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The Influence of Gender and Interest on the Use of Learning Strategies in Biology Lessons

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Abstract: For biology students, the diversity, complexity, and abundance of content in this field yield a heavy study load. Hence, appropriate learning strategies are key in supporting learners' academic success. In biology, the factors gender and interest hold a unique position within the natural sciences, as there is an academic imbalance to the disadvantage of male students. In the present study, we examined the influence of gender and interest as well as its interdependencies on the students' use of learning strategies for biology learning. A total of 180 seventh through tenth grade students ($M_{\text{age}}=14.47$; $SD=1.35$; 60% female) from four general-track secondary schools located in Germany participated in this study. Data on the students' level of interest and the use of learning strategies in biology lessons were collected. We used multivariate analysis of covariance with the students' age as the covariate to analyse our data. Results revealed a significant effect of gender on the students' use of the learning strategies rehearsal, organisation, effort, and time management. With regard to elaboration and effort, the effects of interest were found to be significant. The gender gap regarding learning strategy use was narrower for students with high levels of interest. These findings might have implications for beneficial teacher behaviour in biology.

Keywords: *Biology lessons, gender, interest in biology, learning strategies.*

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Introduction

The use of learning strategies helps learners organise and maintain knowledge achievement, understanding, and long-lasting learning in biology (Shen et al., 2018). The acquisition of scientific literacy (Organisation for Economic Cooperation and Development [OECD], 2016) requires an enhanced understanding of learning processes, their mechanisms, and learning strategies. Lifelong learning skills may be supported through the use of learning strategies in biology lessons (Cornford, 2002). Cognitive learning strategies in particular appear to have a direct influence on learning as they entail the processing and storage of information (den Elzen-Rump et al., 2008). Numerous studies suggest that students profit from using learning strategies for their knowledge achievement (Isaak et al., 2020; Souvignier & Gold, 2004). Thus, learning can be influenced by the knowledge and application of adequate learning strategies. Depending on the learning objective, the domain, and the specific subject, some learning strategies may be more useful (Ziegler & Dresel, 2006). Research on learning strategies often examines gender-related differences and the effects of interest on the use of learning strategies; however, the interdependencies of gender and interest on learning strategies have been scantily researched (McWhaw & Abrami, 2001; Soric & Palekcic, 2009; Ziegler & Dresel, 2006). When it comes to biology education, it is important to consider gender, interest, and the specifics of the subject area in order to better identify and understand which learning strategies learners use in order to gain insights into how they may be optimally fostered. To date, no studies have investigated whether learning strategies are influenced by gender or interest in biology learning. To address this research desideratum, the present study investigates the effect of gender and interest on the use of learning strategies in biology lessons.

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Literature Review

Learning strategies for biology learning

Weinstein and Mayer (1986) define learning strategies “as behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner’s encoding process” (p. 315). Learning strategies can be categorised into *cognitive strategies*, *resource management* and *metacognitive strategies* (den Elzen-Rump et al., 2008). The use of these different learning strategies could be relevant for learning biology (Shen et al., 2018). Cognitive learning strategies support biology learning by helping learners process information (Weinstein & Mayer, 1986). They include the strategies of *rehearsal*, *elaboration*, and *organisation* (den Elzen-Rump et al., 2008; Weinstein & Mayer, 1986). *Rehearsal strategies* are used to memorise and acquire a learning content (e.g., repeating facts). With regard to the quantity and variety of biology topics, the use of various *rehearsal strategies* could be important, especially before exams. The use of *elaboration strategies* helps to integrate the learning content into prior knowledge (Weinstein & Mayer, 1986). They involve aspects such as summarising the learning content, constructing analogies, and answering questions about the new learning material (Roelle et al., 2017; Weinstein & Mayer, 1986). For biology learning, *elaboration* might help the learner to really understand overarching key concepts such as compartmentalisation (see Secretariat of the Standing Conference of Education Ministers of the Länder in the Federal Republic of Germany, 2005) and to make connections between the sub-disciplines of biology (Kattmann, 2016). For the systematisation of newly acquired knowledge, *organisational strategies* can be helpful. They include prioritisation, categorisation and systematisation, which manifest themselves in techniques such as marking content items or creating a mind map (Pribadi & Susilana, 2021; Roelle et al., 2017; Weinstein & Mayer, 1986). The subject of biology is characterised by varying system levels such as ecosystems, organisms, organs, cells, cell organelles or biochemical processes within cell compartments (Hammann, 2019). Thus, studying biology requires the understanding of these system levels (Parker et al., 2012). Lastly, the use of *organisational strategies* could counteract the acquisition of unrelated factual knowledge (Jördens et al., 2016). Fiorella and Mayer (2016) found that visualising knowledge in the form of mind-maps and diagrams helped students to develop their knowledge structures (see also Stokhof et al., 2020).

The strategies of resource management consist of internal and external resources (den Elzen-Rump et al., 2008; Waldeyer et al., 2019). Internal resources comprise *effort*, *attention management*, and effective *time management* (den Elzen-Rump et al., 2008). The use of *effort* and *time management strategies* could help learners deal with the considerable volume and complexity of biology-related topics. *Time management strategies* could be especially important before an exam and help learners to maintain an overview of content relevant to learning. External resources involve the *use of literature*, the *arrangement of the learning environment*, and working in a *study group* (den Elzen-Rump et al., 2008).

The last group of learning strategies, metacognitive strategies, aim to control and regulate the cognitive learning strategies (den Elzen-Rump et al., 2008). They consist of *planning*, *monitoring*, and *regulation strategies*, which help students to structure and observe their learning process at a meta level (den Elzen-Rump et al., 2008). According to Brod (2020), the use of metacognitive strategies is mostly relevant for college and university students. Hence, in our study we only included cognitive strategies and resource management to receive first insights into student’s strategy use for biology learning with respect to the interdependencies between the factors gender and interest.

Learning strategies for biology learning in relation to gender

In science education, several empirical studies have found differences between females and males, mostly in favor of males (Schiepe-Tiska et al., 2016). However, when it comes to the subject of biology, this issue becomes more complicated. Although biology belongs to science, females generally exhibit better grades and choose biology as a subject more often than boys do (Kessels et al., 2014). As stated above, biology is characterised by a high number of various and complex topics and thus requires a very good understanding of the vertical and horizontal connectivity within the different system levels (Hammann, 2019). One reason for these gender related differences in favor of females might be the more appropriate use of learning strategies. Previous studies have mostly examined gender differences in learning strategy use without regard to a specific domain (Ziegler & Dresel, 2006). In biology, the appropriate use of learning strategies might help girls to cope with the complexity of the subject. However, to our knowledge, there are currently no studies that have assessed gender differences with respect to the use of learning strategies for learning biology. In the following section, the results of previous studies regarding learning strategies (cognitive strategies: *rehearsal*, *elaboration* and *organisation*; resource management: *effort* and *time management*) and gender are presented considering the respective domain of the study (subjects and contexts).

The research on cognitive strategies have yielded ambiguous results to date (Ziegler & Dresel, 2006). For *rehearsal strategies*, the findings of the Programme for International Student Assessment (PISA) study (Artelt et al., 2003) suggest that girls are more likely to use rehearsal strategies than boys. These results have been supported by several studies (Artelt et al., 2003; Dresel et al., 2004; Rozendaal et al., 2003; Ruffing et al., 2015). Bembenutty (2007) found similar results among university students. It should be noted that these studies did not assess learning strategies in a specific domain. Zimmerman and Martinez-Pons (1990) assessed rehearsal strategies at school using a structured interview in eight different learning *contexts* (e.g., doing homework tasks or preparing for class work). Their findings revealed no

gender-related differences in the use of rehearsal strategies. For *elaboration* and *organisational strategies*, the results of the PISA study suggest that there were no significant gender differences (Artelt et al., 2003). Rozendaal et al.'s (2003) investigation found that males reported to use elaboration strategies more frequently than females. In the context of geometry, Pokay and Blumenfeld (1990) found that girls reported a more frequent use of elaboration and organisational strategies. In short, the findings on gender differences with regard to *elaboration* and *organisational strategies* are ambiguous (see also Ziegler & Dresel, 2006). We did not find any studies on cognitive learning strategies and gender in the subject domain of biology at any educational level.

Previous studies on *effort* and *time management* are quite limited (Ziegler & Dresel, 2006), and none could be found for biology. Bembenutty (2007) examined the *effort* and *time management* of higher education students regarding gender. His results indicated no significant differences between the genders concerning *time management*. However, the females reported a more frequent use of *effort*. In addition, the investigation of Ruffing et al. (2015) confirmed these gender differences regarding effort strategies. In a study by Dresel et al. (2004), the male students of Grades 5 to 10 reported using *time management* more often.

These ambiguous findings could be explained by the gender role expectations and stereotypic beliefs in different subjects (Ziegler & Dresel, 2006). Female and male learners prefer learning behaviour that correspond to these gender roles and identity (Hannover & Kessels, 2008). As a consequence, female learners are likely to report a higher use of learning strategies in girls' domains such as languages (Moschner, 2010). By contrast, male students could increasingly use learning strategies in subjects that are described as boys' domains (e.g., the natural sciences except for biology and mathematics; Schiepe-Tiska et al., 2016). In this context, Kurman (2004) and Patrick et al. (2000) found that gender-specific differences in the use of learning strategies depend on the learning context. For the subject of biology, it might be especially interesting to investigate the gender-related strategy use due to the fact that females tend to be more interested in and perform better in biology than males do even though the reverse tends to be the case when it comes to the other natural sciences.

Learning strategies for biology learning in relation to students' interest

Interest plays an important role for learning in school (Krapp, 1992). According to Hidi and Harackiewicz (2000) interest can be characterised as a person-object interaction. Positive experiences accompanying these person-object relation can foster the acquisition of profound knowledge and the learning performance in school (Krapp, 1999; Renninger & Hidi, 2016). However, investigations have shown a decline in students' individual interest in the science-related subjects (biology, chemistry, physics) during their school careers (Krapp & Prenzel, 2011). As a consequence, science teachers should therefore foster the students' interest by dealing with phenomena relevant to the students (Ministry for Schools and Education of the State of North Rhine-Westphalia, 2019). Moreover, gender appears to be one factor that has an impact on interest and motivation in the various subject domains. For example, Schiepe-Tiska et al. (2016) found that boys show a higher degree of interest in the topics related to chemistry and physics, whereas girls are more interested in biology (Schroeders et al., 2013). Learning based on individual interest plays an important role for biology learning (Krapp, 1992). It is therefore assumed that interest can be described as a predictor of the learning strategy use.

Numerous investigations have examined the relationship between interest and motivation and the use of learning strategies (Hariri et al., 2021; McWhaw & Abrami, 2001; Pokay & Blumenfeld, 1990; Schiefele, 1991). Pintrich's study (1999) found that interest fosters the use of deep processing learning strategies such as *elaboration* and *organisational strategies*, as well as the application of surface strategies such as *rehearsal*. In addition, McWhaw and Abrami (2001) found that interest has an impact on the use of deep processing learning strategies. The study by Tulis and Fulmer (2013) also showed the effects of interest on the use of elaboration strategies. Further investigations characterise learning strategies as a mediator in the relationship between students' interest and their learning achievement (Soric & Palekcic, 2009). In science education and in biology education, investigations on the effects of interest on the use of learning strategies are scarce.

Methodology

Hypotheses

To date, learning strategies in biology and the effects of gender, interest and its interdependences on learning strategies in biology have not yet been investigated. To better understand the use of learning strategies in biology, we conducted the present study. Despite the somewhat uncertain state of research, reasonable hypotheses about the learners' use of learning strategies can be formed:

H1: The gender of the students has an impact on students' learning strategy use in biology lessons. Female students report a higher use of *rehearsal strategies* (H1a), *organisational strategies* (*transformation* and *illustrating*) (H1b) and *effort strategies* (H1c). Male students report a higher use of *elaboration strategies* (H1d) and *time management strategies* (H1e).

H2: Interest has a positive effect on the students' learning strategy use in biology lessons, specifically *organisation* (*transformation* and *illustrating*) (H2a) and *elaboration* (H2b).

H3: Gender differences regarding the use of learning strategies in biology lessons are less pronounced for students with high interest in biology than for those with low interest.

Sample

Our sample consisted of 180 students (60% female) from Grades 7 to 10 at four general-track secondary schools. On average, the students were 14.47 ($SD=1.35$) years old. Before the survey was completed, the students were informed that participation would be anonymous and would have no impact on their learning performance. The students were also divided into the following two groups based on their level of interest in biology using the median as a cut-off value ($Md=1.6$): students with high interest in biology ($n=87$) and students with low interest in biology ($n=93$). Comparing these two groups, ANOVA revealed a significant difference regarding their interest ($F(1,178)=397.95, p=.000, \eta^2=.691$).

Test instruments

The questionnaire 'How do you learn?' (Souvignier & Gold, 2004) was conducted to measure the students' use of learning strategies. Cognitive strategies and resource management were measured. The questionnaire included six subscales with 35 items. The items were assessed using a four-point rating scale from 0 (strongly disagree) to 3 (strongly agree). The cognitive learning strategies consisted of the subscales *rehearsal*, *transformation*, *illustrating*, and *elaboration*; resource management included the scales *time management* and *effort*. The two subscales *transformation* and *illustrating* assessed *organisational strategies* (Souvignier & Gold, 2004). The internal consistency was satisfactory, ranging from Cronbach's alpha $\alpha=.74$ to $.80$ (Table 1).

Table 1. Cronbach's alpha-values (α), example items, and the number of subscale items.

Subscale (number of items)	Example item When I study in biology, ...	Cronbach's α
<i>Rehearsal</i> (5)	... I practice saying the most important things to myself over and over.	.78
<i>Transformation</i> (7)	... I write short summaries of key points.	.80
<i>Illustrating</i> (5)	... I make drawings and sketches so I can understand the subject matter better.	.76
<i>Elaboration</i> (7)	... I try to find my own examples that are appropriate for the subject matter.	.74
<i>Effort</i> (6)	... I do not give up even though the subject matter is very difficult or complex.	.75
<i>Time management</i> (5)	... I stick to a specific schedule.	.76

We assessed the students' interest in topics related to biology with four adapted items from a PISA questionnaire (Frey et al., 2009; Organisation for Economic Cooperation and Development [OECD], 2007). The test instrument measured interest in topics and issues related to biology and consist of a four-point rating scale from 0 (strongly disagree) to 3 (strongly agree). For example, students had to rate the item: *I like to deal with topics in biology*. Cronbach's alpha was $\alpha=.79$.

Statistics

We conducted a 2 (gender: female/male) $\times$ 2 (interest: high/low)-MANCOVA to investigate differences in the learning strategies (*rehearsal*, *transformation*, *illustrating*, *elaboration*, *time management*, and *effort*) with regard to gender and interest. The requirements of the MANCOVA were checked. A normal distribution can be assumed for all subscales (*rehearsal*, *transformation*, *illustrating*, *elaboration*, *time management*, and *effort*). In addition, the Levene-tests showed that the homogeneity of variances (homoscedasticity of variances) can be assumed regarding all dependent variables. Box tests showed that the homogeneity of the variance-covariance matrix is fulfilled with regard to all subscales. Since the students' age could be described as a predictor for students' use of learning strategies (Brod, 2020; Lehmann & Hasselhorn, 2010), age was applied as the covariate. ANOVAs were calculated to examine the independence of the covariate from gender and interest. The results revealed no significant difference of the students' age with regard to gender ($F(1,178)=3.46, p=ns$) and interest ($F(1,168)=0.41, p=ns$) (Field, 2013). The homogeneity of regression slopes as the second requirement for using a covariate was fulfilled (Field, 2013). Regarding the students' use of learning strategies (*rehearsal*, *transformation*, *illustrating*, *elaboration*, *time management*, and *effort*), the requirements for the implementation of age as the covariate were thus fulfilled (Field, 2013).

Findings / Results

In the following section, we present the results of the 2 (gender) x 2 (interest)-MANCOVA to examine the influence of gender, and interest on the students' use of learning strategies. Regarding the learning strategies *elaboration* and *effort*, we found significant effects of the covariate *age*. This covariate had no impact on the learning strategies *rehearsal*, *transformation*, *illustrating*, and *time management* (Table 2). With regard to *gender*, we found a significant and substantial main effect ($F(6,160)=7.57$, $p=.000$, $\eta^2=.221$). For the learning strategies *rehearsal*, *transformation*, *illustration*, *time management* and *effort*, significant gender differences were found. Females showed a higher use of these learning strategies in biology lessons. Concerning the learning strategy *elaboration*, the effect of gender was found not to be significant. The female and male biology students reported nearly the same use of elaboration strategies (Table 2). For *interest*, we found a significant effect of medium effect size ($F(6,160)=1.13$, $p=.006$, $\eta^2=.105$). For the learning strategies *transformation*, *elaboration* and *effort*, the effects of interest were found to be significant (Table 2). The students with a high degree of interest in biology reported a higher level of use of these learning strategies than the students with low interest. However, we found no significant effect of the factor interest on the use of *illustrating* and *time management* strategies (Table 2). Regarding the main *interaction effect* of *gender x interest* on the students' learning strategy use, we also found a significant effect of medium effect size ($F(6,160)=2.52$, $p=.024$, $\eta^2=.086$). For biology students with low interest and for the learning strategies *transformation* and *effort*, the girls reported a higher use of these learning strategies than the boys, whereas the students with high levels of interest of both genders showed nearly the same degree of use of the learning strategies *transformation* and *effort* (Table 2). With regard to the other learning strategy subscales (*rehearsal*, *illustrating*, *elaboration*, and *time management*), no significant interaction effects of gender and interest were found (Table 2).

Table 2. Results of the multivariate analysis of covariance with regard to the learning strategy subscales.

Subscale	Gender	Interest	<i>M</i>	<i>SD</i>	Effect of gender	Effect of interest	Interaction effect (gender x interest)	Effect of the covariate
<i>Rehearsal</i>	Female	High	2.28	0.59	$F(1,165)=18.82$, $p=.000$, $\eta^2=.102$	$F(1,165)=3.26$, $p=ns$	$F(1,165)=1.02$, $p=ns$	$F(1,165)=0.08$, $p=ns$
		Low	2.20	0.62				
	Male	High	1.94	0.70				
		Low	1.65	0.66				
<i>Transformation</i>	Female	High	1.86	0.56	$F(1,165)=12.04$, $p=.000$, $\eta^2=.068$	$F(1,165)=5.77$, $p=.017$, $\eta^2=.034$	$F(1,165)=6.22$, $p=.014$, $\eta^2=.036$	$F(1,165)=1.99$, $p=ns$
		Low	1.88	0.66				
	Male	High	1.74	0.55				
		Low	1.26	0.70				
<i>Illustrating</i>	Female	High	1.39	0.63	$F(1,165)=10.08$, $p=.002$, $\eta^2=.058$	$F(1,165)=1.35$, $p=ns$	$F(1,165)=0.84$, $p=ns$	$F(1,165)=3.24$, $p=ns$
		Low	1.21	0.73				
	Male	High	0.96	0.63				
		Low	0.91	0.69				
<i>Elaboration</i>	Female	High	1.27	0.58	$F(1,165)=0.09$, $p=ns$	$F(1,165)=4.48$, $p=.036$, $\eta^2=.026$	$F(1,165)=3.28$, $p=ns$	$F(1,165)=5.72$, $p=.018$, $\eta^2=.034$
		Low	1.22	0.51				
	Male	High	1.48	0.67				
		Low	1.11	0.61				
<i>Effort</i>	Female	High	2.06	0.53	$F(1,165)=23.77$, $p=.000$, $\eta^2=.126$	$F(1,165)=9.59$, $p=.002$, $\eta^2=.055$	$F(1,165)=4.08$, $p=.045$, $\eta^2=.024$	$F(1,165)=8.21$, $p=.005$, $\eta^2=.047$
		Low	1.99	0.53				
	Male	High	1.79	0.61				
		Low	1.36	0.56				
<i>Time management</i>	Female	High	1.23	0.85	$F(1,165)=19.77$, $p=.000$, $\eta^2=.107$	$F(1,165)=0.15$, $p=ns$	$F(1,165)=0.44$, $p=ns$	$F(1,165)=2.35$, $p=ns$
		Low	1.37	0.65				
	Male	High	0.80	0.65				
		Low	0.77	0.60				

Discussion

The objective of the present study was to investigate the influence of gender and interest and the interaction of these variables on the students' learning strategy use in biology lessons.

First, we hypothesised that gender would have an impact on the students' use of rehearsal, organisation (transformation and illustrating), elaboration, effort, and time management strategies in biology lessons. Our results revealed that the girls reported a higher use of rehearsal (H1a), organisation (transformation and illustrating) (H1b), effort (H1c) and time management (H1e) strategies. The students' gender seemed to have an important impact on these learning strategies. However, the gender of the students did not appear to influence the learning strategy elaboration (H1d). Thus, our hypotheses H1a, H1b, and H1c with regard to gender could be confirmed, while hypotheses H1d and H1e should be rejected.

Most of our results are in accordance with previous findings in areas that were not specific to biology education. Several studies have found that females reported using rehearsal strategies more often than males (Artelt et al., 2003; Bembenutty, 2007; Dresel et al., 2004; Rozendaal et al., 2003; Ruffing et al., 2015). The findings concerning organisational strategies are in line with previous results in which females reported using organisational strategies more often than males (Pokay & Blumenfeld, 1990; Ruffing et al., 2015). The results regarding effort are also in accordance with previous findings which showed that females report that they use this strategy more often than males (Bembenutty, 2007; Ruffing et al., 2015). Contrary to the findings of Dresel et al. (2004), we found that girls reported a higher use of time management strategies. In this context, the subject-specificity of biology could play a key role in explaining gender differences regarding the use of learning strategies (see also Lauermann et al., 2019). Quaiser-Pohl (2012) describes biology as a girls' domain. It is therefore assumed that girls show higher degrees of interest in biological topics (Schroeders et al., 2013). Since students generally want to be in accordance with their gender role expectations, they prefer learning activities that correspond to them (Hannover & Kessels, 2008). Furthermore, gender-related learning behaviour could explain the gender differences regarding the learning strategy use. Several studies have found that girls show more diligence, self-discipline, and self-regulation (Duckworth & Seligman, 2006; Matthews et al., 2009; Wagner et al., 2008). Therefore, this study confirms the influence of gender-specific learning characteristics on the application of learning strategies. However, contrary to our expectation that the boys would use more elaboration strategies than the girls (Rozendaal et al., 2003), the students' gender did not have a significant impact on elaboration. The higher interest of female students in biology (e.g., Quaiser-Pohl, 2012) might have compensated for the generally higher use of elaboration strategies by male learners.

Second, we hypothesised that the students' interest in biology would have an impact on their use of organisation (transformation and illustrating) and elaboration in biology lessons. Our results revealed that interest did not influence organisational strategies (transformation and illustrating) (H2a). We also found that elaboration strategies were used mainly by the students with a high degree of interest (H2b). Thus, hypothesis 2a was not confirmed, whereas hypothesis 2b was supported. Our finding concerning elaboration strategies (H2b) is in accordance with those of McWhaw and Abrami (2001), Pintrich (1999), Tulis and Fulmer (2013), and Walkington and Bernacki (2014). Hence, interest appears to support the use of elaboration strategies (see also Schweder & Raufelder, 2021). Surprisingly, interest did not appear to be a predictor of the deep processing strategy organisation (Pintrich, 1999). Our results showed that the students with a high degree of interest reported using more effort. As mentioned previously, interest could promote the acquisition of long-term and profound knowledge (Krapp, 1999). In addition, these experiences can result in the reactivation as well as the autonomous and voluntary extension of this knowledge (Krapp, 1999). For this reason, interest could lead to a higher degree of student activation and the development of independent involvement with this subject. Therefore, the students with a higher degree of interest probably reported a higher degree of effort.

Third, we hypothesised that gender differences with regard to learning strategy use would be less pronounced for students with a high degree of interest in biology than for those with a low degree of interest (H3). The results of our study showed a reduction of the gender gap in terms of the learning strategies transformation and effort with respect to male students without any disadvantage for the female students. The students with a high degree of interest in biology reported nearly the equal amount of use of these learning strategies regardless of their gender. These results showed that male students could use the same degree of these learning strategies as female students in biology lessons. When male learners are more interested in the field of biology, gender-related differences could be minimised. It is therefore assumed that fostering interest in biology would promote strategy use for all learners, especially for the boys. These results are in accordance with Desch et al. (2017), who showed that autonomy supportive teaching behaviour as a method to foster students' interest (Großmann & Wilde, 2020) could mitigate gender-related differences in biology classes. As a consequence, the findings of our investigation revealed the importance of the factor interest to overcome the gender gap regarding the students' learning strategy use in biology classes.

Conclusion

In our study, we found that *gender* and *interest* have an impact on the use of learning strategies in biology lessons. With regard to gender, the girls reported a higher use of *rehearsal*, *organisational*, *effort*, and *time management* strategies in

biology lessons. These differences in the use of learning strategies regarding gender could be explained by gender-specific learning behaviour (Matthews et al., 2009; Wagner et al., 2008). Since biology is described as a feminine domain, the subject-specificity of biology could play a key role in explaining gender differences with regard to the use of learning strategies. Concerning the students' interest, a high level of subject-related interest is important because it encourages learners to use deep processing learning strategies in biology lessons. All in all, the present study shows the relevance of the factors gender and interest for the use and promotion of learning strategies. Therefore, our investigation highlighted the need to consider students' gender and interest in teaching and learning biology.

Recommendations

Our study revealed various implications for researchers and biology teachers. With regard to the higher use of learning strategies by female students, teachers should encourage the use of learning strategies and promote their use in the biology classroom, especially among males. Den Elzen-Rump et al. (2008) argue that the application of learning strategies should be explicitly explained and practiced in specific learning environments. In addition, biology teachers should constantly foster the use of learning strategies so that the autonomous application of these strategies can be ensured (den Elzen-Rump et al., 2008). Isaak et al. (2020) emphasised the relationship between learning strategies and the specific learning situation. Furthermore, different learning methods could be used in biology lessons to foster the male students' use of learning strategies. While female students prefer to work in groups (Aldridge & Rowntree, 2021), the use of competitive learning methods might be beneficial for male learners in particular. Moreover, mathematical, chemical, and physical contexts (e.g., biochemistry, mathematical evaluation of biological experiments) that are more congruent with male students' interests could be integrated into biology lessons (Schiepe-Tiska et al., 2016).

Interest in biology should be promoted, especially when deep processing learning strategies such as elaboration are required for the learning process. The results of the present investigation suggest that promoting interest could not only minimise gender-related differences in biology lessons with regard to the learning strategy use, but support all learners regardless of their gender. In this context, autonomy supportive teaching behaviour could be implemented to support students' interest in biology classes (Großmann & Wilde, 2020). For this reason, our study could address the lack of practical and theoretical implications for reducing gender differences in the use of learning strategies in biology education.

Limitations

A limitation of the current study might be that the various learning strategies were assessed using a questionnaire. Questionnaires measure the self-reported use of learning strategies. However, the described problem of the retrospective measurement of learning strategies could be addressed by the used questionnaire of Souvignier and Gold (2004). They found that rehearsal strategies could predict students' rote learning while elaboration strategies had an impact on the higher levels of achievement (Souvignier & Gold, 2004). In future studies, the use of learning strategies might also be measured by using qualitative methods during a learning task such as thinking aloud protocols and traces so that the learning strategies can be measured closer to the learning situation at hand (Rogiers et al., 2020). In this case, follow-up studies are needed for further clarification. A second limitation of this study is that metacognitive strategies were not measured. Hence, future studies might address the use of these strategies.

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References

- Aldridge, J. M., & Rowntree, K. (2021). Investigating relationships between learning environment perceptions, motivation and self-regulation for female science students in Abu Dhabi, United Arab Emirates. *Research in Science Education*. Advance online publication. <https://doi.org/10.1007/s11165-021-09998-2>
- Artelt, C., Baumert, J., Julius-McElvany, N., & Peschar, J. (2003). *Learners for life: Student approaches to learning: Results from PISA 2000*. OECD. <https://bit.ly/3Ggee8l>
- Bembenutty, H. (2007). Self-regulation of learning and academic delay of gratification: Gender and ethnic differences among college students. *Journal of Advanced Academics*, 18(4), 586-616. <https://doi.org/10.4219/jaa-2007-553>
- Brod, G. (2020). Generative learning: Which strategies for what age? *Educational Psychology Review*. Advance online publication. <https://doi.org/10.1007/s10648-020-09571-9>
- Cornford, I. R. (2002). Learning-to-learn strategies as a basis for effective lifelong learning. *International Journal of Lifelong Education*, 21(4), 357-368. <https://doi.org/10.1080/02601370210141020>
- den Elzen-Rump, V., Leutner, D., & Wirth, J. (2008). Lernstrategien im Unterrichtsalldag [Learning strategies in everyday teaching]. In S. Kliemann (Ed.), *Schülergerechtes Arbeiten in der Sekundarstufe I: Diagnostizieren und Fördern* [Student-centered work in secondary level I: Diagnosis and support] (pp. 101-113). Cornelsen-Scriptor.

- Desch, I., Basten, M., Großmann, N., & Wilde, M. (2017). Geschlechterdifferenzen in der wahrgenommenen Erfüllung der Prozessmerkmale gemäßigt konstruktivistischer Lernumgebungen – Die Effekte von Autonomieförderung durch Schülerwahl [Gender differences in the perception of moderate constructivist learning environments – The effects of autonomy support by means of students' choice]. *Journal for Educational Research Online*, 9(2), 156-182. <https://bit.ly/3Gf7Nm8>
- Dresel, M., Stöger, H., & Ziegler, A. (2004). *Lernstrategiegebrauch in Abhängigkeit von Bildungsgängen und Jahrgangsstufen in der Sekundarstufe* [The dependence of learning strategy use on academic program and grade levels at the secondary level] (Ulmer Forschungsberichte aus der Pädagogischen Psychologie, 11). Universität, Abt. Pädagogische Psychologie.
- Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology*, 98(1), 198-208. <https://doi.org/10.1037/0022-0663.98.1.198>
- Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). Sage.
- Fiorella, L., & Mayer, R. E. (2016). Eight ways to promote generative learning. *Educational Psychology Review*, 28, 717-741. <https://doi.org/10.1007/s10648-015-9348-9>
- Frey, A., Taskinen, P., Schütte, K., Prenzel, M., Artelt, C., Baumert, J., Blum, W., Hammann, M., Klieme, E., & Pekrun, R. (2009). *PISA 2006 Skalenhandbuch. Dokumentation der Erhebungsinstrumente* [PISA 2006 scale manual. Documentation of the survey instruments]. Waxmann.
- Großmann, N., & Wilde, M. (2020). Promoting interest by supporting learner autonomy: The effects of teaching behaviour in biology lessons. *Research in Science Education*, 50, 1763-1788. <https://doi.org/10.1007/s11165-018-9752-5>
- Hammann, M. (2019). Organisationsebenen biologischer Systeme unterscheiden und vernetzen: Empirische Befunde und Empfehlungen für die Praxis [Distinguishing and networking organisational levels of biological systems: Empirical findings and recommendations for practice]. In J. Groß, M. Hammann, P. Schmiemann & J. Zabel (Eds.), *Biologiedidaktische Forschung: Erträge für die Praxis* [Biology-didactic research: Income for practice] (pp. 77-91). Springer. https://doi.org/10.1007/978-3-662-58443-9_5
- Hannover, B., & Kessels, U. (2008). Geschlechtsunterschiede beim Lernen [Gender differences in learning]. In W. Schneider & M. Hasselhorn (Eds.), *Handbuch der Pädagogischen Psychologie* (Reihe Handbuch der Psychologie) [Handbook of pedagogical psychology] (pp. 116-125). Hogrefe.
- Hariri, H., Karwan, D. H., Haenilah, E. Y., Rini, R., & Suparman, U. (2021). Motivation and learning strategies: Student motivation affects student learning strategies. *European Journal of Educational Research*, 10(1), 39-49. <https://doi.org/10.12973/eu-jer.10.1.39>
- Hidi, S. E., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research*, 70(2), 151-179. <https://doi.org/10.3102/00346543070002151>
- Isaak, R., Hüfner, C., Basten, M., & Wilde, M. (2020). Der Einfluss von Elaborationsstrategien auf die Lernleistung im Biologieunterricht unter Berücksichtigung unterschiedlicher kognitiver Anforderungsbereiche [The influence of elaboration strategies on learning performance in biology lessons regarding different cognitive achievement levels]. *Psychology in Education and Teaching/ Psychologie in Erziehung und Unterricht*, 67(2), 124-137. <https://bit.ly/31yLdWH>
- Jördens, J., Asshoff, R., Kullmann, H., & Hammann, M. (2016). Providing vertical coherence in explanations and promoting reasoning across levels of biological organization when teaching evolution. *International Journal of Science Education*, 38(6), 960-992. <https://doi.org/10.1080/09500693.2016.1174790>
- Kattmann, U. (2016). Auswahl und Verknüpfung der Lerninhalte [Selection and linking of learning content]. In H. Gropengießer, U. Harms & U. Kattmann (Eds.), *Fachdidaktik Biologie* [Biology Didactics] (pp. 29-38). Aulis Verlag.
- Kessels, U., Heyder, A., Latsch, M., & Hannover, B. (2014). How gender differences in academic engagement relate to students' gender identity. *Educational Research*, 56(2), 220-229. <https://doi.org/10.1080/00131881.2014.898916>
- Krapp, A. (1992). Interesse, Lernen und Leistung. Neue Forschungsansätze in der Pädagogischen Psychologie [Interest, learning, and achievement. New empirical approaches in pedagogical psychology]. *Journal of Pedagogy/ Zeitschrift für Pädagogik*, 38(5), 747-770. <https://bit.ly/3mEyoBA>
- Krapp, A. (1999). Intrinsische Lernmotivation und Interesse. Forschungsansätze und konzeptuelle Überlegungen [Intrinsic motivation for learning and interest. Empirical approaches and conceptual considerations]. *Journal of Pedagogy/ Zeitschrift für Pädagogik*, 45(3), 387-406. <https://bit.ly/31CCDG4>
- Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, 33(1), 27-50. <https://doi.org/10.1080/09500693.2010.518645>

- Kurman, J. (2004). Gender, self-enhancement, and self-regulation of learning behaviors in junior high school. *Sex Roles*, 50, 725-735. <https://doi.org/10.1023/B:SERS.0000027573.36376.69>
- Lauermann, F., Meißner, A., & Steinmayr, R. (2019). Relative importance of intelligence and ability self-concept in predicting test performance and school grades in the math and language arts domains. *Journal of Educational Psychology*, 112(2), 364-383. <http://doi.org/10.1037/edu0000377>
- Lehmann, M., & Hasselhorn, M. (2010). The dynamics of free recall and their relation to rehearsal between 8 and 10 years of age. *Child Development*, 81(3), 1006-1020. <https://doi.org/10.1111/j.1467-8624.2010.01448.x>
- Matthews, J. S., Ponitz, C. C., & Morrison, F. J. (2009). Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology*, 101(3), 689-704. <https://doi.org/10.1037/a0014240>
- McWhaw, K., & Abrami, P. C. (2001). Student goal orientation and interest: Effects on students' use of self-regulated learning strategies. *Contemporary Educational Psychology*, 26(3), 311-329. <https://doi.org/10.1006/ceps.2000.1054>
- Ministry for Schools and Education of the State of North Rhine-Westphalia (Ed.). (2019). *Kernlehrplan für die Sekundarstufe I Gymnasium in Nordrhein-Westfalen. Biologie* [Core curriculum for the secondary school in North Rhine-Westphalia. Biology]. Ritterbach Verlag.
- Moschner, B. (2010). Pädagogische Psychologie. Pädagogische Psychologie und Geschlechterforschung [Educational psychology. Educational psychology and gender studies]. In G. Steins (Ed.), *Handbuch Psychologie und Geschlechterforschung* [Handbook of psychology and gender studies] (pp. 175-188). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92180-8_10
- Organisation for Economic Cooperation and Development. (2007). *PISA 2006. Science competencies for tomorrow's world (volume 1: Analysis)*. National Bank of Belgium Museum. <https://bit.ly/3Fwwydt>
- Organisation for Economic Cooperation and Development. (2016). *PISA 2015. (volume I): Excellence and equity in education*. OECD Publishing. <https://bit.ly/318IFPa>
- Parker, J. M., Anderson, C. W., Heidemann, M., Merrill, J., Merritt, B., Richmond, G., & Urban-Lurain, M. (2012). Exploring undergraduates' understanding of photosynthesis using diagnostic question clusters. *CBE-Life Sciences Education*, 11(1), 47-57. <https://doi.org/10.1187/cbe.11-07-0054>
- Patrick, H., Ryan, A. M., & Pintrich, P. R. (2000). The differential impact of extrinsic and mastery goal orientations on males' and females' self-regulated learning. *Learning and Individual Differences*, 11(2), 153-171. [https://doi.org/10.1016/S1041-6080\(00\)80003-5](https://doi.org/10.1016/S1041-6080(00)80003-5)
- Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research*, 31(6), 459-470. [https://doi.org/10.1016/S0883-0355\(99\)00015-4](https://doi.org/10.1016/S0883-0355(99)00015-4)
- Pokay, P., & Blumenfeld, P. C. (1990). Predicting achievement early and late in the semester: The role of motivation and use of learning strategies. *Journal of Educational Psychology*, 82(1), 41-50. <https://doi.org/10.1037/0022-0663.82.1.41>
- Pribadi, B. A., & Susilana, R. (2021). The use of mind mapping approach to facilitate students' distance learning in writing modular based on printed learning materials. *European Journal of Educational Research*, 10(2), 907-917. <https://doi.org/10.12973/eu-jer.10.2.907>
- Quaiser-Pohl, C. (2012). Mädchen und Frauen in MINT: Ein Überblick [Girls and women in STEM: An overview]. In M. Heilemann, H. Stöger & A. Ziegler (Eds.), *Mädchen und Frauen in MINT – Bedingungen von Geschlechtsunterschieden und Interventionsmöglichkeiten* [Girls and women in STEM - Conditions of gender differences and intervention options] (pp. 13-40). LIT.
- Renninger, K. A., & Hidi, S. E. (2016). *The power of interest for motivation and engagement*. Routledge. <https://doi.org/10.4324/9781315771045>
- Roelle, J., Nowitzki, C., & Berthold, K. (2017). Do cognitive and metacognitive processes set the stage for each other? *Learning and Instruction*, 50, 54-64. <https://doi.org/10.1016/j.learninstruc.2016.11.009>
- Rogiers, A., Merchie, E., & Van Keer, H. (2020). What they say is what they do? Comparing task-specific self-reports, think-aloud protocols, and study traces for measuring secondary school students' text-learning strategies. *European Journal of Psychology of Education*, 35, 315-332. <https://doi.org/10.1007/s10212-019-00429-5>
- Rozendaal, J. S., Minnaert, A., & Boekaerts, M. (2003). Motivation and self-regulated learning in secondary vocational education: Information-processing type and gender differences. *Learning and Individual Differences*, 13(4), 273-289. [https://doi.org/10.1016/S1041-6080\(03\)00016-5](https://doi.org/10.1016/S1041-6080(03)00016-5)

- Ruffing, S., Wach, F.-S., Spinath, F. M., Brünken, R., & Karbach, J. (2015). Learning strategies and general cognitive ability as predictors of gender-specific academic achievement. *Frontiers in Psychology*, 6, 1238. <https://doi.org/10.3389/fpsyg.2015.01238>
- Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist*, 26(3-4), 299-323. <https://doi.org/10.1080/00461520.1991.9653136>
- Schiepe-Tiska, A., Rönnebeck, S., Schöps, K., Neumann, K., Schmidtner, S., Parchmann, I., & Prenzel, M. (2016). Naturwissenschaftliche Kompetenz in PISA 2015 - Ergebnisse des internationalen Vergleichs mit einem modifizierten Testansatz [Scientific competence in PISA 2015 - Results of international comparison with a modified test approach]. In K. Reiss, C. Sälzer, A. Schiepe-Tiska, E. Klieme & O. Köller (Eds.), *PISA 2015. Eine Studie zwischen Kontinuität und Innovation* [PISA 2015. A study between continuity and innovation] (pp. 45-98). Waxmann.
- Schroeders, U., Penk, C., Jansen, M., & Pant, H. A. (2013). Geschlechtsbezogene Disparitäten [Gender-related disparities]. In H. A. Pant, P. Stanat, U. Schroeders, A. Roppelt, T. Siegle & C. Pöhlmann (Eds.), *IQB-Ländervergleich 2012: Mathematische und naturwissenschaftliche Kompetenzen am Ende der Sekundarstufe I* [IQB country comparison 2012: Mathematical and scientific competencies at the end of lower secondary level] (pp. 249-274). Waxmann.
- Schweder, S., & Raufelder, D. (2021). Interest, flow and learning strategies how the learning context affects the moderating function of flow. *The Journal of Educational Research*, 114(2), 196-209. <https://doi.org/10.1080/00220671.2021.1887066>
- Secretariat of the Standing Conference of Education Ministers of the Länder in the Federal Republic of Germany. (2005). *Bildungsstandards im Fach Biologie für den Mittleren Schulabschluss. Beschluss vom 16.12.2004* [Educational standards in biology for the secondary school leaving certificate. Decision of December 16, 2004]. Luchterhand.
- Shen, K. M., Li, T. L., & Lee, M. H. (2018). Learning biology as 'Increase ones' knowledge and understanding': Studying Taiwanese high school students' learning strategies in relation to their epistemic views and conceptions of learning in biology. *International Journal of Science Education*, 40(17), 2137-2157. <https://doi.org/10.1080/09500693.2018.1522013>
- Soric, I., & Palekic, M. (2009). The role of students' interests in self-regulated learning: The relationship between students' interests, learning strategies and causal attributions. *European Journal of Psychology of Education*, 24(4), 545-565. <https://doi.org/10.1007/BF03178767>
- Souvignier, E., & Gold, A. (2004). Lernstrategien und Lernerfolg bei einfachen und komplexen Leistungsanforderungen [Learning strategies and learning achievement in simple and complex approaches of learning]. *Psychology in Education and Teaching/ Psychologie in Erziehung und Unterricht*, 51, 309-318. <https://bit.ly/32EuFwO>
- Stokhof, H., de Vries, B., Bastiaens, T., & Martens, R. (2020). Using mind maps to make student questioning effective: Learning outcomes of a principle-based scenario for teacher guidance. *Research in Science Education*, 50, 203-225. <https://doi.org/10.1007/s11165-017-9686-3>
- Tulis, M., & Fulmer, S. M. (2013). Students' motivational and emotional experiences and their relationship to persistence during academic challenge in mathematics and reading. *Learning and Individual Differences*, 27, 35-46. <https://doi.org/10.1016/j.lindif.2013.06.003>
- Wagner, P., Schober, B., & Spiel, C. (2008). Time students spend working at home for school. *Learning and Instruction*, 18(4), 309-320. <https://doi.org/10.1016/j.learninstruc.2007.03.002>
- Waldeyer, J., Fleischer, J., Wirth, J., & Leutner, D. (2019). Validating the resource-management inventory (ReMI): Testing measurement invariance and predicting academic achievement in a sample of first-year university students. *European Journal of Psychological Assessment*, 1(1), 1-10. <https://doi.org/10.1027/1015-5759/a000557>
- Walkington, C. A., & Bernacki, M. L. (2014). Motivating students by "personalizing" learning around individual interests: A consideration of theory, design, and implementation issues. *Advances in Motivation and Achievement*, 18, 139-176. <https://doi.org/10.1108/S0749-742320140000018004>
- Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. Wittrock (Ed.), *Handbook of research on teaching* (pp. 315-327). Macmillan.
- Ziegler, A., & Dresel, M. (2006). Lernstrategien: Die Genderproblematik [Learning strategies: The gender problem]. In H. Mandl & H. F. Friedrich (Eds.), *Handbuch Lernstrategien* [Handbook of learning strategies] (pp. 378-389). Hogrefe.
- Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, 82(1), 51-59. <https://doi.org/10.1037/0022-0663.82.1.51>