molden, 2017), and thus can impede motivation, learning and growth. However, contrary to expectations, higher math self-concept of ability also predicted less subsequent attributions of failure to task difficulty. It is possible that failing due to task difficulty can be linked to not having enough of ability, and thus high self-concept adolescents may avoid using this attribution for failing because it would be in conflict with their self-concept. Also notable that self-concept of ability in literacy was not related to external attributions in failure situations.

Third, in failure situations, as expected (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992) as well as in line with a previous longitudinal study (Dresel, 2001), the results showed that the lower students' self-concepts of ability in literacy and mathematics were, the more they attributed failures to lack of ability. Attributing failure to a lack of ability is considered particularly problematic because it can cause negative feelings and also damage one's self-concept (Weiner, 1986, 2010). Furthermore, blaming one's ability for failure can have a negative influence on future achievement motivation (Weiner, 1986, 2010; Higgins & LaPointe, 2012), particularly if ability is considered fixed instead of malleable (Dweck & Molden, 2017).

Fourth, in success situations it was found, as expected (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992) that the lower the adolescents' self-concepts of ability in both school subjects were, the more they attributed subsequent successes to task easiness. Moreover, in literacy, the lower the self-concept of ability, the more adolescents attributed their successes to getting enough guidance. Attributing successes to external factors can be seen as a maladaptive tendency (Chodkiewicz & Boyle, 2014; Graham & Taylor, 2016) that might affect persistence behaviors negatively (see also Bar-Tal, 1978; Stipek & Weisz, 1981). Therefore, these adolescents do not seem to use the opportunity of being successful to enhance their self-concept but instead seemed to think that they succeed due to getting help and if the task was easy enough. Furthermore,

when they fail, they assign the reason to their own lack of ability, perhaps verifying their self-concept.

Previous empirical results regarding the relations between effort attributions and self-concept of ability have been inconsistent (e.g., Kurtz-Costes & Schneider, 1994; Marsh, 1984; Marsh et al., 1984; Nicholls, 1979), and they have not always been consistent with theoretical assumptions regarding these relations (e.g., Covington, 1984; Swinton et al., 2010; see also Nicholls, 1979). Thus, no hypotheses were assumed for these relations. The results showed that self-concepts of ability did not predict effort attributions in success or failure situations in either of the school subjects. Effort attributions have been described as a double-edged sword in literature because trying hard can have a positive impact on academic outcomes while also being indicative of low ability (Covington, 1984). It is possible that adolescents' tendency to make effort attributions was driven more by their implicit theories of ability rather than by their self-concept of ability. Dweck et al. (e.g., Dweck et al., 1995; Molden & Dweck, 2006) have shown that incremental theorists, that is, students with a belief that ability is malleable instead of fixed, are more likely to make effort attributions than other students, particularly in failure situations. Conversely, entity theorists, that is, students with a belief that ability is fixed and reflects "aptitude" (Weiner, 2010), might be less likely to make effort attributions because they likely think that effort plays no role at all in their success or failure.

Contrary to expectations (Weiner, 1986), none of the attributions predicted subsequent self-concepts of ability in either of the school subjects. Based on Weiner's (1986) theory, it was hypothesized that attributing success to ability would have a positive effect on subsequent self-concepts of ability; whereas, attributing failure to ability would have a negative effect on self-concepts of ability. However, the results concerning the predictive role of attributions on subsequent self-concepts of ability revealed that attributions did not predict self-concepts of ability. In addition to attributions, other factors might play a role in the formation of self-concepts of ability, such as such as other people's perceptions of ability, school grades, external comparisons of abilities in relation to peers' abilities, and internal comparisons between ability areas or in the same school subject over time (Skaalvik & Skaalvik, 2002; see also Bong & Skaalvik, 2003).

In sum, in both school subjects, the present study showed that, low self-concepts of ability contributed to more frequent use of external attributions in success situations and more frequent use of lack of ability attributions in failure situations, reflecting a tendency to use maladaptive attributions consistent with low self-concepts. The results showed also that, consistent with their positive self-concept, higher self-concept, particularly in the math domain, contributed to a more self-serving attributional style (see also Marsh, 1986a; Mezulis et al., 2004; Weiner, 1992), that is, a tendency to attribute successes to ability and a tendency to attribute failures to external reasons. One possible explanation for the subject-specific findings is that, as a subject, mathematics elicits more self-threat, which makes adolescents more vulnerable to self-serving attributions (see also

Schwinger, 2013). One of the conditions creating self-threat in mathematics in lower secondary school could be uncertainty of success (see also Crocker & Park, 2003) due to learning new concepts that are not easily assimilated into previous knowledge, whereas literacy learning is a more gradual extension of previous knowledge (Dweck & Licht, 1980). In previous studies, students have also been found to perceive mathematics as a difficult subject and as a subject in which one either does or does not have ability (Stodolsky, 1985). Moreover, math is usually characterized as having tasks with either right or wrong answers, and students often tend to consider their mistakes as indicative of low ability (Boaler, 2013). Along with students' beliefs of their ability in math, teachers' and parents' possible mindsets of math ability as fixed is communicated to students, which might reinforce students' beliefs of math as a fixed talent (Dweck, 2008). High self-concept adolescents might also be more likely to receive feedback on their talent in mathematics, which may enforce their entity view in mathematics (maintaining smartness and avoiding looking incompetent; see also Boaler, 2013; Snyder et al., 2014).

4.2 The dynamics between self-concepts of ability and achievement emotions

The second aim of the dissertation (studies II and III) was to examine associations between self-concepts of ability and achievement emotions in literacy and mathematics. First, the longitudinal cross-lagged analysis showed, as expected (Pekrun, 2006; Pekrun & Perry, 2014), a positive reciprocal relationship between math self-concepts of ability and enjoyment. This result is in line with a longitudinal study (Pekrun et al., 2019) that showed that adolescents' higher math self-concept predicted higher enjoyment and with studies that have shown that positive mood leads to positive self-perceptions (for reviews, see Lyubomirsky et al., 2005; Sedikides, 1992). This result is also similar to Pinxten et al.'s (2014) study, which showed that enjoying math predicted students' math self-concept (see also Garn et al., 2019). However, these studies did not find a positive reciprocal relationship between enjoyment and self-concept of ability as was found in this study. Higher perception of one's abilities in math might provide information that one is able to complete the required tasks, which, in turn, elicits enjoyment toward learning (Pekrun & Perry, 2014). Enjoyment toward learning mathematics, in turn, may act as source for math self-concept evaluation by interpretation of positive math-related emotions as an indication of one's math self-concept of ability (Clore & Storbeck, 2006; Schwarz 2012; see also Bandura, 1997). Alternatively, it is also possible that positive emotions toward math learning may make positive mood-congruent events and math-related memories more accessible from memory, resulting in positive judgments of self-concept of ability (Bower, 1981; see also Bandura, 1997; Pekrun, Frenzel et al., 2007). To preserve their consistent self-views, adolescents with higher self-

concepts of ability in math might also strive to maintain their positive learning emotions toward math while adolescents with lower self-concepts of ability might be less likely to do so (see also Gomez-Baya et al., 2018; Wood et al., 2003). Thus, enabling adolescents to use positive emotions and memories as a resource to verify or even enhance their self-concept (Kwang & Swann, 2010; Swann & Buhrmester, 2012). Another possibility is that positive emotions may broaden adolescents' momentary thought-action repertoires by triggering novel ideas and creative thinking and by urging them to explore and be open to learning new information. This can lead to actions for building personal resources, such as self-concept of ability, which in turn can increase positive emotions (Fredrickson, 2001).

Second, a negative reciprocal relationship between math self-concept and anxiety was found in this dissertation, as was expected (Pekrun, 2006; Bandura, 2007; Zeidner, 1998), indicating a negative cycle between anxiety and self-concept of ability. These results resemble previous studies that have shown that people are prone to make negative judgments of themselves when in a negative mood (for a review, see Sedikides, 1992; see also Usher & Pajares, 2008). The results are also in line with the findings of Pekrun et al. (2019) and Meece et al. (1990), showing that adolescents' higher math self-concept of ability predicted lower anxiety related to math studying. Similarly, the results are consistent with the cross-lagged longitudinal studies by Ahmed et al. (2012) and Zhang (2020), who showed that higher anxiety predicted lower self-concept and lower self-concept predicted higher anxiety in mathematics. Lower self-concept of ability is likely to inform that one is not able to handle the task demands triggering anxiety (Bandura, 1997; Csikszentmihalyi et al., 2005), particularly if the activity is also considered important (Pekrun & Perry, 2014). Therefore, anxiety can be interpreted as an indication of low ability or anxiety can also trigger past failures and negative memories from memory, thus lowering self-concept (Bower, 1981; Clore & Storbeck, 2006; Schwarz, 2012; see also Bandura, 1997; Pekrun, Frenzel et al., 2007). Furthermore, it is also possible that adolescents with lower self-concepts of ability in math are less likely than adolescents with higher self-concepts of ability to lift their negative feelings toward math (see also Heimpel et al., 2002), thus enabling them to verify their math self-concepts of ability (Kwang & Swann, 2010; Swann & Buhrmester, 2012). Adolescents with lower perception of one's ability, in turn, can show a tendency to have attentional bias, causing them to interpret benign situations as threatening and leading to an increase in math anxiety, which in turn may feed maladaptive coping behavior and cognition related to math and further elaborating and maintaining a negative self-concept of ability in math (Bandura, 1997; see also Zeidner & Matthews, 2005). Overall, these results suggest that adolescents with lower self-concepts of ability may have difficulties restoring a more positive sense of self, whereas adolescents with higher self-concepts may be more likely to do so (see also Gomez-Baya et al., 2018; Heimpel et al., 2002; Wood et al., 2003).

Third, in contrast to the reciprocal expectations concerning self-concept and enjoyment and anxiety, the results showed that lower self-concepts of ability

predicted higher boredom in mathematics but not vice versa. Due to the inconsistent previous findings and theoretical assumptions (e.g., Csikzentmihalyi et al., 2005; Pekrun, 2006; Pekrun et al., 2010), no hypotheses were set concerning boredom and self-concept of ability. This finding is in line with previous cross-sectional studies (e.g., Goetz et al., 2010; Peixoto et al., 2017) that have shown that boredom is related to low self-concept instead of high self-concept and a longitudinal study which showed that academic control (equivalent to self-concept of ability) was negatively related to subsequent course-related boredom (Pekrun et al., 2010). If students with low self-concepts of ability feel they do not have the ability to cope with math tasks, they may start to devalue the subject. Therefore, the combination of low value and low control instigate boredom (Pekrun, 2006). Having low self-concept can create a situation where ability and task demands don't match optimally (creating feelings of overchallenge) (see also Krannich et al., 2019) and reporting boredom in overchallenging situations may act as a way to protect their self-worth, as students can thus avoid attributing the difficulty they have with the task to their ability (Acee et al., 2010; see also Covington, 1984). However, some theoretical assumptions link boredom to higher ability level (Csikzentmihalyi 2005) and there is also some evidence that gifted or high ability students can feel underchallenged and thus be bored (Krannich et al., 2019; Preckel et al., 2010; see also Daschman et al., 2011). It is possible that in this study adolescents with higher self-concepts of ability experienced less boredom due to having an optimal level of challenge and a higher value of math. Although reciprocal linkages are suggested by control value theory, in this study boredom was not related to subsequent self-concept of ability. Previous research has shown that boredom is related to low motivation and effort and poor study strategies (Pekrun et al., 2010; see also Tze et al., 2016). Bored students distance themselves from the learning activities and from the chance to evaluate their abilities in action. These explanations, however, are speculative in nature since, to my knowledge, this study was the first to investigate cross-lagged relationships between boredom and self-concept of ability. Future studies are needed to examine more detailed dynamics between self-concept of ability, task demands, and value when predicting boredom.

In sum, these results suggest that, particularly in math, self-concept of ability and enjoyment of math can create a positive cycle whereas self-concept of ability and math-related anxiety can lead to a negative cycle and higher self-concept of ability of math can also protect against feeling bored. It is noteworthy that, contrary to expectations (Pekrun, 2006; Pekrun & Perry, 2014; see also Bandura, 1997; Zeidner, 1998), in literacy self-concept of ability did not predict any of the achievement emotions and emotions did not predict literacy self-concept of ability. Although cross-sectional relations were examined between these constructs in Study III and the results showed that in both school subjects, higher self-concepts were related to higher enjoyment and lower anxiety. Also, higher self-concept was related to a lower level of boredom, although in mathematics only. However, as some other studies (Goetz et al., 2010; Zhang,

2020) have also shown, the results of Study II and Study III suggest generally stronger associations between math self-concept of ability and achievement emotions compared to literacy. Goetz et al. (2010) have suggested that the stronger relationships in mathematics may be because mathematics typically has a narrower range of classroom activities than literacy does, and therefore has limited sources for emotions and self-concepts construction. Another possible explanation for the divergent results in mathematics and literacy is that individual differences in math increase across time (Aunola et al., 2004) and are wider than in reading (e.g., Leppänen et al., 2004; Parrila et al., 2005). Therefore, there may be more room in math than there is in literacy for influences of motivational factors. However, as far as I know the present study was the first to investigate the developmental dynamics between multiple achievement emotions and self-concept of ability in two domains using a cross-lagged longitudinal procedure.

4.3 Associations between teacher–student relationship quality and achievement emotions

The third aim of the dissertation (Study III) was to investigate to what extent the teacher–student relationship is related to students' achievement emotions (i.e., enjoyment, anxiety and boredom) in mathematics and literacy. According to the expectations and in line with previous studies of quality of instruction, teacher behaviors, expectations, and support (e.g., Frenzel et al., 2007; Goetz et al., 2006, 2013b; Lei et al., 2018), the results showed that higher levels of closeness in the teacher–student relationship as evaluated by the student were related to higher levels of enjoyment and lower levels of boredom in both school domains. This result is also in accordance with a recent study that showed reciprocal positive relations between closeness and positive emotions and negative reciprocal relations between closeness and negative emotions (Goetz et al., 2021). Also, as expected and in line with previous research (cf. Frenzel et al., 2007; Goetz et al., 2013b), higher levels of conflict in the teacher–student relationship in both school subjects were, in turn, related to lower levels of enjoyment and higher levels of boredom and anxiety. Overall, these results are in accordance with the control-value theory of achievement emotions since learning environment is seen to have an impact on achievement emotions (Pekrun, 2006). A close relationship with a teacher is likely to contribute to fulfilling a student's basic needs, which can further boost positive emotions and decrease negative emotions toward learning, whereas a more conflictual relationship with a teacher is unlikely to fulfill the student's needs and, thus, be related to more negative and less positive emotions (Meyer, 2014; Sakiz et al., 2012; Skinner et al., 2014). Teacher–student relationship closeness may also help to adjust teaching quality, behaviors, and expectations to individual needs of the students, which can further impact positively on valuing the subject and feelings of competence which can further affect

achievement emotions (see also Aldrup et al., 2020). In sum, these results suggests that in both school subjects a positive teacher–student relationship was related to more enjoyment and less boredom, whereas a more negative teacher–student relationship was related to less enjoyment and more boredom and anxiety towards these school subjects.

Regarding the relations between teacher–student closeness and anxiety, no specific hypotheses were set due to the previous inconsistent findings (cf. Arbeau et al., 2010; Elmelid et al., 2015; Frenzel et al., 2007; Goetz et al., 2006, 2013b; see also Lei et al., 2018). In the present study, somewhat surprisingly, closeness in the teacher–student relationship was related to slightly heightened anxiety in literacy and was not significantly related to anxiety in mathematics. This result does not support previous studies showing that closeness with the teacher, higher quality teaching or teacher support is related to less anxiety (e.g., Arbeau et al., 2010; Frenzel et al., 2007; see also Lei et al., 2018). However, these results are in line with previous studies that have found that positive instructional practices do not necessarily reduce students' anxiety towards learning (see Becker et al., 2014; Goetz et al., 2013b; see also Elmelid et al., 2015). A close relationship may convey higher value than control to students, thus increasing anxiety or both high control and value, and thus lead to non-significant relations between closeness and anxiety (see also Goetz et al., 2013b). Overall, the results indicate that students' anxiety levels were more strongly influenced by conflict than closeness in the teacher–student relationship, supporting previous research that has shown that negative interactions with teachers may matter more than positive interactions regarding student outcomes (e.g., Jellesma et al., 2015).

4.4 The moderating role of student temperament

The fourth aim of the dissertation (Study III) was to find out whether temperament moderates the associations between self-concepts of ability and achievement emotions and between teacher–student relationship quality and achievement emotions. As far as I know, this research was among the first to investigate these moderation effects, and thus no hypotheses were set for the moderation effects. First, the results showed that for adolescents with weaker temperamental effortful control, a lower self-concept of literacy ability was related to higher levels of anxiety toward literacy learning. A similar effect was not observed among adolescents with higher levels of effortful control. Thus, adolescents with lower effortful control were particularly vulnerable to experience anxiety toward literacy when they also had lower self-concept of ability, while they particularly benefitted from having a higher self-concept of ability. This results suggest that having a higher self-concept of ability can buffer against learning related anxiety which supports assumption of control value-theory (Pekrun & Perry, 2014). However, novel to this finding is that the effect was pronounced only for students with lower effortful control, suggesting that for adolescents who have weaker effortful control, self-concepts might work as a

source of emotion regulation. Therefore, such adolescents may particularly benefit from shaping their self-appraisals in a more positive direction.

Second, according to the results, higher levels of conflict in the teacher–student relationship were particularly detrimental for literacy enjoyment among adolescents with lower surgency (characterized by shyness and low sensation-seeking) as such that they had lower levels of enjoyment toward literacy if they also had a highly conflictual relationship with their teacher. Thus, lower levels of conflict in the teacher–student relationship seemed to protect them against diminished feelings of enjoyment toward literacy. A similar effect was not observed among adolescents with higher surgency (characterized by low shyness and high sensation-seeking). This result is in line with the goodness-of-fit model (Thomas & Chess, 1977) as it shows that classroom factors are related to achievement emotions not solely in isolation but also in conjunction with temperament. The results are also in line with the findings for other student outcomes in other age groups. For example, Essex et al. (2011) showed that teacher–student relationship conflict in the first grade was related to heightened levels of mental health problems by the seventh grade, particularly among inhibited children (see also diathesis stress and differential susceptibility models; Belsky and Pluess 2009). A study by Arbeau et al. (2010) also showed that having a poorer relationship (less close) with the teacher among shyer students made them more vulnerable to higher school avoidance, anxiety, and social withdrawal, whereas a better relationship with the teacher buffered against these effects, a finding which resembles these results. One explanation for the finding that adolescents with lower levels of surgency enjoyed literacy learning more when there were lower levels of conflict in the teacher–student relationship is their temperamental tendency to become overstimulated more easily than adolescents with higher surgency (Rothbart & Hwang, 2005). Therefore, they may prefer low-intensity activities and environments, and they may also be more sensitive to the detrimental effects of conflict than less shy people, thus allowing more enjoyment of the school subject when the relationship with the teacher is less conflictual. Shy and inhibited students have been found to have more difficulties in engaging in peer relationships (for a review, see Coplan & Bullock, 2012), have poorer relationship with teachers (Arbeau et al., 2010; Rudasill & Rimm-Kaufman, 2009), to like school less (Valiente et al., 2012), and to have more internalized symptoms (for a review, see Klein et al., 2012). Thus, shyness may be a vulnerability factor for social and emotional problems, and problems in the teacher–student relationship may pose the additional risk of diminishing their enjoyment of learning for these students (see also Belsky & Pluess, 2009).

Third, the results showed that among adolescents with weaker effortful control, a closer relationship with the teacher was related to higher levels of anxiety toward literacy. Although some previous studies concerning some other student outcomes, such as problem behavior (Wang et al., 2013) and academic achievement (Rudasill et al., 2010), have shown that children and adolescents with low levels of effortful control may particularly benefit from a positive teacher–student relationship, this finding indicates that higher levels of closeness

with the teacher elevated anxiety toward literacy among adolescents with lower levels of effortful control. It is noteworthy, however, that a similar effect was not found among adolescents with higher levels of effortful control. This finding does somewhat resemble a previous study that showed that higher instructional support was related to higher conflict among students with lower effortful control (Rudasill, Callagher et al., 2016; see also Dominguez et al., 2011). One possible explanation for this finding is that a close relationship with the teacher may highlight the value of the topic for the student (see Pekrun, 2006). Due to this, adolescents with weaker effortful control who typically have difficulties in regulating their behavior and emotions, in particular, might have exhibited elevated anxiety when they had a closer relationship with their teacher.

The results showed further that in mathematics none of the interaction effects were significant, suggesting that the associations between the self-concept of math ability and achievement emotions and associations between teacher–student relationship quality and achievement emotions were not dependent on adolescents' temperament. Previous research has shown that, in math development, individual differences increase over time, thus showing a cumulative developmental pattern (Aunola et al., 2004). Reading development typically shows the opposite pattern, particularly in later grade levels; that is, individual differences decrease rather than increase over time, showing a compensatory trajectory (e.g., Leppänen et al., 2004; see also Parrila et al., 2005). One possible explanation for these results in mathematics is that whereas individual differences in math are wider than in reading, there may be more room in math for a stronger influence of motivational and environmental factors that apply to all adolescents regardless of their temperament. Overall, these results suggest that not only individual (i.e., self-concept of ability) and social factors (i.e., teacher–student relationship quality) play a role in students' achievement emotions but also student temperament.

4.5 Strengths, limitations and future directions

In studies I and II, the major strength was the longitudinal cross-lagged study design and the investigation of bidirectional relationships, which previous studies have rarely investigated. The findings of Study I extended previous knowledge about the longitudinal cross-lagged relationships between causal attributions and self-concepts of ability. Similarly, Study II broadened the knowledge of the reciprocal dynamics between self-concepts of ability and achievement emotions. In Study III, the major advantage was that it extended the work of previous studies on the antecedents of achievement emotions by illustrating the importance of both individual (i.e., temperament and self-concept of ability) and distal factors (i.e., teacher–student relationship quality) in the emergence of achievement emotions. This study contributed to the previous research of the role of teachers in student adjustment and academic performance by demonstrating that teacher–student relationship quality also plays a role in

students' achievement emotions. Furthermore, Study III extended previous knowledge by showing that temperamental characteristics can moderate the relationship, on the one hand, between ability beliefs and emotions and, on the other hand, between teacher–student relationship quality and emotions. An additional benefit of these studies is that these variables were examined in two important school subjects, and by doing so it was possible to illuminate differences and similarities in the domains of literacy and math.

Nevertheless, this dissertation is not without limitations. First, although the effects of student gender and academic skills were controlled for in all of the studies, the study relied mostly on self-reports related to the measurement of the key concepts. Thus, the associations might be partly affected by common method bias and social desirability. However, measuring students' perceptions of their self-concepts of ability, causal attributions, achievement emotions, and teacher–student relationship quality with self-report measures can be considered a valid measurement (see also Aldrup et al., 2020; Marsh et al., 2016). Understanding of achievement emotions could be further achieved by examining facial expressions or physiological responses in learning and achievement situations (see also Lehikoinen et al., 2019; Pekrun, 2006). Achievement emotions were also examined as trait-like emotions (i.e., relatively constant emotions toward literacy or mathematics). However, it is likely that there is a state-like within-person variability in achievement emotions in different situations and over time (Pekrun, 2006; see also Goetz et al., 2014). More research is needed to better understand both state and trait aspects of achievement emotions and related dynamics. In addition, this study examined only three achievement emotions, so future studies should expand to include other emotions as well. Completing students' assessments of teacher–student relationship quality with, for example, observer ratings could be beneficial in future studies as it is possible that students' ratings might have been biased by how much they liked the school subject. Moreover, researchers have raised concerns about measuring attributions with hypothetical situations because they might not accurately measure students' attributional tendencies in real-life situations. Future research could thus develop tools that would have more ecological validity (Hirchy & Morris, 2002; Wolters et al., 2013).

Second, the present study examined only adolescents (grades 6–9) and in a particular cultural and social environment. Because the sample included only Finnish students, the results should be carefully interpreted to represent other cultures. For example, previous studies have found cultural differences such that Western cultures (e.g., the U.S.) manifest more self-serving attributions than Asian cultures (e.g., Japan; Mezulis et al., 2004), and many Asian countries place more emphasis on effort as a means of improving ability (Hau & Salili, 1996; Salili, 1996). Further regarding the results of Study II and III, although control-value theory suggests the structure of relations between emotions and antecedents to be universal, different cultural contexts may affect the strengths between these associations (see also Pekrun, 2006).

Third, although the findings concerning the stability of the attributions over time were approximately consistent with the limited body of previous studies on

the topic (e.g., Cole et al., 2008; Dresel, 2001; Morris & Tiggeman, 1999), the stabilities of some of the attributions from grades 7 to 9 were relatively low, which may have affected the finding that self-concepts of ability predicted attributions and not vice versa. Self-concepts of ability tend to become more stable with increasing age (Cole et al., 2001; see also Wigfield et al., 1997). Thus, in Study I the age of the students in the present might have affected the findings and, consequently, the generalizability of the findings in other age groups. Studies II and III investigated the self-concepts of ability as well as enjoyment, anxiety, and boredom in literacy and mathematics of students in grades 6 and 7. It is possible that the relations found could be different in different age groups and in different subject domains (Goetz et al., 2010), meaning one should be cautious about generalizing the results beyond the population used in this study. Moreover, teacher–student relationship quality and its meaning may vary depending on students' age. Future studies should investigate longitudinally the development of achievement emotions in relation to teacher–student relationship quality and whether there are times when its impact is particularly powerful in the development of emotions (see also Aldrup et al., 2020). In addition, this study examined only the effects of the teacher–student relationship on emotions and did not include the possible impact on emotions from other social relationships, such as peers and parents (see Ahmed et al., 2010) or other facets of the learning environment which could have acted as unmeasured variables, and thus affected the results. Future studies should also investigate longitudinal associations between other individual antecedents (e.g., attainment value) and achievement emotions or interaction effects of individual antecedents (e.g., self-concept X attainment values) on emotions and their reciprocal linkages as suggested by the control-value theory of achievement emotions (see Pekrun & Perry, 2014). A longitudinal research design would also allow the testing of mediating mechanisms, between distal and individual antecedents of achievement emotions and how these are further related to different outcomes, such as students' achievement and engagement in school over time (see Ahmed et al., 2013; Aldrup et al., 2020).

Fourth, despite the cross-lagged longitudinal design in studies I and II and the inclusion of a meaningful set of control variables, studies I to III were correlational and causality cannot be implied. Finally, it is notable that in this study the developmental associations between self-concepts of ability and emotions were investigated separately in mathematics and literacy domains. Although these findings expand previous knowledge about the differences between math and literacy domains in these relations, in future studies it would be important to also study spillover effects of self-concepts of ability and emotions between different achievement domains and relate these dynamics to adolescents' achievement. The internal/external frame of reference model of self-concept (I/E model; Marsh, 1986b; Marsh et al., 2015) proposes that in addition to social comparisons in regards to achievement, self-concepts are also influenced by internal comparisons, where individuals compare their own relative achievement and abilities between different academic subjects. It would be an

intriguing challenge for further research to include achievement emotions in different domains in the same model to investigate the assumptions of the I/E model.

4.6 Practical implications

First, the findings of the current study suggest that promoting positive self-concept during adolescence enhances the use of more self-serving attributions in mathematics (i.e., tendencies to attribute successes to high abilities and failures to external factors) and lessens the use of maladaptive attributions in both school subjects (i.e., tendencies to attribute successes to external factors and failures to lack of ability). Self-serving attributional bias can help with the coping of negative affects related to attributing failures internally (Weiner, 1986). However, although maintaining self-concept, attributing failure to external, stable, and uncontrollable factors can also induce a feeling of hopelessness, which might influence engagement and persistence (Weiner, 1986; see also Stipek & Weisz, 1981). This type of reaction to failure can also hinder a realistic internalizing of feedback and the proper consideration of weaknesses, which can be detrimental for further learning (Crocker & Park, 2003). Achievement might be particularly undermined if external attributions become a priori excuses (i.e., self-handicapping).

Attribution retraining studies have shown that attributing successes to ability and/or effort and failures to personally controllable factors is beneficial in terms of self-concept of ability, engagement, and performance (e.g., Chodkiewicz & Boyle, 2014; O'Mara et al., 2006; Weiner, 1986). Similarly, previous studies have shown that incremental vs. entity beliefs about ability (i.e., beliefs about ability as malleable vs. fixed) are related to adaptive attributions, achievement, and self-concept development (for a review, see Molden & Dweck, 2006). Attributions and ability beliefs are communicated by parents and teachers through praise and feedback (Dweck, 2008; Henderlong & Lepper, 2002). In accordance with attribution retraining studies and studies of implicit theories, providing process feedback (e.g., praising effort and task-appropriate strategies), and supporting beliefs of ability as malleable rather than fixed can be beneficial for students' self-concept of ability and achievement (see also Mueller & Dweck, 1998; O'Mara et al., 2006). Above all, teachers could provide opportunities for discussions of students' self-concepts and attributions. These conversations could be used as an opportunity to become aware of and pursue change in maladaptive thinking to become more adaptive in ways of reasoning why a student failed or succeeded and also to see positive sides of one's self (see also Linnenbrink & Pintrich, 2002).

Second, the findings of the current study suggest that achievement emotions and self-concepts of ability are developmentally related in a reciprocal manner at least in mathematics. Previous research has shown that low levels of self-concept of ability can impede learning motivation and achievement (e.g., Valentine et al., 2004), while there is also evidence that enhancing skills and

attribution re-training can promote self-concept of ability (e.g., O'Mara et al., 2006). The findings of the current study added to the literature by showing that math self-concept of ability could also be supported by increasing math enjoyment and reducing math anxiety. Maintenance of enjoyment is vital as a sustaining force in learning activities and has been shown to be positively related to achievement and motivation (for reviews, see Pekrun, 2017a, 2017b). Math anxiety can, in turn, have negative impacts on performance and have long-term educational implications by leading to avoidance of math, thus affecting math skills negatively and decreasing enrollment in advanced math classes and further affecting future career paths (Ashcraft, 2002; Ashcraft & Ridley, 2005; Hembree, 1990). Furthermore, boredom can distract from learning activities, and have deteriorating effects on learning and motivation (for reviews, see Pekrun, 2017a, 2017b). One way to reduce boredom and anxiety and to increase enjoyment of math as suggested by the findings of this research is to boost self-concept of ability in math. Other ways to reduce boredom and anxiety have been suggested, such as methods for coping with boredom (Nett et al., 2010) and cognitive-behavioral treatment of anxiety (Hembree, 1990; see also Zeidner, 2014). It is also important to create classroom environments and practices that can reduce math anxiety and boredom and increase enjoyment and self-concepts (see Finlayson, 2014; Geist, 2010; Goetz & Hall, 2014). Teachers should also have the skills to recognize achievement emotions to help in alleviating negative emotions and enhancing positive emotions. It is also notable, that regarding the importance of good self-concept of ability, the current findings suggest that students with lower levels of effortful control may particularly benefit from supporting their self-concept of ability in order to have lower levels of anxiety when learning literacy.

Finally, the findings suggest that a positive relationship with the teacher may be beneficial for students' achievement emotions, whereas a more negative relationship with the teacher may be detrimental for students' achievement emotions. This information is important for educators simply because teachers' awareness of the associations of the quality of teacher–student relationships with students' achievement emotions may improve the quality of these relationships. Teacher–student relationship quality can also be enhanced by teaching social-emotional skills to teachers and teachers can strengthen their relationship with students, for example, by organizing one-to-one time with a student or by creating informal meetings with students. A positive relationship with adolescents has the potential to inform teachers about students' needs and, in turn, to enable adolescents to cope constructively with tasks, thus further enhancing their motivation and engagement (Skinner et al., 2014). For example, a close and positive relationship with the teacher is likely to enhance teachers' opportunities to support good self-concepts of ability and adaptive attributions and students are likely to be more responsive to teachers' efforts to do so. The findings also suggest that students with lower levels of surgency may especially benefit from a less conflictual teacher–student relationship in terms of enjoying literacy learning. The findings also suggest that higher levels of closeness with the teacher, particularly among students with lower levels of effortful control,

seemed to correspond to having higher anxiety towards literacy. However, it is notable that anxiety is not always detrimental regarding learning motivation and achievement. The effects of anxiety on performance depend on other factors as well, such as level of self-concept of ability, task characteristics (easy vs. difficult task) and interpretation of anxious arousal as a challenge vs. a sign of failure (Zeidner, 2014). Overall, knowledge of students' temperament may provide teachers with further information on how to best meet the students' needs and support their learning and motivation. In sum, regarding the practical implications of the current study, learning motivation and achievement could be enhanced on an individual level by enhancing positive emotions, reducing negative emotions, and promoting self-concepts of ability. On an interpersonal level, it could be supported by constructing positive relationships between teacher and student.

4.7 Concluding remarks

This study focused on adolescents' developmental interrelations between self-concepts of ability and causal attributions and self-concepts and achievement emotions, as well as other factors related to achievement emotions (i.e., teacher–student relationship quality, student temperament) in literacy and math. The results showed, first, that lower self-concepts of ability in both school subjects contributed to more frequent use of external attributions in success situations and more frequent use of lack of ability attributions in failure situations. The results showed further that higher self-concept, particularly in the math domain, contributed to a tendency to attribute successes to ability and a tendency to attribute failures to external reasons. Thus, these results suggest that adolescents' causal attributions related to math and literacy failures and successes are self-consistent. That is, lower self-concept of ability can promote the use of maladaptive attributions, and higher self-concept of ability, particularly in math, can foster self-enhancing and self-protecting attributions.

Second, the results showed that math self-concept of ability was reciprocally related to enjoyment and anxiety. Math self-concept of ability also predicted boredom but not vice versa. This suggests that, particularly in math, self-concept of ability and enjoyment of math can create a positive cycle whereas self-concept of ability and math-related anxiety can lead to a negative cycle and higher self-concept of ability of math can also protect against boredom.

Third, the results showed that not only self-concept of ability but also teacher–student relationship quality played a role in students' achievement emotions. Furthermore, the results illustrated that student temperament moderated some of the associations in the literacy domain. The results suggest that, in particular, students with less effortful control may benefit from a higher self-concept of ability in terms of having less literacy anxiety, whereas a closer relationship with the teacher may increase their anxiety toward literacy learning. Additionally, the results suggest that students with less surgency may be

particularly vulnerable to conflictual relationships with the teacher, resulting in less literacy enjoyment, and would benefit from a less conflictual relationship that promotes enjoyment of learning.

YHTEENVETO (SUMMARY)

Nuorten matematiikan ja äidinkielen oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden taustalla vaikuttavat tekijät

Tässä tutkimuksessa tarkasteltiin nuorten oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden taustalla vaikuttavia tekijöitä matematiikan ja äidinkielen oppiaineissa. Ensimmäinen tavoite oli tutkia millä tavoin epäonnistumisiin ja onnistumisiin liittyvät kausaaliattribuutiot ennustavat oppimisminäkäsityksiä ja millä tavoin oppimisminäkäsitykset ennustavat kausaaliattribuutioita. Toinen tavoite oli tutkia millä tavoin oppimisminäkäsitykset ennustavat oppimisen iloa, ahdistusta ja tylsyyttä ja millä tavoin nämä tunteet ennustavat oppimisminäkäsityksiä. Kolmas tavoite oli tarkastella opettaja-oppilassuhteen läheisyyden ja konfliktin ja oppimisminäkäsitysten yhteyksiä oppimiseen liittyviin tunteisiin sekä millä tavoin nuoren temperamentti muuntaa näitä yhteyksiä. Teoreettisesti oppimisminäkäsityksen oletetaan olevan yhteydessä sekä epäonnistumisiin ja onnistumisiin liittyviin syyselityksiin (kausaaliattribuutioihin) että oppimiseen liittyviin tunteisiin. Suurin osa aiemmista tutkimuksista on kuitenkin ollut poikittaistutkimuksia, joissa tutkittavien tekijöiden välinen kehityksellinen dynamiikka on jäänyt selvittämättä. Oppimisminäkäsityksen lisäksi oppimiseen liittyviin tunteisiin ajatellaan vaikuttavan oppimisympäristöön liittyvät tekijät sekä oppilaan temperamentti. Oppimisympäristöön liittyvien tekijöiden yhteyttä oppimiseen liittyviin tunteisiin on kuitenkin aiemmin tutkittu lähinnä opetukseen liittyvien tekijöiden näkökulmasta eikä niinkään opettajan ja oppilaan välisen suhteen näkökulmasta. Lisäksi oppilaan temperamentin vaikutuksesta oppimiseen liittyviin tunteisiin on vain vähän tietoa. Aiempi tieto on puutteellista etenkin siltä osin, miten temperamentti ja opettaja-oppilassuhde yhdessä vaikuttavat oppimiseen liittyviin tunteisiin sekä miten oppimisminäkäsitys yhdessä temperamentin kanssa on yhteydessä oppimiseen liittyviin tunteisiin. Oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden taustalla vaikuttavien tekijöiden tutkimus on tärkeää, sillä sekä oppimisminäkäsitys että tunteet vaikuttavat muun muassa oppimiseen, motivaatioon ja sinnikkyyteen tehtävätilanteissa ja niillä on havaittu olevan yhteys myös oppilaiden kurssi- ja uravalintoihin/koulutuspolkuihin. Selvittämällä näitä taustatekijöitä voidaan siis saada tietoa, miten tukea oppilaiden osaamista ja suotuisia kehityspolkuja.

Väitöstutkimuksessa käytettiin kahta aineistoa: 237 lapsen aineistoa (*Jyväskylä Entrance into Primary School*), josta analysoitiin yläkouluaikaan sijoittuvia mittapisteitä (Osatutkimus I). Lisäksi osatutkimuksissa II ja III käytettiin noin 850 nuoren aineistoa (*Stairway Study),* jossa seurattiin nuoria alakoulusta yläkouluun. Ensimmäisessä osatutkimuksessa nuoret täyttivät kyselyt matematiikan ja äidinkielen oppimisminäkäsityksistä ja kausaaliattribuutioista seitsemännellä ja yhdeksännellä luokalla. Toisessa osatutkimuksessa nuoret täyttivät kyselyt matematiikan ja äidinkielen oppimisminäkäsityksistä ja oppimiseen liittyvistä tunteista 6. luokan syksyllä ja

keväällä ja 7. luokan syksyllä ja keväällä. Kolmannessa osatutkimuksessa nuoret täyttivät kyselyt 6. luokalla matematiikan ja äidinkielen oppimiseen liittyvistä tunteista, opettaja-oppilassuhteen laadusta, matematiikan ja äidinkielen oppimisminäkäsityksistä ja nuorten vanhemmat täyttivät kyselyn nuorten temperamentista. Kaikissa osatutkimuksissa kontrolloitiin sukupuolen ja taitojen vaikutus.

Ensimmäisessä osatutkimuksessa tavoitteena oli tarkastella millä tavoin oppimisminäkäsitykset ennustivat matematiikan ja äidinkielen epäonnistumisiin ja onnistumisiin liittyviä kausaaliattribuutioita (kyky, yritys, tehtävän vaikeus, opettajan ohjaus) sekä millä tavoin kausaaliattribuutiot puolestaan ennustivat oppimisminäkäsityksiä. Tulokset osoittivat, että nuorten oppimisminäkäsitykset ennustivat molemmissa oppiaineissa kausaaliattribuutioita. Kausaaliattribuutiot eivät sen sijaan ennustaneet oppimisminäkäsityksiä. Etenkin parempi matematiikan oppimisminäkäsitys ennusti minää tukevien attribuutioiden käyttöä (onnistumisten liittämistä sisäisiin tekijöihin sekä epäonnistumisten liittämistä ulkoisiin tekijöihin). Molemmissa oppiaineissa puolestaan heikompi oppimisminäkäsitys ennusti ei-adaptiivisten attribuutioiden käyttöä (epäonnistumisten liittämistä omasta kyvyttömyydestä johtuvaksi sekä onnistumisten liittämistä ulkoisiin tekijöihin).

Toisen osatutkimuksen tavoitteena oli tutkia millä tavoin oppimisminäkäsitykset ennustivat nuorten oppimiseen liittyviä tunteita sekä millä tavoin oppimiseen liittyvät tunteet ennustivat nuorten oppimisminäkäsityksiä. Tulokset osoittivat, että parempi matematiikan oppimisminäkäsitys ennusti runsaampaa oppimiseen liittyvää iloa matematiikassa ja tämä puolestaan ennusti edelleen parempaa matematiikan oppimisminäkäsitystä. Heikompi matematiikan oppimisminäkäsitys puolestaan ennusti lisääntynyttä matematiikan oppimiseen liittyvää ahdistuksen tunnetta, joka puolestaan ennusti heikompaa matematiikan oppimisminäkäsitystä. Parempi matematiikan oppimisminäkäsitys lisäksi ennusti vähäisempää matematiikan oppimiseen liittyvää tylsyyden tunnetta, mutta ei toisinpäin. Äidinkielessä sen sijaan ei löytynyt ajan kuluessa ilmeneviä vastavuoroisia yhteyksiä oppimisminäkäsitysten ja oppimiseen liittyvien tunteiden väliltä.

Kolmannessa osatutkimuksessa tavoitteena oli tarkastella opettaja-oppilassuhteen ja oppimisminäkäsitysten yhteyksiä oppimiseen liittyviin tunteisiin sekä millä tavoin nuoren temperamentti muuntaa näitä yhteyksiä. Molemmissa oppiaineissa enemmän konfliktia sisältävä opettaja-oppilassuhde oli yhteydessä vähentyneeseen oppimisen iloon ja lisääntyneeseen tylsyyden ja ahdistuksen tunteeseen ja läheisempi suhde oli puolestaan yhteydessä lisääntyneeseen oppimisen iloon ja vähentyneeseen tylsyyden tunteeseen. Nuoren temperamentti muunsi joitakin opettaja-oppilassuhteen, oppimisminäkäsitysten sekä oppimiseen liittyvien tunteiden yhteyksiä äidinkielessä. Tulosten mukaan läheisempi opettaja-oppilassuhde ja heikompi minäkäsitys erityisesti niillä oppilailla, joilla oli alhaisempi tahdonalainen itsesäätely, oli yhteydessä korkeampaan ahdistuksen tunteeseen äidinkielessä. Lisäksi, erityisesti oppilailla, joilla oli vähemmän ulospäinsuuntautuneisuutta,

enemmän konfliktia sisältävä opettaja-oppilassuhde oli yhteydessä vähentyneeseen oppimisen iloon äidinkielessä.

Tutkimuksen tulokset osoittivat, että erityisesti matematiikassa oppimisminäkäsitystä voitaisiin tukea lisäämällä oppimisen iloa sekä vähentämällä ahdistuksen tunnetta. Tulosten mukaan parempi oppimisminäkäsitys vaikutti adaptiivisten attribuutioiden kehittymiseen, positiivisten tunteiden lisääntymiseen ja negatiivisten tunteiden vähentymiseen erityisesti matematiikassa. Tulokset osoittivat myös, että molemmissa oppiaineissa kehittämällä opettaja-oppilassuhdetta läheisemmäksi ja vähemmän konfliktia sisältäväksi oppimiseen liittyviä tunteita voitaisiin muokata oppimisen, motivaation ja oppimisminäkäsitysten kannalta suotuisimmiksi. Opettaja-oppilassuhteella ja oppimisminäkäsityksellä oli myös yhteisvaikutusta oppilaan temperamentin kanssa äidinkielen oppimiseen liittyviin tunteisiin. Tulokset siis antoivat viitteitä myös siitä, että ei pelkästään opettaja-oppilassuhde ja oppimisminäkäsitys, vaan myös oppilaan temperamentti on merkityksellinen oppimiseen liittyvien tunteiden synnyssä.

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ORIGINAL PAPERS

I

ADOLESCENTS' DOMAIN-SPECIFIC SELF-CONCEPTS OF ABILITY PREDICT THEIR DOMAIN-SPECIFIC CAUSAL ATTRIBUTIONS: A LONGITUDINAL STUDY

by

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Adolescents' Domain-Specific Self-Concepts of Ability Predict Their Domain-Specific Causal Attributions: A Longitudinal Study

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This study investigated longitudinal associations between mathematics- and literacy-related causal attributions and self-concepts of ability among Finnish adolescents (N = 237). Questionnaires were administered to adolescents in Grades 7 and 9 to obtain information on their causal attributions and self-concepts of ability. The results showed that adolescents attributed their successes and failures in a self-consistent way. Specifically, self-concepts of ability predicted subsequent causal attributions in both school subjects. In mathematics, a higher self-concept of ability contributed to more self-enhancing and self-protective attributions. However, in both school subjects, a lower self-concept of ability contributed to more maladaptive attributions.

Adolescence is characterized by changes in multiple life domains, including new social roles, development of cognitive skills, and biological changes. In particular, self-related issues start to play a more prominent role as adolescents become increasingly self-conscious and introspective, and they reshape their self-theories (e.g., Demo, 1992; Sebastian, Burnett, & Blakemore, 2008). At the same time, one of the main educational objectives

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in adolescence is to enhance students' self-concepts of ability (Preckel, Niepel, Schneider, & Brunner, 2013). Self-concepts of ability have been found to positively relate to adolescents' interest in school subjects (Marsh, Trautwein, Lűdtke, Köller, & Baumert, 2005), success in school (Chiu & Klassen, 2009, 2010; Valentine, Dubois, & Cooper, 2004), subsequent course selection (Durik, Vida, & Eccles, 2006; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006), level of educational attainment (Guay, Larose, & Boivin, 2004), and career aspirations (Durik et al., 2006).

One of the strategies to maintain or enhance self-concepts of ability during adolescence is the way individuals interpret reasons for their perceived successes and failures (i.e., causal attributions; e.g., Weiner, 1986, 1992). Causal attributions are important because, similar to self-concepts of ability, they have been found to be related to adolescents' school achievement and motivation (Graham, 2004; Liu, Cheng, Chen, & Wu, 2009; Vispoel & Austin, 1995; Wolters, Fan, & Daugherty, 2013). It has therefore been suggested that certain kinds of attributions are more adaptive and have a positive impact on self-concept, persistence, and achievement, whereas others are thought to be maladaptive (e.g., Chodkiewicz & Boyle, 2014; Weiner, 1986). Individuals might also interpret their failures and successes in accordance with their self-concept of ability (e.g., Möller & Köller, 2000; Swann & Read, 1981). However, the major limitation of earlier research on causal attributions and self-concepts of ability is that it has typically used cross-sectional data, and, thus, little is known about the direction of the associations between self-concepts of ability and causal attributions. Moreover, previous studies have mostly focused on children, and less is known about these associations among adolescents.

Understanding the direction of the associations between causal attributions and self-concepts of ability is important because it will help us to direct interventions and provide guidelines to promote adolescents' academic development. Consequently, the present study investigates the cross-lagged associations between domain-specific causal attributions and domain-specific self-concepts of ability in mathematics and in literacy among Finnish lower-secondary-school adolescents.

Self-Concept of Ability and Causal Attributions in Adolescence

In existing self-concept literature, various concepts have been used to refer to perceptions of abilities, such as competence beliefs, ability beliefs, and talent perceptions (e.g., Spinath & Spinath, 2005; Watt, 2004; Wigfield & Eccles, 2000). In the present study, we use the term *self-concept of ability* (see also Wigfield & Eccles, 2000) in which *ability* refers to the beliefs that

a person holds about his or her current competence in a particular domain (e.g., literacy or mathematics).

Previous research has reported changes occurring in children's self-concepts of ability as they age while young children's self-concepts of ability are highly positive, they become more realistic and accurate with age (Wigfield et al., 1997; Wigfield & Karpanthian, 1991). On average, self-concepts of ability tend to grow less positive in middle childhood or in early adolescence (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Marsh, 1989; Spinath & Spinath, 2005; Stipek & Mac Iver, 1989). However, the change in the self-concepts of ability might differ depending on the domain (Cole et al., 2001; Jacobs et al., 2002; Wigfield et al., 1997), and its extent and timing might vary between individuals (Archambault, Eccles, & Vida, 2010). Moreover, individual differences in self-concept of ability in various domains have been found to become more stable with increasing age (Cole et al., 2001; see also Wigfield et al., 1997).

The term *causal attribution* refers to the interpretations of the causes that people assign to their failures and successes. Causal attributions can be distinguished according to the following dimensions: locus of causality (internal–external), stability (fixed–variable), and controllability (controllable–uncontrollable; Weiner, 1986, 2010). According to Weiner (1986, 1992), ability and effort are the main causes individuals give for their failures and successes in achievement situations although students also use a variety of other attributions (e.g., task difficulty and luck). *Ability* is typically considered internal, stable, and uncontrollable; *effort* is considered internal, unstable, and controllable; *task difficulty* is considered external, stable, and uncontrollable; and luck is typically considered external, unstable, and uncontrollable (Weiner, 1986, 2010).

It has been suggested that these attribution dimensions have different effects on self, expectancies, and affect (Weiner, 1986, 2010), which are further related to engagement and achievement (Linnenbrink & Pintrich, 2002). In general, attributional style can be called adaptive when the causes of successes are attributed to internal, stable factors (e.g., ability), and the causes of failures are attributed to unstable causes (e.g., luck). These types of attributions have been assumed to have a positive impact on students' perceptions of ability, lead to higher hopes and expectations for future success, and increase striving to succeed in the future. In turn, attributional style can be called maladaptive when the causes of successes are attributed to external, uncontrollable, unstable causes (e.g., luck) and when the causes of failures are attributed to internal and stable causes (e.g., ability). These types of attributions have been assumed to have a negative effect on students' perceptions of ability, generate hopelessness, and reduce effort

to succeed (e.g., Chodkiewicz & Boyle, 2014; Weiner, 1986, 2010; see also Higgins & LaPointe, 2012). Additionally, attributing successes and failures to personally controllable, unstable factors, such as lack of effort, is thought to be beneficial because effort can be modified in the future (Linnenbrink & Pintrich, 2002).

However, students' age or cognitive development plays a role in the conceptualizations of causal attributions (Earn & Sobol, 1991; Folmer et al., 2008; Weitlauf & Cole, 2012). In particular, with increasing age, developmental advances occur in the understanding of the meanings of attributions and the relations between them (e.g., ability is different from effort and difficult tasks require more ability and effort than easy tasks). Therefore, unlike young children, adolescents can understand and separate different causal attributions from one another (e.g., Folmer et al., 2008; Nicholls, 1978; Nicholls & Miller, 1984). Consequently, asking adolescents to self-rate their attributions can be viewed as a meaningful and valid approach to investigating the causes adolescents give for their failures and successes.

The Relations Between Self-Concept of Ability and Causal Attributions

Two different lines of argument have been presented concerning the associations between self-concepts of ability and attributions. First, people tend to attribute success to internal causes and failure to external causes, and therefore internalize positive outcomes and externalize negative outcomes (cf. self-serving or hedonic bias; Marsh, 1986; Mezulis, Abramson, Hyde, & Hankin, 2004; Weiner, 1986, 1992). The use of self-serving strategies can be seen as means of enhancing or protecting one's self-concept (Weiner, 1986, 1992; see also Covington, 1984; Robins & John, 1997). For example, according to the attributional theory of motivation and emotion (Weiner, 1986, 2010), attributing success to internal features (e.g., ability or effort) creates more pride than do external causes, thus affecting self-concept positively, whereas attributing failure to internal causes lowers self-concept (Weiner, 1986, 2010; see also Feick & Rhodewalt, 1997; McRae & Hirt, 2001).

Second, people might perceive events in a way that is consistent with their self-concept (Robins & John, 1997; Swann & Read, 1981; Weiner, 1992). If that is the case, people with higher self-concepts of ability are more likely to make internal attributions for successful outcomes and external attributions for failure outcomes. People with lower self-concepts of ability tend to internalize failure and externalize success (Möller & Köller, 2000; see also Campbell & Sedikides, 1999; Weiner, 1986).

Previous literature on the relations between attributions and self-concept of ability has been mostly cross-sectional. These studies have shown that attributing success to internal causes, such as ability and effort (Marsh, 1984; Marsh, Cairns, Relich, Barnes, & Debus, 1984; Platt, 1988; Zhou & Urhahne, 2013), is positively correlated with academic self-concepts. However, in Nicholls's (1979) study, attributing success to effort was negatively related to academic self-concept among 12-year-olds (see also Kurtz-Costes & Schneider, 1994). One possible explanation for the mixed findings of effort attribution is that attributing outcome to effort might be associated in students' minds with a lack of ability because trying hard can be interpreted as a sign of inability (see also Covington, 1984; Marsh et al., 2016; Swinton, Rowley, Kurtz-Costes, & Okeke-Adeyanju, 2010).

Attributing failure to internal and uncontrollable causes such as to ability (Marsh, 1984; Marsh et al., 1984; Nicholls, 1979; Zhou & Urhahne, 2013) has been found to negatively correlate with academic self-concepts. In addition, the results for effort attribution have been contradictory; some studies show that attributing failure to lack of effort is negatively related with academic self-concept (Marsh, 1984; Marsh et al., 1984; Zhou & Urhahne, 2013), whereas other studies (Nicholls, 1979; Kurtz-Costes & Schneider, 1994) have found no associations between effort and self-concept in failure situations.

Studies regarding external causal attributions have mostly classified these attributions into the same group and are therefore unable to distinguish the role that different external attributions might have in the relationship between attributions and academic self-concepts. The results of the few studies separating different external attributions have been inconsistent. Zhou and Urhahne's (2013) study of fourth graders showed that attributing success to task characteristics is positively related to academic self-concept, whereas Platt's (1988) study of 17- to 19-year-olds showed that attributing successful outcomes to task easiness was negatively related to self-concept. In failure situations, attributions to task characteristics have been found to be negatively related to self-concept (Zhou & Urhahne, 2013). However, in Nicholls's (1979) study, task easiness or difficulty was not related to self-concept of ability.

Longitudinal Associations Between Self-Concept of Ability and Causal Attributions

Although testing the direction of association between self-concepts of ability and attributions requires examining the longitudinal relations between attributions and self-concepts of ability, only few longitudinal studies

have been conducted. In their 2-year longitudinal study, Kurtz-Costes and Schneider (1994) showed that attributing success to ability at age 8 positively predicted domain-general self-concept of ability at age 10 via school grades, and domain-general self-concept of ability at age 8 positively predicted ability attribution in success situations at age 10. Concerning failure situations, Dresel's (2001) 1-year longitudinal study of Grades 6 and 9 (mean age, 13.7) showed that domain-general self-concept of ability negatively predicted attribution of failure to ability. To our knowledge, no prior longitudinal studies have investigated the cross-lagged associations of different domain-specific causal attributions (e.g., ability, effort, guidance, and task difficulty) and self-concepts of ability in both success and failure situations.

The Present Study

Longitudinal research on cross-lagged associations between self-concepts of ability and causal attributions is needed for at least three reasons. First, although theoretical justification can be found for self-concepts of ability predicting causal attributions (self-consistency theories; Robins & John, 1997; Swann & Read, 1981) and for causal attributions predicting self-concepts of ability (attributional theory of motivation and emotion; Weiner, 1986), the direction of the associations has rarely been empirically examined. Second, previous longitudinal studies have focused on domain-general self-concepts of ability and causal attributions, even though there are good reasons to believe that these associations vary from one domain to another. Third, to promote adolescents' academic achievement, motivation, and adjustment, it is essential to deepen our understanding of these underlying cognitive factors.

The present study attempts to overcome the limitations of the previous studies by using longitudinal data on Finnish adolescents' seventh- and ninth-grade domain-specific attributions and domain-specific self-concepts in mathematics and literacy. The reasons for selecting mathematics and literacy school subjects for the current study are twofold. First, as the Finnish language was the students' native language, their literacy skills are likely to provide a basis for learning other school subjects during their school career. Evidence also suggests that early mathematics skills are fundamental for learning other subjects such as science (Claessens & Engel, 2013). Second, both math and literacy skills have been shown to be essential for later academic success (Alexander, Entwisle, & Horsey, 1997; Claessens & Engel, 2013).

The aim of the present study was to examine (a) the extent to which self-concepts of ability in mathematics and literacy predict adolescents'

causal attributions in these school subjects, and (b) the extent to which causal attributions in mathematics and in literacy predict adolescents' self-concepts of ability in mathematics and literacy. Based on Weiner's (1986) attributional theory of motivation and emotion, and the assumptions drawn from self-consistency theories (e.g., Robins & John, 1997; Swann & Read, 1981), attributing success to ability was expected to positively predict subsequent self-concepts of ability, whereas attributing failure to ability was expected to negatively predict later self-concepts of ability. Moreover, adolescents with higher self-concepts of ability were assumed to be more likely to make ability attributions for successful outcomes and external attributions (i.e., lack of guidance or task difficulty) for failure outcomes. By contrast, adolescents with lower self-concepts of ability were expected to have a tendency to attribute failure to ability and success to external attributions. However, owing to the inconsistency of the empirical results regarding the relations between effort attributions and self-concept of ability (e.g., Kurtz-Costes & Schneider, 1994; Marsh, 1984; Marsh et al., 1984; Nicholls, 1979), and because empirical findings have not always been consistent with theoretical assumptions regarding these relations (e.g., Covington, 1984; Swinton et al., 2010; see also Nicholls, 1979), we did not set any specific hypotheses for the relations between effort and self-concept of ability. Moreover, since gender and academic skills are known to be associated with students' self-concepts of ability (e.g., Marsh & Craven, 2006; Valentine et al., 2004; Wilgenbusch & Merrell, 1999) and causal attributions (e.g., Graham, 2004; Meece, Glienke, & Burg, 2006; Vispoel & Austin, 1995), these variables were controlled for in the analyses.

The Finnish Educational System

In Finland, compulsory education begins in the year of a child's seventh birthday. Six-year-olds are entitled to a kindergarten education for 1 year before embarking on their 9-year compulsory school career. Finnish comprehensive school is divided into an elementary level (Grades 1–6) and an upper level (Grades 7–9). After completing 9 years of compulsory education (at approximately age 16), students make a choice about their secondary education. Finnish education is state provided and tuition free. This study focused on students in Grades 7 and 9. According to the national core curriculum for comprehensive education determined by the National Board of Education (2004), the aim of instruction in Finnish schools is not only to meet the objectives of each subject, but also to support students' motivation, active and self-directed learning, and

responsibility for their learning. The emphasis on self-directed learning and responsibility of one's own learning might affect how students build their self-concepts as learners and how they attribute their successes and failures in learning situations.

Methods

Sample and Procedure

The study is part of the Jyväskylä Entrance into Primary School (JEPS) study, which was conducted in 1999–2009 (Nurmi & Aunola, 1999). The original sample consisted of all preschool-aged children ($N = 207$) in 1999 from rural and suburban areas within a close distance of a medium-sized city in Central Finland. The number of students participating in the study grew across measurement points because new students moved to the school districts and joined the classrooms that were participating in the study. Consequently, at the final measurement point (at the end of Grade 9), 237 students (117 girls and 120 boys) participated. Parental written consent and child assent were required for student participation. Permission for the data-gathering purposes was obtained at the beginning of the fall semester when the children were in kindergarten (age 6) and again in the fall of the seventh grade (age 13).

The present study uses data from the last two measurement points of the JEPS study: when the children were in the seventh grade (age 13, $M = 13.25$ years, $SD = 3.30$ months) and ninth grade (age 15, $M = 15.25$ years, $SD = 3.30$ months) of lower secondary school. Of the students, 204 (88.3%) participated in both the seventh- and ninth-grade measurement points, 27 (11.7%) students took part in the study in only the seventh grade, and 33 (14.3%) students took part in only the ninth grade.

The school districts that the participants were from included demographically similar schools, and the achievement level of the classrooms was heterogeneous. (That is, all of the students from the age groups attending the study were included in the sample. See Table 1 for the range of students' literacy and mathematical performances.) Participants were ethnically homogeneous (i.e., Finnish-speaking students in Finnish-speaking schools). The questionnaires were filled by the students during school hours (45 min to complete the questionnaires) in 2007 during the seventh-grade spring semester and again in 2009 during the ninth-grade spring semester (see Rimkute, Hirvonen, Tolvanen, Aunola, & Nurmi, 2012). At the same measurement points, students' skills in literacy and mathematics were tested in classroom group situations.

Table 1. Number of valid cases (*N*), means (*M*), and standard deviations (*SD*) for math-related and literacy-related attributions in success and failure situations, and subject-specific self-concepts of ability and skills in Grades 7 and 9

	Grade 7					Grade 9				
Variables	*N*	*M*	*SD*	Min.	Max.	*N*	*M*	*SD*	Min.	Max.
Ability (S, Ma)	215	2.56	1.09	1.00	4.00	227	2.51	1.15	1.00	4.00
Ability (S, Li)	217	2.64	1.00	1.00	4.00	226	2.57	1.04	1.00	4.00
Effort (S, Ma)	216	3.00	0.92	1.00	4.00	227	2.79	0.95	1.00	4.00
Effort (S, Li)	215	3.02	0.92	1.00	4.00	231	2.86	0.91	1.00	4.00
Task (S, Ma)	210	2.13	1.01	1.00	4.00	222	2.23	0.99	1.00	4.00
Task (S, Li)	211	2.31	0.98	1.00	4.00	225	2.39	0.98	1.00	4.00
Guidance (S, Ma)	212	2.54	0.94	1.00	4.00	226	2.56	1.05	1.00	4.00
Guidance (S, Li)	210	2.25	0.99	1.00	4.00	226	2.27	0.97	1.00	4.00
Ability (F, Ma)	214	2.41	0.92	1.00	4.00	223	2.23	0.97	1.00	4.00
Ability (F, Li)	210	2.34	0.85	1.00	4.00	225	2.19	0.92	1.00	4.00
Effort (F, Ma)	217	3.02	0.95	1.00	4.00	231	3.06	0.92	1.00	4.00
Effort (F, Li)	219	3.21	0.89	1.00	4.00	234	3.25	0.85	1.00	4.00
Task (F, Ma)	209	2.72	0.96	1.00	4.00	226	2.65	0.87	1.00	4.00
Task (F, Li)	207	2.57	0.95	1.00	4.00	222	2.49	0.87	1.00	4.00
Guidance (F, Ma)	208	2.11	1.01	1.00	4.00	224	2.12	0.99	1.00	4.00
Guidance (F, Li)	212	2.12	1.01	1.00	4.00	224	2.13	0.94	1.00	4.00
Math self-concept of ability	231	3.36	0.84	1.33	5.00	237	3.31	0.94	1.00	5.00
Literacy self-concept of ability	231	3.56	0.70	1.33	5.00	237	3.55	0.69	1.67	5.00
Math skills	231	21.52	6.34	4.00	37.00	236	24.23	7.08	4.00	40.00
Literacy skills	231	−0.01	0.86	−2.60	2.11	236	0.00	0.84	−2.50	1.61

Note. S = success situation; F = failure situation; Ma = math; Li = literacy.

Literacy skills are based on standardized scores.

Measures

Self-concept of ability. Students' self-concepts of ability in math and literacy were assessed by using a modified version of Wigfield and colleagues' (1997) scale. The questionnaire included three items for both math and literacy: How good are you at math/Finnish? How good are you at math/Finnish compared to other students in your class? How difficult are

math/Finnish tasks for you? (reverse scored). The students were asked to rate these items using a 5-point Likert scale ranging from 1 (*not good at all/very difficult*) to 5 (*very good/very easy*). In the following sections, the term *literacy self-concept of ability* is used to describe students' self-concepts of ability in the school subject domain of the Finnish language (i.e., students' mother tongue). Hence, the self-concept of ability variables (i.e., literacy self-concept of ability and mathematics self-concept of ability) each consisted of three items on the scale ranging from 1 (*not good at all/very difficult*) to 5 (*very good/very easy*). The Cronbach's alpha reliability for the self-concept of ability in math scale was .87 in Grade 7 and .89 in Grade 9. The Cronbach's alpha for the self-concept of ability in literacy scale was .81 in Grade 7 and .81 in Grade 9.

Causal attributions. Adolescents' attributions for school-related success and failure outcomes were assessed by a scale developed by Rytkönen, Aunola, and Nurmi (2006). The scale was based on items used in previous studies (Natale, Aunola, & Nurmi, 2009; see also Parsons, Meece, Adler, & Kaczala, 1982; Rytkönen, Aunola, & Nurmi, 2005, 2007). Attributions for successful academic outcomes were assessed with two statements in both school subjects: "If I do well in math/Finnish tasks, it is because. . . ." and "When I succeed in math/Finnish, it is because. . . ." Similarly, attributions for failure outcomes were assessed with two statements per school subject: "If I don't do well in math/Finnish, it is because. . . ." and "When I don't succeed in math/Finnish tasks, it is because. . . ." The students were asked to answer each statement separately by rating four answer options according to their importance (e.g., "most describes my thinking" and "least describes my thinking") in rank order on a 4-point scale. The four answer options for success situations were "I get good guidance," "I try hard," "I have the ability to succeed," and "The tasks are easy." The answer options for failure situations were "The guidance I get is not good enough," "I don't try enough," "I'm not capable enough," and "The tasks are too difficult." Because the ranking options were negatively phrased ranging from 1 (*most describes my thinking*) to 4 (*least describes my thinking*), they were reverse scored. In the following sections, the attributions in literacy are used to describe students' attributions in the school-subject domain of Finnish language (i.e., the students' mother tongue). Hence, attribution variables (i.e., guidance, effort, ability, and task difficulty) included two items on the scale ranging from 1 (*least describes my thinking*) to 4 (*most describes my thinking*) separately for success and failure situations and separately for mathematics and literacy. The Cronbach's alphas for math-success attributions ranged .70–.87 in the seventh grade and .80–.91 in the ninth grade. The Cronbach's alphas for literacy-success attributions ranged .72–.76 in the seventh grade

and .67–.79 in the ninth grade. The Cronbach's alphas for the attributions for math-related failures ranged .70–.72 in the seventh grade and .63–.77 in the ninth grade. Finally, the Cronbach's alphas for attributions of failures in literacy ranged .63–.75 in the seventh grade and .67–.68 in the ninth grade.

Control variables. Students' gender and academic skills were controlled in the analyses. Students' *literacy skills* were assessed with three subtests taken from the Test of Word Reading, Spelling, and Reading Comprehension (Holopainen, Kairaluoma, Nevala, Ahonen, & Aro, 2004; for reliability and validity, see also Savolainen, Ahonen, Aro, Tolvanen, & Holopainen, 2008): (a) The error-finding test included 100 words typed on a sheet of paper, and the students' task was to find and mark the spelling errors within 3½ min. The number of correctly detected errors was the score of the test. (b) The word chain test included 100 words that were chained together with no space between them. Each chain consisted of four words, and the students' task was to find and mark the beginning of a new word and the end of another word within 3½ min. The score of the test was the number of correctly found words. (c) The reading-comprehension test included a four-page story, "Dogs of the Village," by a Finnish novelist Veikko Huovinen. The original story by Huovinen was modified to contain 52 words contradictory to the sentence, paragraph, or larger text context. Students had to find and mark the contradictory words. The score of the test was the number of correctly found words (Holopainen et al., 2004; see also Savolainen et al., 2008). A sum score of the three subtests was created by calculating a mean of the standardized test scores. The Cronbach's alpha reliability for the sum score was .81 in the seventh grade and .80 in the ninth grade.

Students' *mathematical performance* was assessed by using a group-administered test for basic mathematical skills (Räsänen & Leino, 2005) designed for students in Grades 7–9 (ages 12–15). The test has four versions from A to D, each comprising 40 items measuring different mathematical skills (e.g., basic calculation, story problems, and equations). The present study used version A. The test was performed by the students during a regular class (45 min). A maximum score in the test was 40 points, meaning that each item was worth 1 point. The Cronbach's alpha reliability for the sum score based on all items was .86 in the seventh grade and .89 in the ninth grade.

Statistical Analyses

We used structural equation modeling (SEM) to answer the research questions. For the statistical analyses, we first investigated the descriptive statistics and, second, we estimated the measurement models for the self-concepts of ability and attributions separately for math and literacy. In the

measurement models, factor loadings of the same items were constrained to be equal across time to ensure invariance of the measurement across time, and the latent factors were allowed to correlate with one another. Third, we estimated cross-lagged SEMs for self-concepts of ability and attributions, separately for literacy and math. In addition, because of the ipsative nature of the attribution measures, each attribution was analyzed separately in its own model to ensure that the assumptions of independence of error variance were not violated.

In these models, factor loadings of the same items were constrained to be equal across time to ensure invariance of the measurement across time. In addition, we estimated the stability paths from Grade 7 self-concept of ability to Grade 9 self-concept of ability, and from Grade 7 attribution to Grade 9 attribution, as well as the cross-lagged paths from Grade 7 self-concept of ability to Grade 9 attribution and from Grade 7 attribution to Grade 9 self-concept of ability. The Grade 7 self-concept of ability and Grade 7 causal attribution were enabled to be correlated. Similarly, the residuals of the Grade 9 self-concept of ability and Grade 9 causal attribution were enabled to be correlated. The effect of students' gender and academic skills on self-concepts of ability and causal attributions was controlled for in the analyses.

The proportion of missing data for the main study variables ranged 0–30% (M = 24.5, SD = 4.8). Little's (1988) missing completely at random test (MCAR) indicated that data in the self-concepts of ability, causal attributions, and control variables were missing completely at random: $\chi^2(1181) = 1246.86$, $p > .05$. In the analyses, full-information maximum-likelihood procedures were used to handle the missing data. Since all of the study variables were not normally distributed, we used maximum-likelihood robust (MLR) estimation. The MLR estimator produces robust standard errors by means of a sandwich estimator and a χ^2-test statistic for nonnormal outcomes. Model fit was investigated by using the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the standardized root mean square residual (SRMR). The analyses were conducted by using the statistical package Mplus (Version 7.31, Muthén & Muthén, 1998–2015).

Results

Descriptive Information

Table 1 presents the descriptive statistics of the study variables. Independent-samples t tests were used to investigate mean-level gender differences in self-concepts of ability and in attributions. Relative to boys, girls had higher self-concepts of ability in literacy in Grades 7 (Cohen d = .43) and 9 (d = .70), whereas boys had higher self-concepts of ability in math in

Grades 7 (d = .34) and 9 (d = .26). Compared to girls, boys attributed math successes more to ability in Grades 7 (d = .40) and 9 (d = .40), and literacy failures more to a lack of ability in Grade 7 (d = .27).

Measurement Models

We built measurement models by using confirmatory factor analysis, which enabled us to take measurement error into account. These models were built separately for each school subject-specific attribution and self-concept of ability. In these models, factor loadings of the same items were constrained to be equal across time to ensure invariance of the measurement across time. If required for model fit, some autocovariances of residuals of the same items were estimated (especially for the second and third self-concepts of ability items and second attribution items). In addition, in four of the models, the slightly negative estimate of the residual variance of the second attribution item was fixed to zero. The measurement models, assuming measurement invariance across time, fit the data well: $\chi^2(29–34) = 30.65–59.62$, $p = 0.00–0.54$, RMSEA ranged 0.00–0.06, CFI ranged 0.97–1.00, TLI ranged 0.96–1.00, and SRMR ranged 0.04–0.05. The standardized estimates of factor loadings for the self-concept of ability in math in Grades 7 and 9 ranged −.75 to .96, and self-concept of ability in literacy in Grades 7 and 9 ranged −.64 to .84. The factor loadings of the attributions made in math in Grades 7 and 9 ranged .57–1.0, and factor loadings of the literacy attributions in Grades 7 and 9 ranged .55–1.0. The fact that the models fit the data well and factor loadings were high suggests good construct validity and item reliability.

Table 2 presents correlations between the latent factors in Grades 7 and 9, and Table 3 presents the stability correlations of the latent factors between Grades 7 and 9. The stability correlation of the self-concept of ability in literacy was .62, indicating moderate stability from Grade 7 to Grade 9, whereas the stability correlation between the math self-concept of ability variables was .80, indicating strong stability across the 2 years (see Table 3). The stability correlations of literacy-related attributions ranged .12–.44, and correlations of math-related attributions ranged .19–.53, suggesting low to moderate stability from Grade 7 to Grade 9 (see Table 3).

SEMs of Self-Concepts of Ability and Causal Attributions

The main purpose of our research was to investigate the extent to which students' self-concepts of ability in Grade 7 predict students' subsequent causal attributions in Grade 9, and the extent to which students' causal attributions predict students' subsequent self-concepts of ability in Grade 9.

Table 2. Correlations between the latent factors of domain-specific self-concepts of ability and domain-specific attributions in Grades 7 and 9[a]

Attributions	Self-concept in Grade 7	Self-concept in Grade 9
Ability (S)	.56***/.54***	.72***/.64***
Effort (S)	−.17+/−.29**	−.21**/−.04
Task (S)	−.20**/.04	−.33***/−.43***
Guidance (S)	−.34***/−.25**	−.36***/−.27**
Ability (F)	−.27**/−.49***	−.35**/−.33***
Effort (F)	.10/.11	.22**/.12
Task (F)	−.05/.02	−.07/−.18
Guidance (F)	.17+/.30***	.17**/.27***

Note. S = success situation; F = failure situation.

[a] The first-mentioned correlation is for math-related variables and the second is for literacy-related variables.

* $p < .05$. ** $p < .01$. *** $p < .001$. + $p < .10$.

Table 3. Stability correlations between Grades 7 and 9 of the latent factors of the domain-specific attributions and the domain-specific self-concepts of ability

Variables	Literacy	Mathematics
Ability (S)	.44***	.51***
Effort (S)	.33**	.38***
Task (S)	.16+	.25**
Guidance (S)	.12	.53***
Ability (F)	.26**	.32***
Effort (F)	.24*	.36***
Task (F)	.43**	.27**
Guidance (F)	.26***	.19+
Self-concept of ability	.62***	.80***

Note. S = success situation; F = failure situation.

* $p < .05$. ** $p < .01$. *** $p < .001$. + $p < .10$.

To answer these questions, we built SEMs separately for each subject-specific attribution and self-concept of ability. In these models, factor loadings of the same items were constrained to be equal across time to ensure invariance of the measurement across time. In these models, we also estimated stability paths of both constructs, as well cross-lagged paths. The effects of students'

gender and academic skills were controlled for in all of the analyses. The final models containing only statistically significant paths fit the data well: $\chi^2(47–52) = 49.52–101.43$, $p = 0.00–0.52$, RMSEA ranged 0.00–0.06, CFI ranged 0.97–1.00, TLI ranged 0.94–1.00, and SRMR ranged 0.04–0.06.

Figures 1–8 show the path coefficients of the final models. *In success situations*, the results show that the lower the self-concepts of ability in literacy and in mathematics were, the more students attributed their subsequent successes to task easiness (see Figure 1 for literacy and Figure 2 for mathematics). Furthermore, the lower the self-concept of ability in literacy was in seventh grade, the more students attributed their subsequent successes to getting enough guidance in ninth grade (see Figure 3). Finally, the higher the self-concept of ability in math was in seventh grade, the more

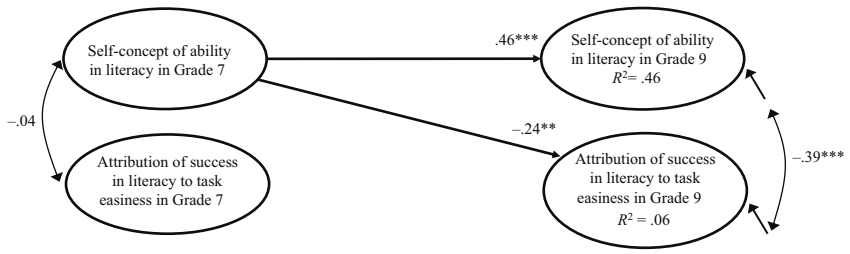

Figure 1. The longitudinal associations between literacy self-concept of ability and attribution of success in literacy to task easiness: standardized structural equation model solution. The model fit information $\chi^2(51) = 55.159$, $p = .3203$, RMSEA = 0.02, CFI = 0.99, TLI = 0.99, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

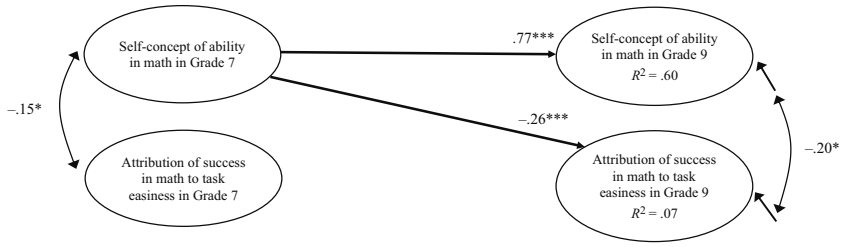

Figure 2. The longitudinal associations between math self-concept of ability and attribution of success in math to task easiness: standardized structural equation model solution. The model fit information: $\chi^2(50) = 86.885$, $p = .0009$, RMSEA = 0.05, CFI = 0.97, TLI = 0.96, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

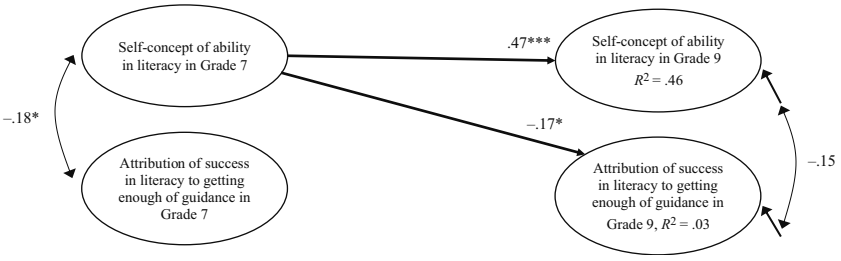

Figure 3. The longitudinal associations between literacy self-concept of ability and attribution of success in literacy to getting enough of guidance: standardized structural equation model solution. The model fit information: $\chi^2(52) = 58.589$, $p = .2465$, RMSEA = 0.02, CFI = 0.99, TLI = 0.99, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

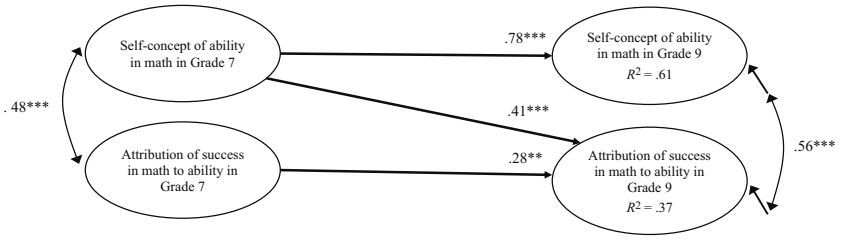

Figure 4. The longitudinal associations between math self-concept of ability and attribution of success in math to ability: standardized structural equation model solution. The model fit information: $\chi^2(47) = 82.343$, $p = .0011$, RMSEA = 0.05, CFI =0.98, TLI = 0.97, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

students attributed their subsequent successes to their ability in ninth grade (see Figure 4). In neither of the school subjects did self-concepts of ability predict subsequent effort attributions in success situations. The results also showed that none of the investigated attributions in success situations predicted subsequent self-concepts of ability.

In failure situations, the results showed that the lower the self-concepts of ability in literacy and in mathematics were in seventh grade, the more students attributed their subsequent failures to their ability in ninth grade (see Figure 5 for literacy and Figure 6 for mathematics). Furthermore, the higher the self-concept of ability in math was in seventh grade, the less students attributed their subsequent failures to task difficulty and the more they attributed them to lack of guidance in ninth grade (see Figures 7 and 8). As in success situations, self-concepts of ability did not predict

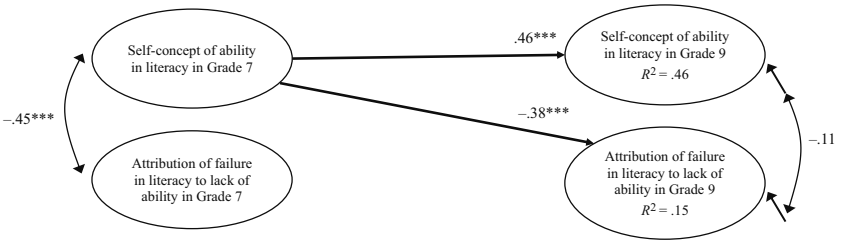

Figure 5. The longitudinal associations between literacy self-concept of ability and attribution of failure in literacy to lack of ability: standardized structural equation model solution. The model fit information: $\chi^2(50) = 55.226$, $p = .2838$, RMSEA = 0.02, CFI = 0.99, TLI = 0.99, SRMR = 0.04. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

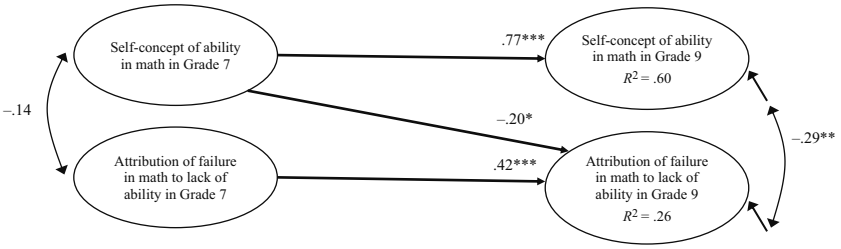

Figure 6. The longitudinal associations between math self-concept of ability and attribution of failure in math to lack of ability: standardized structural equation model solution. The model fit information: $\chi^2(47) = 88.108$, $p = .0003$, RMSEA = 0.05, CFI = 0.97, TLI = 0.95, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

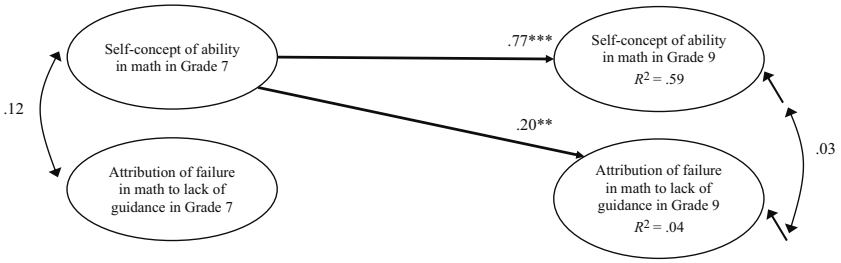

Figure 7. The longitudinal associations between math self-concept of ability and attribution of failure in math to lack of guidance: standardized structural equation model solution. The model fit information: $\chi^2(50) = 97.777$, $p = .0001$, RMSEA = 0.06, CFI = 0.96, TLI = 0.95, SRMR = 0.06. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

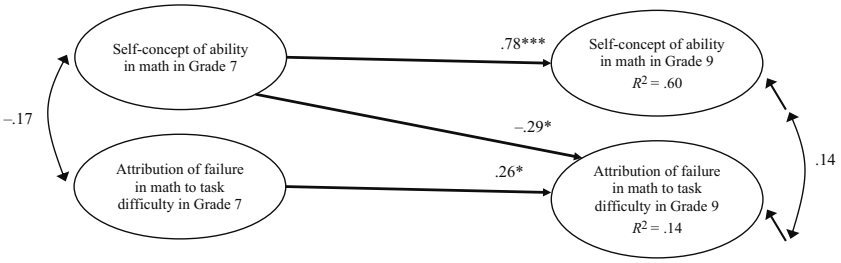

Figure 8. The longitudinal associations between math self-concept of ability and attribution of failure in math to task difficulty: standardized structural equation model solution. The model fit information: $\chi^2(48) = 82.226$, $p = .0015$, RMSEA = 0.05, CFI = 0.97, TLI = 0.96, SRMR = 0.05. Students' gender and academic skills are controlled for in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

subsequent effort attributions in failure situations, and none of the attributions predicted subsequent self-concepts of ability.

Discussion

This study is among the first to investigate the longitudinal relations between self-concepts of ability and causal attributions. More specifically, the aim of this study was to investigate the cross-lagged relations between causal attributions and self-concepts of ability in mathematics and in literacy in Grades 7 and 9. In line with our assumptions, the results showed that self-concepts of ability predicted attributions. Specifically, in math, a higher self-concept of ability predicted self-serving attributions, and, in both school subjects, a lower self-concept of ability predicted maladaptive attributions. However, contrary to our assumption of reciprocal associations between self-concepts of ability and causal attributions, attributions did not predict self-concepts of ability.

Self-Concepts of Ability as Predictors of Causal Attributions in Success and Failure Situations

The main finding of the present study was that self-concepts of ability predicted eight out of 16 subsequent causal attributions in success and failure situations, after controlling for gender, academic performance, and previous level of self-concepts of ability. First, in line with our assumption (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992), the results in the domain of mathematics showed that the

more positive the adolescents' math self-concepts of ability were, the more they attributed successful outcomes in math to ability later. This result is consistent with Kurtz-Costes and Schneider's (1994) study, which showed that a domain-general self-concept of ability at age 8 positively predicted ability attribution in success situations at age 10. Notably, in the present study, literacy self-concept of ability did not predict ability attributions in success situations.

Second, in line with our expectation (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992), the results of the present study showed that the lower students' self-concepts of ability were in literacy and mathematics, the more they attributed failures to lack of ability. This result is consistent with Dresel's (2001) study, which showed that domain-general self-concept of ability negatively predicted attribution of failure to ability. Attributing failure to lack of ability can be seen as maladaptive for academic development (e.g., Chodkiewicz & Boyle, 2014; Weiner, 1986), and such a tendency seems more likely for students with low self-concepts of ability. Students who do not believe in their abilities and blame their lack of talent for their failures might exert less effort in school tasks (since they do not believe that exerting effort will make a difference), further resulting in poorer achievement outcomes (see also Higgins & LaPointe, 2012; Marsh et al., 2016). Students who blame their failures on a lack of abilities might also be more likely to elicit sympathy from other people compared to those demonstrating a lack of effort attribution, which is more likely to elicit anger from other people (see also Weiner, 1986). In sum, in both school subjects, the present study showed that consistent with their low self-concepts of ability, students blamed their lack of ability for failures.

The results for effort attributions showed that seventh-grade self-concepts of ability did not predict the ninth-grade effort attributions in either success or failure situations in either school subject. No hypotheses were set for these associations because previous longitudinal studies on the topic have been scarce, and the results of previous cross-sectional studies have been inconsistent. One possible explanation for the lack of longitudinal association between self-concepts of ability and effort attributions is that effort can be a double-edged sword in the sense that trying hard can have a positive impact on academic outcomes while also being indicative of low ability (Covington, 1984). Another possible explanation is that adolescents' tendency to make effort attributions was driven more by their implicit theories of ability rather than their self-concept of ability. Dweck and colleagues (e.g., Dweck, Chiu, & Hong, 1995; Molden & Dweck, 2006) have shown that

incremental theorists—that is, students with a belief that ability is malleable instead of fixed—are more likely to make effort attributions than are other students, particularly in failure situations. Conversely, entity theorists—that is, students with a belief that ability is fixed and reflecting "aptitude" (Weiner, 2010)—might be less likely to make effort attributions because they likely think that effort plays no role at all in their success or failure.

Our third expectation was that adolescents with lower self-concepts of ability would be more likely to externalize their successes. The results supported this expectation (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992) by showing that the lower the adolescents' self-concepts of ability were in both school subjects, the more they attributed subsequent successes to task easiness. Moreover, in literacy, the lower the self-concept of ability was, the more adolescents attributed their successes to getting enough guidance. This result was not found in mathematics. Similarly, as with attributing failure to lack of ability, attributing successes to external factors can be seen as a maladaptive tendency (e.g., Chodkiewicz & Boyle, 2014) that might affect persistence behaviors negatively (see also Bar-Tal, 1978; Stipek & Weisz, 1981). These results suggest that in both school domains, consistent with their low self-concepts of ability, adolescents in the current study attributed their successes to external factors.

Finally, we expected that adolescents with higher self-concepts of ability would be more likely to make external attributions for failure outcomes. The results partially supported this expectation (Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981; Weiner, 1992) by showing that math self-concept of ability positively predicted attributing subsequent failure to lack of guidance and negatively predicted attributing subsequent failure to task difficulty: The better the adolescents' self-concepts of ability were in math, the more they attributed failures to lack of guidance and the less they attributed failures to task difficulty. Attributing failure to external factors is generally considered a self-protective strategy (Weiner, 1986, 1992; see also Robins & John, 1997). An alternative explanation for these findings in math is that high-self-concept adolescents are more likely to choose (if they have an option) to externalize their failure to lack of guidance, because it implies that they would have needed help to succeed, which suggests that the task had been difficult enough that it also required an ability to succeed. Attributing failure to task difficulty might imply that one is not able enough after all. Therefore, avoiding attribution of failure to task difficulty (and therefore to their inability to solve the task) and instead blaming failures on a lack of guidance might be a more self-protective strategy. However, self-concept of ability in literacy was not related to external attributions in failure situations.

Overall, the findings of the present study suggest that adolescents attribute their successes and failures self-consistently (e.g., Möller & Köller, 2000; Robins & John, 1997; Swann & Read, 1981). However, the findings also indicate that self-concepts of ability can have a different role on subsequent use of attributions, depending on the school subject. More specifically, the results show that a positive self-concept, particularly in the math domain, contributed to a more self-serving attributional style (see also Marsh, 1986; Mezulis et al., 2004; Weiner, 1992)—that is, a tendency to attribute successes to ability and a tendency to attribute failures to external reasons. Low self-concepts of ability in both school subjects also contributed to more frequent use of external attributions in success situations and more frequent use of lack of ability attributions in failure situations, thus reflecting a tendency to use maladaptive attributions consistent with low self-concepts (see also Chodkiewicz & Boyle, 2014).

One possible explanation for the subject-specific findings is that, as a subject, mathematics elicits more self-threat, which makes adolescents more vulnerable to self-serving attributions (see also Schwinger, 2013). One of the conditions creating self-threat in mathematics in lower secondary school could be uncertainty of success (see also Crocker & Park, 2003) due to learning new concepts that are not easily assimilated into previous knowledge, whereas literacy learning is a more gradual extension of previous knowledge (Dweck & Licht, 1980). In previous studies, students have also been found to perceive mathematics as difficult and a subject in which one either does or does not have ability (Stodolsky, 1985). Moreover, math is usually characterized as having tasks with either right or wrong answers, and students tend often to consider their mistakes as indicative of low ability (Boaler, 2013). In addition to students' beliefs in their ability in math, teachers' and parents' possible mind-sets of math ability as fixed are communicated to students, which might reinforce students' beliefs of math as a fixed talent (Dweck, 2008). High-self-concept adolescents might also be more likely to receive feedback of their talents in mathematics, thus enforcing their entity view in mathematics (maintaining smartness and avoiding looking incompetent; see also Boaler, 2013; Snyder, Malin, Dent, & Linnenbrink-Garcia, 2014).

Attributions in Success and Failure Situations as Predictors of Self-Concepts of Ability

Based on Weiner's (1986) theory, we hypothesized that attributing success to ability would positively predict subsequent self-concepts of ability, whereas attributing failure to ability would negatively predict self-concepts

of ability. However, the results regarding the predictive role of attributions on subsequent self-concepts of ability revealed that attributions did not predict self-concepts of ability. In addition to attributions, other factors might play a role in the formation of self-concepts of ability. Students construct their self-concepts based on different information sources such as other people's perceptions of their ability, school grades, external comparisons of their abilities in relation to their peers' abilities, and internal comparisons between their ability areas or in the same school subject over time (Skaalvik & Skaalvik, 2002; see also Bong & Skaalvik, 2003). An investigation of the dynamics between these different factors is an important challenge for future research.

Notably, only few prior longitudinal studies have examined the direction of the associations investigated in the present study. Some of the previous findings differ from the results of this study. Kurtz-Costes and Schneider's (1994) longitudinal study found some indication of reciprocal associations between causal attributions and domain-general self-concepts of ability among 8- to 10-year-olds. Moreover, in accordance with the results in the present study, Dresel (2001) found in his longitudinal study that adolescents' domain-general self-concept of ability predicted their reactions to failures a year later.

Limitations and Future Challenges

There are some limitations to the findings of the present study that should be considered when interpreting the results. First, the sample was relatively small. Even though the study provided a valuable contribution to the understanding of the dynamics between self-concepts of ability and causal attributions in specific school subjects in lower secondary school, it would be informative to replicate the findings with a bigger sample. Second, many researchers have raised concerns about measuring attributions with hypothetical situations because they might not accurately measure students' attributional tendencies in real-life situations. Future research could thus develop tools that would have more ecological validity (e.g., Hirchy & Morris, 2002; Wolters et al., 2013). Third, as the present study was conducted in a particular cultural and social environment, the results need to be replicated in other cultural and educational contexts. For example, previous studies have found cultural differences such that Western cultures (e.g., the United States) manifest more self-serving attributions than do Asian cultures (e.g., Japan; Mezulis et al., 2004), and many Asian countries place more emphasis on effort as a means of improving ability (Hau & Salili, 1996; Salili, 1996). Since the sample in the present study was culturally

homogeneous and included only Finnish students, the results should be carefully interpreted to represent other cultures.

Fourth, although the findings concerning the stability of the attributions over time were approximately consistent with the limited body of previous studies on the topic (e.g., Cole et al., 2008; Dresel, 2001; Morris & Tiggemann, 1999), stabilities of some of the attributions from Grades 7–9 were relatively low, which might have affected the finding that self-concepts of ability predicted attributions and not vice versa. Self-concepts of ability tend to stabilize with increasing age (Cole et al., 2001; see also Wigfield et al., 1997). Therefore, the age of the students in the present study might have affected the findings and, consequently, the generalizability of the findings in other age groups. Fifth, related to the measurement of the key concepts, the study relied on self-reports, so the associations might be affected by common method bias and social desirability. However, since the study's focus was on students' perceptions of their competences and reasons for their achievement outcomes, self-report measures can be considered valid (see Marsh et al., 2016). Sixth, some of the internal consistencies of the attributions were fairly low (<0.70); however, these Cronbach's alphas were similar to those reported by Ciarrochi, Heaven, and Davies (2007) and Marsh et al. (1984) and higher than those reported in other studies (e.g., Marsh, Relich, & Smith, 1983; Morris & Tiggemann, 1999). Furthermore, in the present study, we used SEM with latent variables to ensure that the measurement errors were taken into account, thus adding to the reliability of the study.

Finally, while the present study conducted measurements twice in 2 years, which is one of its major strengths, more frequent measurements of self-concepts of ability and causal attributions, as well as longer follow-up studies, might reveal a more nuanced picture of the predictive associations. Therefore, it would be useful for future studies to investigate real-time dynamics between these constructs.

Conclusions and Implications

The present study has several strengths, including the cross-lagged study design and the investigation of bidirectional relationships of domain-specific self-concepts of ability and causal attributions, which previous studies have rarely investigated. The goal of this study was to contribute to the body of knowledge regarding the role of self-concepts of ability on the causal attributions adolescents make in academic contexts, on the one hand, and the role of causal attributions on self-concepts, on the other. The findings indicate that, during adolescence, from Grades 7–9, self-concepts

of ability predict causal attributions rather than vice versa. The findings also extend previous knowledge about the differences between math and literacy domains in the relations between attributions and self-concepts of ability, thus highlighting the importance of investigating domain-specific achievement-related beliefs instead of general beliefs.

The findings suggest that promoting positive self-concept during adolescence enhances the use of more self-serving attributions in mathematics (i.e., tendencies to attribute successes to high abilities and failures to external factors) and lessens the use of maladaptive attributions in both school subjects (i.e., tendencies to attribute successes to external factors and failures to lack of ability). Self-serving attributional bias can assist in coping with negative affects related to attributing failures internally (Weiner, 1986). However, although maintaining self-concept, attributing failure to external, stable, and uncontrollable factors can also induce a feeling of hopelessness, which might influence engagement and persistence (Weiner, 1986; see also Stipek & Weisz, 1981). This type of reaction to failure can also hinder a realistic internalizing of feedback and the proper consideration of weaknesses, which can be detrimental for further learning (Crocker & Park, 2003). Achievement might be particularly undermined if external attributions become a priori excuses (i.e., self-handicapping).

Attribution retraining studies have shown that attributing successes to ability and/or effort and failures to personally controllable factors is beneficial in terms of self-concept of ability, engagement, and performance (e.g., Chodkiewicz & Boyle, 2014; O'Mara, Marsh, Craven, & Debus, 2006). Similarly, previous studies have shown that incremental vs. entity beliefs about ability (i.e., beliefs about ability as malleable vs. fixed) are related to attributions, achievement, and self-concept development (for a review, see Molden & Dweck, 2006). Attributions and ability beliefs are communicated by parents and teachers through praise and feedback (e.g., Dweck, 2008; Henderlong & Lepper, 2002). In accordance with attribution retraining studies and studies of implicit theories, providing process feedback (e.g., praising effort and task-appropriate strategies) and supporting beliefs of ability as malleable rather than fixed can be beneficial for students' self-concept of ability and achievement (see also Mueller & Dweck, 1998; O'Mara et al., 2006). Above all, teachers could provide opportunities for discussions of students' self-concepts and attributions. These conversations could raise teachers' awareness of the importance of students' self-concepts and causal attributions, and the ways in which they can be promoted (see also Linnenbrink & Pintrich, 2002).

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II

RECIPROCAL RELATIONS BETWEEN ADOLESCENTS' SELF-CONCEPTS OF ABILITY AND ACHIEVEMENT EMOTIONS IN MATHEMATICS AND LITERACY

by

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Reciprocal relations between adolescents' self-concepts of ability and achievement emotions in mathematics and literacy☆

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ABSTRACT

This longitudinal study examined cross-lagged relations of self-concepts of ability and achievement emotions (i.e., enjoyment, boredom, anxiety) in two central school subjects (i.e., mathematics and literacy). Adolescents ($N = 848$) reported their achievement emotions and self-concepts of ability four times during Grades 6 and 7. The pattern of results was different for mathematics and literacy subjects. For mathematics the results of random intercept cross-lagged panel models showed a positive reciprocal relationship between self-concepts of ability and enjoyment and a negative reciprocal relationship between self-concept and anxiety. Lower self-concepts of ability in mathematics also predicted higher boredom in mathematics but not vice versa. For literacy, in turn, self-concept of ability did not predict any of the achievement emotions and emotions did not predict literacy self-concept of ability. The results suggest that achievement emotions act as sources as well as consequences of adolescents' self-concepts of ability, particularly in mathematics.

1. Introduction

Self-concept of ability (i.e., how good students evaluate themselves in different subjects domains) is central to adolescents' academic development because, according to robust research evidence, higher evaluations of one's self-concept as a learner predict interest in school subjects, academic choices, success in school, and educational attainment, and can even protect against school drop-out (Durik, Vida, & Eccles, 2006; Guay, Larose, & Boivin, 2004; Marsh, Trautwein, Lúdtke, Köller, & Baumert, 2005; Rumberger & Lim, 2008; Valentine, DuBois, & Cooper, 2004). Besides self-concept, achievement emotions, such as boredom, anxiety, and enjoyment also play a role in academic outcomes (Pekrun, 2017). For example, boredom in learning is thought to relate to off-task behaviors and ineffective learning strategies, thus undermining motivation and achievement. Similarly, anxiety is commonly assumed to be related to task-irrelevant thinking and decreased intrinsic motivation. Enjoyment related to learning tasks, in turn, can facilitate learning and achievement by boosting interest and adaptive learning strategies, fostering future learning and motivation (for reviews, see Pekrun & Perry, 2014; Pekrun, 2017). Taken together, given the effects of self-concept of ability and achievement emotions on adolescents' development, it is important to investigate how they evolve over time in order to support adolescents' academic development and wellbeing.

Theoretical models (e.g., Pekrun 2006; see also Bandura, 1997; Zeidner, 1998) as well as empirical evidence (e.g., Goetz, Cronjaeger, Frenzel, Lüdtke, & Hall, 2010; for a summary, see Pekrun & Perry, 2014) suggest that self-concept of ability and emotions are related. However, the limitation of earlier research is that few attempts have been made to test reciprocal cross-lagged associations between self-concepts of ability and achievement emotions using longitudinal procedures. In particular, only little is known about bidirectional associations between self-concepts of ability and achievement emotions in different achievement domains and including multiple emotions. In order to foster learning and motivation and to better define targets of interventions for this support (e.g., emotion-focused or self-concept enhancement), it is critical to gain knowledge of the developmental dynamics between achievement emotions and their antecedents (e.g., self-concept of ability). Therefore, the aim of the present cross-lagged longitudinal study is to examine reciprocal associations between adolescents' self-concepts of ability and achievement emotions in two subject domains (i.e., math and literacy).

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1.1. Self-concept of ability and achievement emotions among early adolescents

The present study examined domain-specific emotions and self-concepts of ability in mathematics and literacy (see also Goetz, Frenzel, Hall, Pekrun, & Lüdtke, 2007; Goetz et al., 2010; Raccanello, Brondini, & De Bernardi, 2013). Mathematics and literacy school subjects were chosen because math and literacy skills have shown to play an important role in subsequent academic success (Alexander, Entwistle, & Horsey, 1997; Claessens & Engel, 2013). For example, there is evidence suggesting that early mathematics skills form a central core for learning other subjects (Claessens & Engel, 2013). Moreover, Finnish was the participants' native language and, therefore, their literacy skills in Finnish are likely to form the basis for learning other school subjects.

Self-concept of ability is defined as the beliefs that an individual holds about their competence in a certain domain (e.g., mathematics or literacy) (Wigfield & Eccles, 2000). In the literature, other concepts, such as competence beliefs (Spinath & Spinath, 2005), ability beliefs (Wigfield & Eccles, 2000), and talent perceptions (Watt, 2004), have also been used to refer to perceptions of abilities. Self-concepts of ability tend to decrease during the elementary school years, and thus early adolescents often have less positive self-concepts of ability than younger students (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Marsh, 1989; Spinath & Spinath, 2005; Stipek & Mac Iver, 1989). However, the changes in self-concepts might vary between domains (Cole et al., 2001; Jacobs et al., 2002), and there is also some evidence of individual differences for when and how extensively self-concepts of ability become more negative (Archambault, Eccles, & Vida, 2010). Moreover, individual differences in self-concept of ability in different subject domains tend to become more stable with increasing age (Cole et al., 2001; see also Wigfield et al., 1997).

In the control-value theory, in turn, achievement emotions are defined as emotions related to achievement outcomes (e.g., anxiety) or as emotions occurring in achievement related activities (e.g., enjoyment or boredom) (Pekrun & Perry, 2014). Outcome-related emotions can be further classified as prospective outcome emotions (e.g., anxiety related to anticipated failing in an exam) or retrospective outcome emotions (e.g., pride after a success). Furthermore, achievement emotions differ from each other also in terms of valence (positive or negative emotions) and a level of physiological activation (activating or deactivating emotions).

Adolescents experience a wide variety of achievement emotions and enjoyment, boredom, and anxiety in learning related activities are salient and frequently experienced emotions (Goetz & Hall, 2014; Pekrun, Goetz, Tizt, & Perry, 2002; Raccanello et al., 2013). Due to their central role in adolescents' learning experiences and because they cover all the dimensions of emotions (i.e., negative vs. positive, activating vs. deactivating, outcome vs. activity-related emotions) proposed by the control-value theory (Pekrun & Perry, 2014), the present study focused on enjoyment, anxiety, and boredom.

1.2. The role of self-concepts of ability in subject-specific achievement emotions

The control-value theory of achievement emotions (Pekrun & Perry, 2014) suggests that self-concept of ability affects the way one feels toward learning as it forms a basis for a person's feeling of control over achievement outcomes and activities. The control-value theory also assumes that when students feel that they are competent to master the required tasks, enjoyment is likely to be instigated. Anxiety, in turn, is assumed to be provoked when self-concept is low (Pekrun & Perry, 2014). Lower self-concept of ability might signal that a person is not up to the task demands and anxiety is likely to be triggered (Bandura, 1997; Csikszentmihalyi, Aduhamdeh, & Nakamura, 2005), particularly if the person evaluates the task as important (Pekrun & Perry, 2014). Furthermore, low ability beliefs may create attentional and interpretive biases in the processing of information. More specifically, low self-evaluations can arouse anxiety by increasing students' vigilance of threats and magnifying their evaluation of the severity of threats. In contrast, higher self-evaluations may facilitate viewing potential threats as more benign and adopting adaptive strategies to cope with threats, which decreases anxiety and results in unaffected or enhanced evaluations of self (Bandura, 1997).

The role that self-concept of ability plays in boredom towards learning has been debated. Traditionally, boredom has been assumed to be triggered if ability level is high and task demands are too low (Csikszentmihalyi et al., 2005; see also Van Tilburg & Igou, 2012). However, the control-value theory of achievement emotions (Pekrun, 2006) suggests that boredom is as likely to occur if subjective control over the activity is low or high. Thus, boredom is likely to be instigated if the demands of the situation exceed a person's ability to cope in the situation or if the task demands are too low in relation to ability level (see also Acee et al., 2010; Daschmann, Goetz, & Stupnisky, 2011; Krannich et al., 2019). However, it has also been suggested that school tasks are typically designed to be difficult enough, and therefore high control situations are not common in the school environment. Thus, it is more likely that overchallenging (rather than underchallenging) situations instigate boredom in school (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010).

The results from cross-sectional studies have shown that self-concepts of ability are positively related to enjoyment and negatively to boredom and anxiety in different academic domains (e.g., Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013; Goetz et al., 2010; Goetz, Frenzel, Hall, & Pekrun, 2008; Gogol, Brunner, Martin, Preckel, & Goetz, 2017; Peixoto, Sanches, Mata, & Monteiro, 2017; Van der Beek, Van der Ven, Kroesbergen, & Leseman, 2017). Furthermore, there is also some cross-sectional evidence showing that the relationship between boredom and self-concept of ability is weaker compared to other emotions (Goetz et al., 2010). Despite the cross-sectional evidence of the relations between self-concepts of ability and emotions, little is known about the longitudinal dynamics of these constructs. The few longitudinal studies that have investigated the associations between self-concept of ability and achievement emotions have typically examined the direction of the effect from self-concept to emotions, but not vice versa. For example, in a longitudinal study, university students' academic control (equivalent to self-concept of ability) was shown to be negatively related to subsequent course-related boredom (Pekrun et al., 2010), whereas in a one-year longitudinal study among students in grades 7–9, math-related self-concept of ability was found to negatively predict math-related anxiety (Meece, Wigfield, & Eccles, 1990). Finally, a more recent longitudinal study by Pekrun, Murayama, Marsh, Goetz, and Frenzel (2019) showed that 5th and 9th Grade math self-concept of ability predicted negatively students' math-related anxiety and positively math-related enjoyment a year later. However, these studies did not examine the cross-lagged longitudinal relations between different achievement emotions and self-concepts of ability in several domains simultaneously and, therefore, were not able to show how different achievement emotions and self-concepts of ability in different domains are developmentally related across time.

1.3. The role of achievement emotions in subject-specific self-concepts

Previous literature has shown that mood affects memory, attention and judgments (for a review, see Forgas, 2017). The mood-congruency hypothesis suggests that people are likely to make negative judgments of their abilities when they experience negative mood and positive judgments when they experience positive mood (for a review, see Sedikides, 1992). As, feelings-as-information theory (Schwarz, 2012; see also Clore & Storbeck, 2006) implies, emotions can affect self-evaluation directly by implicitly giving information about a person's performance and this emotionally-biased information can downgrade or upgrade beliefs (Bandura, 1997). Therefore, people are likely to make positive

evaluations of themselves when they experience positive emotions and negative evaluations if they experience negative emotions. In addition, similar to associative network theory (Bower, 1981), control-value theory of achievement emotions (Pekrun, Frenzel, Goetz, & Perry, 2007) suggests that achievement emotions can affect self-concept of ability indirectly by triggering emotion-congruent memory networks. Therefore, negative emotions may activate past failures in memory, affecting self-evaluation negatively, whereas positive emotions may activate past successes, with a positive impact on self-evaluation (Bandura, 1997).

There is evidence supporting the mood-congruency hypothesis mainly from mood inductions studies that have investigated mood as a source of self-evaluations. According to these studies positive mood is positively related to subsequent self-evaluations while negative mood has an opposite effect (for a review, see Sedikides, 1992; see also Lyubomirsky, King, & Diener, 2005; Usher & Pajares, 2008), although there is also some evidence for mood-incongruency (for a review, see Sedikides & Green, 2001). However, as with the studies that have investigated self-concept of ability as a source for emotions, these studies did not test cross-lagged relations between self-concept of ability and specific emotions in different subject domains while also controlling for previous levels of the constructs, and thus they were unable to answer how these constructs are reciprocally related across time.

1.4. The present study

As suggested by the control-value theory (Pekrun, 2006; Pekrun & Perry, 2014), the present study builds on the assumptions that emotions might act as both a source and consequence of self-concept of ability (see also, Bandura, 1997; Zeidner, 1998; Marsh, Craven, & Debus, 1999). To our knowledge, only few studies have investigated reciprocal relations between achievement emotions and self-concepts of ability. Ahmed, Minnaert, Kuyper, and Van der Werf (2012) showed in their three-wave cross-lagged longitudinal study that higher mathematics anxiety predicted lower self-concept and lower self-concept predicted higher anxiety among students in Grade 7, whereas a three-wave longitudinal study from 4th to 7th grade in turn, showed that math self-concept of ability did not predict math related enjoyment but enjoyment predicted students' math self-concept of ability (Pinxten, Marsh, De Fraine, Van Den Noortgate, & Van Damme, 2014). Another two-wave longitudinal study of Grade 5 students (Garn et al., 2019) also investigated enjoyment but the focus was on physical activity enjoyment and its relations with physical self-concept and its different facets (e.g., coordination self-concept, endurance self-concept). The study did not find reciprocal relations between physical self-concept and physical activity related enjoyment, but the results showed that previous coordination self-concept predicted subsequent physical activity enjoyment and previous physical activity enjoyment predicted future sport self-concept. In a more recent cross-lagged longitudinal study, Zhang (2020) examined 8 and 10 Grade students' self-concepts of ability and anxiety in three school subjects (i.e., Chinese, English and mathematics) twice in a year and showed that previous self-concepts of ability negatively predicted subsequent anxiety in all three domains. However, previous anxiety also predicted negatively subsequent Chinese and math self-concepts of ability but not English self-concept of ability. Thus far, no previous longitudinal studies have examined the reciprocal relations between self-concept of ability and multiple achievement emotions simultaneously in several school subjects. Hence, the main aim of this study was to broaden the knowledge of the developmental dynamics between self-concepts of ability in two important subject-domains (mathematics and literacy) and frequently experienced achievement emotions (enjoyment, boredom, and anxiety) in adolescence.

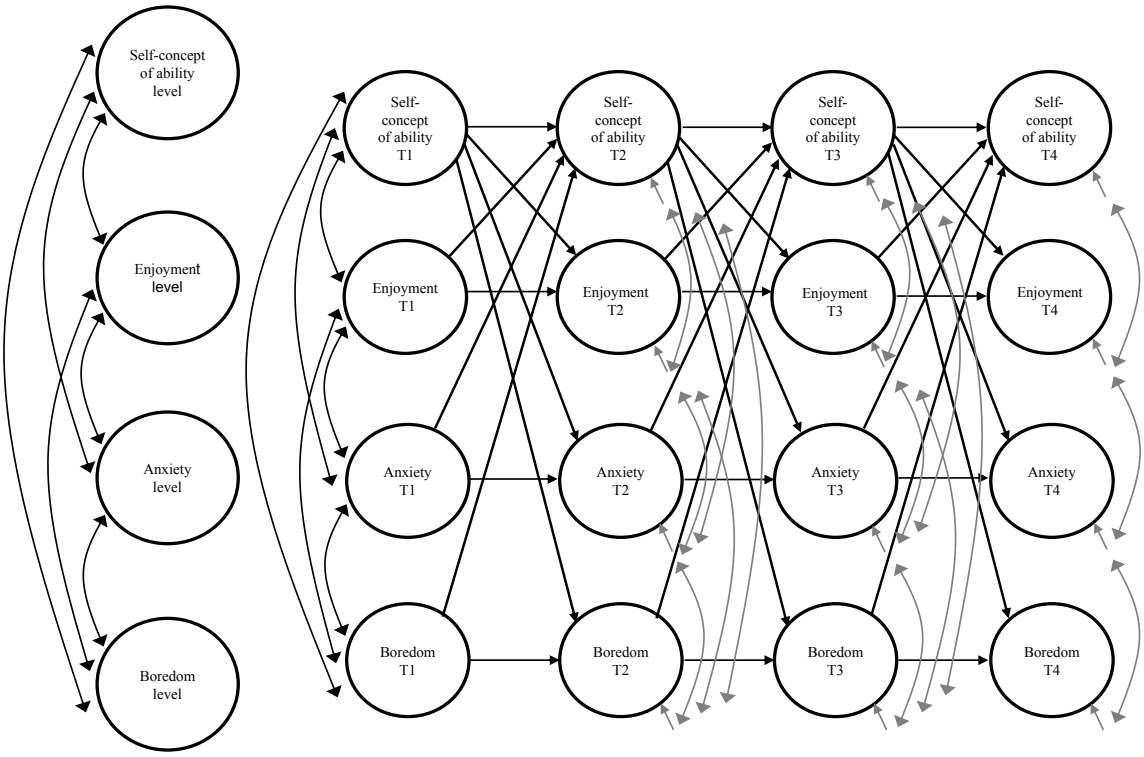

Fig. 1. Schematic model of associations between self-concept of ability and achievement emotions.

The research questions and hypotheses were as follows (for the schematic model, see Fig. 1):

(1) Do math and literacy self-concepts of ability predict adolescents' subsequent subject-specific enjoyment, anxiety, and boredom? H1: We expected prior self-concepts of ability would negatively predict anxiety and positively predict enjoyment (Pekrun, 2006; Pekrun & Perry, 2014; see also, Bandura, 1997; Zeidner, 1998). Because theoretical assumptions and empirical results concerning the relationship between self-concept and boredom have been inconsistent, no specific hypothesis was set concerning boredom.
(2) Do subject-specific achievement emotions (enjoyment, anxiety, and boredom) predict adolescents' subsequent literacy and math self-concepts of ability? H2: We expected prior enjoyment would positively predict self-concepts of ability and prior anxiety would negatively predict self-concepts of ability (Pekrun, 2006; Pekrun & Perry, 2014; see also, Bandura, 1997; Zeidner, 1998). Again, no specific hypothesis was set for boredom, because theoretical assumptions and empirical results of its role have been inconsistent.

Adolescents' gender and skills were controlled for in all the analyses as previous research has shown that gender and academic skills are related to students' self-concepts of ability (e.g., Marsh & Craven, 2006; Valentine et al., 2004; Wilgenbusch & Merrell, 1999). Furthermore, gender differences in achievement emotions have also been found in previous research (e.g., Hembree, 1990; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Soric, Penezić, & Burić, 2013), and skills have been found to play a role in achievement emotions (e.g., Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017; Pekrun et al., 2019).

2. Method

2.1. Participants

The research is part of an ongoing longitudinal study. Of all families initially contacted, 74% consented to the child's participation. The adolescents were recruited from one large town and one middle-sized town in central Finland, both including also semi-rural areas with smaller schools (for more details about the sample and its recruitment, see Hirvonen, Väänänen, Aunola, Ahonen, & Kiuru, 2018; Mauno, Hirvonen, & Kiuru, 2018). Parental written consent and child assent were required, and teachers also gave written consent for the data collection during their lessons. The research plan was approved by the local ethics committee.

The sample of this study consisted of 848 (457 girls, 54%) adolescents who were examined twice in Grade 6 and twice in Grade 7. Out of the 848 students, a total of 841 (99%) adolescents participated in Grade 6 fall, 836 (96%) participated in Grade 6 spring, 802 (95%) participated in Grade 7 fall and 793 (94%) participated in Grade 7 spring. The adolescents came from 57 classes (class size $M = 21$, $SD = 5.3$) and the average age of the adolescents at the outset was 12.32 years ($SD = 0.36$).

2.2. Procedure

The data was collected during normal school hours in four waves (Grade 6 fall, Grade 6 spring, Grade 7 fall, and Grade 7 spring) between 2014 and 2016. Self-concepts of ability and achievement emotions were measured at each wave, whereas achievement levels and gender were measured in Grade 6 fall. The trained research assistants administered the questionnaires.

2.3. Measures

Self-concept of ability. The questionnaires of self-concepts of ability in math and literacy were adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008) and included three items for both math and literacy (e.g., *How good are you at math calculation problems / at reading precisely and fast?*) on a 5-point Likert scale (1 = *very poor* to 5 = *very good*) (see also Pesu, Aunola, Viljaranta, Hirvonen, & Kiuru, 2018). The reliabilities of the self-concept of ability scales were good or adequate. For the math self-concept of ability Cronbach's alphas were 0.85 (Grade 6 fall), 0.86 (Grade 6 spring), 0.85 (Grade 7 fall), and 0.86 (Grade 7 spring). In turn, for the literacy self-concept of ability, Cronbach's alphas were 0.70 (Grade 6 fall), 0.67 (Grade 6 spring), 0.69 (Grade 7 fall), and 0.68 (Grade 7 spring). In the present study, the term *literacy self-concept of ability* refers to students' self-concepts of ability in the school subject of Finnish language (i.e., students' mother tongue).

Achievement emotions. Enjoyment, boredom, and anxiety toward mathematics and literacy were measured with the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011; for validity in the Finnish sample, see Sainio, Eklund, Hirvonen, Ahonen, & Kiuru, 2020). For both math and literacy subjects the AEQ included three items for enjoyment (e.g., *I enjoy acquiring new knowledge*), three items for anxiety (e.g., *I get tense and nervous while studying*), and two items for boredom (e.g., *I get bored while studying*) that were rated on a 5-point Likert scale (1 = *disagree* to 5 = *agree*). The reliabilities of the emotion scales in math and literacy were good or adequate. For math-related emotions the Cronbach's alpha's were as follows: 0.77 for enjoyment, 0.64 for anxiety and 0.76 for boredom (Grade 6 fall); 0.78 for enjoyment, 0.70 for anxiety and 0.78 for boredom (Grade 6 spring); 0.77 for enjoyment, 0.71 for anxiety and 0.77 for boredom (Grade 7 fall); 0.78 for enjoyment, 0.72 for anxiety and 0.79 for boredom (Grade 7 spring). In turn, for literacy-related emotions the Cronbach's alpha's were as follows: 0.72 for enjoyment, 0.62 for anxiety and 0.76 for boredom (Grade 6 fall); 0.77 for enjoyment, 0.70 for anxiety and 0.80 for boredom (Grade 6 spring); 0.75 for enjoyment, 0.69 for anxiety and 0.79 for boredom (Grade 7 fall); 0.76 for enjoyment, 0.69 for anxiety and 0.79 for boredom (Grade 7 spring).

Control variables. Adolescents' gender and academic skills in math and literacy were controlled for in the analyses. Gender was coded as 0 = boy and 1 = girl. Literacy skills were measured using three subtests. Two subtests (the error-finding test and the word-chain test) were from *Dyslexia Screening Methods for Adolescents and Adults* by Holopainen, Kairaluoma, Nevala, and Aho (2004; see also Kiuru et al., 2011) and the third test was the short version of Salzburg's reading fluency test (Landerl, Wimmer, & Moser, 1997). A sum score of the subtests was created by computing the mean of the three standardized test scores ($\alpha = 0.87$). Mathematics skills were assessed with the three-minute basic arithmetic test with the test–retest reliability 0.86 (Aunola & Räsänen, 2007; Räsänen, Salminen, Wilson, Aunio, & Dehaene, 2009).

2.4. Analysis strategy

First, we investigated the descriptive information of the data. Second, to answer the research questions we used random intercept cross-lagged panel model (RI-CLPM) for investigating reciprocal relationships between variables within individuals while controlling for differences between individuals (see Hamaker, Kuiper, & Grasman, 2015; for schematic model, see Fig. 1). The analyses were conducted separately for mathematics and literacy with the focus in the longitudinal associations between self-concept of ability, enjoyment, anxiety, and boredom. First, we built between-level factors for each emotion and self-concept that captured adolescents' average levels of emotions and self-concepts across all four measurement points. In these models, the between-level factors were allowed to correlate with each other. Second, we created within-person factors for each emotion and self-concept separately for each time point. The within-person factors and the residuals of the within-person factors were allowed to be correlated within each measurement point. Third, we estimated stability paths and cross-lagged paths between subsequent measurement points for the within-person factors of self-concepts of ability, and within-person factors of three emotions (enjoyment, anxiety, and boredom; see Fig. 1). Our main

interest was in the within-person cross-lagged paths between self-concept of ability and achievement emotions after accounting for between-person differences in the level of self-concept and academic emotions. In these models we also controlled for the effects of gender and academic skill level in the particular school subject.

The analyses were carried out using the the complex approach of the statistical package Mplus (Version 7.31, Muthén & Muthén, 1998–2015). When using this method the models are estimated at the level of the whole sample, but possible distortions of standard errors caused by the clustering of observations (classroom differences) are corrected. The proportion of missing data in the observed variables ranged from 0% to 8.6% ($M = 3.88$; $SD = 7.96$). Little's MCAR test (Little, 1988) showed that data in the self-concepts of ability, achievement emotions, and control variables were not missing completely at random: $\chi^2(334) = 632.61$, $p < .001$. Hence, missingness at random (MAR) was assumed, which is a weaker condition for missing data than missingness completely at random (MCAR). In the MAR situation, missingness does not depend on unmeasured variables but can depend on the values of the observed variables included in the analyses (Little, 1988). Assuming MAR, full-information maximum likelihood estimation was used in the analyses to deal with the missing data. Because all of the study variables were not fully normally distributed, we used maximum likelihood robust (MLR) estimation that produces robust standard errors by means of a sandwich estimator and a χ^2 test statistic for non-normal outcomes. Goodness-of-fit of the models was evaluated using the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the standardized root mean square residual (SRMR). RMSEA values below 0.06 and SRMR values below 0.06 indicate a good fit to the data, whereas CFI and TLI values close to 0.95 or above indicate a good fit to the data (see also Hu and Bentler 1999).

3. Results

3.1. Cross-lagged associations between self-concepts of ability and achievement emotions

Table 1 shows means, standard deviations, and correlations between the main variables (correlations for mathematics are presented in the upper diagonal and correlations for literacy are presented in the lower diagonal). Next, we present CLPM models separately for mathematics and literacy.

Mathematics. The final CLPM model for mathematics (see Fig. 2) fit the data well: RMSEA = 0.02, CFI = 1.00, TLI = 0.99 and SRMR = 0.02. Factor loadings of between-level factors for self-concept of ability ranged from 0.76 to 84, for boredom from 0.63 to 0.78, for anxiety from 0.62 to 0.75, and for enjoyment from 0.68 to 0.80. The results showed that interindividual differences in achievement emotions and self-concepts of abilities were relatively stable. The between-level self-concept of ability factor had a moderate positive correlation with the between-level enjoyment factor and a weak negative correlation with the between-level anxiety and boredom factors: the higher the adolescents' self-concept of ability in math was, the more enjoyment, the less anxiety and the less boredom toward math they reported.

The within-person level results showed further that self-concept of ability was reciprocally related with math anxiety and enjoyment even after controlling for between-individual differences in the levels of self-concept of ability and emotions, and after accounting for the effects of the control factors (i.e., gender and skill level). The higher the self-concept of ability in the fall of Grade 6, the more enjoyment and less anxiety a student had toward math in the spring of Grade 6. The more enjoyment and less anxiety a student had in the spring of Grade 6, the higher was self-concept in the fall of Grade 7. Finally, the higher the self-concept in the fall of Grade 7, the less anxiety and more enjoyment a student had toward mathematics in the spring of Grade 7. Self-concept of ability also predicted boredom: the higher the self-concept in the fall of Grade 6, the spring of Grade 6, and the fall of Grade 7, the less boredom a student had toward math at subsequent measurement points (see Fig. 2). However, boredom did not predict subsequent self-concept of ability. Self-concepts of ability accounted for 8% to 16% of the variance in subsequent emotions at the within-person level. Total variance in self-concepts of ability at the within-person level explained by emotions and control variables ranged from 9% to 12%. Achievement emotions accounted for 8% to 10% of the variance in subsequent self-concepts of ability at the within-person level, whereas the proportion of the variance in emotions at the within-person level explained by control variables and self-concepts of ability ranged from 3% to 7%.

Literacy. The final model of literacy (see Fig. 3) fit the data well: RMSEA = 0.02, CFI = 1.00, TLI = 0.99 and SRMR = 0.03. Factor loadings of the between-level factor for self-concept of ability ranged from 0.79 to 81, for boredom from 0.64 to 0.76, for anxiety from 0.65 to 0.80, and for enjoyment from 0.70 to 0.81. The between-level self-concept of ability factor had a weak positive correlation with the between-level enjoyment factor and a weak negative correlation with the between-level anxiety and boredom factors: the higher the adolescents' self-concept of ability in literacy, the more enjoyment, the less anxiety and the less boredom toward literacy they reported. The within-level results showed that self-concept of ability did not predict subsequent emotions and emotions did not predict subsequent self-concept of ability.

4. Discussion

The main purpose of this study was to investigate to what extent adolescents' self-concepts of ability predict their achievement emotions (enjoyment, boredom, and anxiety) and to what extent these achievement emotions predict self-concepts of ability in mathematics and literacy from grades 6 to 7. Although the relations between domain-specific self-concept of ability and achievement emotions has been well demonstrated in previous research (for a summary, see Pekrun & Perry, 2014), there has been a lack of knowledge on the developmental dynamic of these constructs across time. Particularly, longitudinal studies focusing on multiple achievement emotions in many academic domains simultaneously have been lacking. This study increased our understanding of how self-concepts of ability in two main school subjects (literacy and mathematics) and frequently experienced achievement emotions (enjoyment, anxiety and boredom) influence each other over time among adolescents. The results indicated first that in mathematics higher self-concept of ability was longitudinally and reciprocally related to subsequent higher enjoyment and lower anxiety, when controlling for previous levels of the constructs as well as gender and skill level. For boredom, a lower self-concept of ability in mathematics predicted higher subsequent boredom toward mathematics, but boredom did not predict self-concept of ability. Second, in literacy, no longitudinal cross-lagged predictions between self-concept of ability and achievement emotions were found.

4.1. Associations between self-concepts of ability and emotions in mathematics

Our results regarding developmental dynamics between enjoyment and self-concepts of ability in mathematics were in line with our hypotheses H1 and H2 and theoretical assumptions (Pekrun, 2006; Pekrun & Perry, 2014). Accordingly, the results among early adolescents showed that higher math self-concept of ability predicted higher enjoyment and higher enjoyment predicted better self-concept of ability, creating a positive cycle between self-concept and enjoyment of mathematics. This result is in line with Pekrun et al. (2019) study showing that adolescents' higher self-concept in math was related to higher enjoyment toward studying math a year later and with studies that have shown that positive mood lead to positive self-perceptions (for reviews, see Lyubomirsky et al., 2005; Sedikides, 1992). This result is also similar

Table 1
Correlations Between the Main Study Variables and Means and Standard Deviations (math at the upper diagonal and literacy at the lower diagonal).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Literacy/math self-concept of ability T1		0.78***	0.71***	0.63***	0.48***	0.50***	0.41***	0.35***	−0.30***	−0.33***	−0.27***	−0.19***	−0.20***	−0.20***	−0.19***	−0.17***	−0.23***	0.47***	3.83	0.73
2. Literacy/math self-concept of ability T2	0.71***		0.76***	0.70***	0.46***	0.55***	0.46***	0.38***	−0.31***	−0.36***	−0.29***	−0.23***	−0.19***	−0.24***	−0.21***	−0.17***	−0.20***	0.49***	3.80	0.73
3. Literacy/math self-concept of ability T3	0.67***	0.71***		0.76***	0.47***	0.53***	0.57***	0.47***	−0.27***	−0.35***	−0.35***	−0.29***	−0.19***	−0.23***	−0.30***	−0.26***	−0.16***	0.47***	3.81	0.73
4. Literacy/math self-concept of ability T4	0.63***	0.64***	0.69***		0.45***	0.47***	0.51***	0.53***	−0.24***	−0.30***	−0.32***	−0.26***	−0.18***	−0.23***	−0.26***	−0.28***	−0.11**	0.43***	3.73	0.80
5. Enjoyment T1 toward literacy/math	0.34***	0.33***	0.33***	0.31***		0.69***	0.61***	0.52***	−0.31***	−0.31***	−0.30***	−0.23***	−0.54***	−43***	−0.37***	−0.34***	−0.04	0.23***	3.30	1.00
6. Enjoyment T2 toward literacy/math	0.32***	0.38***	0.32***	0.31***	0.67***		0.68***	0.56***	−0.33***	−0.41***	−0.33***	−0.29***	−0.44***	−0.52***	−0.42***	−0.36***	−0.06	0.29***	3.32	1.00
7. Enjoyment T3 toward literacy/math	0.31***	0.31***	0.37***	0.33***	0.61***	0.66***		0.64***	−0.27***	−0.31***	−0.38***	−0.29***	−0.37***	−0.43***	−0.51***	−0.42***	−0.03	0.25***	3.40	0.93
8. Enjoyment T4 toward literacy/math	0.27***	0.29***	0.32***	0.36***	0.44***	0.53***	0.63***		−0.23***	−0.30***	−0.29***	−0.33***	−0.31***	−0.35***	−0.37***	−0.53***	0.03	0.22***	3.10	1.00
9. Anxiety T1 toward literacy/math	−0.29***	−0.29***	−0.29***	−0.25***	−0.30***	−0.32***	−0.28***	−0.18***		0.61***	0.54***	44***	0.40***	0.27***	0.27***	0.23***	0.05	−0.16***	1.90	0.81
10. Anxiety T2 toward literacy/math	−0.28***	−0.33***	−0.32***	−0.31***	−0.30***	−0.39***	−0.31***	−0.25***	0.61***		0.63***	0.49***	0.30***	0.44***	0.31***	0.25***	0.02	−0.19***	1.82	0.83
11. Anxiety T3 toward literacy/math	−0.26***	−0.30***	−0.29***	−0.31***	−0.29***	−0.33***	−0.34***	−0.26***	0.50***	0.62***		0.54***	0.27***	0.34***	0.49***	0.30***	0.05	−0.15***	1.70	0.80
12. Anxiety T4 toward literacy/math	−0.22***	−0.24***	−0.22***	−0.24***	−0.21***	−0.27***	−0.29***	−0.30***	0.38***	0.46***	0.51***		0.24***	0.31***	0.32***	0.52***	−0.07	−0.09**	2.01	0.90
13. Boredom T1 toward literacy/math	−0.14***	−0.13**	−0.17***	.−0.12**	−0.53***	−0.47***	−0.39***	−0.26***	0.39***	0.31***	0.26***	0.23***		0.60***	0.48***	0.43***	−0.03	−0.06	2.02	1.02
14. Boredom T2 toward literacy/math	−0.12**	−0.15***	−0.19***	−0.13**	−0.44***	−0.55***	−0.43***	−0.33***	0.28***	0.43***	0.34***	0.25***	0.60***		0.59***	0.51***	−0.10**	−0.04	1.90	1.00
15. Boredom T3 toward literacy/math	−0.16***	−0.18***	−0.20***	−0.16***	−0.36***	−0.44***	−0.50***	−0.39***	0.28***	0.35***	0.49***	0.31***	0.52***	0.62***		0.52***	−0.04	−0.06	1.84	1.00
16. Boredom T4 toward literacy/math	−0.11**	−0.13**	−0.16***	−0.13***	−0.30***	−0.39***	−0.52***	−0.52***	0.18***	0.25***	0.28***	0.51***	0.40***	0.50***	0.56***		−0.10*	−0.04	2.31	1.13
17. Gender	0.10**	0.12**	0.13**	0.11***	0.14***	0.14***	0.18***	0.17***	−0.10**	−0.10**	−0.08*	−0.16***	−0.14***	−0.16***	−0.18***	0.19***		−0.09**	0.54	0.50
18. Literacy/math skills	0.50***	0.49***	0.43***	0.48***	0.15***	0.15***	0.15***	0.15***	−0.18***	−0.19***	−0.12***	−0.12***	0.03	0.04	0.01	0.04	0.22***		0.10	1.00
19. Literacy/math mean	4.00	3.94	4.00	3.90	3.10	3.12	3.30	3.00	1.90	1.80	1.70	2.00	2.12	2.04	1.90	2.31	0.54	0.06		
20. Literacy/math standard deviation	0.54	0.53	0.54	0.60	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.84	1.03	1.10	1.02	1.14	0.50	1.01		

to Pinxten et al. (2014) results from a 3-year longitudinal study among 4th graders which showed that enjoying math predicted students' math self-concept and Garn et al. (2019) cross-lagged longitudinal study that showed that 5th graders coordination self-concept predicted enjoying physical activities and enjoying these activities, in turn, predicted sport self-concept. However, these studies did not find a positive reciprocal relationship between enjoyment and self-concept of ability as was found in our study. An explanation for this positive cycle can be provided by the broaden-and-build theory of positive emotions (Fredrickson, 2001), which suggests that positive emotions broaden an individual's momentary thought-action repertoires by triggering novel ideas and creative thinking and by urging one to explore and be open to learning new information. This can lead to actions for building personal resources such as self-concept of ability, which in turn can increase positive emotions.

There are also other possible explanations for the reciprocal associations between self-concept of ability and enjoyment in math. First, positive perception of one's abilities in math might signal that one is able to master the required tasks, which instigates enjoyment toward learning (Pekrun & Perry, 2014). Second, enjoyment toward learning mathematics may instigate mood-congruent judgments of one's math abilities by directly acting as source for math self-concept evaluation by interpreting positive math-related emotions as an indication of one's math self-concept of ability (Schwarz 2012; Clore & Storbeck, 2006; see also Bandura, 1997). Third, positive emotions toward math learning may make positive mood-congruent events and math-related memories more accessible from memory, resulting in positive judgments of self-concept of ability (Bower, 1981; see also Bandura, 1997; Pekrun et al., 2007). This may enable adolescents to use positive emotions and memories as a resource to verify or even enhance their self-concept (Kwang & Swann, 2010; Swann & Buhrmester, 2012). To preserve their consistent self-views, adolescents with higher self-concept of ability in math might also strive to maintain their positive learning emotions toward math while adolescents with lower self-concept of ability are less likely to do so (see also Gomez-Baya, Mendoza, Gaspar, & Gomes, 2018; Wood, Heimpel, & Michela, 2003). Overall, there is increasing evidence of positive emotions' power to build capabilities and resources, which further increase positive emotions and over time may lead to emotional wellbeing (for reviews, see Fredrickson, 2005, 2013; see also Aspinwall, 1998).

The findings for the relationship between self-concept and anxiety in mathematics were in line with our hypotheses H1 and H2 and theoretical assumptions (Bandura, 1997; Pekrun, 2006; Pekrun & Perry, 2014; Zeidner, 1998) by showing that lower self-concept of ability predicted higher anxiety toward learning and higher anxiety in turn predicted lower self-concept. These results resemble previous studies that have shown that people are prone to make negative judgments of themselves when in a negative mood (for reviews, see Sedikides, 1992; see also Usher & Pajares, 2008). The results are also in line with the findings of Pekrun et al. (2019) and Meece et al. (1990) showing that adolescents' higher math self-concept of ability predicted lower anxiety related to math studying. Similarly, the results are consistent with the cross-lagged longitudinal studies by Ahmed et al. (2012) and Zhang (2020) who showed that higher anxiety predicted lower self-concept and lower self-concept predicted higher anxiety in mathematics. Zhang (2020) also found similar reciprocal relationship between self-concept and Chinese subject, whereas in English a lower self-concept was related to higher anxiety but not vice versa.

There are several possible explanations for why we found math self-concept of ability and anxiety toward math-learning to be reciprocally related. First, low self-concept of ability in math might give information to the student that one is not up to the task demands thereby triggering anxiety (Bandura, 1997; Csikszentmihalyi et al., 2005). Second, as in the case of enjoyment and self-concept of ability relations, it is possible that anxiety toward math instigates mood-congruent judgments of one's math abilities (Bower, 1981; Clore & Storbeck, 2006; Schwarz, 2012; see also Bandura, 1997; Pekrun et al., 2007), and thus results in lowered self-concept of ability in math. Furthermore, it is also possible that adolescents with lower self-concept of ability in math are less likely than adolescents with a higher self-concept of ability to lift their negative feelings toward math (see also Heimpel, Wood, Marshall, & Brown, 2002), thus enabling them to verify their math self-concept of ability (Kwang & Swann, 2010; Swann & Buhrmester, 2012). Overall, the found negative reciprocal relations between math anxiety and self-concept of ability indicate a negative cycle. It is possible that lower self-concept of ability in math can heighten vigilance of threats and magnify the severity of threats, leading to an increase in math anxiety, which in turn may feed maladaptive coping behavior and cognitions related to math and further elaborating and maintaining a negative self-concept of ability in math (Bandura, 1997; see also Zeidner & Matthews, 2005). In sum, it seems that as suggested by self-verification theory (Swann & Buhrmester, 2012), adolescents with lower self-concept of ability in math may have a tendency to hang on to their unfavorable view of themselves, whereas adolescents with a higher self-concept of ability may have a tendency to restore their positive self-views.

Because theoretical assumptions and empirical findings concerning the relationship between self-concept and boredom have been inconsistent, no specific hypothesis was set concerning their relations. Our findings for the relationship between boredom and self-concept of ability in mathematics showed that lower self-concept of ability predicted higher boredom but boredom did not predict subsequent self-concept of ability. This result is in line with a previous study among university students showing that academic control (equivalent to self-concept of ability) was negatively related to subsequent course-related boredom (Pekrun et al., 2010). The found negative relationship between self-concept of ability and subsequent boredom in math is also similar to previous cross-sectional studies that have found boredom to be associated with low self-concept of ability (e.g., Goetz et al., 2010; Peixoto et al., 2017). If students with low self-concept of ability feel that they do not have the ability to cope with math tasks, they may start to devalue the subject and this perceived lack of control and low value then creates boredom (Pekrun, 2006). It is likely that students with low self-concept feel overchallenged (see also Krannich et al., 2019) and reporting boredom in overchallenging situations may act as a way to protect their self-worth, as students can thus avoid attributing the difficulty they have with the task to their ability (Acee et al., 2010; see also Covington, 1984). In contrast, although it has been suggested that gifted or high ability students can experience boredom in school because boredom may be triggered when ability level is high and task demands are low (Csikszentmihalyi et al., 2005) or when they feel underchallenged instead of overchallenged (Krannich et al., 2019; Preckel, Götz, & Frenzel, 2010; see also Daschmann et al., 2011), our results suggest that high self-concept of ability was related to low feelings of boredom. Consequently, it is possible that students with high self-concept of ability are generally satisfied with the level of challenge they face at school and they value the tasks they are given, and thus experienced less boredom. However, these explanations are speculative in nature since, to our knowledge, this study was the first that investigated cross-lagged relationships between boredom and self-concept of ability. Future studies are needed to examine more detailed dynamics between self-concept of ability, task demands and value when predicting boredom.

It is also notable that although math self-concept predicted subsequent boredom, boredom toward math, in turn, was not related to subsequent math self-concept of ability. One possible explanation for this result is that when they are bored, students distance themselves from the learning activities and from the chance to evaluate their abilities in action. Boredom has been associated with low motivation and effort and poor study strategies (Pekrun et al., 2010; see also Tze, Daniels, & Klassen, 2016). Disengagement from the tasks and the use of ineffective strategies, on the other hand, do not provide students realistic information about the abilities they would need to build their self-

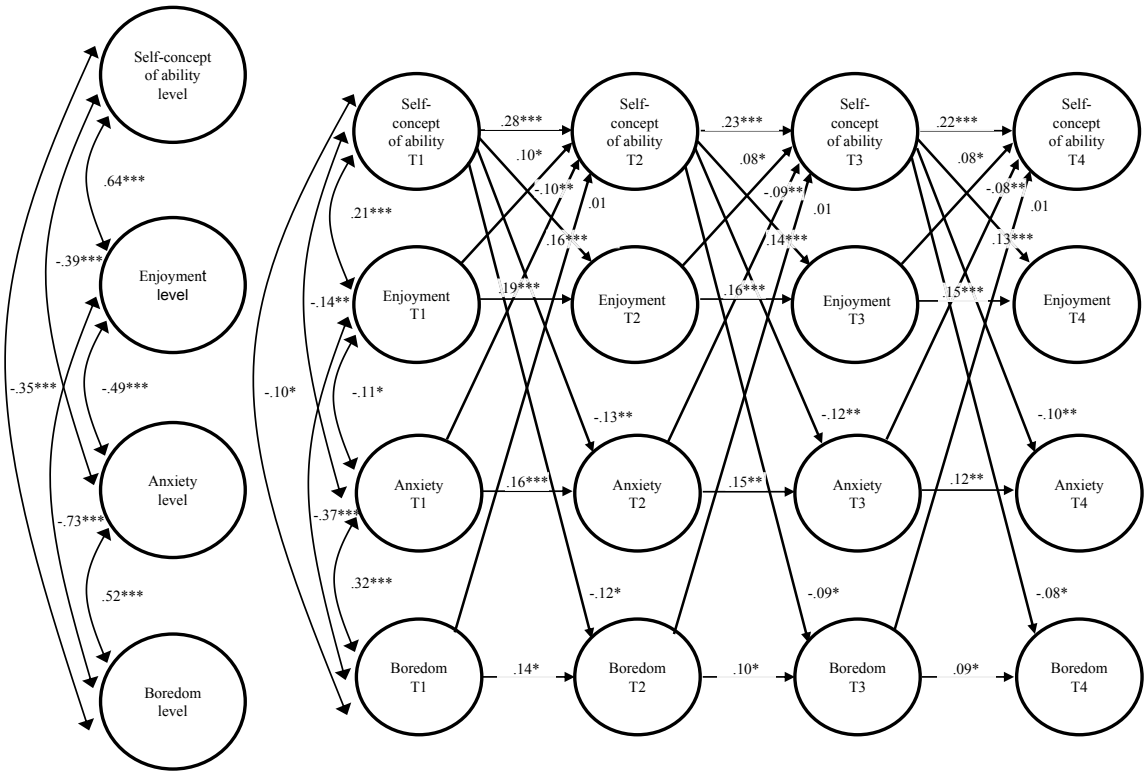

Fig. 2. Final random intercept cross-lagged panel model for mathematics. Standardized estimates are presented, ***p < .001, **p < .01, *p < .05.

concept of math ability.

4.2. Associations between self-concepts and achievement emotions in literacy

Our results regarding developmental dynamics between achievement emotions (enjoyment, anxiety and boredom) and self-concepts of ability in literacy domain did not support our hypotheses H1 and H2 or theoretical assumptions (Pekrun, 2006; Pekrun & Perry, 2014; see also Bandura, 1997; Zeidner, 1998). That is, in literacy (as opposed to mathematics), no predictions between self-concept of ability and achievement emotions were found. In general, our results revealing longitudinal associations in mathematics but not in literacy resemble some previous cross-sectional studies (Clem, Rudasill, Hirvonen, Aunola, & Kiuru, 2020; Goetz et al., 2010) that have shown that relations between self-concept of ability and emotions is stronger in quantitative fields such as mathematics compared to verbal domains, as well as with a recent longitudinal study that also found stronger relations between math self-concept of ability and math-related anxiety compared to language domains (Zhang, 2020).

Goetz et al. (2010) suggest that the stronger relationships in mathematics may be due to mathematics typically having a narrower range of classroom activities than in literacy, therefore having also limited sources for emotions and self-concepts construction. Another possible explanation for the divergent results in mathematics and literacy is that individual differences in maths increase across time (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004) and are wider than in reading (e.g., Leppänen, Niemi, Aunola, & Nurmi, 2004; Parrila, Aunola, Leskinen, Nurmi, & Kirby, 2005). Therefore, there may be more room in maths (than in literacy) for influences of motivational factors. However, as far as we know the present study was the first to investigate the developmental dynamics between multiple achievement emotions and self-concept of ability in two domains using cross-lagged longitudinal procedure. Therefore future studies should examine in more depth the differences in multiple subject-domains to gain better understanding of the possible differences between different school subjects.

4.3. Strengths, limitations and future directions

Previous longitudinal cross-lagged studies of the relations between self-concept of ability and achievement emotions are rare and have mainly been concerned with single emotions in single achievement domains. The major strength of this study was that we were able to test the theoretical assumptions concerning the relations between self-concept of ability and achievement emotions in a cross-lagged longitudinal study in two important school subjects and three different achievement emotions, thus allowing us to broaden the knowledge of the reciprocal dynamics between self-concept of ability and emotions. More specifically, this study was able to broaden knowledge of developmental dynamics of self-concept of ability and achievement emotions by showing that at least in mathematics achievement emotions are material for self-concept construction, and that self-concept of ability plays a role in the development of enjoyment, anxiety and boredom toward math learning.

As in any research, there are some limitations in the study that need to be taken into account when interpreting the results. First, this study investigated the self-concepts of ability as well as enjoyment, anxiety, and boredom in literacy and mathematics of students in grades 6 and 7. It is possible that the relations we found could be different in different age groups and in different subject domains (Goetz et al., 2010), and

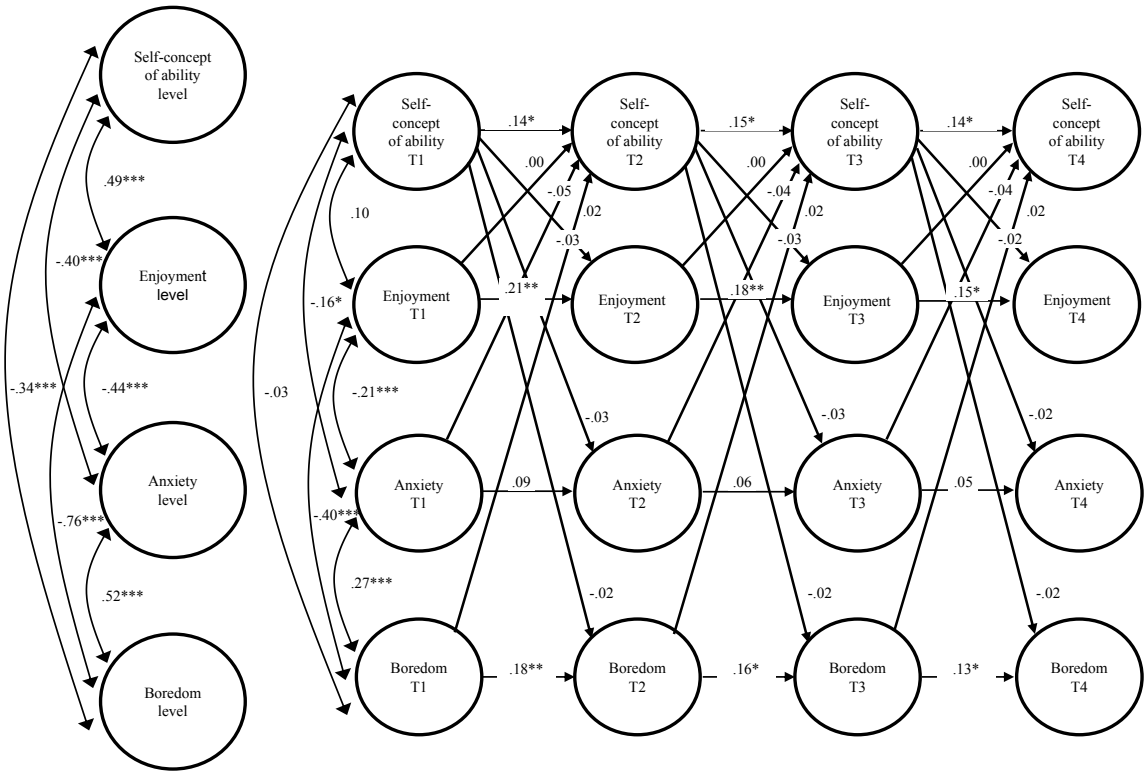

Fig. 3. Final random intercept cross-lagged panel model for literacy. Standardized estimates are presented, ***p < .001, **p < .01, *p < .05.

thus, one should be cautious about generalizing the results beyond the population used in this study. Second, although most of the reliabilities of the used scales were good or adequate, some were relatively low, which may partly result from the fact that the scales used to measure self-concepts and emotions were relatively short. Future studies should consider measuring adolescents' self-concepts and emotions more thoroughly with longer scales, although keeping in mind how to motivate adolescent participants to fill the questionnaires carefully. Third, it is notable that in this study the developmental associations between self-concepts of ability and emotions were investigated separately in mathematics and literacy domains. In future studies it would be important to also study spillover effects of self-concepts of ability and emotions between different achievement domains and relate these dynamics to adolescents' achievement. The internal/external frame of reference model of self-concept (I/E model; Marsh, 1986; Marsh et al., 2015) proposes that in addition to social comparisons in regards to achievement, self-concepts are also influenced by internal comparisons, where individuals compare their own relative achievement and abilities between different academic subjects. It would be an intriguing challenge for further research to include achievement emotions in different domains in the same model to investigating the assumptions of the I/E model. In the future, it would also be important to examine more distant antecedents (e.g., teacher–student relationship quality) of emotions and investigate the role of self-concept as a possible mediator between environmental factors and achievement emotions in longitudinal samples. Finally, it would be also important to examine how these dynamics between self-concepts of ability and achievement emotions are related to students' achievement, engagement in school and wellbeing over time.

4.4. Conclusions and implications

The findings of the current study suggest that achievement emotions and self-concept of ability are developmentally related in a reciprocal manner at least in mathematics. Previous research has shown that low levels of self-concept of ability can impede learning (e.g., Valentine et al., 2004), while there is also evidence that enhancing skills and attribution re-training can promote self-concept of ability (e.g., O'Mara, Marsh, Craven, & Debus, 2006). The findings of the current study added to the literature by showing that math self-concept of ability could also be supported by increasing math enjoyment and reducing math anxiety. Maintenance of enjoyment is vital as a sustaining force in learning activities and has been shown to be positively related to achievement and motivation (for a review, see Pekrun, 2017). Math anxiety can, in turn, have long-term educational implications by leading to avoidance of math, thus affecting math skills negatively and decreasing enrollment in advanced math classes and further affecting future career paths (Ashcraft, 2002; Ashcraft & Ridley, 2005; Hembree, 1990). Furthermore, boredom can distract from learning activities, and thus have deteriorating effects on learning and motivation (for a review, see Pekrun, 2017). One way to reduce boredom and anxiety and increase enjoyment toward math as suggested by findings of this research is to boost self-concept of ability in math. Other ways to reduce boredom and anxiety have been suggested, such as methods for coping with boredom (e.g., Nett, Goetz, & Daniels, 2010), cognitive-behavioral treatment of anxiety (e.g., Hembree, 1990; see also Zeidner, 2014), and creating classrooms that can reduce math anxiety and boredom in school (e.g., Finlayson, 2014; Geist, 2010; Goetz & Hall, 2014). In sum, regarding the practical implications of the current study, learning motivation and achievement in mathematics, in particular, could be enhanced by enhancing positive

emotions, reducing negative emotions, and promoting self-concept of ability.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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III

THE ROLES OF TEACHER-STUDENT RELATIONSHIP QUALITY AND SELF-CONCEPT OF ABILITY IN ADOLESCENTS' ACHIEVEMENT EMOTIONS: TEMPERAMENT AS A MODERATOR

by

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The roles of teacher–student relationship quality and self-concept of ability in adolescents' achievement emotions: temperament as a moderator

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Abstract

This study examined to what extent teacher–student conflict and closeness, on the one hand, and students' self-concepts of ability in literacy and mathematics, on the other, are related to students' achievement emotions (enjoyment, anxiety and boredom) in mathematics and literacy among Finnish early adolescents ($N = 854$). We also investigated the extent to which these associations are moderated by student temperament (surgency/extraversion, negative affectivity and effortful control). The results showed, after accounting for relevant covariates, that in both school subjects, teacher–student conflict was negatively related to enjoyment and positively to anxiety and boredom, whereas teacher–student closeness was positively related to enjoyment and negatively to boredom. Self-concepts of ability in both school subjects were positively related to enjoyment and negatively to anxiety, whereas the self-concept of ability was only negatively related to boredom in mathematics. Student temperament also moderated some of the associations in the literacy domain. Lower levels of conflict in the teacher–student relationship were related to higher levels of enjoyment in literacy, particularly among students who had lower levels of surgency/extraversion. Also, a closer relationship with the teacher or a lower self-concept of ability in literacy was related to higher levels of anxiety, particularly among students who had low effortful control. In the mathematics domain, the associations between the self-concept of ability and achievement emotions were somewhat stronger than in literacy, and the domain-specific associations were not dependent on student temperament.

Keywords Adolescence · Achievement emotions · Self-concept of ability · Teacher–student relationship · Temperament

This investigation was conducted as part of an ongoing longitudinal Finnish study called the STAIRWAY Study (Ahonen and Kiuru 2013).

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Introduction

Students experience a variety of emotions related to learning activities (Raccanello et al. 2013). In previous literature, positive emotions (e.g. enjoyment) have been found to be beneficial for motivation and facilitative of the use of flexible learning strategies, thus enhancing achievement (e.g. Pekrun et al. 2002), whereas negative emotions (e.g. boredom) have been found to have adverse effects on motivation, cognitive resources and learning strategies, and thereby have a negative impact on performance (e.g. Goetz and Hall 2014). According to Pekrun's (2006) control-value theory of achievement emotions, antecedents of achievement emotions include characteristics of students, such as the self-concept of ability, on the one hand, and instructional and social factors, on the other. In previous empirical research (for an overview, see Pekrun and Perry 2014), the role of students' self-concept of ability in achievement emotions has been well established, whereas the role of the quality of teacher–student relationships is less studied. It has also been suggested that student temperament, that is, individual differences in responding to external and internal stimuli and in regulating these reactions (Rothbart and Bates 2006), might impact adolescents' developmental plasticity and susceptibility to environmental influence (Belsky and Pluess 2009). However, it is not known what role adolescent temperament plays in the associations of the self-concept of ability and the teacher–student relationship with achievement emotions. Consequently, this study aimed to investigate the roles of the self-concept of ability and the teacher–student relationship in the evolvement of early adolescents' achievement emotions and to discover whether these associations differ depending on adolescent temperament.

Self-concept of ability as an antecedent of achievement emotions

Achievement emotions refer to emotions that relate to achievement outcomes or to emotions that occur during achievement-related activities (Pekrun and Perry 2014). The present study examined frequently experienced achievement emotions (Goetz and Hall 2014), namely, enjoyment, boredom and anxiety, among early adolescents. Because previous research has shown that achievement emotions are domain-specific (e.g. Goetz et al. 2007; Raccanello et al. 2013), in the present study, achievement emotions were assessed separately in two central academic subjects, namely, mathematics and Finnish language.

According to the control-value theory of achievement emotions (Pekrun and Perry 2014), students' control and value appraisals are central to the emergence of achievement emotions. The self-concept of ability forms a basis for experiences of subjective control over achievement activities and outcomes. In previous research, self-concepts of ability in different subject domains have been found to be positively related to enjoyment and negatively to boredom and anxiety (Bieg et al. 2013; Goetz et al. 2006, 2010). However, the majority of the studies investigating the relations between the self-concept of ability and achievement emotions have been conducted on older students, and less is known about these associations in primary school students (see also Pekrun and Perry 2014). Consequently, the first aim of the present study is to investigate the domain-specific relations of maths and literacy self-concepts of ability and achievement emotions in sixth-grade adolescents.

Teacher–student relationship quality and achievement emotions

According to the control-value theory of achievement emotions, not only are individual characteristics potential sources of emotions but instructional and social antecedents are also

important antecedents of achievement emotions (Pekrun and Perry 2014). The present study focuses on teacher–student relationship quality, applying an attachment-based teacher–student relationship model (see also Pianta 2001; Verschueren 2015). In this model, closeness and conflict are considered as key dimensions of the teacher–student relationship. Closeness is characterised by high levels of affection and open communication between the teacher and the student, whereas conflict refers to perceived negativity within the teacher–student relationship (Jerome et al. 2009; Pianta 2001).

Teacher–student relationships are developmentally significant for students' socioemotional adjustment and achievement in school (e.g. Bergin and Bergin 2009; Hamre and Pianta 2001; Pakarinen et al. 2018). There are several theoretical reasons as to why teacher–student relationship quality can be assumed to also be related to adolescents' achievement emotions. For example, close and supportive teacher–student relationships can boost adolescents' sense of social relatedness and belonging within the classroom, which, in turn, may promote positive and hinder negative emotions towards learning (Meyer 2014; Sakiz et al. 2012; Skinner et al. 2014). Although teacher–student relationship quality has been found to be important in terms of academic outcomes, such as higher school engagement and academic performance (for a meta-analysis, see Roorda et al. 2011), less is known about the role of the teacher–student relationship quality in the arousal of early adolescents' subject-specific achievement emotions. Previous empirical studies have suggested that high teacher support tends to be related with lower negative and higher positive achievement emotions (for a meta-analysis, see Lei et al. 2018). However, less is known about the role that teacher–student relationships have on single achievement emotions, such as enjoyment, boredom and anxiety. There is nevertheless some evidence to suggest that high-quality teaching is related to more enjoyment and less boredom and anxiety in mathematics and Latin among students in grades 5–10 (Frenzel et al. 2007; Goetz et al. 2006). Similarly, there is some evidence among students in grades 8–11 that suggests that a teacher's supportive presentation style is related to higher learning enjoyment and decreased boredom but not related to anxiety, whereas a teacher's excessive lesson demands are related to higher anxiety and boredom and lesser enjoyment (Goetz et al. 2013). Teacher punishment behaviour, in turn, has been found to be related to higher levels of anxiety and boredom (Frenzel et al. 2007). However, less is known thus far about how early adolescent-perceived closeness and conflict in the teacher–student relationship are related to achievement emotions. Therefore, the second aim of the present study is to find out to what extent the closeness and conflict of teacher–student relationships are related to adolescents' boredom, enjoyment and anxiety with regard to literacy and mathematics.

Temperament as a moderator

According to the diatheses stress and differential susceptibility models (Belsky and Pluess 2009), individuals with different temperaments vary in their developmental plasticity and susceptibility to environmental influence. Temperament can be defined as early occurring individual differences in reactivity towards environmental and internal stimuli and in self-regulation modulating this reactivity (Rothbart and Bates 2006). Temperament develops via a complex interplay among genes and biological and environmental factors (Shiner et al. 2012), and, thus, it is influenced by experience and maturation (Rothbart and Derryberry 1981). In the present study, we applied Rothbart's temperament model, which has consistently identified three broad dimensions of temperament (Rothbart 2011; Rothbart and Bates 2006; Rothbart and Hwang 2005). *Effortful control* refers to the ability to control behaviour and regulate

emotions, including attentional, inhibitory and activation control. *Negative affectivity* refers to individual differences in proneness to distress and negative emotions and rate of recovery. *Surgency/extraversion* relates to individual differences in approach behaviour and positive affect.

The goodness-of-fit model (Thomas and Chess 1977) posits that goodness of fit (i.e. adaptive outcome) will result if the child's or adolescent's temperament fits well with the demands and expectations of the environment. However, the most typical environment that has been studied in relation to temperament characteristics is the parent–child relationship, along with parenting behaviours (e.g. Rothbart and Bates 2006). As far as we know, no previous studies have investigated whether student temperament moderates the associations between the teacher–student relationship and achievement emotions. However, there are a few studies on other student outcomes. For example, previous research has suggested that children and adolescents with low levels of effortful control may particularly benefit from positive relationships with teachers as demonstrated by decreased problem behaviours (Wang et al. 2013) and increased academic achievement (Rudasill et al. 2010). There is also some evidence suggesting that children with high effortful control are less influenced by a negative teaching style in terms of general anxiety symptoms compared to children with weaker effortful control (LaBillois and Lagacé-Séguin 2009).

Similarly, as temperament may make some adolescents more susceptible to teacher effects, it may play a role in how self-concept affects emotions. Temperament can influence how students interpret their experiences (Lonigan et al. 2004; Shiner and Caspi 2012). For example, previous research has shown that effortful control plays a role in modulating the affective consequences of threat-relevant stimuli (Lonigan et al. 2004). Thus, higher effortful control may provide protection from the detrimental effects of a low self-concept on achievement emotions by allowing the shifting of attention from threatening stimuli and internal feelings of inadequate ability to more positive information that enables efficient coping, whereas weak effortful control may make students susceptible to focusing on their internal distress, thus exacerbating the effects of a low self-concept on achievement emotions (see also Derryberry and Rothbart 1997; Rothbart and Jones 1998). However, to our knowledge, research on the interactions of the self-concept of ability and temperament on achievement emotions is lacking. Therefore, the present study also investigated the extent to which adolescent temperament moderates the associations between teacher–student relationship quality and self-concepts of ability with achievement emotions in literacy and mathematics.

Research questions and hypotheses

The aim of the present study was to examine the role of teacher–student conflict and closeness and students' self-concepts of ability in students' achievement emotions in mathematics and literacy. Student temperament was considered as a possible moderator in these associations. The following research questions were investigated:

(1) a) To what extent are adolescents' self-concepts of ability in literacy and mathematics associated with adolescents' achievement emotions (i.e. enjoyment, anxiety and boredom) towards literacy and mathematics? and (b) Do these associations differ depending on adolescent temperament?

H1a: Based on earlier research (e.g. Goetz et al. 2010), we expected to find positive relationships between self-concepts of ability and learning enjoyment and negative relationships between self-concepts of ability and learning anxiety and boredom.

H1b: Due to the scarce previous research regarding temperament and achievement emotions, we did not set specific hypotheses regarding the moderating role of temperament.

(2) a) To what extent are closeness and conflict in the teacher–student relationship associated with adolescents' achievement emotions (i.e. enjoyment, anxiety and boredom) towards literacy and mathematics? and b) Do these associations differ depending on adolescent temperament?

H2a: We expected that closeness would be positively related to enjoyment and negatively to boredom (cf. Frenzel et al. 2007; Goetz et al. 2006, 2013; see also Lei et al. 2018).

H2b: In contrast, conflict was expected to be related to higher boredom and anxiety (cf. Frenzel et al. 2007; Goetz et al. 2013) and lower enjoyment of literacy and mathematics (cf. Goetz et al. 2013).

H2c: No specific hypotheses were set for the role of teacher–student closeness in anxiety because the related previous results have been contradictory (cf. Arbeau et al. 2010; Elmelid et al. 2015; Frenzel et al. 2007; Goetz et al. 2006, 2013; see also Lei et al. 2018).

H2d: Due to the lack of previous research, we did not set specific hypotheses regarding the moderating role of temperament.

Adolescents' gender, subject-specific attainment values and academic skills were controlled for in all the analyses to predict academic subject-specific achievement emotions. Gender differences in achievement emotions have been reported (Pekrun et al. 2011; Soric et al. 2013), suggesting that male students have a tendency to report higher levels of negative achievement emotions and lower levels of positive achievement emotions than female students, with the exception of anxiety, in which female students report higher levels than or equal levels to male students. Also, attainment values and skills are assumed to have an impact on achievement emotions through the control-value theory of achievement emotions (Pekrun 2006, 2014). In the present study, these were controlled for in aiming to reveal unique associations between self-concepts of ability, teacher–child relationships and achievement emotions.

Method

Participants and procedure

A total of 854 primary school students (464 girls, 390 boys) from two municipalities in central Finland participated in the study. Parental written consent and child assent were required for student participation. The teachers of the participating classrooms also gave their written consent for the data collection to be conducted during their lessons, and the research plan was approved by the local ethics committee. The students came from 57 sixth-grade classes (class size: $M = 21$, SD = 5.3). The mean age of the participating students at the beginning of the study was 12.29 years (SD = 0.40). The sample was fairly representative of the general Finnish population; however, compared to the same-age Finnish population, the parents in the sample were slightly more educated (Official Statistics of Finland 2016a), single-parent

households were underrepresented, and two-parent households were overrepresented (Official Statistics of Finland 2016b).

The collection of data on the student participants was conducted during normal school days. The questionnaires were administered by trained test administrators. Temperament evaluations of the adolescents were collected via questionnaires sent to the parents. The data were gathered in autumn 2014.

Measures

Self-concept of ability The adolescents' self-concepts of ability in maths and literacy were assessed using a scale adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008). The questionnaire included three items for both maths and literacy (e.g. *How good are you at maths calculation problems/reading precisely and fast?*) assessed on a 5-point Likert scale (1 = *very poor* to 5 = *very good*; see also Pesu et al. 2018). The Cronbach's alpha reliability for the self-concept of maths ability was 0.85, and for the self-concept of literacy ability, it was 0.70.

Teacher–student relationship The quality of the adolescents' relationship with their classroom teachers was assessed using a short Finnish version of the Student-Teacher Relationship Scale (STRS, short form; Pianta 2001; see also Jerome et al. 2009). The scale was designed to measure adolescents' experience of closeness (five items, e.g. *I have a close and warm relationship with my teacher*) and conflict (six items, e.g. *I often fight with my teacher*) with their classroom teacher on a 5-point Likert scale ranging from 1 (*I disagree*) to 5 (*I agree*). The Cronbach's alpha for closeness was 0.82, and for conflict, it was 0.76.

Achievement emotions Adolescents' enjoyment, boredom and anxiety towards mathematics and literacy were assessed using a Finnish version of the Achievement Emotions Questionnaire (AEQ; Pekrun et al. 2011; for validity of the Finnish version, see Sainio et al. 2020). The questionnaire included three items for enjoyment (e.g. *I enjoy acquiring new knowledge*) and anxiety (e.g. *I get tense and nervous while studying*) and two items for boredom (e.g. *I get bored while studying*), regarding both maths and literacy. The students were asked to rate the degree to which they experience these emotions towards literacy and maths using a 5-point Likert scale ranging from 1 (*disagree*) to 5 (*agree*). The Cronbach's alpha reliability for the emotions towards maths ranged from 0.65 to 0.76, while those towards literacy ranged from 0.63 to 0.76.

Student temperament The adolescents' temperament was reported by parents using the Finnish version of the Early Adolescent Temperament Questionnaire (Revised; EATQ-R; Capaldi and Rothbart 1992; Ellis and Rothbart 2001; for the validity of the Finnish sample, see Kiuru et al. 2020). The 56 statements of the questionnaire were designed to measure broader dimensions of temperament, namely, effortful control (e.g. *It is easy for me to really concentrate on homework problems*; *I have a hard time finishing things on time (reversed)*), negative affectivity (e.g. *I get sad more than other people realise; I get irritated when I have to stop doing something that I am enjoying*) and surgency/extraversion (e.g. *I would not be afraid to try a risky sport, like deep-sea diving; I am shy (reversed)*). Mean scores for effortful control ($\alpha = 0.80$), negative affectivity ($\alpha = 0.84$) and surgency/extraversion ($\alpha = 0.74$) were calculated.

Control variables Gender was coded as 0 = girl and 1 = boy. Attainment values in maths and literacy were assessed by two questions (e.g. *How important is it for you to be good at reading and reading comprehension/maths calculation problems?*) on a 5-point Likert scale ranging from 1 (*not important at all*) to 5 (*very important*) and adapted from Eccles et al. (1983). The Cronbach's alpha value for literacy attainment was 0.82, and for mathematics, it was 0.84. Literacy skills were assessed using three subtests, of which two subtests (the error-finding test and the word-chain test) were from *Dyslexia Screening Methods for Adolescents and Adults* by Holopainen et al. (2004; see also Kiuru et al. 2011). The third test was the short version of Salzburg's reading fluency test (Landerl et al. 1997). A summed score of the three subtests was created by calculating the mean of the standardised test scores. The Cronbach's alpha reliability for literacy skills was 0.87. Mathematics performance was measured using the three-minute basic arithmetic test (Aunola and Räsänen 2007; see also Räsänen et al. 2009). The test–retest reliability for this task was found to be 0.86 (Räsänen et al. 2009).

Analysis strategy

Structural equation modelling was used to answer the research questions. The analyses were carried out according to the following steps. First, we investigated the descriptive statistics. Second, we built measurement models separately for each construct and school subject in question. Third, we integrated these separate measurement models into the final measurement models. In these measurement models, latent factors were allowed to correlate with each other.

Fourth, structural equation models were constructed separately for each school subject. In these models, latent factors of adolescents' subject-specific emotions (i.e. enjoyment, anxiety and boredom) were predicted by latent factors of subject-specific self-concepts of ability as well as by latent factors of closeness and conflict in the teacher–student relationship. The predictors, namely, the latent factors of the self-concept of ability, closeness in the student–teacher relationship and conflict in the teacher–student relationship, were allowed to correlate. In addition, the residuals of the outcome variables, namely, the latent factors of achievement emotions, were allowed to correlate. We also controlled for the effects of subject-specific attainment values, gender and academic skill level on the particular school subject.

Finally, to investigate the role of temperament characteristics (i.e. effortful control, negative affectivity and surgency/extraversion) in the examined associations, we added the following interaction terms: self-concept of ability × particular temperament characteristic, and conflict and closeness in student–teacher relationship × temperament characteristic to the models. The main effects of the temperament characteristics were also included in these models. Follow-up analyses on the significant interaction terms were carried out by calculating and visualising simple slopes separately for adolescents with low (− 1 SD) and high (+ 1 SD) levels of the particular temperament dimension. We also used the computational tool developed by Preacher et al. (2006) to calculate the statistical significance of these simple slopes.

The statistical analyses were performed using the M*plus* statistical package (Version 7.3) and applying the complex approach (Muthén and Muthén 1998–2015). This method estimates the models at the level of the whole sample, but corrects possible distortions of standard errors in the estimation caused by the clustering of observations (classroom differences). The proportion of missing data for the main study variables ranged from 1.5 to 21.4% ($M = 6.51$; SD = 7.96). Little's (1988) MCAR test indicated that data were not missing completely at random: $\chi^2(334) = 632.61$, $p < 0.001$. Thus, in the analyses, full-information maximum

likelihood procedures were used to deal with the missing data. Since not all the study variables were normally distributed, we used maximum likelihood robust (MLR) estimation. The MLR estimator produces robust standard errors by means of a sandwich estimator and a χ^2 test statistic for non-normal outcomes. Model fit was investigated using the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI) and the standardised root mean square residual (SRMR). A model typically fits the data well when the p value associated with the χ^2 test is non-significant. RMSEA values below 0.06 and SRMR values below 0.08 indicate a relatively good fit between the hypothesised model and the observed data (see also Hu and Bentler 1999). Because the χ^2 test is sensitive to sample size, the use of relative goodness-of-fit indices is also recommended in the case of large sample sizes (Bentler and Bonett 1980). Consequently, the following two relative goodness-of-fit indices were also used to evaluate model fit: the CFI and the TLI. CFI and TLI values close to 0.95 indicate a relatively good fit to the data (see also Hu and Bentler 1999).

Results

Measurement models

Measurement models were built separately for each school subject using confirmatory factor analysis, which enabled us to take measurement error into account. In these models, latent factors were allowed to correlate. The final measurement models including all latent factors were shown to fit the data well for both school subjects: $\chi^2(265) = 603.60–641.90$, $p < 0.001$, RMSEA = 0.04, CFI = 0.94, TLI = 0.93 and SRMR = 0.04. The factor loadings of the latent factors in the final models ranged from 0.43 to 0.88. The fact that the models fit the data well and that the factor loadings were high suggest good construct validity and item reliability.

Structural equation models

We next built a separate structural equation model (SEM) for each school subject to predict the adolescents' achievement emotions by using their self-concept of ability and closeness and conflict in the teacher–student relationship. The effects of the adolescents' attainment values, gender and academic skills were controlled for in all the analyses. The final models containing only statistically significant paths fit the data well: for mathematics, $\chi^2(272) = 645.87$, $p < 0.001$, RMSEA = 0.04, CFI = 0.94, TLI = 0.93 and SRMR = 0.04; and for literacy, $\chi^2(272) = 611.01$, $p < 0.001$, RMSEA = 0.04, CFI = 0.94, TLI = 0.93 and SRMR = 0.05. The final model for mathematics is shown in Fig. 1 and that for literacy in Fig. 2.

Self-concept of ability, temperament and achievement emotions

The descriptive statistics of the study variables are presented in Table 1, and a correlation matrix is shown in Table 2. Our first research question was to investigate the extent to which the adolescents' self-concept of ability is associated with their achievement emotions (i.e. enjoyment, anxiety and boredom) towards literacy and mathematics. The results (see Figs. 1 and 2) showed that after controlling for the effects of attainment values, gender and academic skill level in the particular subject, self-concepts of ability were positively related to the adolescents' enjoyment of both school subjects and negatively related to anxiety experienced

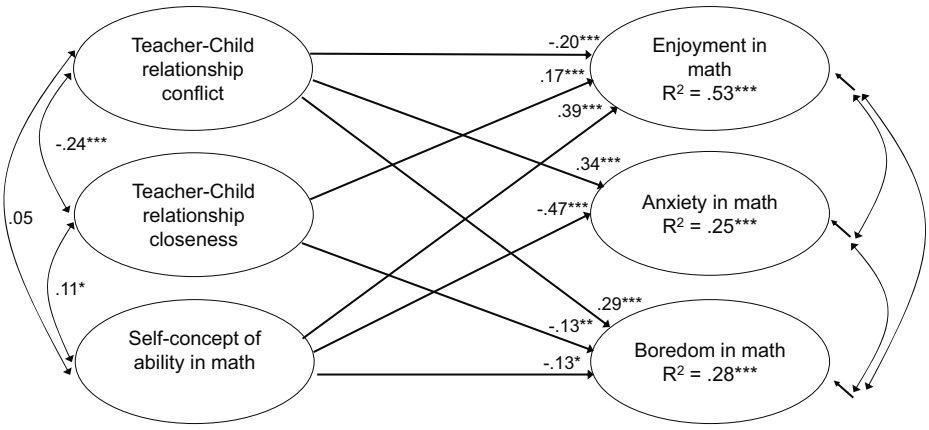

Fig. 1 Associations of teacher–student relationship and self-concept of ability with students' emotions towards mathematics: standardised solution of the structural equation model. The effects of attainment value, gender and math performance level were controlled for in the analysis. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

towards the school subjects. Furthermore, the self-concept of ability was negatively related to boredom experienced in mathematics but not in literacy (see Fig. 1).

We also investigated the extent to which adolescent temperament moderated the associations of the self-concepts of ability in mathematics and literacy with the adolescents' achievement emotions. This was analysed by adding the interaction terms of self-concept of ability in maths and literacy × temperament dimension to the previous models (see Fig. 3). Also, the main effects of temperament were included in all the models. The results showed that one out of six of the interaction terms tested was statistically significant: the interaction term of self-concept of ability in literacy × effortful control was a significant predictor of the adolescents' anxiety towards literacy ($\beta = 0.10$, SE = 0.05, $p = 0.035$; Fig. 3). For adolescents with weaker effortful control, a lower self-concept of ability in literacy was related to more anxiety experienced towards literacy ($\beta = -0.34$, SE = 0.06, $p < 0.001$). For adolescents with a higher level of effortful control, anxiety did not change as a function of the self-concept of ability

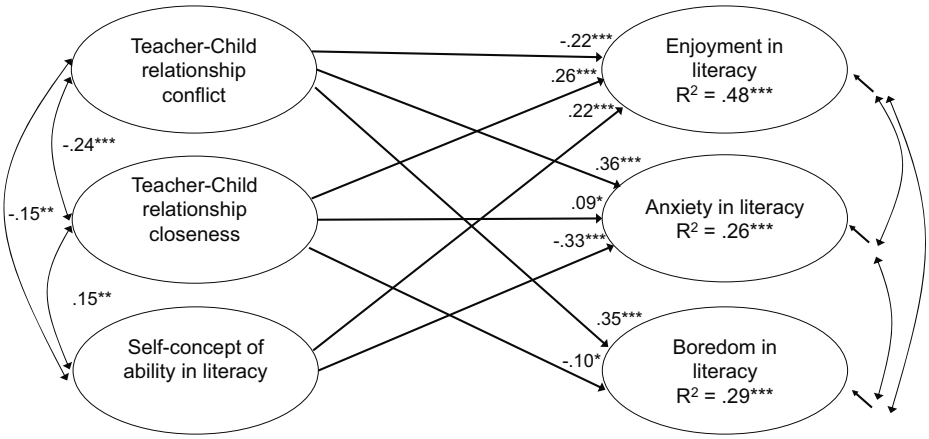

Fig. 2 Associations of teacher–student relationship and self-concept of ability with students' emotions towards literacy: standardised solution of the structural equation model. The effects of attainment value, gender and literacy skill level were controlled for in the analysis. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table 1 The descriptive statistics of the main study variables

Variable	*n*	*M*	SD
Reading self-concept of ability	850	3.96	0.54
Maths self-concept of ability	850	3.84	0.73
Closeness with teacher	845	2.32	0.83
Conflict with teacher	847	1.63	0.67
Enjoyment towards literacy	849	3.12	0.85
Anxiety towards literacy	844	1.85	0.78
Boredom towards literacy	841	2.11	1.02
Enjoyment towards maths	838	3.28	0.96
Anxiety towards maths	842	1.85	0.81
Boredom towards maths	841	2.01	1.02
Negative affectivity	678	2.30	0.53
Surgency	678	3.47	0.66
Effortful control	678	3.60	0.57

($\beta = -0.14$, SE = 0.11, $p = 0.215$). The main effect of adolescents' effortful control on literacy anxiety, in turn, was not significant ($\beta = -0.03$, SE = 0.03, $p = 0.207$). None of the interaction terms between adolescent temperament characteristics and the self-concept of ability in maths had significant effects on math-related achievement emotions.

Quality of teacher–student relationship, temperament and achievement emotions

Our second research question was formulated to investigate the extent to which closeness and conflict in the teacher–child relationship are associated with adolescents' achievement emotions (i.e. enjoyment, anxiety and boredom) towards literacy and mathematics. The results (see Figs. 1 and 2) showed, after controlling for the effects of attainment values, gender and academic skill level in the particular subject, that conflict with the teacher was negatively related to enjoyment and positively related to anxiety and boredom in both school subjects. Closeness with the teacher, in turn, was positively related to enjoyment and negatively related to boredom in both school subjects. Furthermore, closeness with the teacher was positively related to anxiety, but only in literacy (see Fig. 2).

To examine the moderating role of temperament, the interaction terms of quality of teacher–student relationship with respect to conflict and closeness × temperament dimension were next added to the previous models. Furthermore, the main effects of temperament were included in all the models. The results showed that two out of 12 interaction terms tested were statistically significant.

First, the interaction term conflict with teacher × surgency was statistically significant in predicting the adolescents' feelings of enjoyment towards literacy ($\beta = 0.12$, SE = 0.05, $p = 0.013$; see Fig. 4). For adolescents with low levels of surgency, lower levels of teacher–student conflict were associated with greater enjoyment of literacy ($\beta = -0.44$, SE = 0.06, $p < 0.001$), whereas for students with higher levels of surgency, enjoyment did not change as a function of teacher–student conflict ($\beta = -0.20$, SE = 0.11, $p = 0.06$). In turn, the main effect of the adolescents' surgency on literacy enjoyment was not significant ($\beta = -0.02$, SE = 0.03, $p = 0.537$).

Second, the results showed that the interaction term closeness with teacher × effortful control was statistically significant in predicting the adolescents' feelings of anxiety towards literacy ($\beta = -0.11$, SE = 0.06, $p = 0.042$; see Fig. 5). For adolescents with weak effortful control, higher levels of teacher–student closeness were associated with more anxiety towards

Table 2 Correlations between the main study variables (mathematics subject above the diagonal and literacy subject below the diagonal)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Self-concept of ability		0.11**	0.05	0.55***	−0.38***	−0.25***	−0.13**	0.00	0.21***	0.24***	0.47***	0.49***
2.	Closeness with teacher	0.15**		−0.24***	0.35***	−0.09	−0.28***	−0.01	0.03	0.15**	−0.08*	0.26***	−0.02
3.	Conflict with teacher	−0.15**	−0.24***		−0.29***	0.29***	0.36***	0.15***	0.12**	−0.23***	0.28***	−0.18***	0.00
4.	Enjoyment	0.44***	0.45***	−0.38***		−0.50***	−0.73***	−0.11*	−0.01	0.27***	−0.01	0.60***	0.25***
5.	Anxiety	−0.40***	−0.05	0.38***	−0.46***		0.61***	0.15**	0.02	−0.20***	−0.01	−0.11*	−0.18***
6.	Boredom	−0.21***	−0.28***	0.42***	−0.72***	0.61***		0.14**	0.00	−0.16***	0.04	−0.41***	−0.07
7.	Negative affectivity	−0.05	−0.01	0.15***	−0.06	0.13**	0.13**		−0.27***	−0.58***	0.01	−0.05	−0.17***
8.	Extraversion/surgency	0.06	0.03	0.11**	−0.04	0.03	0.01	−0.28***		0.03	0.07	0.09	0.06
9.	Effortful control	0.23***	0.15**	−0.22***	0.23***	−0.20***	−0.14**	−0.58***	0.04		−0.19***	0.17***	0.28***
10.	Gender	−0.10*	−0.08*	0.28***	−0.23***	0.19***	0.18***	0.00	0.08	−0.18***		−0.04	0.09**
11.	Attainment value	0.32***	0.32***	−0.21***	0.54***	−0.13*	−0.37***	0.00	0.01	0.18***	−0.26***		0.21*
12.	Academic skills	0.58***	−0.01	−0.09*	0.18***	−0.23***	0.02	−0.08*	0.00	0.28***	−0.22***	0.08***	

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

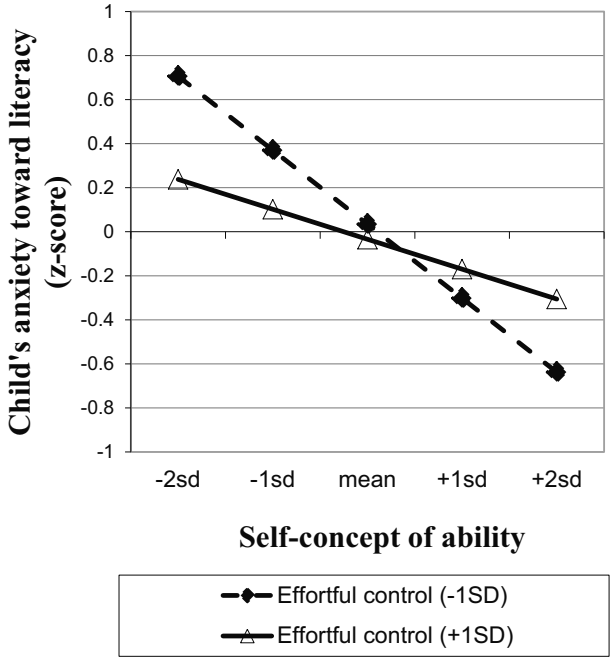

Fig. 3 Effortful control as a moderator of the associations between literacy self-concept of ability and anxiety towards literacy learning

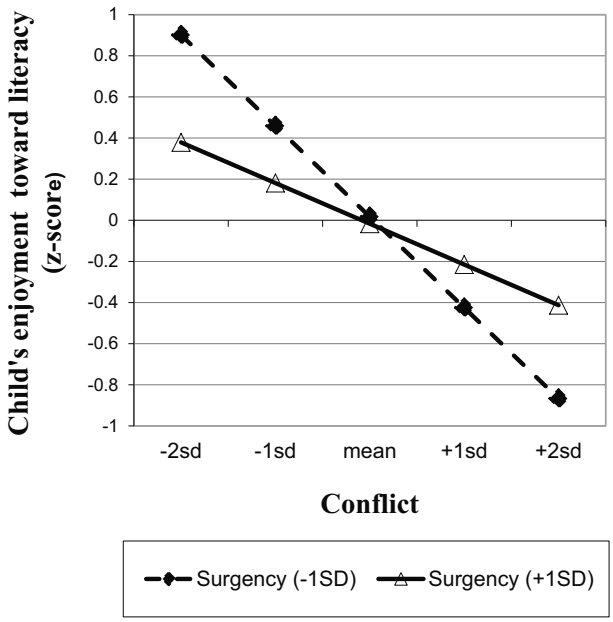

Fig. 4 Surgency as a moderator of the associations between conflict in teacher–student relationship and enjoyment towards literacy learning

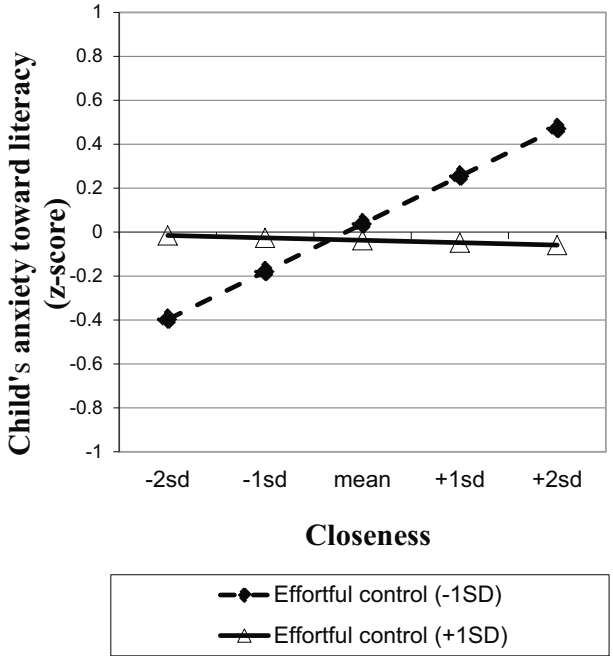

Fig. 5 Effortful control as a moderator of the associations between closeness in teacher–student relationship and anxiety towards literacy learning

literacy learning ($\beta = 0.22$, SE = 0.09, $p = 0.02$). In turn, for adolescents with higher levels of effortful control, anxiety towards literacy learning did not change as a function of teacher–student closeness ($\beta = -0.01$, SE = 0.06, $p = 0.862$). The main effect of the adolescents' effortful control on literacy anxiety was not significant ($\beta = -0.04$, SE = 0.03, $p = 0.17$). None of the interaction terms between adolescent temperament characteristics and student–teacher relationship quality had significant effects on mathematics-related achievement emotions.

Discussion

The aim of this study was to investigate the associations of the self-concept of ability and the quality of the teacher–student relationship with adolescents' achievement emotions regarding literacy and mathematics and whether adolescent temperament moderates these associations. The results showed, first, that in both school subjects, high self-concepts were related to higher enjoyment and lower anxiety. A high self-concept was also related to a lower level of boredom in mathematics. Second, in both school subjects, a closer and less conflictual relationship with the teacher was related to higher levels of enjoyment and lower levels of boredom, whereas conflict in the teacher–student relationship was related to higher anxiety levels in both school subjects. Third, the associations of the self-concept of ability with achievement emotions were generally stronger in mathematics than in literacy. In mathematics, domain-specific associations were not dependent on student temperament, whereas three significant interaction effects with temperament were observed when predicting achievement emotions towards literacy.

Self-concepts of ability, temperament and achievement emotions

Our first aim was to investigate the relations between domain-specific self-concepts of ability and achievement emotions towards literacy and mathematics. Perceived control over learning activity is considered to be one of the main determinants in the control-value theory of achievement emotions (Pekrun 2006), and its role in the emergence of achievement emotions has been corroborated by numerous studies, particularly among high school and university students (for an overview, see Pekrun and Perry 2014). The present study provides a novel understanding of the relations between subject-specific self-concepts of ability and achievement emotions in a younger sample (i.e. sixth-grade adolescents).

The findings for enjoyment and anxiety in mathematics and literacy were in line with our H1a and the control-value theory of achievement emotions (Pekrun and Perry 2014). The results for both academic subjects revealed that primary school adolescents' high self-concepts of ability were related to their higher levels of enjoyment and lower levels of anxiety, after controlling for the effects of gender, teacher–student relationship quality, academic skills and attainment values. Our results are similar to earlier findings among high school students (e.g. Goetz et al. 2010). One possible explanation for the results is that a high self-concept of ability is related to students' adaptive beliefs about their abilities to complete a task and about the likelihood of attaining a desired outcome, resulting in positive emotional experiences. A low self-concept of ability, in turn, is not assumed to coincide with such adaptive beliefs; therefore, a lack of belief in one's abilities may result in negative emotions and, in particular, instigate anxiety if the activity is also considered important (Pekrun and Perry 2014).

The results for boredom also partially supported our H1a and the control-value theory of achievement emotions (Pekrun 2006) by showing that a low self-concept of ability was uniquely related to higher levels of boredom in mathematics. This finding is in line with previous results among high school students (Bieg et al. 2013; Goetz et al. 2010). It is possible that when the achievement situation demands exceed students' ability to cope with the situation, they may start to devalue the subject, leading to boredom experiences (Pekrun 2006) characterised by disengagement from school activities. However, a significant association between the self-concept of ability and boredom was not found for literacy after controlling for the effects of gender, teacher–student relationship quality, academic skills and attainment value. The results suggest that in literacy, the self-concept of ability plays a relatively more important role in enjoyment and anxiety than in boredom. These results are in line with some previous studies (Goetz et al. 2010; see also Goetz et al. 2006) showing that the strength of association between self-concept and boredom may be weaker compared to the equivalent relationships with anxiety and enjoyment and stronger in mathematics compared to in verbal domains (e.g. Goetz et al. 2010).

We further aimed to examine the moderating role of adolescent temperament (i.e. surgency/extraversion, negative affectivity and effortful control) in the associations of self-concepts of literacy and math ability with achievement emotions. To our knowledge, this study is the first to investigate the joint relations of the self-concept of ability and temperament on achievement emotions. The results for mathematics showed generally stronger associations than in literacy. Also, none of the interaction effects were significant, suggesting that the associations between the self-concept of math ability and achievement emotions were not dependent on adolescents' temperament. In turn, for literacy, overall associations between self-concept and achievement emotions were weaker than in maths, and one significant interaction effect (self-concept of ability × effortful control) when predicting anxiety towards literacy was detected. For

adolescents with weak temperamental effortful control, a low self-concept of literacy ability was related to higher levels of anxiety towards literacy learning. In other words, adolescents with low effortful control were particularly vulnerable to the detrimental effects of a low self-concept of ability on anxiety, while they particularly benefitted from a high self-concept of ability. A similar effect was not observed among adolescents with high levels of effortful control. The result supports the control-value theory of achievement emotions (Pekrun and Perry 2014) by showing that a low self-concept of ability is a risk factor for experiencing anxiety in literacy, whereas a high self-concept of ability can act as a buffering factor. Novel to this finding is that the effect was only pronounced for adolescents who had difficulties in self-regulation. This suggests that for adolescents who have weak effortful control, self-concepts might work as a source of emotion regulation; therefore, such adolescents may particularly benefit from shaping their self-appraisals in a more positive direction.

Teacher–student relationship, temperament and achievement emotions

Our second aim was to investigate how teacher–student relationship quality is related to adolescents' achievement emotions towards literacy and mathematics. Earlier studies have mainly investigated the characteristics of the classroom learning environment (e.g. instruction quality) and their relationship with students' achievement emotions. Thus far, less has been discovered about the role of teacher–student relationship quality, which can vary from one student to another.

The results for predicting enjoyment and boredom on the basis of the teacher–student relationship quality showed that a high level of closeness with the teacher was related to higher levels of enjoyment and lower levels of boredom in both mathematics and literacy, after controlling for the effects of gender, self-concepts of ability, attainment values and academic skill level in the particular subject. A conflictual relationship with the teacher, in turn, was related to lower levels of enjoyment and higher levels of boredom and anxiety in both school subjects. These results are in line with our H2a and H2b, previous studies showing that high-quality teaching is related to increased enjoyment and decreased boredom (Frenzel et al. 2007; Goetz et al. 2006, 2013; see also Lei et al. 2018), and a study showing that teacher affective support is related to higher enjoyment (Sakiz 2012). These results are also in accordance with previous studies showing that a lower quality of instruction is related to higher levels of boredom and anxiety (Frenzel et al. 2007; Goetz et al. 2006, 2013) and lower levels of enjoyment (Goetz et al. 2013). It is possible that in a warm and supportive teacher–student relationship, adolescents' basic psychological needs for relatedness are fulfilled and teachers are more sensitive and responsive to adolescents' individual learning-related needs. This may enable adolescents to engage in school tasks with enjoyment and curiosity, which is also likely to support better learning outcomes. In contrast, the need for relatedness is unlikely to be fulfilled in a teacher–student relationship characterised by a high level of conflict. As a result, students are likely to experience less enjoyment and more anxiety and boredom towards learning (Skinner et al. 2014).

However, whereas conflict in the teacher–student relationship was found to predict higher levels of anxiety, closeness in the teacher–student relationship was related to higher anxiety in literacy but was not significantly related to anxiety in mathematics. No specific hypotheses were set for the role of teacher–student closeness in anxiety because the previous related results have been contradictory (cf. Arbeau et al. 2010; Elmelid et al. 2015; Frenzel et al. 2007; Goetz et al. 2006, 2013; see also Lei et al. 2018). These results do not support previous ones

showing that closeness with the teacher, higher quality teaching or teacher support is related to less anxiety (e.g. Arbeau et al. 2010; Frenzel et al. 2007; see also Lei et al. 2018). However, these results are in line with some previous studies that have found that positive instructional practices do not necessarily reduce students' anxiety towards learning (see Becker et al. 2014; Goetz et al. 2013; see also Elmelid et al. 2015). It is possible that anxiety is reduced by increasing control and increased by enhancing the value of the topic (Pekrun 2006). Therefore, a close relationship may convey higher value than control to students, thus increasing anxiety or both high control and value and, thus, leading to non-significant relations between closeness and anxiety (see also Goetz et al. 2013). Overall, the results indicate that students' anxiety levels were more strongly influenced by conflict than closeness in the teacher–student relationship, supporting previous research that has shown that negative interactions with teachers may matter more than positive interactions regarding student outcomes (e.g. Jellesma et al. 2015).

Finally, our aim was also to investigate the extent to which adolescent temperament moderates the associations between the quality of the teacher–student relationship and achievement emotions in mathematics and literacy. As far as we know, our study is the first to investigate the joint relations of the teacher–student relationship quality and temperament on achievement emotions. The results for mathematics showed, first, that none of the interaction effects were significant, suggesting that the associations between the quality of the teacher–student relationship and achievement emotions were not dependent on adolescents' temperament. In turn, for literacy, two significant interaction effects were found.

First, the interaction effect conflict in teacher–student relationship × surgency was statistically significant for predicting enjoyment towards literacy. A high level of conflict in the teacher–student relationship was particularly detrimental for literacy enjoyment among adolescents with low surgency (characterised by shyness and low sensation-seeking). In contrast, a low level of conflict in the teacher–student relationship seemed to protect adolescents with low surgency against diminished feelings of enjoyment towards literacy. For adolescents with high surgency (characterised by low shyness and high sensation-seeking), conflict in the teacher–student relationship was unrelated to enjoyment towards literacy. One explanation for the finding that adolescents with low levels of surgency enjoyed literacy learning more when there was a low level of conflict in the teacher–student relationship is their temperamental tendency to become overstimulated more easily than adolescents with higher surgency (e.g. Rothbart and Hwang 2005). Therefore, they may prefer low-intensity activities and environments, and they may also be more sensitive to the detrimental effects of conflict than less shy people, thus allowing more enjoyment of the school subject when the relationship with the teacher is less conflictual. This result is in line with the goodness-of-fit model (Thomas and Chess 1977) as it shows that classroom factors are related to achievement emotions not solely in isolation but also in conjunction with temperament. In other words, achievement emotions experienced might depend on the extent of fit between temperament and the demands and expectations of the classroom environment. The results are also in line with the findings for other student outcomes in other age groups. For example, Essex et al. (2011) showed that teacher–child relationship conflict in the first grade was related to heightened levels of mental health problems by the seventh grade, particularly among inhibited children (see also diathesis stress and differential susceptibility models; Belsky and Pluess 2009). Shy and inhibited students have been found to have more difficulties in engaging in peer relationships (for a review, see Coplan and Bullock 2012), to like school less (Valiente et al. 2012) and to have more internalised symptoms (for a review, see Klein et al. 2012). Thus, shyness may be a

vulnerability factor for social and emotional problems, and problems in the teacher–student relationship may pose the additional risk of diminishing their enjoyment of learning for these students (see also Belsky and Pluess 2009).

Second, our results showed that the interaction effect closeness in teacher–student relationship × effortful control was statistically significant for predicting anxiety towards literacy. Among adolescents with weak effortful control, a very close relationship with the teacher was related to higher levels of anxiety towards literacy. A similar effect was not found for adolescents with a high level of effortful control. These findings differ from those of some previous studies on other student outcomes, such as problem behaviours (Wang et al. 2013) and academic achievement (Rudasill et al. 2010), which have shown that children and adolescents with low levels of effortful control may particularly benefit from a positive teacher–student relationship. However, none of the previous studies have examined anxiety towards academic subjects as an outcome variable. Our finding, indicating that a high level of closeness with the teacher elevated anxiety towards literacy among adolescents with low levels of effortful control, somewhat resembles one prior study among preschoolers that showed that higher instructional support was related to more conflict with the teacher among pupils with lower effortful control (Rudasill et al. 2016; see also Domínguez et al. 2011). Hence, one possible explanation for our finding is that a close relationship with the teacher may highlight the value of the topic for the student (see Pekrun 2006). Due to this, adolescents with weaker effortful control typically characterised by facing challenges in regulating their behaviour and emotions, in particular, might have exhibited elevated anxiety when they had a close relationship with their teacher.

Differences between the literacy and mathematics domains

Overall, the results of the present study showed that self-concepts of ability and the teacher–student relationship play a role in students' achievement emotions and that students' temperament, to some extent, moderates these relationships. Interestingly, the pattern of results was slightly different for mathematics and literacy: First, in mathematics, the self-concept of ability was negatively related to boredom, whereas, in literacy, no significant relationship was found. It has been suggested that a stronger relationship in mathematics between self-concept and emotions might reflect the fact that mathematics is more narrowly defined, and thus, have a narrower range of classroom activities compared to those in literacy, therefore restricting the sources of emotions and self-concepts (Goetz et al. 2010). Second, in mathematics, teacher closeness was not significantly related to student anxiety, whereas, in literacy, teacher closeness was related to slightly heightened anxiety. However, this result may at least partially be explained by the interaction effect found in literacy concerning teacher closeness and anxiety.

In mathematics associations between self-concept of ability, teacher–child relationship quality and achievement emotions were not dependent on temperament. Previous research has shown that, in maths development, individual differences increase over time, thus showing a cumulative developmental pattern (Aunola et al. 2004). Reading development typically shows the opposite pattern, particularly in later grade levels; that is, individual differences decrease rather than increase over time showing a compensatory trajectory (e.g. Leppänen et al. 2004; see also Parrila et al. 2005). Thus, one possible explanation for these results in mathematics is that whereas individual differences in maths are wider than in reading, there may be more room in maths for stronger influences of motivational and environmental factors that apply to all adolescents regardless of their temperament.

In turn, three of the literacy-related associations were moderated by adolescent temperament (i.e. the associations were not true for all the adolescents but depended on adolescent temperament). More specifically, adolescents with low effortful control were particularly vulnerable to the detrimental effects of a low self-concept of ability on anxiety towards literacy, whereas the self-concept of ability was not related to anxiety for adolescents with high effortful control. In other words, a simultaneous low self-concept and low temperamental effortful control posed a double risk for the development of literacy-related anxiety (see also Belsky and Pluess 2009). Also, for adolescents with low effortful control, a close relationship with the teacher was related to higher levels of anxiety towards literacy, whereas closeness in the teacher–student relationship was not related to anxiety for adolescents with high effortful control. Finally, a high level of conflict in the teacher–student relationship was particularly detrimental for literacy enjoyment among adolescents with low surgency (high shyness and low sensation-seeking), whereas conflict in the teacher–student relationship was not related to lower enjoyment among students with high surgency (low shyness and high sensation-seeking). One other possible explanation for these moderation effects, seen only in literacy, also relates to the differing contexts of teaching and learning between maths and literacy (see also Vitiello et al. 2012). Compared to mathematics, literacy is typically seen by teachers as less defined, less sequential and more dynamic, and these features have been shown to have consequences on teachers' curricular practices (Stodolsky and Grossman 1995). However, further studies are needed to explore these differences in more detail.

Limitations and future directions

The present study also has its limitations. First, despite the inclusion of a meaningful set of control variables, this study was correlational in nature; thus, any conclusions on the causal relations between the study constructs cannot be made. Future studies should investigate longitudinal associations between both distal and individual antecedents of achievement emotions and their reciprocal linkages, as suggested by the control-value theory of achievement emotions (see Pekrun and Perry 2014). A longitudinal research design would also allow the testing of mediating mechanisms, between the teacher–student relationship quality, the self-concept of ability and achievement emotions, and how these are further related to academic outcomes.

Second, our sample consisted of 12-year-olds, thus warranting studies with different age groups. Third, it is possible that adolescents' self-reports of emotions, self-concepts and the teacher–child relationship quality may have led to the overestimation of the strengths of the main effects because of the shared method variance. Future studies could, for example, link the self-assessment of emotions to physiological indicators of emotions.

Conclusions and practical implications

This study extends the work of previous studies on the antecedents of achievement emotions by illustrating the importance of both individual and distal factors in the emergence of achievement emotions. More specifically, our findings suggest that in addition to self-concepts of ability, the teacher–student relationship quality plays an important role in adolescents' achievement emotions in mathematics and literacy. Moreover, our findings indicate that some of the relations (especially in the literacy domain) between the teacher–student relationship quality, the self-concept of ability and emotions were dependent on student temperament.

Generally, our results suggest that a higher self-concept of ability is important in promoting positive emotions and lessening negative emotions. Moreover, our study extended previous knowledge by revealing that in literacy, a low self-concept seemed to increase anxiety towards learning for adolescents low in effortful control, whereas a higher self-concept protected against anxiety. Overall, our results suggest that in order to boost students' positive emotions and mitigate their negative emotions towards school, students' self-concepts of ability should be enhanced. In addition, students with low levels of effortful control may particularly benefit from support of their self-concept of ability.

This study contributed to the previous research on teacher–student relationships by demonstrating that teacher–student relationship quality is related to students' emotions and that certain relationship characteristics may be particularly detrimental to students with certain temperament characteristics in terms of achievement emotions towards literacy. Overall, the results suggest that a positive relationship with the teacher may be beneficial for students' achievement emotions. This information is important for educators because teachers' awareness of the associations of the quality of teacher–student relationships with students' achievement emotions may improve the quality of these relationships. A positive relationship with adolescents has the potential to inform teachers about students' needs and, in turn, to enable adolescents to cope constructively with tasks, thus further enhancing their motivation and engagement (Skinner et al. 2014). The results also suggest that a knowledge of students' temperament may provide teachers with further information on how to best meet the students' needs and support their learning and motivation.

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