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I find this task interesting, so do you? Preservice teachers' judgments of students' enjoyment, boredom, and situational interest regarding tasks with and without a connection to reality

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Abstract

Students' emotions (e.g., enjoyment, boredom) while doing math and their situational interest in mathematics are important for their learning of mathematics, but examinations of teachers' judgments of students' emotions and interest while solving tasks are rare. Moreover, we do not know much about the predictors of teachers' judgments of students' emotions and interest. In this study, we addressed preservice teachers' judgments of students' task-specific enjoyment, boredom, and situational interest and analyzed whether such judgments are related to preservice teachers' own enjoyment, boredom, and interest. Furthermore, we aimed to analyze whether preservice teachers' judgments differ between the two types of tasks under investigation (tasks with and without a connection to reality). To achieve these aims, 182 preservice teachers were randomly assigned to one of two study conditions. In one condition, preservice teachers' judgments of task-specific emotions and situational interest for fictitious 9th-grade students were measured, and in the second condition, preservice teachers' own task-specific emotions and situational interest were measured. The results show that preservice teachers' judgments of students' task-specific emotions and situational interest differ for tasks with and without a connection to reality. Further, our findings indicate that preservice teachers' judgments of students' task-specific emotions and interest differ from preservice teachers' own task-specific emotions and interest. Implications for theoretical models of teachers' judgments and consequences for teacher education are discussed.

Keywords Teacher judgment · Enjoyment · Boredom · Situational interest · Preservice teachers · Real-world problems

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Introduction

In recent years, we have observed an increasing number of studies that have analyzed the roles of affective variables in teaching and teacher education (Di Martino et al., 2015; Schukajlow et al., 2023). This tendency has resulted from evidence that we cannot rely on cognitive learning processes only. Emotional and motivational theories suggest the importance of emotions and interest for students' achievement, careers, and well-being and emphasize the significance of noncognitive factors for students' learning. Consequently, teachers' judgments of students' emotions and interest can better enable mathematics students to learn (Hannula et al., 2019; Hidi & Renninger, 2006; Pekrun, 2006). Prior research has demonstrated that enjoyment and boredom are the most frequently reported positive and negative emotions, respectively, in mathematics classrooms (Larson & Richards, 1991; Pekrun, 1998; Schukajlow et al., 2017), and many students were found to lack an interest in learning mathematics (Heinze et al., 2005). However, perceived enjoyment, boredom, and interest in the mathematics classroom are the most prevalent reasons that students give for continuing or not continuing with mathematics in their future academic careers (Brown et al., 2008). Given that in mathematics classrooms, about 70% of class time is spent solving mathematical tasks (Hiebert et al., 2003) and that students' experience of emotions and interest is connected to their responses to mathematical tasks (Hannula et al., 2019; McLeod, 1992), teachers' judgments of students' enjoyment, boredom, and interest regarding solving tasks are of high importance for the teaching of mathematics. Teachers' judgments are considered essential for adaptive teaching including the decisions about mathematical tasks and the individual support of students emotions and interest (Reuker & Künzell, 2021; Südkamp et al., 2012; Urhahne & Wijnia, 2021).

In the mathematics classroom, solving different types of tasks can result in different emotions and situational interest. Two well-known important types of tasks are tasks with and without a connection to reality (Niss & Blum, 2020). The ability to judge students' emotions and interest with respect to the different types of tasks should therefore be a matter of teacher education. Previous research has shown that preservice teachers have trouble judging students' task-specific enjoyment, boredom, and situational interest (Rellensmann & Schukajlow, 2017, 2018). In order to improve the education of mathematics teachers, the mechanisms behind preservice teachers' judgments of students' emotions and interest need to be uncovered. To the best of our knowledge, not much is known about such mechanisms. Thus, in the present study, we primarily aimed to analyze whether preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest are related to preservice teachers' own enjoyment, boredom, and interest. We investigated this relationship by addressing preservice teachers' emotions and situational interest regarding tasks with and without a connection to reality. Another aim was to find out whether preservice teachers' judgments differ between the two types of tasks under investigation. The theoretical foundations of this research are theories about emotions and interest (Hidi & Renninger, 2006; Mitchell, 1993; Pekrun, 2006), a theory about teachers' judgments (Kahneman, 2003; Südkamp et al., 2012), and a theory about the processes involved in solving tasks with a connection to reality (Niss & Blum, 2020).

Theoretical background

Mathematical tasks with and without a connection to reality

Mathematical tasks are often divided into two groups by the strength of their connection to the real world: tasks with and without a connection to reality (Niss et al., 2007). The starting point in tasks with a connection to reality is a real-world situation, whereas tasks without a connection to reality refer to an (intra)mathematical task (e.g., solve the equation $5x-3=6$). Two established types of tasks with a connection to reality are modelling tasks and ("dressed-up") word tasks. Modelling tasks are characterized by a demanding process of transferring information between reality and mathematics (Cai et al., 2022; Galbraith & Fisher, 2021; Galligan et al., 2019; Inglis & Foster, 2018; Niss & Blum, 2020; Niss & Højgaard, 2019). In order to solve modelling tasks, the given situation must be understood, structured, and simplified before transforming it into a mathematical model. By contrast, the complexity of reality-related mental activities are much easier for "dressed-up" word tasks where the purpose of the real context is to "dress-up" a mathematical task (Krawitz & Schukajlow, 2018; Maaß, 2010). Even if the situation given in the task is not understood completely, a solution is possible because students just need to "undress" the "dressed-up" word task and apply mathematical procedures to it. In contrast to tasks with a connection to reality, tasks without a connection to reality refer directly to mathematical objects and relations. These tasks can be solved by using appropriate mathematical procedures and do not require any transformation process between reality and mathematics.

Enjoyment, boredom, and interest

Enjoyment and boredom

Emotions are defined as multicomponent processes of the psychological subsystems and include affective, cognitive, motivational, expressive, and peripheral processes (Pekrun, 2006; Shuman & Scherer, 2014). Enjoyment and boredom are the two most important emotions in mathematics classrooms (Larson & Richards, 1991; Pekrun, 1998). Both emotions affect students' psychological and physical health and are related to cognitive processes and achievement (Hannula, 2012; Pekrun et al., 2002; Schukajlow & Krug, 2014; Schutz & Lanehart, 2002; Zan et al., 2006). Enjoyment and boredom can arise concerning different objects, such as school in general, the learning of mathematics, or mathematical task-solving (Schukajlow et al., 2017). One of the most widely accepted theories that describes emotions in academic settings is a social-cognitive control-value theory of achievement emotions (Pekrun, 2006). According to this theory, two types of appraisals are of importance for the arousal of emotions. Control appraisals refer to the level of controllability of actions and outcomes in a given situation (e.g., confidence in solving mathematical problems in class or in an exam). Value appraisals refer to the perceived value of the activity or outcome (e.g., the value of learning mathematics or the importance of mathematics grades).

Enjoyment Enjoyment is a positive activating emotion that can trigger students' motivation, strategies for learning, cognitive resources, and self-regulation (Pekrun, 2006). Control- and value-related appraisals determine students' experience of enjoyment. If control appraisals and value appraisals are high, enjoyment occurs. For example, this is the case when the perceived competence and importance of a task or an activity are high. Accordingly, a student who enjoys a task perceives himself or herself as competent to handle the task (high level of control appraisals) and perceives the task as important (high level of value appraisals). In academic settings with less guidance and a greater necessity for self-regulation, enjoyment is a crucial factor for academic achievements and for continuing with mathematics (Di Martino & Gregorio, 2019).

Boredom Boredom could be described as a negative, deactivating emotion (Brown et al., 2008; Pekrun et al., 2010). The reason for feeling boredom is a lack of value for a task or an activity (e.g., task solving). From a theoretical point of view, the subjective value is negatively related to the frequency and intensity of boredom. Additionally, boredom is influenced by subjective control. For example, a mismatch between individual abilities and the specific demands (too high or too low control appraisals), can lead to boredom. However, boredom is not identical to a lack of interest or a lack of positive emotions (Martínez-Sierra et al., 2014; Pekrun et al., 2010). Boredom, as one of the most frequently reported emotions, reduces cognitive activation and implies low engagement (Danckert et al., 2018; Fahlman et al., 2009; Macklem, 2015; Pekrun, 2006). Furlong et al., (2021) found that a high perceived level of boredom is associated with lower well-being in school. Furthermore, most studies have demonstrated negative effects of boredom on students' performance (Camacho-Morles et al., 2021; Pekrun et al., 2014).

Interest

Interest is a motivational variable that describes a specific relationship between people and objects. This relationship is set up when a person shows a positive affect towards the object, considers the object to be valuable, engages and re-engages with the object of interest (e.g., mathematics) over time (Hidi & Renninger, 2006; Krapp, 2000). Interest is characterized by increased levels of attention, concentration, and affect (Hidi, 2006). Thus, interest is an important predictor of students' learning and achievement (Schiefele et al., 1992). In the mathematics classroom, interest is important because highly interested students are better able to focus on their work, use deeper processing strategies, and deal with difficulties (Ainley et al., 2002; Harackiewicz et al., 2008; Heinze et al., 2005). Interest in a specific object at a specific moment could be described as situational interest (Krapp, 1992). Teachers can capture students' situational interest directly through situational factors, for example, by presenting a picture next to a task or describing the context that a task occurs in. Situational interest can easily disappear when students start working on a task, or it can emerge during task solving (Schulze Elfringhoff & Schukajlow, 2021). It appears to be important to capture students' situational interest, which is likely to happen when the process of solving the task is meaningful to the student (Mitchell, 1993) and students feel positive emotions and have strong beliefs in their efficacy in solving a task (Schulze Elfringhoff & Schukajlow, 2021). However, we do not know much about how teachers judge different tasks regarding their potential to capture students' situational interest, enjoyment, or boredom. Accurate judgment is a prerequisite for being able to appropriately support students' enjoyment, boredom, and situational interest while they work on mathematical tasks.

Diagnostic competence

As the tasks used in mathematics classrooms are crucial for students' enjoyment, boredom, and interest, teachers can shape these by selecting appropriate tasks for classroom instruction (Baumert et al., 2010). The selection of tasks is a recurring challenge for many teachers. Control- and value-related appraisals play a decisive role in task selection. For example, in the case of value-related appraisals, teachers might select a task because the solving of this task is important for understanding the topic, or being able to solve a selected task is important for students' future lives. Apart from cognitive prerequisites for selecting tasks (e.g., mathematical topic or prior knowledge), teachers may also take their students' emotions and interest into account while selecting which tasks to use in their lessons. Moreover, teachers should be able to judge students' task-specific emotions and interest in order to adjust their teaching to their students. The ability to accurately judge students' emotions and interest is described as diagnostic competence (Schrader, 2009), which is a crucial aspect of teachers' expertise that influences the quality of learning instructions and student assessments (Südkamp et al., 2012). In previous research, two components have commonly been used to measure judgment accuracy as an indicator of teachers' diagnostic competencies: the level and the rank component (Helmke & Schrader, 1987). For example, the level component would describe whether the teacher overestimates, accurately estimates, or underestimates student interest in a task. The rank component provides information about whether a task is ranked in the right order according to students' interest (e.g., from more to less interesting tasks for students). Judgment accuracy is high when the correlation between students' rank ordering and teachers' rank ordering is high. In the present study, we were interested in judgments of students' emotions and interest regarding mathematical tasks. Such judgments are crucial for learning instructions because they are particularly relevant for task selection (McElvany et al., 2009). We focus on judgments of task-specific enjoyment, boredom, and interest regarding tasks with and without a connection to reality. As these judgments are an important part of the diagnostic competence of inservice teachers, there is a need to address judgments of emotions and interest earlier in mathematics teacher education (i.e., by preservice teachers). However, the diagnostic competence of noncognitive factors has rarely been considered in prior research so far, and not much is known about how preservice teachers judge students' emotions and interest.

Teachers' judgments of students' enjoyment, boredom, and interest in solving tasks with and without a connection to reality

Only a few studies have investigated the preservice and inservice teachers' judgments of students' emotions and interest in the past (Givvin et al., 2001; Kriegbaum et al., 2019; Praetorius et al., 2010; Zhu & Urhahne, 2021). For example, Zhu and Urhahne (2021) examined teachers' accuracy in judging students' motivation, test anxiety, and interest. In this study, mathematics teachers' judgments and students' motivation, test anxiety, and interest were measured twice within a 4-week period in nine classes of sixth graders in a Chinese school. Students worked on a standardized mathematics test and a questionnaire used to measure student motivation and emotion. The teachers judged each student's motivation and emotion using one item. The study demonstrated that Chinese elementary school teachers were able to make accurate judgments about student motivation, but students' emotions were difficult to judge. For preservice teachers, Rellensmann and

Schukajlow investigated judgments of students' interest (2017) and students' enjoyment and boredom (2018) in solving tasks with and without a connection to reality. They found that preservice teachers tended to overestimate students' interest in tasks with a connection to reality and underestimate students' interest in tasks without a connection to reality. The estimated judgment accuracy was low and varied across preservice teachers. Rellensmann and Schukajlow (2018) found similar results for preservice teachers' judgments of students' task-specific enjoyment and boredom. Consequently, prior research has found that especially preservice teachers have trouble accurately judging students' task-specific emotions and interest, and judgment accuracy varied considerably across preservice teachers.

Mechanisms of prospective teachers' judgments of students' enjoyment, boredom, and interest in solving tasks with and without a connection to reality

According to the influential theory of judgments by the Nobel Prize winner Kahneman (2003), there are two different systems that can produce a judgment in a given situation. Judgments made by System 1 are rather intuitive and emotional, whereas the judgments made by System 2 are more deliberative and logical. A central component in Kahneman's theory is the so-called "what-you-see-is-all-there-is rule." System 1 only uses information that is already available at the moment of judgment and that had already been activated by intuitive associations. Further, System 1 often makes task modifications and replaces the original task with a similar but easier to solve judgment task. So, system 1 is connected to intuition and is fast, intuitive, effortless, and influenced by affect. In contrast to System 1, System 2 is aimed at more precise reasoning. It seeks to investigate new judgment-relevant information and systematically compare possible options for making a judgment. In the context of judgments of mathematical tasks and students' emotions and interest while they solve the tasks, System 2 needs to consider a lot of information—in our case, task characteristics (task with and without a connection to reality), theories about emotions and interest, as well as theories about solution processes. For judgments by System 2, deep pedagogical content knowledge is essential. Thus, system 2 is associated with reasoning and therefore tends to be slow, controlled, effortful and rather neutral. As preservice teachers are just at the beginning of their teaching careers and usually do not have profound pedagogical content knowledge at this stage, it can be assumed that preservice teachers' judgments are made by System 1. In order to describe potential factors that influence the rather intuitive judgments that preservice teachers make about students' task-specific emotions and interest, Südkamp et al. (2012) suggested that researchers should take into account teachers' characteristics and test characteristics as two potential factors of importance for the accuracy of teachers' judgments. Accordingly, preservice teachers' judgments might be influenced by the characteristics of preservice teachers' own emotions and interest. By relying on the intuitive judgments made by System 1, preservice teachers might replace the goal of judging students' emotions and interest with the goal of judging their own emotions and interest, as it is easier to make judgments about themselves than about others. Moreover, the characteristics of the materials offered for judgment need to be considered. In the case of mathematical tasks, their possible connection to reality seems to be a crucial factor of the test characteristics. Whereas the judgments of affect for tasks with a connection to reality rely to a great extent on tasks in the real world, judgments of intramathematical tasks refer to the particular mathematical task that is presented. Even though preservice teachers are aware of the importance of different types of tasks for mathematics learning, they might assign higher value to the ability to solve real-world tasks, and consequently, their judgments of students' affect regarding tasks with a connection to reality might be higher than for tasks without a connection to reality. Thus, preservice teachers' judgments of students' task-specific emotions and interest might be different if they judge tasks with versus without a connection to reality.

Research questions and expectations

In this study, we addressed preservice teachers' judgments of students' enjoyment, boredom, and interest with respect to solving tasks with and without a connection to reality in two steps. First, we analyzed preservice teachers' judgments of students' task-specific emotions and interest for tasks with and without a connection to reality. Second, we compared preservice teachers' judgments of students' task-specific emotions with preservice teachers' own task-specific emotions and interest regarding tasks with and without a connection to reality. Our research questions were the following:

RQ 1:Do preservice teachers' judgments of students' task-specific enjoyment, boredom, and situational interest differ for tasks with and without a connection to reality?

RQ 2:Do preservice teachers' judgments of students' enjoyment, boredom, and interest for tasks with and without a connection to reality differ from preservice teachers' own enjoyment, boredom, and situational interest regarding these types of tasks?

For the first research question, we expected that preservice teachers' judgments of students' enjoyment and interest would be higher and their judgments of boredom would be lower for tasks with a connection to reality compared with tasks without a connection to reality. These expectations were based on theories of achievement emotions (Pekrun, 2006) and theories of interest (Hidi & Renninger, 2006) as well as on theories of the cognitive processes that are required to solve tasks with and without a connection to reality (Niss & Blum, 2020).

To address the second research question, we calculated level and rank components (Helmke & Schrader, 1987). On the basis of theoretical models about judgments (Kahneman, 2003; Südkamp et al., 2012), we expected that preservice teachers would make intuitive judgments (System 1) that were based on their own experiences in solving tasks. Consequently, no differences between the two perspectives were expected (i.e., similar levels of judgments according to the level component and a strong positive correlation between preservice teachers' judgments of students and the teachers' own judgments according to the rank component).

Methods

Participants and procedure

The participants were 182 preservice teachers at a large German university who wanted to become mathematics teachers in the low and intermediate tracks of German secondary schools (Hauptschule, Realschule, and Gesamtschule). Preservice teachers voluntarily participated in the study while they were enrolled in a regular university course that both graduate and undergraduate students could take. All students had a comparable level of prior experience, as they had taken a compulsory lecture on the fundamentals of mathematics education and a lecture on applications in mathematics education. The content of the lectures included information about tasks with and without connection to reality. In order to examine the research questions, the participating preservice teachers were randomly assigned to one of two study conditions. In one condition, preservice teachers' own enjoyment, boredom, and interest were assessed, and in the other condition, preservice teachers judged students' task-specific enjoyment, boredom, and interest. A total of 97 of the 182 preservice teachers (74.2% women) reported their own task-specific enjoyment, boredom, and interest. The mean age of this group was $M = 23.55$ ($SD = 3.045$). A total of 85 of the 182 preservice teachers (76.5% women) reported their judgments of students' task-specific enjoyment, boredom, and interest. Their mean age was $M = 23.33$ ($SD = 3.114$).

In each condition, 12 tasks were presented. Preservice teachers were not required to solve the tasks but were instead asked to answer a questionnaire that was presented below each task. The questionnaire differed with respect to the study conditions. In the first condition, preservice teachers were asked to judge fictitious students' task-specific emotions and interest in solving the presented tasks. Consequently, in the second condition, teachers were asked to indicate their own task-specific emotions and interest in the tasks. The general instructions for each condition were: "There are tasks presented below. Read each task carefully and then answer the questions. You are not supposed to solve the tasks."

Measures

Mathematical tasks

In this study, we used four tasks without a connection to reality and eight tasks with a connection to reality (the latter consisting of four "dressed up" word tasks and four modelling tasks). The tasks we selected for the study emerged from a pool of tasks that had been developed and used in prior studies (Schukajlow et al., 2012). By selecting the four tasks of each type, we followed theoretical considerations and the methodological approach applied in previous studies (Rellensmann & Schukajlow, 2017, 2018) to obtain comparable results and ensure consistency in research. We subsumed the "dressed-up" word tasks and modelling tasks under tasks with a connection to reality and distinguished them from tasks without a connection to reality. A confirmatory factor analysis (CFA) implemented in Mplus (Muthén & Muthén, 2017) supported this manner of distinguishing between the types of tasks (tasks with and without a connection to reality) for the judgments of enjoyment, boredom, and interest. The fit statistics indicated that the model fit (Table 1) was acceptable for enjoyment, boredom and interest, even though the CFI and SRMR, which are preferable

Table 1 Confirmatory factor analysis statics

	Enjoyment	Boredom	Interest
X^2 (*df*)	121.038 (35)	141.790 (35)	184.837 (35)
Standardized root mean square residual (SRMR)	0.06	0.07	0.09
Root mean square error of approximation (RMSEA)	0.08	0.09	0.11
Comparative fit index (CFI)	0.90	0.86	0.77
Tucker-Lewis index (TLI)	0.88	0.83	0.71

for samples $N < 250$ as in this study, were slightly below and slightly above the cut-off indices of 0.90 (CFI) and 0.06 (SRMR), respectively. (Hu & Bentler, 1999).

All the tasks we used could be solved by using the Pythagorean theorem. This is an incremental part of national and international curricula (e.g., Kultusministerkonferenz, 2004; National Council of Teachers of Mathematics, 2000). By focusing on just one mathematical content area, we aimed to avoid the effects of preferences for different content areas. By selecting these tasks, we considered the difficulty levels of the tasks in order to balance differences in difficulty between different types of tasks. Different real-world contexts were also used for the tasks with a connection to reality. Examples of the tasks are presented in Figs. 1, 2, and 3. The tasks in Figs. 1 and 2 are tasks with a connection to reality. The "Maypole" task (Fig. 1) is a modelling task.

The "Maypole" task contains a verbal description and a picture of an authentic real-world situation. The task is about the traditional dance around the maypole in Germany. To solve the task, students need to engage in a substantial number of processes through which information is transferred between the given situation and the mathematics that are required to solve the task. The transfer process includes an intensive

Maypole

Every year on Mayday in Bad Dinkelsdorf, there is a traditional dance around the maypole (a tree trunk approximately 8 m high). During the dance, the participants hold ribbons in their hands, and each ribbon is fixed to the top of the maypole. The participants dance around the maypole with these 15-m-long ribbons, and as the dance progresses, the ribbons produce a beautiful pattern on the stem (such a pattern can already be seen at the top of the maypole stem in the picture).
At what distance from the maypole do the dancers stand at the beginning of the dance (the ribbons are tightly stretched)?

Fig. 1 Task with a connection to reality: the Maypole task

Soccer Field

Trainer Manfred would like to carry out a diagonal run with his soccer team. To do so, he wants to know how long the diagonal of the soccer field is. Can you help him?
Calculate the length of the diagonal of the soccer field.

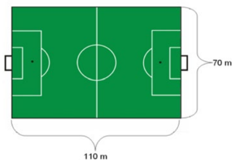

Fig. 2 Task with a connection to reality: the Soccer Field task

Angle

Where is the right angle in the triangle (not drawn true to scale) so that the equation $n^2 - o^2 = m^2$ is satisfied?
Draw the right angle in the triangle.

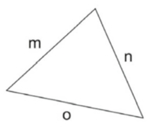

Fig. 3 Task without a connection to reality: the Angle task

understanding of the given situation, followed by structuring and simplifying, then identifying a right triangle, constructing a mathematical model, and obtaining mathematical results that need to be interpreted and validated in relation to reality. A characteristic challenge in solving modelling tasks is that students need to make assumptions about vague conditions. For the "Maypole" task, an assumption should be made about the attachment of the ribbons to the tree trunk. Another assumption may be related to the height at which the dancers hold the ribbons. Figure 2 shows another type of task with a connection to reality, the "dressed-up" word task "Soccer Field."

This task is also connected to reality. However, the task is already prestructured and simplified. The mathematical model can easily be identified from the picture. Compared with modelling tasks (e.g., Fig. 1), the cognitive processes of understanding, structuring, and simplifying the given situation do not need to be implemented in an elaborated way. In particular, no assumptions need to be made. The task shown in Fig. 3 "Angle" is an example of a task without a connection to reality. The task is presented entirely with mathematical symbols. Thus, task solvers do not need any processes for transferring information between reality and mathematics.

Emotion and interest scales

Questionnaires including well-evaluated scales from previous studies (Schukajlow et al., 2012) were used to measure prospective teachers' own enjoyment, boredom, and interest and prospective teachers' judgments of students' enjoyment, boredom, and interest in solving the tasks. In order to reduce response and reflection time, single-item measures were used for each scale. If it takes too long to answer a questionnaire, the assessment of psychological states can become compromised (Goetz et al., 2010).

Preservice teachers were asked to indicate their task-specific enjoyment, boredom, and interest by rating statements that were presented in the questionnaire below each task. The statement about preservice teachers' own enjoyment was: "I would enjoy working on this task." The statement about preservice teachers' boredom was: "I would be bored by working on this task." The statement about preservice teachers' interest was: "It would be interesting to work on this task." Preservice teachers were asked to use a 5-point Likert scale (1 = *not true at all*, 5 = *completely true*) to rate the extent to which they agreed with the statements. In order to form scales for measuring preservice teachers' enjoyment, boredom, and interest for tasks with and without a connection to reality, preservice teachers' scores for task-specific enjoyment, boredom, and interest were aggregated. All scale reliabilities were acceptable (Cronbach's alpha > 0.70).

On the questionnaire that asked for preservice teachers' judgments of students, after each task was a statement about students' enjoyment, boredom, and interest. Ratings were again made on a 5-point Likert scale (1 = *not true at all*, 5 = *completely true*). The statement for measuring students' enjoyment was: "Students would enjoy working on this task." The statements for measuring students' task-specific boredom and interest were built analogously. Again, two scales were constructed by aggregating them to measure preservice teachers' judgments with respect to tasks with and without a connection to reality. The scale reliabilities were also acceptable (Cronbach's alpha > 0.70).

Data analysis

In order to estimate whether preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest are related to the two types of tasks under investigation (tasks with and without a connection to reality), Bonferroni-adjusted *t* tests for dependent samples were computed.

In order to estimate whether preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest are related to preservice teachers' own task-specific enjoyment, boredom, and interest, we considered two well-established indicators: the level component and the rank component (Helmke & Schrader, 1987; Spinath, 2005). To estimate the level component, we computed difference scores between preservice teachers' judgments of students' affect and preservice teachers' own task-specific enjoyment, boredom, and interest. A positive difference score would indicate that the mean level of preservice teachers' judgments of students was higher than the mean level of preservice teachers' own task-specific enjoyment, boredom, and interest. Respectively, a negative difference score would indicate a higher mean level for preservice teachers' own task-specific enjoyment, boredom, and interest in comparison with the mean level of preservice teachers' judgments of students. A difference score of 0 would represent equal mean levels for preservice teachers' own task-specific enjoyment, boredom, and interest and preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest. Bonferroni-adjusted *t* tests for independent samples were used to investigate whether preservice teachers' judgments of students' enjoyment differed significantly from preservice teachers' own mean level of enjoyment. To interpret nonsignificant results, we computed Bayes factors, which quantify whether a nonsignificant result supported the null hypothesis or whether the data were just insensitive (Dienes, 2011). As an illustration, a Bayes factor of 10 in favor of the null hypothesis as opposed to the alternative hypothesis implies that the observed data are 10 times more likely under the null hypothesis than under the alternative hypothesis (Lortie-Forgues & Inglis, 2019). Guidelines for interpreting Bayes factors were given by Jeffreys (1998), suggesting that Bayes factors between 3 and 1/3 are barely worth mentioning. Bayes factors between 3 (1/3) and 10 (1/10) indicate moderate evidence, those between 10 (1/10) and 30 (1/30) indicate strong evidence, those between 30 (1/30) and 100 (1/100) indicate very strong evidence, and those over 100 (below 1/100) indicate decisive evidence.

In order to estimate the rank component, we ranked the investigated tasks according to preservice teachers' own level of task-specific enjoyment, boredom, and interest when solving the tasks. In addition, for each preservice teacher, we ranked the tasks according to their judgments of students' levels of enjoyment, boredom, and interest. Then, we computed the rank order correlation between preservice teachers' own rank order and each preservice teacher's judgment of students' rank order. In order to compute mean correlation coefficients across preservice teachers, these rank order correlations were Fisher z transformed, and the resulting mean coefficients were transformed back into correlations.

Results

Preliminary analyses

The correlations between the measures used in the study were in the expected directions (see Table 2). For example, the correlations between the measures of enjoyment and boredom were negatively correlated for both types of tasks and in both samples.

All correlations were significant ($p < 0.01$). The correlations between the measures of preservice teachers' judgments of students' enjoyment, boredom, and interest are presented above the diagonal, and the correlations between the measures of prospective teachers' own task-specific enjoyment, boredom, and interest are presented below the diagonal (Table 2).

Preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest for tasks with and without a connection to reality

Results for preservice teachers' judgments of students' enjoyment, boredom, and interest when solving tasks with and without a connection to reality are presented in Fig. 4.

Preservice teachers predicted that students would experience a mean level of enjoyment of $M = 3.48$ ($SD = 0.51$) for tasks with a connection to reality and $M = 2.45$ ($SD = 0.68$) for tasks without a connection to reality. In line with our expectations, a *t* test indicated a significant difference between preservice teachers' judgments of students' enjoyment while they solved the types of tasks we investigated, $t(84) = -14.97$, $p < 0.01$. The effect size $d = 1.32$ was adjusted for the correlation between the dependent measures and indicated a large effect. Furthermore, preservice teachers predicted a mean level of boredom of $M = 3.27$ ($SD = 0.72$) and $M = 2.49$ ($SD = 0.50$) for tasks with and without a connection to reality, respectively. The difference in preservice teachers' judgments of students' boredom for the two types of tasks was statistically significant, $t(84) = 10.47$, $p < 0.01$. The adjusted effect size *d* was 0.99, again indicating a large effect. In addition, preservice teachers gave a mean rating of $M = 3.43$ ($SD = 0.44$) for interest for tasks with a connection to reality and $M = 2.32$ ($SD = 0.63$) for tasks without a connection to reality. The difference between these means was significant, $t(84) = -16.65$, $p < 0.01$, and the adjusted effect size $d = 2.27$ indicated a large effect.

Differences in preservice teachers' judgments of students' enjoyment, boredom, and interest and preservice teachers' own task-specific enjoyment, boredom, and interest

Enjoyment

The mean difference scores between preservice teachers' judgments of students' task-specific enjoyment and preservice teachers' own levels of enjoyment were $M = -0.14$

Table 2 Correlations between measures of task-specific enjoyment, boredom, and interest

	Tasks	Enjoyment		Boredom		Interest	
		With a connection to reality	Without a connection to reality	With a connection to reality	Without a connection to reality	With a connection to reality	Without a connection to reality
Enj	With	–	0.45	−0.79	−0.33	0.78	0.40
	Without	0.65	–	−0.34	−0.71	0.34	0.78
Bor	With	−0.54	−0.491	–	0.40	−0.70	−0.29
	Without	−0.48	−0.808	0.70	–	−0.32	−0.56
Int	With	0.83	0.57	−0.51	−0.44	–	0.38
	Without	0.58	0.83	−0.39	−0.72	0.65	–

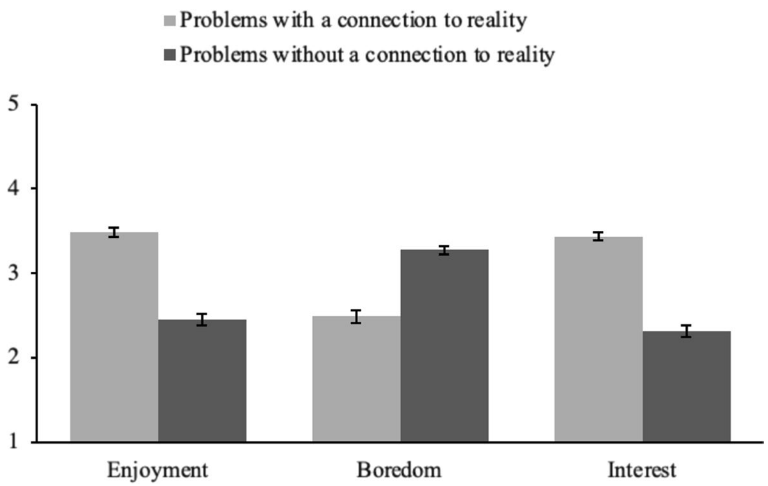

Fig. 4 Preservice teachers' mean judgments of students' enjoyment, boredom, and interest while solving tasks with and without a connection to reality. Error bars represent standard errors

($SD = 0.09$) for tasks with a connection to reality and $M = -0.86$ ($SD = 0.12$) for tasks without a connection to reality. In line with our expectations, preservice teachers' judgments did not differ significantly from preservice teachers' own task-specific enjoyment for tasks with a connection to reality, $t(176.84) = -1.60$, $p = 0.226$. Also, a Bayes factor of $B = 2.65$ indicated that, given the data, there was evidence of no difference. Contrary to our expectations, preservice teachers' judgments differed significantly from preservice teachers' own task-specific enjoyment for tasks without a connection to reality, $t(172.58) = -7.12$, $p < 0.01$, $d = 1.03$, indicating that preservice teachers' ratings of their own enjoyment had a higher mean level than preservice teachers' judgments of students' mean level of task-specific enjoyment.

The mean rank-order coefficients for task-specific enjoyment were $M_r = 0.17$, ranging from $r = -0.75$ to 0.92 for tasks with a connection to reality, and $M_r = 0.13$, ranging from $r = -0.89$ to 0.95 for tasks without a connection to reality, indicating only a weak positive relation between preservice teachers' judgments of students' enjoyment and preservice teachers' own enjoyment.

Boredom

The mean difference scores between preservice teachers' judgments and preservice teachers' own mean level of boredom were $M = 0.07$ ($SD = 0.09$) and $M = 0.50$ ($SD = 0.12$) for tasks with and without a connection to reality, respectively. In line with our expectations, a t test did not indicate a significant difference between preservice teachers' judgments and preservice teachers' own mean level of boredom for tasks with a connection to reality, $t(175.82) = 0.858$, $p = 0.784$. A Bayes factor of $B = 6.12$ supported this finding. Contrary to our expectations, preservice teachers' judgments of students' task-specific boredom differed for tasks without a connection to reality, $t(178.63) = 4.14$, $p < 0.01$, $d = 0.60$, indicating a lower mean level for preservice teachers' own boredom compared with preservice teachers' judgments of students' mean level of task-specific boredom.

The mean rank-order coefficients for task-specific boredom were $M_r = -0.07$, ranging from $r = -0.91$ to 0.76 for tasks with a connection to reality, and $M_r = 0.22$, ranging from $r = -0.95$ to 0.99 for tasks without a connection to reality. Consequently, preservice teachers ordered the tasks without a connection to reality similarly when they judged students' boredom and their own boredom, but these results did not confirm the expectation of a strong positive relation between preservice teachers' judgments of students' boredom and teachers' own boredom.

Interest

The difference scores between preservice teachers' judgments of students' interest and preservice teachers own interest were $M = -0.03$ ($SD = 0.08$) for tasks with a connection to reality and $M = -0.92$ ($SD = 0.11$) for tasks without a connection to reality. In line with our expectations, for tasks with a connection to reality, preservice teachers' judgments of students' interest did not differ significantly from preservice teachers' own interest, $t(167.86) = -0.371$, $p = 0.711$. A Bayes factor of $B = 8.09$ confirmed the result that there was no difference in the mean levels of interest. Contrary to our expectations, preservice teachers' judgments of students' interest differed significantly from preservice teachers' own task-specific interest for tasks without a connection to reality, $t(176.05) = -8.46$, $p = 0.004$, $d = 1.24$, indicating a higher mean level for preservice teachers' self-reported interest compared with preservice teachers' judgments of students' mean level of task-specific interest.

The mean rank-order coefficients for task-specific interest were $M_r = 0.06$, ranging from $r = -0.78$ to 0.89 for tasks with a connection to reality, and $M_r = 0.16$, ranging from $r = -0.95$ to 0.95 for tasks without a connection to reality. For tasks with a connection to reality, the rank order of interest was different for preservice teachers' judgments of students' interest and preservice teachers' own interest. For tasks without a connection to reality, the rank order of interest was only slightly similar for preservice teachers' judgments of students' interest and preservice teachers' own interest. Therefore, we did not find a strong relation between preservice teachers' judgments of students' interest and preservice teachers' own interest.

Discussion

Empirical contributions

An important finding of the present study was that preservice teachers' judgments of students' enjoyment, boredom, and situational interest while solving tasks were more positive for tasks with a connection to reality than for tasks without a connection to reality. Preservice teachers assume that a task's connection to reality has a positive effect on students' enjoyment, boredom, and interest. Teachers' judgments of students' enjoyment and interest while solving tasks without a connection to reality were higher than their judgments of students' enjoyment and interest while solving tasks with a connection to reality. Further, teachers' judgments of students' boredom while solving tasks without a connection to reality were lower than their judgments of students' boredom while solving tasks with a connection to reality. These findings add to previous research on preservice teachers' judgments, in which similar effects were found for students at the beginning of their studies (Rellensmann & Schukajlow, 2017, 2018).

Another important finding was that we could observe differences between preservice teachers' judgments of students' task-specific emotions and interest and preservice teachers' own task-specific emotions and interest. For tasks without a connection to reality, the findings for the level component indicate that there are significant differences between preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest and preservice teachers' ratings of their own emotions and interest. However, the two perspectives did not differ for tasks with a connection to reality. With respect to the rank component, the low to zero mean magnitudes of the correlations indicate that preservice teachers' judgments of students' task-specific enjoyment, boredom, and situational interest differ from the relative position of one task in terms of preservice teachers' own task-specific enjoyment, boredom, and situational interest in relation to other tasks for the types of tasks under investigation. The findings of frequent significant differences in the level and rank components are important because they contribute to uncovering the mechanisms through which preservice teachers' judgments of students' emotions and situational interest are influenced. Preservice teachers' judgments of students might not be influenced by their own perceptions of enjoyment, boredom, and interest in solving mathematical tasks. To the best of our knowledge, no previous studies have investigated the influence of these kinds of judgments in the context of emotions and situational interest. Thus, our work investigated for the first time the role of preservice teachers' own emotions and interest in judgments of students' emotions and situational interest.

Theoretical contributions

On the basis of the control-value theory of achievement emotions (Pekrun, 2006), theories of interest (Hidi & Renninger, 2006; Mitchell, 1993), the domain-specific theory of solving tasks (Niss & Blum, 2020), and theories about judgments (Kahneman, 2003; Südkamp et al., 2012), we investigated preservice teachers' judgments of task-specific enjoyment, boredom, and situational interest. As we assumed that a task's connection to reality is an important task characteristic, we chose tasks with and without a connection to reality for our study. Our first expectation was that preservice teachers would rate students' enjoyment higher, students' boredom lower, and students' situational interest higher for tasks with a connection to reality compared with tasks without a connection to reality. This expectation was based on the assumption that preservice teachers notice the differences in the tasks with and without a connection to reality and that they will believe that the relation to reality is an important predictor of emotions and situational interest. The latter belief might result from prior experiences as a student, and it is consistent with the control-value theory of achievement emotions for enjoyment and boredom and on theories about interest, which suggest the positive effects of tasks' relations to reality on enjoyment, boredom, and interest. Our second expectation was that preservice teachers would make rather intuitive judgments of students' enjoyment, boredom, and situational interest that were based on their own enjoyment, boredom, and interest regarding the two types of tasks offered to students.

Our first finding of differences in preservice teachers' judgments of students' affect between the types of tasks was consistent with our expectations. This result provides support for the theories of achievement emotions and interest and demonstrates that these theories are also valid for preservice teachers' judgments. Preservice teachers indicate greater enjoyment and less boredom for tasks with a connection to reality. One explanation for this finding is that preservice teachers indicate higher control- and value-related appraisals for tasks with a connection to reality, leading to a higher judgment of students' enjoyment and a lower judgment of students' boredom for tasks with a connection to reality. Concerning situational interest, tasks with a connection to reality seem to be more interesting for students than tasks without a connection to reality from preservice teachers' perspective. Abstract mathematical tasks were not seen as interesting for students; rather, the real-world context of a task might capture students' interest. This view was also predicted in prior research (Beswick, 2011; Boaler, 1993). Another important theoretical implication of this first finding contributes to the theory of teachers' judgments (e.g., Südkamp et al., 2012), suggesting that what is being judged is important for the judgments. Our finding may indicate that the types of tasks and their characteristics are important for the process of forming judgments about students' emotions and interest. When preservice teachers make a judgment, the characteristics of the tasks that are being judged will be considered as well; consequently, the judgments might differ for different types of tasks.

The second, rather unexpected new finding from our study that was only partly consistent with our expectations was that there are differences between preservice teachers' judgments of students' task-specific enjoyment, boredom, and interest and preservice teachers' judgments of their own task-specific enjoyment, boredom, and interest. The expectation that preservice teachers' judgments rely to a great extent on their own experience of affect was partly confirmed by our research. One explanation for this new finding may be that it makes a difference whether the judgments are made about oneself or about others (e.g., students). The investigated differences between preservice teachers' judgments and their own affect seem to indicate that preservice teachers underwent a change in perspective. This finding might indicate that preservice teachers' judgments of students' task-specific affect were not just intuitive judgments that were based on preservice teachers' own affect. With respect to Kahneman's (2003) theory, our findings suggest that preservice teachers' judgments were made in a more deliberative way, which would suggest that System 2 also seems to be relevant when investigating preservice teachers' judgment process. Moreover, our findings contribute to Südkamp et al.'s (2012) theory. In their model of teacher judgments, the authors suggested that researchers should take the characteristics of the teachers into account. With our research, we can contribute to this model the finding that (preservice) teachers' judgments of students' affect do not result from preservice teachers' own emotions and interest only. Other characteristics of the teachers are of considerable relevance for understanding the complex process of teachers' judgments.

Practical contributions

In educational research, it has become evident that emotions and interest are crucial for students' learning and achievement. Consequently, the support of students' emotions and interest in mathematical classrooms is important, and judgments of students' emotions and interest need to be done by teachers (Schukajlow et al., 2017). In order to improve the professional development of mathematics teachers, the mechanisms behind preservice teachers' judgments of students' emotions and interest need to be investigated. Along with results from other studies, the results of the present study also suggest that it is necessary to emphasize questions about teachers' judgments of students' characteristics in mathematics teachers' education (Jamil et al., 2018; Thiede et al., 2015; Zhu & Urhahne, 2018). As the results of our study show, preservice teachers' judgments of students' emotions and interest rely only in part on preservice teachers' own emotions and interest. Moreover, the wide range observed for the magnitudes of the correlations indicates notable variability in preservice teachers' judgments of the relative positions of tasks in terms of students' task-specific enjoyment, boredom, and interest. These findings provide a first indication that the role of a person's own perceptions in their judgments can be different for different types of tasks (e.g., tasks with and without a connection to reality in our study) as well as for different tasks. As enjoyment, boredom, and interest seem to be very individual, a practical implication might be that it is challenging to find a task that has the same effects on all task solvers, implying that a selection of different tasks should be invoked by selecting several different kinds of tasks for students to work on. Preservice teachers seem to have implicit beliefs about students' emotions and interest right at the beginning of their mathematics teacher education that are not in line with students' real experiences of emotions and interest, as prior research (Rellensmann & Schukajlow, 2017, 2018) has shown that preservice teachers' judgment accuracy is low. Thus, an important practical contribution of our study is that the education of mathematics teachers should focus a great deal on preservice teachers' judgments by improving preservice teachers' knowledge about students' emotions and interest regarding different types of mathematical tasks. This new focus may require changes in teacher education curricula. Our results suggest the importance of mathematical pedagogical content knowledge, which is also mentioned in different theories of teachers' judgments and diagnostic competences (e.g., Südkamp et al., 2012) and in research on mathematics teacher education (e.g., Charalambous et al., 2020), in order to improve the education of mathematics teachers. This implication has been supported by several studies (e.g., Seidel et al., 2021) that have found that expert teachers make more accurate judgments than novices, thus implying that there should be more emphasis on the practical aspects of mathematics teacher education.

Limitations and future directions

Several limitations of the present study should be considered. One limitation concerns how the results of this study are related to the theory of diagnostic competence and teachers' decision making. In our study, we found that it is important for judgments of task-specific emotions and interest from which perspective (one's own perspective vs. students' perspective) the judgments were made. Thus, we could not assume that preservice teachers' judgments of students were based on their own emotions and interest only. However, we still do not know how preservice teachers form their judgments. With respect to our study, we conclude that one factor (preservice teachers' own emotions and interest) does not determine the complex judgment process. In order to further investigate the influence of preservice teachers' own perspectives on the judgment process, a within-design might be helpful. Furthermore, we call for the qualitative in-depth analysis of preservice teachers' responses in future studies. Further research should also consider other potential factors of preservice teachers' judgment processes in order to investigate the complex process of judgments. These factors might consist of preservice teachers' content knowledge, teaching experience, and many other factors. A qualitative design could provide deeper insights into how teachers form their judgments.

Another limitation is that the preservice teachers judged a fictitious learning group of students (ninth graders in our study). This approach has been taken in research in the past (e.g., Ostermann et al., 2015; Rellensmann & Schukajlow, 2017, 2018), and we followed it in this study in order to get information about the demands associated with classroom instructions that include the different types of mathematical tasks. For example, such a judgment is necessary for decisions about the selection of teaching materials, when planning a lesson for a previously unknown class or for a topic with a lack of experience with a specific learning group. However, another study design is needed for judging the emotions and interest of a concrete group of students. As one example, Martz et al. (2018) found that sociodemographic and contextual factors were related to students' boredom. Such factors need to be taken into account when judging a concrete learning group. In future studies, a learning group that is familiar to preservice teachers should be considered in addition to judgments of fictitious students. This should also be taken into account for questions about the generalizability of the results of our study to inservice teachers. Further, preservice teachers from only one university in one country were asked to judge students in the ninth grade. A generalization to preservice teachers all over the world and to students in other grades is possible only to a limited extent because emotions and situational interest might differ for different tasks and in different countries and might change over time (Ahmed et al., 2013; Schulze Elfringhoff & Schukajlow, 2021). Additionally, all of the tasks used in the present study could be solved by applying the Pythagorean theorem in order to avoid confounding effects of topic preferences. However, because of this element of the study design, we do not know whether our results will generalize to other content areas or tasks.

Conclusion

In this study, we demonstrated the importance of individual affective prerequisites (i.e., preservice teachers' judgments of their own emotions and situational interest) and teaching materials (i.e., tasks with and without a connection to reality) for preservice teachers' judgments of students' emotions and situational interest. On a theoretical level, our significant results suggest that preservice teachers do not rely exclusively on their own task-specific enjoyment, boredom, and situational interest when making judgments of students' enjoyment, boredom, and interest. We suggest that students' emotions and interest be addressed in mathematics teacher education programs as a practical implication from our study.

Author contributions JK: Formal analysis, Methodology, Writing—Original Draft. SS: Conceptualization, Methodology, Supervision, Project administration, Writing—Review and Editing.

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Availability of data and materials Materials can be provided by request.

Code availability Code can be provided by request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Consent to participate Students participated voluntary and anonymously on this study.

Consent for publication Both authors consent to submit this study to JMTE.

Ethics approval The study was conducted according to ethical standards of the University of Münster.

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