Students' motivation in biology lessons—can student autonomy reduce the gender gap?

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Received: 25 August 2021 / Revised: 24 January 2022 / Accepted: 2 February 2022 /
Published online: 5 March 2022
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Abstract

When it comes to biology lessons in Germany, girls generally exhibit higher levels of self-determined motivation than boys. Previous research suggests that fostering student autonomy could be a way to effectively address this gender gap. To investigate gender-related effects in biology education, a sample of 303 sixth-grade students ($M_{\text{age}}=11.31$ years, $SD_{\text{age}}=0.58$ years) participated in a 3-h teaching unit on harvest mice that was taught in either an autonomy-supportive or controlling manner. The results revealed a significant effect of the treatment on self-determined motivation, with the effect being stronger for the boys. In the treatment with controlling teaching behavior, gender-related differences in self-determined motivation became apparent. In contrast, the gender gap was mainly smaller in the treatment with autonomy-supportive teaching behavior. Thus, the results suggest that satisfying the need for autonomy appears to be an effective means to help bridge the gender gap in biology lessons.

Keywords Self-determination theory · Motivation · Teaching behavior · Gender · Autonomy

Introduction

Gender studies are an essential field of educational and didactic research (Flaake, 2006; Palm, 2012), for gender is one characteristic of a diverse classroom that teachers must consider to include all students (Ainscow & César, 2006; Bartlett & Burton, 2011; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2009). In recent discussions in this field, boys have been attracting the attention of researchers as they are described as educationally disadvantaged (Bartlett & Burton, 2011; Blossfeld et al., 2009; Flaake, 2006; Kuhn, 2008; Ridge et al., 2017; Watson et al., 2010). This description stems from boys more frequently repeating a year and their overrepresentation in the lower tracks and underrepresentation in the higher tracks of the German school system (Blossfeld et al., 2009; Ehmke et al., 2008).

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Boys have less successful school careers than girls, which is attributed, among other things, to a rather feminine school environment that does not meet their needs (Budde, 2008; Heyder & Kessels, 2013) or motivational beliefs (Heyder et al., 2017). When it comes to the natural sciences, boys perform better in chemistry and physics than girls (Blossfeld et al., 2009; Schiepe-Tiska et al., 2016; Stanat & Kunter, 2001). In contrast, biology is often considered to be a girls' domain (Budde, 2008; Hannover & Kessels, 2002; Quaiser-Pohl, 2012). Studies show that girls have a stronger motivational orientation toward and a higher interest in biology and are assumed to perform better in this subject than boys (Budde, 2008; Dietze et al., 2005; Hannover & Kessels, 2002; Kahle et al., 1993; Quaiser-Pohl, 2012).

The central question in gender studies in the academic context remains how to face and mitigate the negative effects of such gender differences in class. Self-determination theory (SDT; Ryan & Deci, 2017) might provide approaches to creating environments that enable learning beneficial to both boys and girls. Satisfying the psychological needs anchored in this theory is essential to the development of interest and motivation regardless of gender (Adie et al., 2008; Assor et al., 2005; Ryan & Deci, 2017). In particular, the experience of autonomy is assumed to have a positive impact on students' self-determined motivation, such as their intrinsic motivation and flow experience in class (Hofferber et al., 2016; Reeve, 2015). However, the current state of research suggests that autonomy-supportive teaching behavior (ASTB) can affect the way in which boys and girls experience autonomy in school and their quality of motivation differently (Budde, 2008; Desch et al., 2017; Lietaert et al., 2015; see also Patall et al., 2018). For example, boys might especially benefit when teachers provide them with autonomy-supportive measures such as showing appreciation, offering choices, and providing rationales (see Budde, 2008; Desch et al., 2017; Flaake, 2006; Guggenbühl, 2008).

Thus, we were interested in exploring possible gender-related effects of ASTB and controlling teaching behavior (CTB) on students' quality of motivation in biology lessons. Understanding such gender differences and being able to address them in the classroom is important to enabling both boys and girls to experience self-determined motivation and facilitating successful learning processes (see Ryan & Deci, 2017). If such differences are not considered, they can manifest themselves and ultimately lead to gender-related decisions, for example, in the choice of courses and careers (Baumert et al., 2000; Kessels et al., 2014). Specifically, we investigated ASTB as a means to reduce possible gender gaps in biology by helping boys to be motivated in a more self-determined manner in this subject (see Desch et al., 2017; Lietaert et al., 2015; Lüftenegger et al., 2011; Schweder & Raufelder, 2021). As topics in biology are often of high social relevance (e.g., the conservation of biodiversity, education for sustainable development; see also UNESCO, 2017), it is essential to foster boys' motivation and commitment in this field. Otherwise, boys may not engage personally, vocationally, or politically in these issues as adult citizens because they have not recognized their relevance and cannot comprehend or confront them (see Simpkins et al., 2006; Watt, 2016; Watt et al., 2006). This withdrawal can lead to an exacerbation of the problems facing today's society.

Theory

Autonomy support

In SDT, Ryan and Deci (2017) state that there are three innate psychological needs (competence, relatedness, and autonomy) that have a profound impact on motivation. The need for autonomy—emphasized in the current study—entails one's desire to have the feeling

of being the master of one's actions (Reeve, 2015). This need further describes one's striving to act voluntarily and perceive a sense of choice in actions (Reeve, 2015; Reeve et al., 2003).

As teachers largely determine what happens in class, their behavior has a major impact on the degree of autonomy a student experiences (Reeve, 2015). Hence, previous studies have identified and investigated different teaching behaviors that aim at supporting learner autonomy in educational settings. ASTB comprises the provision of meaningful choices and rationales that emphasize the personal relevance and meaningfulness of a topic or activity in class (Katz & Assor, 2007; Reeve, 2015; Su & Reeve, 2011). Furthermore, autonomy-supportive teachers use non-controlling language in their classroom interactions that do not pressure learners to behave in an expected manner, thus enabling flexible behavior (Su & Reeve, 2011). ASTB also manifests itself in informative feedback, which presents student performance appreciatively and offers choices regarding the further learning process (see Ryan et al., 1983). Moreover, autonomy-supportive teachers consider students' wishes and ideas as well as negative feelings that might occur (Reeve, 2015).

In contrast to ASTB, CTB does not allow for flexible learner behavior and denies students opportunities for self-paced learning (Reeve, 2015). This behavior manifests itself, among other things, in the use of controlling language and the provision of controlling feedback that pressure students into executing expected behavior and task-processing (e.g., by using directives or commands; see Ditton & Müller, 2014; Kast & Connor, 1988; Reeve, 2015; Su & Reeve, 2011). In controlling feedback, student performance is evaluated based on the teacher's expectations and social comparisons (see Kast & Connor, 1988; Katz & Assor, 2007). Finally, controlling teachers do not provide learners with rationales and choices, nor do they consider their wishes, ideas, and feelings (Reeve, 2015; Su & Reeve, 2011).

On the one hand, numerous studies have confirmed the positive effects of ASTB on students' intrinsic motivation and their flow experience (Froiland et al., 2017; Haerens et al., 2015; Hofferber et al., 2016; Tessier et al., 2010). On the other hand, CTB has been found to harm these qualities of motivation (Assor et al., 2005; De Meyer et al., 2014; Hofferber et al., 2016), which are elaborated in the following sections.

Motivation in self-determination theory

A prominent perspective on motivation is depicted in SDT (Ryan & Deci, 2017). In this framework, a distinction is made between extrinsic and intrinsic motivation. An action is intrinsically motivated when an individual acts out of his or her interest and enjoyment and is rewarded by performing the activity itself (Deci et al., 1999; Ryan & Deci, 2017; Vallerand & Ratelle, 2002). In such actions, the locus of causality is perceived as internal (Ryan & Deci, 2017). In contrast, extrinsically motivated behaviors are instrumental and externally determined (Ryan & Deci, 2017; Thomas & Müller, 2016; Vallerand & Ratelle, 2002). That is, they are executed because of external rewards or punishments that can be separated from the action itself (Ryan & Deci, 2017; Vallerand & Ratelle, 2002). Extrinsically motivated actions can differ in their degree of perceived self-determination (Ryan & Deci, 2017; Vallerand & Ratelle, 2002). Depending on this degree, four types of regulation are described: external, introjected, identified, and integrated (Ryan & Deci, 2017; Vallerand & Ratelle, 2002).

The depicted qualities of motivation and their underlying regulations can be measured as current (less stable) or habitual (more stable) motivation (Schiefele & Schaffner, 2015;

Vallerand & Ratelle, 2002). The habitual form, which combines the types of regulation, shall henceforth be referred to as “motivational regulation” (see “14” section). A type of motivation that can only be measured as a state is covered in the following section.

Motivation in flow theory

A complementary conceptual approach to intrinsic motivation is illustrated in flow theory (Csikszentmihalyi, 1997; Sheldon & Filak, 2008), which focuses on the process-related requirements of an intrinsically motivated action (Taylor et al., 2006). The term “flow” describes a positive psychological state in which individuals are fully immersed in a fluent activity and act without even reflecting on what they are doing (Csikszentmihalyi, 1990; Rheinberg et al., 2003). The individuals’ attention is centered on a limited stimulus field, and his or her consciousness is merged with the action (Csikszentmihalyi, 2000; Rheinberg et al., 2003). Potential problems, unease, and fears are temporarily suppressed as this mental state is accompanied by a feeling of safety and control (Csikszentmihalyi, 2000; Rheinberg et al., 2003). A balance between an individual’s ability and the difficulty of a chosen task is essential to reach a state of flow (Csikszentmihalyi, 2000).

Flow experience and intrinsic motivation are described as being conceptually similar (Csikszentmihalyi, 1997; Sheldon & Filak, 2008). Both describe intrinsically rewarding actions that are autotelic and whose execution does not depend on external incentives (Nakamura & Csikszentmihalyi, 2002; Ryan & Deci, 2017). Flow experience is often described as the result of intrinsic motivation (Kowal & Fortier, 1999), and conversely, intrinsic motivation is described as an essential prerequisite for the emergence of flow (Demerouti, 2006; Mills & Fullagar, 2008; Taylor et al., 2006). Intrinsic motivation enables the individual to consciously focus on the execution of actions and not be distracted by external incentives (Csikszentmihalyi, 1997; Taylor et al., 2006). Given these discussions, it is unsurprising that positive correlations between these types of motivation have been empirically shown in various studies (Csikszentmihalyi & Schiefele, 1993; Kowal & Fortier, 1999; Mills & Fullagar, 2008; Sheldon & Filak, 2008).

In the school context, self-determined qualities of motivation have been found to have a critical impact on students’ engagement and performance in class (Reeve, 2015; Schiefele & Schaffner, 2015). One way to foster these qualities of motivation is to support the students’ need for autonomy (Reeve, 2015). The next section depicts how this can be explained theoretically and empirically.

Motivation and autonomy support

In autonomy-supportive learning environments, students are given the freedom to independently deal with the learning objectives without unnecessary interruptions or interference (see “3” section). This autonomy allows students to focus on a limited stimulus field and be completely absorbed in a smooth action (see Taylor et al., 2006). In addition, the personal relevance and practical usability of the learning objects and actions in class are made transparent (see “3” section). The perceived relevance of an action can help an individual to identify with the underlying goals of that action, favor the perception of an internal locus of causality, and subsequently trigger self-determined qualities of motivation (see Bakker et al., 2011; Csikszentmihalyi, 1997; Reeve et al., 2002; Ryan & Deci, 2017).

Finally, offering choices can be conducive to these motivational qualities (Katz & Assor, 2007). For example, if students have a choice of the tasks, they can carry out the ones they feel best correspond to their abilities, thus working with a suitable amount of challenge. This balance between ability and task difficulty can favor the merging of action and consciousness (Csikszentmihalyi, 2000) as well as the perception of one's own competence (Danner & Lonky, 1981; Ryan & Deci, 2017). Perceived competence is considered to be a crucial prerequisite for the perception of autonomy and the development of self-determined qualities of motivation (Ryan & Deci, 2017).

In view of these interconnections, it follows that the key conditions for experiencing intrinsic motivation and flow can be fulfilled by implementing ASTB in class (see Ryan & Deci, 2017; Taylor et al., 2006). If autonomy is restricted in controlling learning environments, these self-determined qualities of motivation can be undermined (see Reeve, 2015; Ryan & Deci, 2017; Taylor et al., 2006). In these learning environments, external incentives are used that distract students from carrying out an intrinsically rewarding action (Reeve, 2015). In addition, the students are frequently interrupted by controlling instructions and put under pressure (see [Autonomy support](#)). As a result, CTB is believed to hinder the experience of intrinsic motivation and flow, as it favors an external locus of causality and undermines a voluntary execution of actions (Reeve, 2015). At the same time, controlling instructions make it more difficult to focus on a limited stimulus field and be completely absorbed in an action (Taylor et al., 2006; Triemer & Rau, 2001).

Previous studies suggest that there are gender-related differences in the depicted qualities of motivation in the school context (Blossfeld et al., 2009; Meece et al., 2006; Schiepe-Tiska et al., 2016; Wang & Degol, 2017). These differences are the focus of the following section.

Gender differences in motivation

Although gender-related differences in motivation and personality are assumed to be key predictors of disparities in performance, little research has been conducted in these areas (Palm, 2012; Steinmayr and Spinath, 2008). In Germany, Blossfeld et al. (2009) found that boys had stronger motivational orientations toward the natural sciences than girls. However, these results only depict a general picture and are not subject-specific. The male motivational orientation toward the natural sciences was echoed in Schiepe-Tiska et al.'s (2016) more recent study, which found significant differences in boys' and girls' interest, enjoyment, and motivation in natural science subjects with a strong effect size (Schiepe-Tiska et al., 2016; international: see Meece et al., 2006; Wang & Degol, 2017). Gender-related differences in Germany are distinctly than the Organization for Economic Cooperation and Development (OECD) averages and in countries such as the United Kingdom, Finland, or Canada (Schiepe-Tiska et al., 2016). Research reveals that girls show a higher degree of interest in biology, and the subject is considered a female domain (Budde, 2008; Dietze et al., 2005; Hannover & Kessels, 2002; Quaiser-Pohl, 2012). Therefore, we assume that these gender-related findings apply particularly to the natural science subjects chemistry and physics but not the natural science subject biology, where gender differences in favor of girls might be presumed.

In engaging diverse student groups, teachers should understand that gender not only affects motivational orientations toward subject areas but also the ways students respond to different teaching behaviors and the learning environments teachers offer. Hence, ASTB and CTB will be discussed regarding gender issues in the following section.

Gender differences and autonomy support

As boys and girls perceive and adapt to learning environments differently (Giest, 1997; Guggenbühl, 2008), ASTB and CTB might yield different effects on their motivation (see Desch et al., 2017; Lüftenegger et al., 2011). Boys experience fewer choices and feel less self-determined at school (Budde, 2008; Ratelle & Duchesne, 2014), though they have a general orientation toward an ideal of autonomous, independent, and dominant masculinity (Flaake, 2006; Palm, 2012). That is, boys think that things are decided over their heads more frequently than girls and experience themselves as consuming and uninvolved in school processes (Budde, 2008). Boys see freedom of choice and action only in the interaction with their classmates (Budde, 2008). Due to this lack of self-determination in the school environment, boys hardly develop any interest or motivation toward the learning objects (Budde, 2008; see also Ryan & Deci, 2017). This reluctance might be mitigated by the opportunities for self-paced learning and decision-making offered in autonomy-supportive settings.

Furthermore, through demonstrations of strength and independence, boys attempt to clearly distinguish themselves from girls (Flaake, 2006). Boys disturb class more frequently to gain attention, are distracted more easily, and do not feel obligated to abide by the rules (Flaake, 2006; Guggenbühl, 2008; Kessels & Heyder, 2020). As a consequence, boys tend to have conflicting relationships with their teachers (Hughes & Chen, 2011) and are more frequently criticized or admonished by the teacher than girls (Wienekamp, 1990). This might lead boys to perceive a high degree of control (Großmann et al., 2018).

The roots of these behaviors might stem from a lack of consideration of boys' ideas, perspectives, and feelings, as well as boys not understanding why they have to abide by the rules. ASTB might be an opportunity to address these problems because it considers the views and feelings of the students (Reeve, 2015). This awareness can improve the relationship between boys and their teachers and reduce the number of conflicts (see Froiland et al., 2019; Reeve, 2015; Ryan & Deci, 2017). Moreover, because autonomy-supportive settings require the teacher to provide rationales for work processes and explanations regarding why rules are relevant for both the individual student as well as the whole class, boys might be more likely to follow the rules and disrupt the lessons less frequently (see Reeve, 2015; Su & Reeve, 2011).

CTB most likely exacerbates the depicted problems and conflicts between boys and their teacher because it denies them self-paced learning and choice-making and leaves them without rationales for doing work and following rules. Moreover, CTB does not consider boys' wishes, ideas, and feelings. This assumption is in line with Abós et al.'s (2021) study in physical education that showed externally controlling behaviors such as using commands to be particularly harmful to boys.

In contrast, girls are thought to be diligent, dependent, and less dominant (Flaake, 2006; Heyder & Kessels, 2015; Palm, 2012). Girls generally accept and execute directives more readily and are less assertive and more accommodative in interactions with their significant attachment figures (Assor et al., 2005; Guggenbühl, 2008; Lindsey et al., 1997; Maccoby, 1998). The directives and commands communicated in controlling learning environments might therefore not impair girls' perception of autonomy and motivation to the same extent as that of boys. Furthermore, research shows that girls adapt to the learning requirements in school more easily and have lower levels of conflict with their teachers (Giest, 1997; Hughes & Chen, 2011). Girls might consequently cope better with controlling learning environments and experience more autonomy and self-determined motivation than boys.

To shed light on possible gender-related effects, we investigated the impact of ASTB and CTB on boys' and girls' motivation in biology lessons. As such gender-related differences have rarely been examined (Patall et al., 2018), this investigation is of particular significance. In our study, we deliberately included both intrinsic motivation and flow experience to make motivation visible from complementary perspectives in the classroom (see Sheldon & Filak, 2008).

Hypotheses

Based on previous findings on the effects of ASTB on students' need satisfaction and motivation (Froiland et al., 2017; Haerens et al., 2015; Hofferber et al., 2016; Tessier et al., 2010), we assumed that this type of teaching behavior fosters the students' perception of autonomy as well as their intrinsic motivation and flow experience in class. In contrast, CTB was assumed to have a negative effect on students' perceived degree of autonomy, intrinsic motivation, and flow experience (Assor et al., 2005; De Meyer et al., 2014; Hofferber et al., 2016).

However, some studies and discussions suggest that boys and girls may perceive their degree of autonomy in school differently (Budde, 2008; Desch et al., 2017; Guggenbühl, 2008; Lindsey et al., 1997; Maccoby, 1998; Patall et al., 2018), which could affect their quality of motivation (Reeve, 2015; Ryan & Deci, 2017). Given that boys exhibit lower interest and perform worse than girls in biology (Dietze et al., 2005; Hannover & Kessels, 2002; Quaiser-Pohl, 2012; Schroeders et al., 2013), these gender differences may especially occur in biology lessons. ASTB might be a means to support both genders while minimizing possible gender-related differences in motivation (Desch et al., 2017; Lietaert et al., 2015; Lüftenegger et al., 2011; Schweder & Raufelder, 2021). These considerations lead to the following hypotheses.

Gender-specific differences regarding the following predictors of intrinsic motivation are less severe in lessons taught with ASTB than in those taught with CTB:

- H1a) Interest/enjoyment
- H1b) Perceived choice
- H1c) Perceived competence
- H1d) Pressure/tension

H2) Gender-specific differences regarding flow experience are less severe in lessons taught with ASTB than in those taught with CTB.

Method

Participants

Twelve classes ($N=303$; 52% girls, 48% boys) from five public secondary schools in the same district of Germany participated in the current study. These classes came from three school types of the German school system: "Realschule" (33%), "Gesamtschule" (39%), and "Gymnasium" (28%). The average age of the investigated sixth-grade students was

11.31 years ($SD=0.58$ years). Six of the classes ($n=156$) were taught autonomy-supportively and six of the classes ($n=147$) were taught in a controlling manner. The classes were randomly assigned to one of the two teaching-behavior treatments.

Procedures

One week prior to the intervention, the academic self-regulation questionnaire (SRQ-A; Müller et al., 2007) was implemented. Afterward, a teaching unit on the harvest mouse (*Microtus minutus*) was conducted in which the students worked with living animals. The students investigated the rodents' behavior and their adaptations to the habitat (e.g., climbing ability) in the first and second lessons. In the third lesson, the students' results were discussed in plenum. The intrinsic motivation short scale (Wilde et al., 2009) and the flow short scale (Rheinberg et al., 2003) were implemented at the end of the first lesson. This point in time was chosen because all ASTBs and CTBs were applied in this first lesson. The time required for the surveys was thus kept to a minimum. The lesson was embedded in a teaching unit as a special offer for the participating schools. Both intrinsic motivation and flow experience were assessed to observe motivation from complementary perspectives (see Sheldon & Filak, 2008). Intrinsic motivation was used to assess a retrospective action-related quality of experience, whereas flow experience was used to survey a current motivation related to the moment (see Csikszentmihalyi, 2010; Rheinberg et al., 2003; Wilde et al., 2009). Moreover, the investigation of both constructs can be used to obtain information about the internal validity of the study. One week after the teaching unit, the students' perceived autonomy was assessed using the perceived self-determination questionnaire (Reeve et al., 2003). In that the items for assessing the students' perceived autonomy related directly to the students' instructor who conducted the teaching unit, the assessment took place after the teaching unit by a person unknown to the students. The study design is summarized in Fig. 1.

Two student teachers (one male and one female) in advanced semesters of university studies conducted the lessons in the treatments with ASTB or CTB equally often. The use of student teachers was deemed particularly suitable for this type of intervention as they are still flexible regarding their teaching behavior because their teacher personalities are still being formed (Tessier et al., 2010). The conduct of both treatments was identical in 11 and content but varied regarding the teaching behavior exhibited (see "3" section).

In the ASTB treatment, choices were offered, and rationales were provided (see Reeve, 2015; Su & Reeve, 2011). The choices comprised the composition of the groups in which the students wanted to work, the order of the tasks, and the materials the students wanted to use. For example, the students could choose which food they wanted to give to the mice. The rationales pointed out, for instance, that the knowledge the students acquire in their work with the mice is significant to be able to build an appropriate habitat for them. Harvest mice are listed as endangered species in Germany and therefore require special protection. Choices and rationales were not offered in the CTB treatment. In the ASTB treatment, the teacher used non-controlling language by using phrases such as "you may" or "you can" (see Su & Reeve, 2011). In contrast, the controlling language used in the respective treatment contained phrases that emphasized obligation, such as "you should" or "you must/have to" (see Su & Reeve, 2011). The last aspect that was varied was the feedback provided. While the students in the ASTB treatment received informative feedback, the students in the CTB treatment received controlling feedback (see Ditton and Müller 2012; Katz & Assor, 2007; Reeve, 2015). Example statements of informative feedback include: "You did a particularly good job closely observing the harvest mice climbing behavior. You could make sure to read the information

Fig. 1 Study design

texts more carefully so that you can classify the mouse accurately. In the next lesson, you could work with the harvest mouse fact sheet so that we can discuss these findings together in the third lesson.” Example statements of controlling feedback are: “You made mistakes in describing the habitat of harvest mice. Other students were better at this task. You should read the informational texts more carefully. You worked on the task about the body characteristics of the harvest mouse, as I asked.”

To counteract instructor effects, the student teachers conducting the teaching were trained (Brosius et al., 2016). In the training, these teachers learned to implement the standardized instructions of both treatments and to react to anticipated behaviors of the students in a sufficiently similar manner. Specific rules and procedures, as well as timelines for each element of the lessons, govern the implementation of the treatments. In the training, the student teachers dealt with these rules and plans and learned to follow them. This procedure aligned with Brosius et al. (2016), who cited such training as essential in reducing instructor effects.

Measures

To assess the students' motivational regulation in their regular biology lessons, we used an adapted German version of the academic self-regulation questionnaire (e.g., Grolnick & Ryan, 1987) by Müller et al. (2007). This questionnaire captures a habitual motivation that was used to compare students in both treatments in terms of their motivational prerequisites before the intervention. The survey consists of four subscales that measure external, introjected, identified, and intrinsic types of regulation. With these subscales, the self-determination index (SDI) can be calculated using the following formula: $SDI = 2 \times \text{intrinsic} + \text{identified} - \text{introjected} - 2 \times \text{external}$. A shortened and validated German version of the intrinsic motivation inventory (e.g., McAuley et al., 1989) by Wilde et al. (2009) was used to assess intrinsic motivation. This short scale consists of four subscales with three items each (positive predictors: interest/enjoyment, perceived choice, and perceived competence; negative predictor: pressure/tension). The students' flow experience was investigated with ten items from Rheinberg et al.'s (2003) flow short scale. Eight translated items of the perceived self-determination questionnaire (Reeve et al., 2003) were ultimately used to assess the students' perceived degree of autonomy and thus check the implementation of the respective teaching behavior.

The items of all used measures were rated on a five-point rating scale (0 = strongly disagree to 4 = strongly agree). The internal consistencies of the scales ranged from sufficient to satisfactory (see DeVellis, 2012; Table 1).

Statistics

First, the students' SDI values prior to the intervention were compared regarding gender (0 = female; 1 = male) and treatment (0 = CTB treatment; 1 = ASTB treatment) employing analysis of variance (ANOVA). Afterward, we calculated an ANOVA to investigate the students' perceived degree of autonomy in both treatments to control the implementation of the teaching behavior. For students' intrinsic motivation, we applied a 2 (treatment) $\times$ 2 (gender)-multivariate analysis of covariance (MANCOVA), whereas student flow experience was investigated with a 2 (treatment) $\times$ 2 (gender)-analysis of covariance (ANCOVA). In a case where MANCOVA and ANCOVA revealed significant interactions, simple effects analyses with a Bonferroni confidence interval adjustment were conducted.

The student teachers who conducted the lessons were inserted as the covariate. Teachers can implement ASTB and CTB differently due to, for example, their orientation toward autonomy and control (Reeve, 2015). In addition, the teachers' gender can have an impact on the degree to which the students perceive their needs as being fulfilled (see Eckes et al., 2020). Consequently, the student teacher can have an impact on the students' perception of autonomy and their motivation and therefore needs to be considered in the analyses. Regarding intrinsic motivation and flow experience, the requirements for the use of the covariate were fulfilled except for the homogeneity of regression slopes (see Field, 2016). Presumably, the violation of this requirement does not affect the statistical power or the likelihood of a type 1 error due to the equal distribution of the sample size in each group (Bortz & Schuster, 2010; Stevens, 2001). Regarding the students' perceived autonomy, we found no correlation with the variable "student teacher." As this lack of correlation violates an essential requirement for the use of the covariate (see Field, 2016), the student teacher variable was not included in the ANOVA for the students' perceived autonomy.

Table 1 Number of items, example items, as well as internal consistencies of the applied scales

Test instrument	Subscale	Number of items	Example item	Cronbach's α
Academic Self-Regulation Questionnaire (Müller et al., 2007)			I learn in biology lessons...	
	<i>Intrinsic</i>	5	... because it's fun.	0.804
	<i>Identified</i>	4	... because I will get a better job with the knowledge gained.	0.813
	<i>Introjected</i>	4	... because I would have a bad conscience if I didn't.	0.694
Intrinsic Motivation Short Scale (Wilde et al., 2009)	<i>External</i>	4	... because I have to learn it.	0.636
	<i>Interest/enjoyment</i>	3	The activity in the lesson was very interesting.	0.823
	<i>Perceived choice</i>	3	I could choose how to handle the activity in the lesson.	0.729
Flow Short Scale (Rheinberg et al., 2003)	<i>Perceived competence</i>	3	I did a good job on the activity in the lesson.	0.750
	<i>Pressure/tension</i>	3	I felt pressured during the activity in the lesson.	0.602
	-	10	I have the feeling that I have the activity in the lesson under control.	0.799
Perceived Self-Determination (Reeve et al., 2003)	-	8	This teacher allowed me to decide how to handle the task by myself.	0.871

Results

Preliminary results

At first, correlations between all dependent variables were investigated (Table 2). To check for differences in the students' motivational regulation in their regular biology lessons prior to the intervention, the SDI values were compared using ANOVA. In the comparison of the ASTB ($M=3.26$, $SD=2.91$) and CTB treatments ($M=2.65$, $SD=3.06$), no significant difference in the students' motivational regulation was found ($F(1, 301)=3.22$, $p=0.074$, $\eta^2=0.01$). Regarding gender, the ANOVA yielded a significant difference in boys' and girls' motivational regulation in favor of the girls ($M_{\text{girls}}=3.36$, $SD_{\text{girls}}=2.99$; $M_{\text{boys}}=2.53$, $SD_{\text{boys}}=2.94$; $F(1, 301)=5.94$, $p=0.015$, $\eta^2=0.02$). Finally, we examined whether the implementation of ASTB and CTB was successful. The ANOVA revealed significant differences in the students' perceived autonomy in the comparison of the ASTB and CTB treatments in favor of the students in the ASTB treatment ($F(1, 254)=58.19$, $p=0.000$, $\eta^2=0.19$; Table 3).

Main results

Regarding hypotheses H1a and H1b, the MANCOVA showed significant interaction effects of gender and treatment on the subscales interest/enjoyment and perceived choice (Fig. 2; Table 4). In the CTB treatment, the girls experienced a higher level of interest and enjoyment than the boys, but they reported a nearly equal amount of interest and enjoyment in the ASTB treatment (Table 3). Simple effects analysis revealed a significant effect of the treatment on boys' interest and enjoyment ($F(1, 299)=19.73$, $p=0.000$, $\eta^2=0.06$), but no significant effect on girls' interest and enjoyment ($F(1, 299)=2.46$, $p=0.118$, $\eta^2=0.01$). With regard to the subscale perceived choice, the girls perceived having more choice than the boys in the CTB treatment, while the boys perceived having more choice than the

Table 2 Intercorrelations of all investigated variables in the treatments with autonomy-supportive (A) and controlling teaching behavior (C)

Variable	1	2	3	4	5	6
1 SDI						
2 Perceived autonomy	A: 0.21* C: 0.08					
3 Interest/enjoyment	A: 0.21** C: 0.24**	A: 0.23** C: 0.26**				
4 Perceived choice	A: 0.24** C: 0.17*	A: 0.20* C: 0.38***	A: 0.53*** C: 0.46***			
5 Perceived competence	A: 0.25** C: 0.12	A: 0.17 C: 0.28**	A: 0.59*** C: 0.60***	A: 0.58*** C: 0.48***		
6 Pressure/tension	A: -0.29*** C: -0.25**	A: 0.03 C: 0.05	A: -0.18* C: 0.02	A: -0.09 C: 0.08	A: -0.03 C: 0.08	
7 Flow	A: 0.21** C: 0.14	A: 0.31*** C: 0.36***	A: 0.51*** C: 0.61***	A: 0.49*** C: 0.50***	A: 0.55*** C: 0.66***	A: -0.15 C: -0.01

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Means and standard deviations of students' perceived autonomy, their perception of the predictors of intrinsic motivation, and their flow-experience

	Group A/G <i>M (SD)</i>	Group A/B <i>M (SD)</i>	Group C/G <i>M (SD)</i>	Group C/B <i>M (SD)</i>
Perceived autonomy	3.14 (0.61)	3.25 (0.72)	2.67 (0.55)	2.41 (0.83)
Interest/enjoyment	3.63 (0.61)	3.66 (0.44)	3.46 (0.69)	3.16 (0.94)
Perceived choice	2.71 (0.85)	3.01 (0.73)	2.37 (0.83)	2.18 (0.84)
Perceived competence	3.03 (0.63)	3.09 (0.62)	2.93 (0.79)	2.71 (0.74)
Pressure/tension	1.19 (0.71)	1.65 (0.97)	1.42 (1.00)	1.60 (0.88)
Flow	2.98 (0.57)	2.95 (0.54)	2.90 (0.55)	2.56 (0.66)

Note: A/G, ASTB, girls; A/B, ASTB, boys; C/G, CTB, girls; C/B, CTB, boys. Range of the rating scale: 0 (*strongly disagree*) to 4 (*strongly agree*)

girls in the ASTB treatment (Table 3). However, boys' and girls' perception of choice was higher in the ASTB treatment than in the CTB treatment (Table 3). Simple effects analysis showed that the effect of the treatment is significant for boys ($F(1, 299) = 37.83, p = 0.000, \eta^2 = 0.11$) and for girls ($F(1, 299) = 7.01, p = 0.009, \eta^2 = 0.02$).

For the subscales perceived competence and pressure/tension, no significant interactions of gender and treatment were found (H1c, H1d; Fig. 2; Table 4). A significant main effect of the treatment can be reported for the subscale perceived competence, whereas a significant main effect of gender can be shown for the subscale pressure/tension (Table 4). Students in the ASTB treatment perceived themselves as more competent than students in the CTB treatment (Table 3). With regard to the subscale pressure/tension, the boys perceived nearly the same amount of pressure and tension in the ASTB and the CTB treatment, whereas girls in the ASTB treatment felt less pressured than those in the CTB treatment. Finally, the covariate had a significant impact on all subscales except for the subscale interest/enjoyment (Table 4).

Regarding our last hypothesis (H2), and thus the students' flow experience, the ANCOVA revealed a significant interaction between gender and treatment (Fig. 2; Table 4). In the CTB treatment, the girls experienced higher degrees of flow than the boys, whereas both genders experienced nearly the same amount of flow in the ASTB treatment (Table 3). Simple effects analysis showed a significant impact of the treatment on the flow experience for the boys ($F(1, 299) = 16.46, p = 0.000, \eta^2 = 0.05$), but not for the girls ($F(1, 299) = 0.74, p = 0.389, \eta^2 = 0.00$). A significant effect of the covariate was found for the students' flow experience as well (Table 4).

Discussion

In the current study, we investigated students' quality of motivation in biology lessons with ASTB and CTB. Against the background of gender-related theoretical and empirical findings, we assumed these teaching behaviors would likely yield different effects on boys' and girls' quality of motivation.

Fig. 2 Interaction of treatment and gender for all investigated constructs

Our results for the investigated predictors of intrinsic motivation were inconsistent. Regarding the positive predictor interest/enjoyment, we found a significant interaction effect of gender and treatment (H1a). This subscale measures intrinsic motivation per se (Wilde et al., 2009). Given that girls generally have a higher interest in and a higher motivational orientation toward biology (Dietze et al., 2005; Schiepe-Tiska et al., 2016), we expected the girls to have higher values on this subscale. The gender-related differences in the SDI-values lend credence to this assumption (see “Preliminary results” section). Our results show that the girls exhibited a nearly equal amount of interest and enjoyment in both treatments (Fig. 2). CTB had little effect on their interest and enjoyment in comparison to ASTB. Given that girls are more likely to accept and execute directives and commands from significant attachment figures (Assor et al., 2005; Lindsey et al., 1997;

Table 4 Results of the uni- and multivariate analyses of covariance regarding students' perception of the predictors of intrinsic motivation as well as their flow experience

	Main effect treatment	Main effect gender	Interaction effect (treatment x gender)	Effect of the covariate (student teacher)
Interest/enjoyment	$F(1, 301) = 18.85, p = 0.000, \eta^2 = 0.06$	$F(1, 301) = 3.58, p = 0.059, \eta^2 = 0.01$	$F(1, 301) = 4.48, p = 0.035, \eta^2 = 0.02$	$F(1, 301) = 3.52, p = 0.062, \eta^2 = 0.01$
Perceived choice	$F(1, 301) = 40.81, p = 0.000, \eta^2 = 0.12$	$F(1, 301) = 0.05, p = 0.823, \eta^2 = 0.00$	$F(1, 301) = 6.86, p = 0.009, \eta^2 = 0.02$	$F(1, 301) = 7.62, p = 0.006, \eta^2 = 0.03$
Perceived competence	$F(1, 301) = 9.42, p = 0.002, \eta^2 = 0.03$	$F(1, 301) = 1.73, p = 0.190, \eta^2 = 0.01$	$F(1, 301) = 3.21, p = 0.074, \eta^2 = 0.01$	$F(1, 301) = 6.68, p = 0.010, \eta^2 = 0.02$
Pressure/tension	$F(1, 301) = 0.78, p = 0.377, \eta^2 = 0.00$	$F(1, 301) = 8.21, p = 0.004, \eta^2 = 0.03$	$F(1, 301) = 1.77, p = 0.185, \eta^2 = 0.01$	$F(1, 301) = 4.57, p = 0.033, \eta^2 = 0.02$
Flow	$F(1, 301) = 13.44, p = 0.000, \eta^2 = 0.04$	$F(1, 301) = 9.99, p = 0.002, \eta^2 = 0.03$	$F(1, 301) = 5.56, p = 0.019, \eta^2 = 0.02$	$F(1, 301) = 14.18, p = 0.000, \eta^2 = 0.05$

Maccoby, 1998), they might have perceived the exhibited CTB as only moderately coercive and therefore still showed a high degree of interest and enjoyment in the biology lessons.

Our results further show that the boys experienced comparable levels of interest and enjoyment to the girls when they were taught in an autonomy-supportive manner and reported less interest and enjoyment than the girls when their teacher behaved in a controlling manner. Thus, the effects of ASTB and CTB on their interest and enjoyment were significantly stronger than the effects on girls' interest and enjoyment. This might be ascribed to the fact that ASTB can help boys to overcome the difficulties they commonly struggle within the school, such as their perception of having little freedom of choice and self-determination as well as their propensity for rule-breaking and disrupting lessons (see Budde, 2008; Flaake, 2006; Guggenbühl, 2008; Kessels & Heyder, 2020). ASTB offers them the possibility to develop a similar level of interest and enjoyment in biology lessons that girls exhibit, regardless of the teaching behavior. Our results also support the notion that CTB seems to be a source of tension that keeps boys from becoming interested in and enjoying the learning content. As a result of these different effects of ASTB and CTB on boys' and girls' motivation, the gender gap in the students' interest and enjoyment was distinctly smaller in the ASTB treatment than in the CTB one (Fig. 2).

In the comparison of the ASTB and CTB treatments, the same pattern can be seen for the positive predictor of intrinsic motivation perceived competence descriptively. However, we did not find a significant interaction between the treatment and the students' gender regarding their perceived competence (H1c). The satisfaction of the basic need for competence is assumed to be a prerequisite for intrinsically motivated behavior (Ryan & Deci, 2017). We, therefore, expected the subscale perceived competence to show the same gender-specific effects as the subscale interest/enjoyment. Given that the effects of gender differences are usually small, one explanation for our observation might be that our sample was not large enough to detect an effect in this subscale. Alternatively, it might be that students benefit from ASTB regarding their perception of competence regardless of their gender. As the needs for autonomy and competence are interdependent (see Krapp, 2005; Ryan & Deci, 2017), this observation is surprising. In order to express their skills and feel effective, students need a certain degree of autonomy (Großmann et al., 2020; Krapp, 2005). Therefore, it is more difficult for students to satisfy their need for competence in controlling than in autonomy-supportive environments (Großmann et al., 2020). This seems to apply equally to boys and girls.

A significant interaction between gender and treatment was again found in the subscale perceived choice (H1b). The gender gap in the students' perception of being able to make choices regarding their learning was nearly equal in both treatments (Fig. 2). However, the boys perceived having more choice in the ASTB treatment, and girls perceived having more choice in the CTB treatment. This result suggests that having more freedom of choice seemed to be particularly important for the boys. As boys generally experience few possibilities to make choices at school (Budde, 2008; Flaake, 2006; Palm, 2012), the choices provided in ASTB treatment might have been more meaningful to them than to the girls (see Katz & Assor, 2007). This result is in line with a study by the Desch et al. (2017), who showed that boys can especially benefit from a democratic choice of the topic of a teaching unit in biology lessons. The results of the present study show that this is also the case when small-scale methodological choices are offered (see "13" section).

Regarding the subscale pressure/tension, the boys perceived an equal amount of pressure and tension in both treatments, whereas the girls experienced less pressure and tension in the ASTB treatment. Contrary to our previous results, the gender gap was distinctly smaller in the CTB treatment than in the ASTB treatment (H1d; Fig. 2). This result might

be ascribed to the fact that the students in this study had just reached adolescence. In this developmental phase, gender-stereotypic beliefs gain importance as students come to terms with their own identity (Flaake, 2006). During this process, they compare their subjectively perceived identity with the prototype of the subject (Kessels, 2012). Biology is generally perceived as a feminine domain (Budde, 2008; Hannover & Kessels, 2002; Quaiser-Pohl, 2012). Teachers attest to girls performing better in this subject than boys (Kahle et al., 1993). If boys perceive such gender-specific teacher expectations, they might feel pressured into not fulfilling these expectations (see Thomas, 2017), regardless of the teaching behavior. However, to test these assumptions, future studies would need to assess additional variables such as students' attitudes toward and beliefs about the domain. In contrast, the girls felt less pressure and tension when they were taught in an autonomy-supportive manner, which is in line with theoretical assumptions and previous studies (Assor et al., 2005; Hofferber et al., 2016; Reeve, 2015; Ryan & Deci, 2017).

Regarding the students' flow experience, our theory-based assumptions about gender-related effects of ASTB and CTB on students' motivation were confirmed (H2). The more destructive effects of CTB on boys' experiences in class and, as a result, a smaller gender gap in the ASTB treatment was also identified concerning this quality of motivation. In that intrinsic motivation is described as a vital prerequisite for the emergence of flow (Demerouti, 2006; Mills & Fullagar, 2008; Taylor et al., 2006), we expected to find comparable effects of the implemented teaching behavior on students' interest and enjoyment, which depicts their intrinsic motivation per se as well as their flow experience. Due to the interrelationships between intrinsic motivation and flow experience, the assumptions about the causes of the gender-related effects of ASTB and CTB on students' interest/enjoyment apply to their flow experience as well.

In sum, we found that CTB had more destructive effects on the boys' quality of motivation in biology lessons (see Abós et al., 2021). The milder effects of CTB on the girls' motivation might be ascribed to girls generally adapting to learning requirements more readily than boys (Giest, 1997) and that boys and girls experience learning environments differently (Guggenbühl, 2008; see also Patall et al., 2018). In addition, students' own stereotypic beliefs can impact how they perceive their teachers' behaviors (Patall et al., 2018). If boys and girls believe that biology is a girls' domain (see Budde, 2008; Hannover & Kessels, 2002; Quaiser-Pohl, 2012), they may perceive the behavior of the biology teacher differently.

That said, the effects of the student teacher have to be discussed. Teachers can implement ASTB and CTB differently due to their own orientations toward autonomy and control (Reeve, 2015), which can affect students' motivation. As only one female and one male student teacher conducted the treatments, their gender might also have caused the effects of the covariate on students' intrinsic motivation and flow experience (see Eckes et al., 2018b). Future studies might choose other types of implementation control to examine the effects of the teacher in a more differentiated way.

The results of our study suggest that ASTB can help diminish differences in motivation in biology classes, particularly concerning the male gender, without putting the female gender at a disadvantage. Boys can experience the same quality of motivation as girls in biology and overcome the negative effects of the discipline being stereotyped as a feminine domain. In addition to the advantages regarding motivation, addressing both genders simply through teaching behavior might be a further step toward successfully creating an inclusive classroom (Ainscow & César, 2006; UNESCO, 2009). Future research should therefore focus on both boys and girls by designing learning environments that support both sexes (see Bartlett & Burton, 2011). The current findings, as well as the findings of

earlier studies (Desch et al., 2017; Lietaert et al., 2015; Lüftenegger et al., 2011; Schweder & Raufelder, 2021), suggest that autonomy support as a viable approach to address gender differences should be part of this research as well as studies on teacher education (see Kollmayer et al., 2019).

Limitations and implications

Despite our promising results, some limitations of our study need to be addressed. First, examining the descriptive statistics, all the values of the students' perception of autonomy and their quality of motivation were above the medium category. Consequently, ceiling effects in the data cannot be excluded. Such ceiling effects might explain the small to medium effect sizes that we found in the current study. To avoid ceiling effects, future studies might investigate biology lessons with a less interesting topic.

Although there are small effect sizes behind gender differences, one should keep in mind that even small differences can have significant educational consequences. One clear manifestation of such an effect is the selection of courses at the upper levels of secondary school as well as at the tertiary level (Baumert et al., 2000; Kessels et al., 2014). Moreover, interest in a subject (or lack thereof) can have far-reaching societal impacts. For example, many topics covered in biology lessons have a great social relevance (e.g., the conservation of biodiversity, education for sustainable development; see also UNESCO, 2017). If boys lose or do not develop an interest in these topics, they will not confront these societal issues in the future.

However, it should be considered that science lessons may not always adequately address societal issues. In the German core curriculum for biology in secondary education, for example, education for sustainable development is defined as a cross-curricular task (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen [MSW NRW], 2019). In addition, nature conservation is one of the six content areas anchored in the core curriculum (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen [MSW NRW], 2019). Societal issues are also addressed in the other five content areas, even if they are not specifically named as such (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen [MSW NRW], 2019). Since the core curriculum is mandatory, societal issues must be addressed in class. However, the extent to which teachers implement these issues needs to be the subject of further research. Furthermore, the curricula of other countries may differ from the German curriculum regarding societal issues.

In addition, the nested data structure ought to be considered. It is possible that characteristics relevant to the intervention might not have been distributed in a sufficiently similar way in the individual classes and schools. If these differences are not taken into account, the standard error may be underestimated, and an inaccurate significance test may be a possible consequence (Ditton, 1998). To estimate differences in the students' motivational regulation in their regular biology lessons, we determined the intraclass correlation for the SDI ($ICC=0.05$). Cohen et al. (2003) assume that even such small intraclass correlations can impact the test of significance. However, in multilevel analyses that could account for the effects of the class affiliation, a too-small number of cases at the second level ($n=10$) would lead to distortions in the estimation of standard errors when the variance components are distributed to different levels (Maas & Hox, 2004). To make statements based on multilevel analyses, the current study would have to be replicated on a larger scale.

Regarding treatment fidelity, note that the success of the implementation of the ASTB and CTB was derived from the students' perception of autonomy in our study. In addition to checking implementation using test instruments, future studies could use external trained observers to assess the implementation of the behaviors (see Aelterman et al., 2014; Cheon & Reeve, 2015). Audio and video recordings of the lessons represent another alternative. However, with these alternative methods, it is important to consider that they may influence the actors involved in the lesson and subsequently can lead to biased results (Praetorius, 2013; Praetorius et al., 2017). Furthermore, classroom assessments by external observers have been critically discussed regarding objectivity, among other things (Praetorius, 2013).

When considering ASTB and CTB, it should be noted that the teaching behaviors "providing a rationale" and "offering choices" can be characterized as either autonomy-supportive or controlling, depending on whether a teacher implements them. However, this characterization is not so simple for the applied language and given feedback. A teacher's language and feedback can contain both neutral or informative and controlling aspects. Moreover, a teacher can implement ASTB and CTB in class simultaneously. For example, a teacher can provide students with a rationale for the topics and actions but not offer freedom of choice. Future studies could investigate the extent to which teachers in real classroom settings implement these different behaviors. Such studies could, for example, identify types of teachers who implement a particular combination of these teaching behaviors (see Escrivá-Boulley et al., 2021).

Regarding offering choices, it must be considered that students might also choose an option for reasons other than the selection of an optimal challenge, such as completing the task quickly or having fun with classmates while doing it. One way to deal with this might be that the teacher determines the level of the challenge but allows for freedom of choice regarding the material with which the task is completed, as was the case in our study. As shown in our findings, these choices can have a positive impact on students' perception of autonomy (see also Hofferber et al., 2016; Desch et al., 2017).

Lastly, consideration should be given to biological sexes not reflecting the spectrum of gender identities. In our study, no student identified him or herself as non-binary. Nevertheless, students who identify themselves as non-binary should also be included in future gender studies. As the percentage of these students might be small in classes, some thought would need to be given to sampling recruitment.

In future research, the implemented behaviors in our study can be investigated in studies related to other subjects. Various studies show that similar effects of ASTB on motivation and other variables relevant to learning can be expected in other subjects (e.g., Haerens et al., 2015; Mittag et al., 2009; Shen, 2015). Regarding the reduction of gender differences in other subjects that are considered to be boys' domains, ASTBs must be considered in a differentiated way according to the reasons underlying the gender-specific differences. For example, Shen (2015) found that if reduced interest and lower self-determined motivation of girls in physical education is based on them not recognizing the personal relevance of the content and activities in class, providing rationales could contribute to reducing gender differences. If the low self-determined motivation of girls in other subjects that are considered boys' domains (e.g., chemistry and physics) is also caused by a lack of perceived relevance, providing rationales might help reduce the gender gap in these subjects as well.

Moreover, due to the increasing striving for autonomy during adolescence (Reindl et al., 2013), biology classes in higher grades should be included when examining the effects of ASTB and CTB. This rising desire for autonomy could lead to CTB having a stronger impact on girls' perception of autonomy and motivation. As a consequence, the gender gap

in the CTB treatment would turn out to be smaller. In this case, both genders could benefit equally from ASTB. However, an adaptation of the ASTBs and CTBs should be considered in such studies. For example, it may be that the choices offered to the sixth graders in our study are not meaningful for older students. In this case, the positive effects of choice on students' perceived autonomy and motivation are not to be expected (see Katz & Assor, 2007).

Funding Open Access funding enabled and organized by Projekt DEAL. This project is part of the “Qualitätsoffensive Lehrerbildung,” a joint initiative of the Federal Government and the *Länder*, which aims to improve the quality of teacher training. The program is funded by the Federal Ministry of Education and Research (funding code: 01JA1908). The authors are responsible for the content of this publication.

Declarations

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent for publication All authors have approved the final version of this manuscript and agree with the order of the authors.

Conflict of interest The authors declare no competing interests.

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