"Bed bugs live in dirty places"—How Using Live Animals in Teaching Contributes to Reducing Stigma, Disgust, Psychological Stigma, and Misinformation in Students

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ABSTRACT

Bed bugs are on the rise and are increasingly perceived as harmful parasites. Because individuals affected by bed bugs often feel disgust and shame and are stigmatized, bed bugs are an important public health and environmental justice concern and therefore a health education issue as well. In this quasi-experimental study, we examine how different constructs, namely, forms of stigma, disgust, psychological distance, and myths about bed bugs (dependent variables), change over time (pre/posttest) in response to two forms of teaching intervention (independent variables) in upper secondary-level high school. The content of the interventions was the same, but in class, we showed live bed bugs to one group of students, assuming this would lead to a more realistic, less imaginative response to bed bugs than in the group presented with only pictures of bed bugs. Together with previous studies, we assumed that live bed bugs would be perceived as less disgusting and with a lower degree of stigmatization. Our results show that stigma, psychological distance, and myths can be reduced through intervention (regardless of live animal or picture). Disgust was more strongly reduced by live animals than by pictures. We present implications for biology education and contemporary health education.

INTRODUCTION

Social Relevance of Bed Bugs

Common bed bugs (*Cimex lectularius*) have undergone a considerable resurgence worldwide since the 1990s and represent an important public and environmental health issue (Doggett *et al.*, 2004; Harlan *et al.*, 2008; Akhoundi *et al.*, 2020). Although not definitely identified, many factors likely contribute to the upsurge, including increased air travel and increased transfer through the secondhand furniture trade. Either way, bed bugs are easily transported on or in luggage, furniture, boxes, and even on clothes (Doggett *et al.*, 2018), because they are very thin, except just after a blood-meal, and hide in very narrow cracks or folds. Even though they have always been a "companion" of humans, the current rise in infestation cases has brought bed bugs back into the social consciousness (Reinhardt, 2018). They have also returned to being a pressing public health problem that is related to economic and environmental inequality (Comack and Lyons, 2011; Eddy and Jones, 2011; Sutherland *et al.*, 2020). For some reason, and in contrast to many other blood-sucking arthropods, bed bug infestations have retained the false image of being self-inflicted, and stigmatization abounds. Tackling both bed bug infestations and the associated stigmatization requires education about biological facts. Biology education about bed bugs should be proactive and

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aimed at reducing both stigmatization and myths as well as increasing students' psychological awareness that bed bugs can be a personal, meaningful issue for them. To this end, the bed bug has recently been identified as a pertinent topic for biology education in the school context (Anderson, 2020; Asshoff *et al.*, 2020).

Bed bugs are associated with many popular myths in terms of false beliefs (Allchin, 2003). One myth, having proven to be as ineradicable as the bed bugs themselves (Reinhardt, 2018), is that they preferably settle in dirty and poor hygienic conditions. Moreover, bed bugs definitely do not act as vectors for diseases (Harlan *et al.*, 2008; Doggett *et al.*, 2012, 2018). However, this fact has been continuously challenged for a variety of reasons (Reinhardt, 2018), which therefore is psychologically harmful. Bed bug attacks, and even the mere imagination of an infestation, produce a variety of negative emotional and psychological effects, for example, emotional traumas, some of which meet the criteria of posttraumatic stress disorder (Goddard and de Shazo, 2012). In addition to the financial costs for pest control, affected people feel and may in fact be stigmatized precisely because people assume that they live in dirty surroundings and may be disease carriers. At least before the anonymity of Internet shopping, people felt a fear of seeking remedies against bed bugs because of the social stigma of disclosing the very fact that they had bed bugs (Krinsky, 2002; Munoz-Price *et al.*, 2012; Usinger, 1966). Even today, people are known to self-isolate and avoid family and friends out of concern for spreading the infestation, or they may be avoided by friends or others in the community because they have bed bugs (Loyola University Health System, 2013).

This experience of marginalization and stigmatization is a problem for society as a whole. Contrary to some myths, bed bugs can affect everyone regardless of socioeconomic status, ethnicity, gender, and location (a notion that, by the way, has emerged in past bed bug upsurges but always with a delay; Reinhardt 2018). However, the poor or unkempt, usually living under more crowded conditions – a predictor of infestation incidences (Reinhardt and Siva-Jothy, 2007) – and with fewer opportunities to defend themselves in society, are typically targeted as suspects for carrying the pest and, consequentially, are stigmatized (Aultman, 2013). Thus, there is negative stereotyping and social stigma for those who are unfortunate enough to experience bed bugs (Comack and Lyons, 2011).

A convenient place to start reducing a stigma of interest to society might be the classroom. Here, in addition to clarifying biology and generally counteracting myths, it could be a crucial insight to students that people with bed bug infestations are victims of unjust stigmatization. However, the success of instructional interventions is largely unknown. Asshoff *et al.* (2020) found that teaching about bed bugs and showing live bugs promotes interest in them. Teaching also led to more proactive student behavior (measured as a behavioral component of attitudes, for example, if they found an animal that looks like a bed bug, they would have it verified by an expert), but at the same time, bed bugs had significantly more negative connotations (disgust) after instruction than before instruction. In this study, live bed bugs were shown, so it could not be differentiated whether the teaching itself or the showing of the live animal caused the greater disgust. One way to separate the two is to teach the same content to two groups of students, with one group shown live animals and the other shown pictures only. Pictures are widely used to increase bed bug awareness in public, nonschool contexts (but their success is also unknown; Seidel and Reinhardt, 2013).

In the present study, we use a teaching intervention and a pre/posttest design to examine the extent to which teaching about bed bugs can revise myths, increase students' psychological awareness of bed bugs (measured as the perceived psychological distance toward bed bugs), and reduce disgust and stigma associated with the animals (dependent variable). In the quasi-experimental design, one part of the sample is shown live bed bugs during classroom activities, and the other part is shown only pictures of bed bugs (independent variable). To clarify the concepts of stigma, disgust, and psychological distance, we provide a small introduction to these topics below.

Stigma, Disgust, and Psychological Distance and Biology Teaching

Stigma. Stigma is socially assigned or a social construction (Goffman, 1963) and has even been considered an expression of social power through the identification of a socially conferred mark that distinguishes individuals who bear that mark from others, portraying them as deviant from the normal and deserving of devaluation (Link and Phelan, 2001). The expression and meaning of stigma can also be explained in evolutionary terms (Kurzban and Leary, 2001), whereby one function of stigma is to keep people away as a means of avoiding disease. Others include exploitation and domination (keeping people down) and norm enforcement (keeping people in; Phelan *et al.*, 2008). Stigmatization can then occur in several ways. For example, Major *et al.* (2018) defined four different types of stigma, namely, enacted stigma, felt stigma, internalized stigma, and anticipated stigma. In this study, we focus on enacted stigma at the interpersonal level, that is, negative biases in feelings toward and devaluation of stigmatized groups and unfair treatment of those groups (i.e., discrimination).

Disgust. Disgust is an emotion of negative valence that is perceived as unpleasant. It has emotion-specific components, can be found across cultures, and is therefore counted among the basic emotions according to Ekman (1999; cf. Rozin *et al.*, 1999). Over time, the originally food-related disgust has spread to other domains; "animal-nature disgust" is felt toward all things that remind humans of their animal nature and from which contamination emanates, such as body products, animals as disease vectors, corpses, decay, or sexual intercourse.

Tybur *et al.* (2013), in contrast to Rozin's traditional classification, categorize emotional disgust into three different domains: pathogenic disgust, which serves to avoid contact with infectious and disease-threatening things; sexual disgust, which serves to avoid sexual partners who endanger one's sexual fitness (e.g., disgust with incest); and moral disgust, which serves to evaluate, coordinate, and express rejection and condemnation toward fellow humans and their behavior (cf. Tybur *et al.*, 2013). In the present study, we investigated pathogenic disgust. An important point in this context is that health in general is associated with antiparasite behavior (Prokop *et al.*, 2010) and that disgust sensitivity protects against infection in a high-pathogen environment (Cepon-Robins *et al.*, 2021).

Relationship between Disgust and Stigma

Disgust and stigma are two interrelated concepts. Disgust can be characterized as an adaptive system of disease avoidance (Oaten *et al.*, 2009; Curtis *et al.*, 2011; Kasperbauer, 2015). Disease avoidance can result in social avoidance, the avoidance of individuals showing signs of infectious disease, as well as the stigmatization of others (Oaten *et al.*, 2011), for example, in the context of COVID-19 (Saeed *et al.*, 2020) or HIV (St. Lawrence *et al.*, 1990). Bed bugs themselves are not a "disease" or a "pathogen," but insect disgust and pathogen disgust may be understood as part of the same construct (Lorenz *et al.*, 2014). In this case, greater disgust toward bed bugs is predicted to lead to greater avoidance or stigmatization of individuals affected by bed bugs. There is some evidence supporting this prediction. Study participants who rated their subjective disgust experience as particularly strong on paper were, for example, more likely to refuse to touch a cockroach (Rozin *et al.*, 1999). In another study, significant positive correlations were found between pathogen disgust and stigmatization for types of mental illness (Dawydiak *et al.*, 2019). Disgust traits also have significant links with particular dimensions of stigma toward people with cancer, including awkwardness and avoidance. The findings of this study supported the idea that stigma may be associated with a conservative defense against disease (Azlan *et al.*, 2020).

Disgust, Stigma, and Psychological Distance

Disgust and stigma are often stronger if one has the feeling that the disgusting object or stigmatized person is more psychologically close to oneself (van Dijke *et al.*, 2018). Correspondingly, disgust and stigma are lower if the object or person is psychologically distant. In this regard, psychological distance describes how people mentally construe their direct experience of an object or event (Liberman *et al.*, 2007). Based on construal level theory, Trope and Liberman (2010) and Liberman and Trope (2014) conceptualized that psychological distance refers to four different dimensions. Humans differ in their assessment of objects whether the object is rated as being geographically nearby or far away (spatial dimension) or relevant in an immediate time frame or in the far away future (temporal dimension), whether the object affects primarily people like oneself or distant others (social dimension), and whether the object is likely or unlikely to be encountered at all (hypothetical dimension).

Disgust, Stigma, and Psychological Distance in Education

The topic of disgust has primarily been studied in relation to working with live animals in the classroom, whereby the use of live "disgusting" animals increased motivation and interest (and thus decreased psychological distance, even if this subject has not been explicitly investigated; Randler *et al.*, 2011). Several studies (cf. Randler *et al.*, 2012; Prokop and Fančovičová, 2017; Wüst-Ackermann *et al.*, 2018) have shown that working with animals in the classroom leads to a reduction of disgust. For example, Randler *et al.* (2013) showed that students feel less fear and disgust toward organisms after physical contact with them, in this case, woodlice. However, not only working with the animals but also just showing them—as in the present study—has benefits. Tomažič *et al.* (2020) recommended that students should be offered many firsthand experiences with live poisonous and venomous animals, as this significantly increases learning interest and reduces disgust (e.g., for vipers, spiders, and scorpions) in comparison to a control group. In addition, contact with live animals can also lead to a more realistic assessment and thus most likely decreases psychological distance. For example, Majekodunmi *et al.* (2002) found more rational views (and thus perhaps less disgust and less stigmatization) among tenants living in cockroach-infested houses than among tenants without a cockroach infestation.

The topic of stigma encompasses many fields of biology education, especially health-related issues. Stigma plays an important role, for example, in the context of mental illness, sexual orientation (Herek, 2015), infectious diseases (Kalichman and Simbayi, 2004), stuttering (Boyle *et al.*, 2017), obesity (Puhl *et al.*, 2008; Puhl and Heuer, 2010), or head lice infestation (Hurst *et al.*, 2020). Recently, there have been reports that first responders to COVID-19 are stigmatized with consequences that are similar to people suffering from a bed bug infestation: feelings of isolation, lack of support and understanding by family or friends, decreased or forced removal in immediate social interactions (e.g., within family and friend circles), sentiments of being infected or dirty, increased feelings of sadness and anxiety, and reluctance to ask for help or seek treatment (e.g., self-approval of being isolated; Zolnikov and Furio, 2020). More closely related to (school) education, studies on mental health stigmatization have shown that intervention and social contact lead to an increase in knowledge, improved attitudes, and greater willingness to interact (Lanfredi *et al.*, 2019; for a summary and further information, see Chen *et al.*, 2018; Waqas *et al.*, 2020). A study that addressed stigma in the context of wild animals showed that teaching leads to a better relationship between humans and wild animals and thus less stigmatization (Wu *et al.*, 2020).

For stigma and disgust, psychological distance has been suggested as an important moderator for seeking mental health treatment and for moral judgments (van Dijke *et al.*, 2018), showing that perceived psychological distance affects human behavior. Empirical data showed that lower psychological distance corresponded to greater motivation to adhere to protective measures and engagement in proactive behaviors of disease prevention (Blauza *et al.*, 2021; Büssing and Heuckmann, 2021). Thus, challenging one's psychological distance by classroom activities in general might also offer a potential route for targeted intervention of an individual's perception of stigma and disgust.

PEDAGOGICAL APPROACH AND TEACHING INTERVENTION

The pedagogical approach used to tackle the challenging issue of bed bugs in this study was a combination of 1) developing a constructivist learning environment that aims to confront students with their (pre)conceptions about bed bugs and 2) enriching the learning environment by targeting disgust, stigma, and psychological distance from a health education perspective. In the present paper, we consciously use the term "myths" to refer to some of the students' conceptions of bed bugs. According to Allchin (2003), myths can be described as false beliefs. However, for bed bug myths, the use of the controversial term "misconception" may still be acceptable (Organization for Economic Co-Operation and Development [OECD], 2002; Grospietsch and Mayer, 2021). The reason for this is that students' conceptions

FIGURE 1. The treatments in this study: live animals vs. picture. The photo of the live animals (left) was provided by K.R., and the picture of the bed bugs (right) is from Karen Vail at the University of Tennessee's Institute of Agriculture (https://bedbugs.tennessee.edu/biology-and-identification).

about bed bugs are mainly due to a form of misinformation triggered by media reports and the students' lack of knowledge about the issue. It is possible that the name "bed bug" itself triggers ideas (Asshoff *et al.*, 2020). Thus, bed bug myths are epistemologically different from deeply embodied students' concepts that are typically present in science education (e.g., the conception that trees feed exclusively from the soil due to a lack of an adequate concept of photosynthesis or the conception that matter is converted into energy due to an inadequate concept of the conservation of matter; Wilson *et al.*, 2006; Parker *et al.*, 2012). In teaching, some classes were able to observe live bed bugs (*Cimex lectularius*) in a sealed glass tube. Other classes were given a typical picture of bed bugs, as found in the press or on the Internet (Figure 1). All students worked through three different intervention materials during the course of the lesson. First, they read a text, "On the Way with the Pest Controller," that illustrates how a person affected by bed bug infestation (the character "Mark") has a conversation with an exterminator who is called in to help. Mark talks about how he became aware of the infestation (bites on his body) and explains that his social environment (i.e., friends and family) reacted with aversion and fear. The exterminator explains where bed bugs can be found and how to fight them. Learners discussed the consequences of a bed bug infestation for those affected. This part of the lesson was mainly intended to engage students in the context of bed bugs, elicit students' conceptions about bed bugs, and demonstrate how emotionally laden and stigmatizing bed bug infestations are. Second, the learners explored the biology of the bed bug. A summary similar to a textbook page outlined basic aspects of bed bug morphology, life history (parasite), reproduction, distribution, and dispersal. For example, it was mentioned here that bed bugs can locate their host by CO_2 emissions but that they cannot sense dirt, grime, or hygienic conditions. The material also included illustrations of bed bug bites and fecal traces of bed bugs on a bed frame. Third, a fictional text message conversation between Mark (a person with bed bug infestation) and a pest control professional served to dispel various myths. From the chat history, students elaborated on how bed bugs spread, what preventative measures can be taken, that bed bugs can occur even in five-star hotels, that the bites can be painful but not contagious, and what the pest controller does when an infestation occurs. A class discussion of these three materials concluded the lesson and helped the students evaluate bed bugs. In this regard, the study partly adopts the 5E learning cycle (Bybee, 2014) and aims to foster students' scientific literacy (Asshoff *et al.*, 2020).

From the perspectives of health education and biology education on health matters, cognitive, affective, and social aspects should be taken into consideration when teaching about societal health-related issues such as bed bugs (Labov *et al.*, 2010; Byrne and Grace, 2018). Regarding cognitive learning outcomes, being able to apply subject matter knowledge still plays a key role. Recently, Arnold (2018) proposed a framework on health-related knowledge that should be taken into consideration when addressing health-related issues. The author differentiates between health-related knowledge dedicated to understanding health, the human body and its (mal-)functions (system-health knowledge), knowledge about actions that preserve functioning and prevent malfunctioning of the body and health (action-related health knowledge), and knowledge about the relative potential of actions that affect health and the body (effectiveness health knowledge). Applied to the context of bed bugs, system-health knowledge addresses how bed bug infestations affect health (i.e., mental health stigmatization) and how they do not (i.e., bed bug myths). Action-related health knowledge describes actions that can help prevent bed bug infestation, and effectiveness health knowledge illustrates the effectivity of these actions (i.e., shaking out infested bed sheets will likely spread the infestation). Accurate health knowledge therefore helps to raise awareness of unknown health hazards and supports informed decision making. Mental health and stigmatization are serious issues associated with bed bug infestations (Aultman, 2013), so affective and social learning outcomes also need to be taken into consideration. In their systematic review on school-based interventions on mental health stigmatization, Schachter *et al.* (2008) highlighted the important role of empathy development as a promising mechanism to reduce stigmatization and introduce behavioral change. Regarding bed bugs, changing one's perspective to the perspective of a person infested by bed bugs might be a promising approach that can reduce the level of stigmatization (Schachter *et al.*, 2008). Furthermore, fostering contact interventions has been identified as the main strategy to reduce stigma (Rüsch *et al.*, 2005). Typically, contact interventions refer to personally meeting people facing a health issue. However, in the context of bed bugs, actually seeing and "meeting" bed bugs can also have a destigmatizing effect. This might be because seeing bed bugs reduces the level of disgust, which in turn is strongly associated with the level of associated stigma (Dawydiak *et al.*, 2019).

RESEARCH QUESTION AND HYPOTHESES

In this study, we investigated the following research question: "To what extent can the described pedagogical approach and teaching intervention about bed bugs affect students' stigma, disgust, psychological distance and level of misinformation?"

We derive the following hypotheses from the literature with respect to our dependent variables.

Intervention and Stigma

Hypothesis 1 (H1): Health literacy studies have indicated the potential role of reducing stigma through targeted interventions (e.g., Boyle *et al.*, 2017; Chen *et al.*, 2018). The teaching

intervention aims to reduce stigma through a constructivist learning environment that strengthens students' empathy and perspective changing as well as discussing what the consequences of a bed bug infestation are for those affected (Schachter *et al.*, 2008). In this regard, the students actively and consciously engage with the topic of bed bugs and prevent unnecessary fears (cf. contact intervention; Rüsch *et al.*, 2005; Dawydiak *et al.*, 2019). We thus hypothesize that stigma can be reduced through the applied teaching intervention.

Intervention and Disgust

Hypothesis 2 (H2): A wide range of empirical studies demonstrate that working with animals in the classroom can reduce disgust and lead to a more realistic assessment of the animals (Majekodunmi *et al.*, 2002; Randler *et al.*, 2012; Prokop and Fančovičová, 2017; Tomažič *et al.*, 2020). In the present study, students have firsthand experiences with bed bugs and get to know the biological background of bed bugs, and the intervention material aims to dispel various myths about bed bugs that are related to students' disgust (e.g., bed bugs live in dirty places). For these reasons, we hypothesize that disgust is reduced by participating in the teaching intervention.

Intervention and Psychological Distance

Hypothesis 3 (H3): Studies in the context of health-related issues have demonstrated that lower psychological distance and thus higher awareness were associated with higher motivation for protective action (e.g., Zika disease; Johnson, 2018; van Lent *et al.*, 2017). Psychologically close diseases were rated as more dangerous than psychologically distant ones (White *et al.*, 2014). Regarding bed bugs, the teaching intervention presents a learning opportunity for students; for many students, it will also be the first instance in which they have to deal intensively with bed bugs. In particular, students get to know how to become aware of a bed bug infestation and that bed bugs can affect everyone, regardless of social and economic status (Reinhardt, 2018; Seidel and Reinhardt, 2013). Accordingly, we hypothesize that the teaching intervention will increase awareness of bed bugs and decrease students' psychological distance from bed bugs between the pre- and posttest.

Intervention: Live Animal versus Picture (Treatment)

Hypothesis 4 (H4): In the present study, students were divided into groups that either worked with live bed bugs or saw a picture of a bed bug (see Figure 1). We expected that showing the (relatively unspectacular) live animal may lead to a more realistic assessment. Following construal level theory of psychological distance (Liberman *et al.*, 2007), this type of assessment produces more concrete mental representations and corresponds to psychological proximity. Thus, showing live animals should lower psychological distance more strongly than showing a picture, which is likely to even generate more unpleasant fantasies (van Dijke *et al.*, 2018). Similarly, based on previous studies indicating that firsthand experience with live animals can reduce the disgust and stigma associated with the issue (Majekodunmi *et al.*, 2002; Randler *et al.*, 2012; Prokop and Fančovičová, 2017; Tomažič *et al.*, 2020), we suspect that the reduction in stigma and disgust toward bed bugs will be stronger for the group of students who worked with live animals than for the group of students who saw a picture of bed bugs.

Intervention and Bed Bug Myths

Hypothesis 5 (H5): There is strong evidence from the literature on epilepsy (Simon *et al.*, 2016) and AIDS (Faust and Yaya, 2018) that knowledge-based interventions can help to generally dismantle myths about an issue. For bed bugs, we assume that working with the three different intervention materials described earlier should enable students to identify and dispel myths about bed bugs. For this reason, we hypothesize that students' adherence to bed bug myths should be reduced from pretest to posttest.

Following data analysis, we identified systematic differences in the students' response behavior related to their gender. This phenomenon has previously been reported; for example, girls scored higher on disgust than boys with respect to live animals in the classroom (Randler *et al.*, 2012). However, analyzing gender effects was not the main purpose of the present study. For this reason, we included gender as an additional factor in the data analysis post hoc but did not formulate explicit hypotheses on gender.

METHODS

Sample and Study Design

A total of 196 students attending five different high schools voluntarily participated in the intervention study (121 females, 75 males). Of the 196 students, 180 were finally included in the analysis, and 16 students were excluded because the test was abandoned, the pre- and posttest codes did not match, or the indication of gender was missing. We conducted the study at the introductory stage of upper secondary school (grade 10), when students are ~16 years old. Two classes from each school participated. One class served as the treatment group and was able to observe live bed bugs (*Cimex lectularius*) in a sealed glass tube. The other class served as a control group and was given a typical picture of bed bugs as found in the press or on the Internet (Figure 1). Both teaching materials remained with the students until the end of the lesson. We randomly assigned the classes to the treatment or control group and thus applied a quasi-experimental study design. A pretest paper-and-pencil questionnaire was administered before the intervention; the posttest questionnaire was administered immediately after the intervention. The intervention lasted 67 to 90 minutes, depending on the respective time lesson model of the school. Different teachers taught the 10 classes, except for two classes at one school, which were taught by one of the authors (M.R.). The participating teachers were instructed about the intervention materials as well as the study and lesson procedures in a videoconference before they taught the lesson. In addition, a set of verbal statements was given to the teachers, and these statements were used as obligatory transitions of the different phases of the lesson. This ensured that the lessons taught at different schools were comparable.

We ensured via the guidelines for safety in the classroom at general education schools in North Rhine-Westphalia, Germany (Ministerium für Schule und Bildung des Landes Nordrhein Westfalen, 2020), that a lesson on live bed bugs is allowed. Students were informed in advance that there would be a lesson on bed bugs. We provided information on the purpose of the study and guaranteed anonymity. Students who had concerns or were strongly disgusted before the study did not have to attend the lesson, of course; participation was voluntary and

TABLE 1. Evaluation of the results for the teaching intervention based on situational emotions[a]

		Effect of treatment[b]				Effect of gender[c]			
Situational emotions	Total	Live animal (EG)	Picture (CG)	*t* test	*p*	Males	Females	*t* test	*p*
Interest	3.68 ± 0.92	3.62 ± 0.80	3.74 ± 1.04	–0.89	0.38[ns]	3.64 ± 0.88	3.70 ± 0.95	–0.44	0.66[ns]
Boredom	1.66 ± 0.73	1.70 ± 0.72	1.61 ± 0.75	–0.78	0.44[ns]	1.75 ± 0.77	1.60 ± 0.71	1.32	0.19[ns]
Well-being	4.16 ± 0.78	4.12 ± 0.80	4.20 ± 0.77	–0.70	0.49[ns]	4.08 ± 0.82	4.20 ± 0.76	–0.96	0.34[ns]

[a]Items were measured on a five-point Likert scale (1 = do not agree at all to 5 = agree totally; theoretical scale mean: 2.5; values above 2.5 indicate agreement). Values are the mean ± SD. Students evaluated the teaching intervention as not boring, and they felt comfortable in class. The *t* tests revealed no effects of treatment or gender.
[b]EG, experimental group, $n_{EG} = 91$; CG, control group, $n_{CG} = 89$.
[c]$n_{male} = 67$, $n_{female} = 113$.
[ns]$p > 0.05$.

could be stopped at any time without any consequences. No incentives were given. The lesson took place in an assessment-free space. All procedures were conducted in accordance with ethical standards (e.g., the code of conduct of the American Psychological Association) and in line with the General Data Protection Regulation (GDPR) of the European Union (EU).

To assess how the teaching was evaluated by the learners and to ensure that the same quality of instruction was provided to both groups, we used an instrument by Randler *et al.* (2011) in the posttest to measure situational emotions, namely, interest (three items, $\alpha = 0.76$), boredom (three items, $\alpha = 0.80$), and well-being (three items, $\alpha = 0.75$). Each item was assessed on a five-point rating scale. We report the mean (M) and SD as descriptive statistics. For evaluation, we considered the responses as interesting, boring, and how comfortable the students felt in class (well-being) if the scale mean exceeded the theoretical mean of the scale. With regard to situational emotions, students evaluated the teaching intervention positively (Table 1). The intervention was assessed as interesting (M = 3.68, SD = 0.92) and not as boring (M = 1.66, SD = 0.73). At the same time, the students felt comfortable in class (M = 4.16, SD = 0.78), even though the lesson dealt with a parasite. A series of *t* tests revealed no effects of treatment (live animal vs. picture) or gender effects (male vs. female) on situational emotions (see Table 1). Thus, we assumed that instructional quality was equally good in each group.

Test Instruments and Assessment of the Instrument Quality (Reliability and Validity)

Table 2 provides an overview of the psychometric properties of the items and scales used to measure stigma, disgust, and psychological distance in the pretest and the posttest. All items were assessed using a five-point rating scale. Cronbach's alpha was used as a measure of reliability, and we aimed for values of $\alpha \geq 0.70$ as documenting a good internal consistency of the scale (George and Mallery, 2003).

To adequately measure enacted stigma (Major *et al.*, 2018), we used two different scales: First, we applied the "social interaction scale" created by St. Lawrence *et al.* (1990). This study used vignettes describing different scenarios: heterosexual or homosexual individuals diagnosed with either AIDS or leukemia. The degree of stigmatization was measured with a total of seven items (e.g., "Would you attend a party where Mark was present?"). Even though AIDS or leukemia are different contexts and the reasoning behind stigmatization may be different, we found the item wording adequate for our study and adopted the item formulations. In the end, three items of the original seven-item scale were removed due to low item-discriminatory power and after contextual review ("If Mark is a friend of mine, I would be willing to continue the friendship at this time"; "It would be a problem for me if the neighbor's children want to visit Mark at his apartment"; and "Mark's lease is up in two months. If you were his landlord, would you renew his lease?"). Because students were asked to rate from a perspective of someone who knows Mark (e.g., whether she or he would go to a party where Mark was present), we name this scale "stigma-self-perception."

The final scale comprised four items and showed good reliability. High values indicated that the students were willing to socially interact with Mark, and thus, high values represent less stigmatizing behavior (see Table 2).

Second, we applied the Standardized Stigmatization Questionnaire developed by Haghighat (2005). The scale refers to social self-interest as a dimension of stigma. For example, one item of this scale reads, "Would most people be happy to sit next to this man on a bus?" We replaced "man" with the already named person Mark. Because this item formulation requires students to make decisions not directly from their point of view but from the point of view of "most people," we named this scale the "stigma-social perception" scale.

The scale comprises four items. Higher values indicated that other people would be willing to socially interact with Mark, and thus, high values represent less stigmatizing behavior (see Table 2). The item-total correlations, especially in the posttest, were high, and the scale showed acceptable reliability.

For disgust, we adapted a scale by Randler *et al.* (2012), which was originally used to measure how working with live, unpopular animals (wood louse, snail, and mouse) could reduce disgust during teaching. The scale comprised five items. Higher values indicated stronger disgust. However, we obtained a lower value for Cronbach's alpha than expected based on the reliability of the original scale by Randler *et al.* (2012), which ranged between $\alpha = 0.68$ and 0.76 for the different animals. We decided to maintain the disgust scale, because we regarded the item-total correlations in the posttest as sufficiently high ($r_{it} \geq 0.30$; see Table 2). This finding indicated that students were probably not yet familiar with bed bugs in the pretest and might have found it difficult to answer the pretest items consistently.

For psychological distance, we modified a scale originally intended to measure psychological distance from COVID-19 by Blauza *et al.* (2021) to meet the context of this study. Three items each were used to measure the spatial, temporal, social, and hypothetical dimensions of psychological distance toward

TABLE 2. Item wording and overview of the psychometric properties of the scales and items used in the study before (pretest) and after (posttest) teaching intervention

Scale	Item[a]	Item discriminatory power[b]		α[c]	
		Pretest	Posttest	Pretest	Posttest
Stigma: self-perception	(SEP1): If you met Mark, would you be willing to strike up a conversation with him?	0.373	0.549	0.77	0.86
	(SEP2): Would you attend a party where Mark was present?	0.675	0.753		
	(SEP3): Would you attend a party where Mark was preparing dinner?	0.666	0.774		
	(SEP4): Would you be willing to work in the same office with Mark?	0.583	0.742		
Stigma: social perception	(SOP1): Most people would be happy to sit next to Mark on the bus.	0.386	0.436	0.61	0.68
	(SOP2*): Most people would try to avoid talking to Mark.	0.493	0.53		
	(SOP3): Most people would be happy to eat something that Mark has cooked.	0.403	0.509		
	(SOP4*): Most people would think Mark should be in hospital for a long time.	0.293	0.396		
Disgust	(D1): When I am in my room and I see a bed bug, I become frightened.	0.287	0.408	0.52	0.63
	(D2*): I think working with real bed bugs in class would be exciting.	0.209	0.376		
	(D3): If the teacher brought live bed bugs into class, I would prefer to leave the classroom.	0.304	0.471		
	(D4*): Bed bugs are pretty animals.	0.262	0.288		
	(D5): Bed bugs are disgusting.	0.392	0.397		
Psychological distance	(PD S1): Bed bugs mainly affect people who live differently than I do.	0.414	0.527	0.63	0.65
	(PD R1): I first associate bed bugs with other countries.	0.334	0.5		
	(PD R3): Bed bugs are mainly found in places that are far away from here.	0.581	0.383		

[a]The fictitious person Mark was stated to suffer from a bed bug infestation. An asterisk (*) indicates an item was reverse coded.
[b]r_{it}, item discriminatory power.
[c]α, Cronbach's alpha.

bed bugs. We conducted an exploratory factor analysis to investigate the dimensionality of the scale. However, unlike Blauza *et al.* (2021) and other studies (e.g., Spence *et al.*, 2012), we were unable to combine the psychological distance items to either a unidimensional or a four-dimensional scale (one scale per dimension of psychological distance) with sufficient reliability. For this reason, we substantially reduced the item pool so that the final scale for psychological distance toward bed bugs consisted of three items. The scale showed acceptable reliability (see Table 2). Higher values represent larger psychological distance. That is, students rated bed bugs as spatially (i.e., they affect people in faraway places) and socially distant (i.e., they affect people different from me). The item-total correlations, especially in the posttest, were high, and the scale showed acceptable reliability.

Finally, we investigated how the lessons affected students' knowledge about bed bugs. The students assessed their agreement with five single-item statements that relate to common myths about bed bugs (e.g., "Bed bugs live in dirty places"). We sourced items based on a description of common bed bug myths provided by the U.S. Environmental Protection Agency website (EPA, 2021).

All scales allowed good convergent and discriminant valid inferences to be drawn from the data (see Rios and Wells, 2014; Table 3).

Data Analysis

For data analysis, we specified a series of linear mixed-effects models (LMMs; Kuznetsova *et al.*, 2017). LMMs are a flexible analytical approach used to describe the relationship between dependent and independent variables, wherein the exploratory (independent) variables are separated into fixed and random effects (Magezi, 2015). In the present study, treatment (live bed bugs) versus control (pictures of bed bugs), teaching intervention (pretest and posttest), and student gender (male or female) were introduced as fixed effects to the model. We chose LMM over repeated-measures analysis of variance (rmANOVA) as an alternative choice 1) because the data were not balanced (clustered) among the different schools involved in the study and 2) to remove overdispersion of the model. In addition, the LMM is able to handle missing data, whereas repeated-measures ANOVA is not (Magezi, 2015). Furthermore, by defining participating schools and subject IDs as random effects in the LMM, we were able to account for the variation in the measures introduced by the different schools participating in our study and to allow for random intercepts.

For each LMM, a maximal model was obtained with all main and interaction effects. Statistically nonsignificant random or fixed effects were removed using an *F* test–based backward elimination of random effect terms followed by backward elimination of fixed effect terms (Kuznetsova *et al.*, 2017). The findings for these reduced model procedures are available in the Supplemental Material. All computations were performed using IBM SPSS Statistics v. 26, MacOS (IBM Corporation, 2017), and the packages lme4 (Bates *et al.*, 2015) and lmerTest (Kuznetsova *et al.*, 2017) in R Studio (RStudio Team, 2016).

TABLE 3. Relationships between the parameters[a]

	Scale	1	2	3	4	5	6	7
1	Disgust (pre)	—						
2	Stigma: social perception (pre)	–0.198 **	—					
3	Stigma: self-perception (pre)	–0.288***	0.387***	—				
4	Psychological distance (pre)	0.074^{ns}	-0.082^{ns}	–0.223**	—			
5	Disgust (post)	*0.594****	-0.076^{ns}	–0.184*	-0.00^{ns}	—		
6	Stigma: social perception (post)	-0.075^{ns}	*0.518****	0.222**	-0.038^{ns}	–0.212**	—	
7	Stigma: self-perception (post)	0.010^{ns}	0.243**	*0.341****	-0.016^{ns}	-0.044^{ns}	0.494 ***	—
8	Psychological distance (post)	0.158*	–0.203**	–0.211**	*0.459****	0.017^{ns}	0.004^{ns}	0.023^{ns}

Spearman correlation coefficients indicated that the pretest measures correlated more strongly with their corresponding measures at posttest (diagonal values in the lower left quadrant; $0.341 \leq |r| \leq 0.594$, italic) than with the other measures (off-diagonal values in the lower left quadrant; $0.001 \leq |r| \leq 0.243$), ensuring convergent and discriminant validity (Rios and Wells, 2014). $^{ns}p > 0.05$; $^{*}p \leq 0.05$; $^{**}p \leq 0.01$; $^{***}p \leq 0.001$.

RESULTS

Effects of the Teaching Intervention on Stigma, Disgust, Psychological Distance, and Bed Bug Myths

The LMM showed that teaching intervention was a significant predictor of stigma related to self-perception but not stigma related to social perception (H1). Specifically, students expressed higher willingness to interact with people affected by bed bugs in the posttest than in the pretest, $\beta = -0.027$, SE = 0.04, $t(194) = -6.85$, $p < 0.001$ (see Table 4 and Figure 2A). Measures of self-perception were not significantly different between treatments (H4) or genders (Table 4 and Figure 2, A and E). For "social perception," none of the independent variables was a significant predictor. Teaching intervention, treatment (H4), or gender and any interaction were removed from the model (Table 4 and Figure 2, B and F). Hence, engaging in the teaching intervention described in this study had no influence on how students assessed the interaction of others with someone suffering from bed bugs (H1).

Disgust was significantly explained by an interaction effect of treatment (H4) × teaching intervention (H2), $\beta = 0.011$, SE = 0.10, $t(194) = 4.62$, $p < 0.001$ (Table 4 and Figure 2C). As predicted, teaching reduced students' disgust in the experimental group (live animal) but not in the control group (picture; Figure 2C). The significant main effect of treatment retained in the model is not interpreted here because of the significant interactions. We detected a main effect of gender. Female students rated bed bugs as significantly more disgusting than male students, $\beta = -0.017$, SE = 0.05, $t(193) = -3.49$, $p < 0.001$ (see Table 4 and Figure 2G).

The teaching intervention increased awareness of bed bugs and decreased students' psychological distance from bed bugs between the pre- and posttest. We found a significant interaction effect between teaching intervention and gender (H3). As predicted, the teaching intervention decreased students' psychological distance from bed bugs between the pre- and posttest. However, this was only true for female students. That is, through the teaching intervention, female students felt psychologically closer to bed bugs than male students, $\beta = -0.08$, SE = 0.04, $t(194) = -2.24$, $p < 0.05$ (Table 4 and Figure 2H). Significant main effects for time and for gender (Table 4) again need to be interpreted with caution. Psychological distance was reduced from pretest to posttest, $\beta = 0.19$, SE = 0.04, $t(194) = 5.82$, $p < 0.001$, and female students perceived bed bugs as more psychologically close than did male students, $\beta = 0.017$, SE = 0.06, $t(194) = 2.94$, $p < 0.001$.

Students' agreement with the myths was significantly reduced from pretest to posttest, irrespective of the treatment (H5). That is, students more often correctly identified the presented statements about bed bugs as myths. For item M1 ("You can't see bed bugs"), we found, not surprisingly, that students in the experimental group (live animal) significantly more often identified this statement as a myth compared with those in the control group (picture), $t(193) = -2.69$, $p < 0.01$ (see Table 5), and that finding yielded a strong effect, Cohen's $d = 0.386$. Students learned—or revised the myths—that bed bugs need not be associated with dirt (M2; Table 5), that bed bugs do not transmit disease (M3; Table 5), that bed bugs can be found in light (M4; Table 5), and that pesticides alone are not enough to eliminate bed bugs (M5; Table 5).

DISCUSSION

The present study was devoted to investigating the effect of a teaching intervention on stigma, disgust, psychological distance, and myths toward bed bugs using live animals or pictures. Reducing the expressions of these variables in teaching can be seen as an overall aim of science education. We discuss the findings of the study with respect to our main hypotheses and the treatment effects: 1) the intervention leads to destigmatization; 2) the intervention reduces the level of disgust; and 3) the intervention helps to reduce students' psychological distance from bed bugs.

The Intervention Leads to Destigmatization

Bringing the topic of bed bugs to biology classrooms is an important issue, because stimulating discussions about bed bugs can be a starting point to prevent destigmatization of affected individuals. This is a salient aim from a public health perspective, because stereotyping, prejudice, and unfair treatment of affected individuals correspond with adverse health outcomes (Major *et al.*, 2018). Our results showed that applying a pedagogical approach using a combination of a constructivist learning environment and strategies from health education can contribute to the destigmatization of individuals affected by bed bugs irrespective of using live animals or a picture.

On the one hand, this result was achieved through a combination of biological information on bed bugs as well as action-related knowledge on pest control. These findings correspond to studies by Arnold (2018) indicating that providing action-related knowledge (e.g., pest control) in addition to health-related system knowledge (disentangling myths) leads to more

TABLE 4. Findings from the LMM analysis[a]

Predictor	Self-perception β	SE	df	T	p	Social perception β	SE	df	T	p	Disgust β	SE	df	T	p	Psychological distance β	SE	df	T	p
Intercept	2.86	0.11	4	24.86	<0.001	2.59	0.05	195	54.80	<0.001	3.52	0.10	4	37.03	<0.001	230.13	0.06	194	39.164	<0.001
Treatment (T)	—	—	—	—	—	—	—	—	—	—	−0.16	0.05	190	−3.31	<0.01	—	—	—	—	—
Teaching Intervention (TI)	−0.27	0.04	195	−6.85	<0.001	—	—	—	—	—	−0.02	0.02	194	−0.84	0.40	0.19	0.04	194	5.282	<0.001
Gender (G)	—	—	—	—	—	—	—	—	—	—	−0.17	0.05	193	−3.49	<0.001	0.17	0.06	194	2.947	0.004
T * TI	—	—	—	—	—	—	—	—	—	—	0.11	0.02	194	4.62	<0.001	—	—	—	—	—
T * G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TI * G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	−0.08	0.04	194	−2.235	0.027
T * TI * G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]Effects of teaching intervention (pretest vs. posttest), treatment (live bed bugs vs. picture), and gender (male vs. female) on stigma: self-perception; stigma: social perception; disgust; and psychological distance. The teaching intervention significantly affected stigma related to self-perception (β = −0.027, SE = 0.04) but not stigma related to social perception (not explained by any of the independent variables in the model). The significant effect of the treatment × teaching intervention for disgust (β = 0.11, SE = 0.02) explained that disgust was reduced in the experimental group with live bed bugs but not in the control group with pictures. The significant effect of teaching intervention × gender on psychological distance (β = −0.08, SE = 0.04) indicated that for females, the intervention decreased psychological distance more strongly than for males.

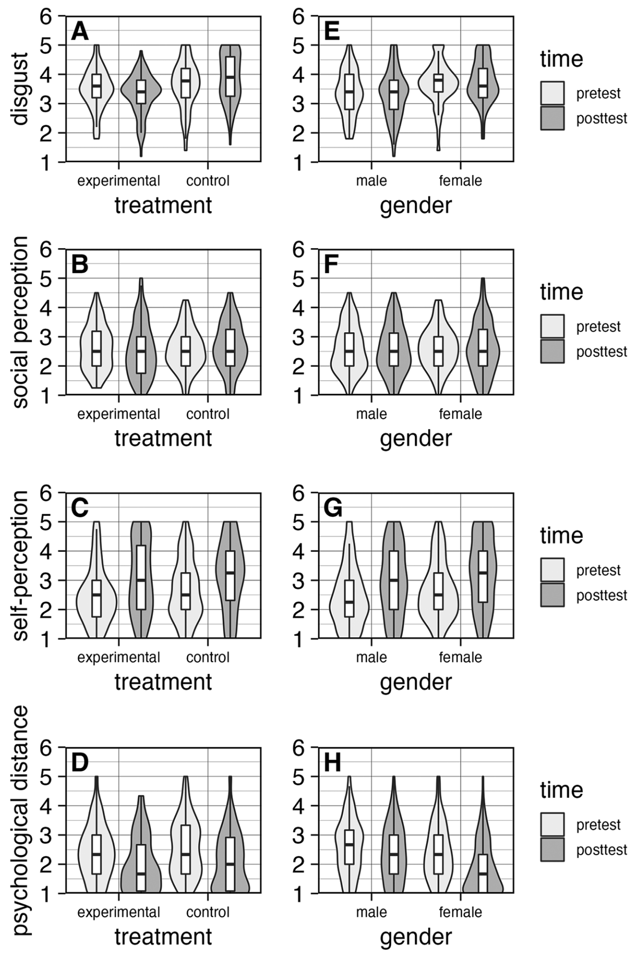

FIGURE 2. Violin plots for disgust, social perception, self-perception, and psychological distance separated by teaching intervention and treatment (A–D) as well as by teaching intervention and gender (E–H). Experimental: live animal; control: bed bug picture. Light gray plots indicate pretest data, dark gray plots indicate posttest data; items assessed on a six-point rating scale. Disgust (A, E): higher values indicate stronger disgust; social perception (B, F): higher values indicate less stigmatizing behavior; self-perception (C, G): higher values indicate less stigmatizing behavior; psychological distance (D, H): higher values indicate a larger psychological distance.

profound learning outcomes. However, it can be assumed that our teaching approach creates learning opportunities that go beyond cognitive learning outcomes. Due to the item formulation and the teaching material, the students were forced to put themselves in the situation of an individual affected by bed bugs. This approach may also promote aspects such as empathy and important mechanisms that can produce substantive behavioral change (Schachter *et al.*, 2008; Zeyer and Dillon, 2019). This is probably also the reason why the live animal had no influence on the degree of destigmatization. At the moment when one puts oneself in someones's situation who knows Mark and evaluates the items, the live animal or the picture recedes into the background. However, due to the complexity of the applied pedagogical approach and the diversity of different teaching materials used, it is not possible for us to identify

TABLE 5. Agreement with different myths using a Likert scale (mean ± SD)[a]

	Pretest		Posttest		Main effect for teaching intervention (pretest vs. posttest)	
Item (myths)	EG (mean ± SD)	CG (mean ± SD)	EG (mean ± SD)	CG (mean ± SD)	*F* test	η_p^2
M1: You can't see a bed bug. (wrong)	2.94 ± 1.42	2.96 ± 1.45	1.53 ± 1.12	2.01 ± 1.32	$F(1, 192) = 92.51$***[,b]	0.33
M2: Bed bugs live in dirty places. (wrong)	3.15 ± 1.18	3.19 ± 1.25	1.42 ± 0.99	1.37 ± 0.89	$F(1, 193) = 306.36$***	0.61
M3: Bed bugs transmit diseases. (wrong)	3.23 ± 1.09	3.27 ± 1.08	1.45 ± 0.82	1.74 ± 1.12	$F(1, 193) = 257.68$***	0.57
M4: Bed bugs won't come out if the room is brightly lit. (wrong)	2.71 ± 1.03	2.70 ± 1.04	2.52 ± 1.44	2.41 ± 1.32	$F(1, 193) = 4.45$*	0.02
M5: Pesticide applications alone will easily eliminate bed bug infestations. (wrong)	3.09 ± 0.97	2.93 ± 0.94	2.88 ± 1.35	2.64 ± 1.42	$F(1, 191) = 4.41$*	0.02

[a]1 = low agreement to 5 = high agreement (theoretical scale mean: 2.5; values above 2.5 indicate agreement). *F* values refer to a main effect for teaching intervention (pretest vs. posttest) calculated through rmANOVA; no interaction effects of teaching intervention × treatment (live bed bugs vs. picture) were found except for myth M1. The levels of significance refer to the *F* test from repeated-measures analysis of variance (rmANOVA): [ns]$p > 0.05$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; effect size partial eta-square (η_p^2). EG, experimental group (live bed bug); CG, control group (picture).

[b]There was a marginally significant interaction effect of teaching intervention × treatment, $F(1, 192) = 3.62$, $p = 0.059$. That is, in the experimental group (live bed bug), there was significantly more agreement with this statement in the posttest compared with the pretest than in the control group (picture).

cause–effect relationships for a specific part of the intervention. Instead, the results indicate that the intervention as a whole was effective in reducing stigma, disgust, and psychological distance.

Furthermore, the findings reveal that only certain facets of stigma (e.g., enacted stigma; Major *et al.*, 2018) were addressed in this study. The study distinguished between stigma related to self-perception and stigma related to the perceptions of others (St. Lawrence *et al.*, 1990; Haghighat, 2005), which allowed us to investigate the effects of the intervention more precisely. Specifically, the findings suggested that through the intervention, destigmatization could solely be achieved at a personal level (changes in stigma related to self-perception), whereas there was no destigmatization at the interpersonal level (stigma related to social perception). It is important to note that this finding comes as no surprise, as challenging the stigmatizing behavior of social others was not the main purpose of the teaching intervention. However, it is here where future biology education on stigma-related issues (e.g., HIV/AIDS, epilepsy, sexually transmitted infections) should aim to make a more holistic contribution in terms of the equally important cognitive, affective, and social learning outcomes (Hofstein *et al.*, 2011).

The Intervention Reduces the Level of Disgust

In our study, disgust was reduced by the teaching intervention, the extent of which was dependent on whether a picture or a live animal was used in the classroom. As in other studies (e.g., Prokop and Fančovičová, 2017; Tomažič *et al.*, 2020), disgust was lower when live animals were used (or only shown). Interestingly, this result differs from that of our previous study (Asshoff *et al.*, 2020). In the latter study, only live bed bugs were used in the intervention, and disgust among students increased in the posttest compared with the pretest. This may be related to the fact that our previous study primarily focused on more abstract bed bug biology, such as reproduction, rather than on a person (Mark) suffering from bed bugs. The different outcomes suggest that the context of the lesson may play a critical role in reducing disgust. Teaching the combination of biological aspects and health education issues (e.g., how Mark can be helped) can reduce disgust, but teaching only about biological aspects does not necessarily do so.

Interestingly, disgust and stigma—although conceptually different—are two interrelated constructs (Dawydiak *et al.*, 2019). Reducing disgust is important in destigmatization, as these constructs are correlated (Dawydiak *et al.*, 2019; Azlan *et al.*, 2020). Even though we did not find a significant effect in terms of stigma and live animal/picture, it may thus be useful to show live animals in a destigmatizing lesson.

The Intervention Helps to Raise Awareness about Bed Bugs

Psychological distance has been identified as an emerging target in biology education, because it has repeatedly been associated with proactive outcomes, such as preventive behavior (Büssing and Heuckmann, 2021). In the present study, we identified a prevention success, because students became more conscious of the topic of bed bugs and were less accepting of common bed bug myths. By applying the construct of psychological distance, we were able to show that the topic is becoming more relevant to the students (decreased psychological distance). We found a gender difference in psychological distance, female students felt psychologically closer to bed bugs than male students, which agrees with previous findings on gender differences in working with animals in the science classroom (Randler *et al.*, 2012). It seems useful to consider these differences when teaching similar topics. Finally, but no less important, our teaching intervention reduced students' acceptance of common myths. This is a very important part of biology education and the task of addressing health-related issues: making people aware of topics and dismantling myths.

In summary, we were able to show that it is possible to reduce stigma, disgust, and psychological distance in relation to bed bugs through a classroom intervention. Only in relation to disgust did our treatment (live animal/picture) show an effect, namely, that exposure to the live animal reduced disgust significantly more than the mere picture. Previous studies that have addressed the issue of stigma were largely in the field of health education. We were able to show that destigmatization can also take place in relation to a biology lesson on parasites, which is highly relevant to society, given the large number of parasites that people can suffer from (e.g., Hurst *et al.*, 2020).

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