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Predictors and outcomes of situational interest during a science learning task

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Abstract In this study we examined change in students' situational interest as a function of student and task characteristics. Fifth- and sixth-graders (n = 52) were assigned to one of two task conditions that used a different version of a science simulation. The versions differed in how concrete vs. abstract the simulation elements were. Students' prior knowledge, achievement goal orientations, and subject-specific interest were assessed before the task and situational interest was measured repeatedly in different phases of the task. Post-task performance was assessed 1 day after the task. The results showed different mean-level changes in situational interest in the two task conditions; students working with the more concrete version of the simulation reported increase in their interest while the opposite was true for students working with the more abstract version. The ratings of situational interest were nevertheless rather stable over time, regardless of the task condition. Students' situational interest at the beginning of the task was predicted by mastery-intrinsic goal orientation and subject-specific interest. Post-task performance was predicted by prior knowledge and the task condition; students working in the more concrete task condition performed better. The importance of acknowledging both individual characteristics and task elements in the emergence of students' situational interest is discussed.

Keywords Motivation · Interest · Achievement goal orientation · Science learning

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Introduction

In order to cope with a learning task, students need a sufficient level of initial motivation to get started, as well as maintained motivation to perform it (Sansone and Thoman 2005). The concept of situational interest has been used to describe a situation-specific and evolving motivational state that arises from the interaction between person and task characteristics (Hidi 2006; Krapp 2007). The relevance of situational interest in educational settings has been demonstrated in numerous studies showing its ability to positively enhance students' persistence, attention focusing, and quality of learning (Harackiewicz et al. 2002; Hidi and Berndorff 1998; Schraw and Lehman 2001; Vollmeyer and Rheinberg 2000). Current models of interest development also state that even momentary experiences of interest—that may be regarded as educational objectives at their own right—may function as a basis for the development of a more stable individual interest (Hidi and Renninger 2006; Krapp 2002).

However, while current conceptualizations highlight the dynamic nature of situational interest, rather little is still actually known how the aroused level of interest *evolves* when a student proceeds with a learning task. Experimental studies on the effects of task characteristics on students' situational interest are also infrequent and have mainly focused on text-based learning tasks. Finally, even though previous research has identified certain individual or situational factors that predict the state of interest and related task performance, work that integrates the effects of both person and context in different phases of a task is still limited. This study aims to contribute to these issues by examining the influence of student and task characteristics on the level and change in students' situational interest and performance.

To achieve this aim, a science simulation on the basics of electricity was used as a learning task for elementary school students. The development of students' situational interest was compared in two task conditions using two versions of the simulation with different levels of concreteness.

Task concreteness and situational interest

One important pedagogical challenge simulation designers face—especially when modeling scientific phenomena—is the optimal degree of concreteness of the simulation elements (Son and Goldstone 2009). The perceptual concreteness of the elements within a simulation may vary in a continuum from highly concrete, detailed, and realistic representations to simplified and stylized abstract illustrations. High concreteness may be achieved by emphasizing the similarity between the simulation and real-world objects or situations, whereas in a more abstract form the objective is to highlight the generalizability of the representations at the expense of realistic and contextual details (Goldstone and Son 2005).

Research suggests that variation in the concreteness of the simulation affects students' learning outcomes and that both concrete and abstract elements may each have their benefits and costs (Goldstone and Son 2005). Concrete representations (e.g., in graphical illustrations) seem to ease students' reasoning, recall, and immediate performance during the simulation. The use of exclusively concrete representations, however, may hinder the inference of abstract principles and the transfer of learning by promoting excessively context-bound understanding. Consequently, recent studies have focused on the effects of gradually decreasing the concreteness during the simulation (i.e., concreteness fading, see

Goldstone and Son 2005; Son and Goldstone 2009). While the results, in terms cognitive benefits such as the transfer of learning, are supportive of concreteness fading, less is known about the potential motivational benefits.

Recent studies indicate that situational interest may evolve during interaction with a learning task (Moos and Azevedo 2008; Rotgans and Schmidt 2011). Certain task characteristics or changes in the instructional setting that contribute to the arousal of and changes in situational interest have been identified (e.g., novelty, varying activity types, and autonomy, Palmer 2009; Rotgans and Schmidt 2011). Task concreteness has also been suggested to contribute to both situational interest and related performance. In studies on text-based learning, concreteness has been found to influence the comprehensibility of the material, which in turn has been shown to predict the interestingness and recall; some level of comprehension is needed for the feelings of meaningfulness and interest (Sadoski 2001; Sadoski et al. 2000).

The advantage of concrete material has been explained by the easiness of forming rich and alive mental representations, which are seen to facilitate comprehension and activate interest and other affective reactions (Paivio 1991). Concreteness may also influence interest by facilitating the linkages between the content and one's own everyday-life experiences, thus increasing the feelings of familiarity, utility value, and personal meaning (Sadoski et al. 2000; Wilhelm and Beishuizen 2003). The benefits of task concreteness are also more likely when prior knowledge on the content is scarce (Wade 2001).

Individual characteristics and situational interest

While the earlier research emphasized environmental factors as the primary source of situational interest, more recent work has started to focus on individual factors, such as gender and prior knowledge (Ainley et al. 2002). Girls and boys have systematically shown different levels of both situational and individual interest in various domains (Hoffmann 2002; Meece et al. 2006); although the differences may depend on the specific topic, compared to boys, girls seem less interested in mathematics, science and technology (e.g., Murphy and Whitelegg 2006).

The positive effect of prior knowledge on interest arousal and subsequent performance has been attributed to heightened attention towards familiar content and to being able to link the presented material to existing knowledge. Conversely, weaker prior knowledge may lead to superficial and less engaging cognitive activity due to the structurally incoherent or fragmented domain knowledge (Alexander et al. 1995; Wade 2001).

Of the motivational factors, students' individual interest, the stable tendency to re-engage with certain subject content (Krapp 2002; Renninger et al. 2002), has been considered as the strongest predictor of momentary interest states (Ainley et al. 2002; Tsai et al. 2008). That is, in the presence of particular content, one's individual interest is likely to elicit the psychological state of interest (Hidi 2006). Individual interest has also been closely linked to prior knowledge (Hidi and Renninger 2006; Renninger et al. 2002).

The connection between students' achievement goals and interests, both individual and situational, has recently been addressed in motivation research (Harackiewicz et al. 2008; Hidi and Harackiewicz 2000). Goal theorists assume that in an achievement situation the students pursue qualitatively different types of goals that represent the higher-order reasons for achievement strivings (for a review, see Kaplan and Maehr 2007). Mastery goals (i.e., the strive for learning and self-improvement) have been shown to positively predict students' situational interest (Ainley and Patrick 2006; Harackiewicz et al. 2000), whereas the opposite holds for the pursuit of work-avoidance goals (i.e., a passive and reluctant posture towards effort expenditure in achievement situations, Harackiewicz et al. 2002, 2008). The findings concerning the links between interest and performance-related strivings have been less clear showing either null or weak positive associations for performance-approach goals (i.e., aim to demonstrate one's competence to others) and interest (Harackiewicz et al. 2002; Huang 2011), and either null or negative associations for performance-avoidance goals (i.e., desire to avoid appearing incompetent, Harackiewicz et al. 2008). These findings appear similar for both situational and individual interest (Chen and Shen 2004; Harackiewicz et al. 2008).

Present study

The first objective of this study was to examine the level of and change in fifth- and sixth-grade students' situational interest when working on a computer-based science simulation to learn the basics of electricity. To examine the influence of task characteristics, two different versions of the simulation with varying degree of concreteness were used. In one version (here labelled as the *concrete* version), the simulation elements remained perceptually concrete throughout the task, while in the other version (here labelled as the *concreteness fading* version, see also Goldstone and Son 2005), the simulation elements switched from concrete to abstract during the experimentation. Based on our literature review, students' situational interest ratings were expected to be higher in the *concrete* condition. Similarly, based on previous findings, we expected boys to display higher interest irrespective of the condition.

The second objective was to investigate the predictive relationships between student characteristics, task condition, situational interest, and post-task performance. For this purpose, students' level of prior knowledge on electricity, individual interest in related school subjects, and personal achievement goal orientations were examined as antecedents of situational interest. Achievement goal orientations were conceptualized as dispositional motivational tendencies that guide the activation and selection of certain types of goals in interaction with situational demands (Nicholls 1989; Pintrich 2000). Consequently, they were hypothesised to precede subject-specific interest. Students' subject-specific interest and prior knowledge were assumed to correlate with each other, to influence the arousal of situational interest, and, to predict students' post-task performance. The succeeding measures of students' situational interest were assumed to predict one another, thus displaying considerable stability over time.

In sum, then, the first research objective focused on the level of situational interest and changes in it as a function of task characteristics, whereas the second objective addressed the sequential predictive effects of task and individual characteristics on situational interest and their influence on the learning outcome.

Method

Participants

Our sample consisted of 57 fifth- and sixth-graders (33 girls and 24 boys of ages 11–12) from three elementary classes in South-western Finland. Altogether 52 students were present in all three data collections, so the data on five students were omitted due to incomplete information. The students had only a limited experience of physics as a school subject, and were thus considered as "novices" in terms of the topic of the learning task. An informed consent for participation was acquired from the students' parents before the study.

The simulation

The simulation used in this study was designed to model the basic functions of electrical circuits. The representation level of the simulation—"Electricity Exploration Tool" (2003; EET)—is semi-realistic, meaning that on one hand, the simulation includes concrete and realistic elements such as light bulbs with dynamically changing brightness and realistic measuring devices, while on the other hand, the circuits are displayed schematically instead of mimicking the appearance of real bulbs and wires in detail. With the EET simulation, students are able to construct various DC circuits by using the mouse to drag wires, bulbs and resistors to the desired location in the circuits. After constructing the circuit or putting the circuit onto a particular configuration, students can observe the effects of their actions. They can also conduct electrical measurements with a multimeter by dragging its probes to the required testing points.

In the *concrete* condition, students were instructed to construct circuits with bulbs, observe changes in bulb brightness, and measure the potential difference across bulbs (Fig. 1, left picture). In the *concreteness fading* condition, students were instructed to construct circuits with bulbs only at the very beginning of the experimentation. From then on, they were instructed to construct circuits with resistors, and measure the potential difference across them (Fig. 1, right picture). In other words, the concreteness of the representations decreased in the *concreteness fading* condition right after the first introductory examples. Thus, the main difference between the conditions was that in the concrete condition the students constructed all circuits with bulbs whereas in the concreteness fading condition they constructed majority of the circuits with resistors. Consequently, only the students in the concrete condition received immediate feedback for their trials as they were able to observe instantly the changes in bulb brightness.

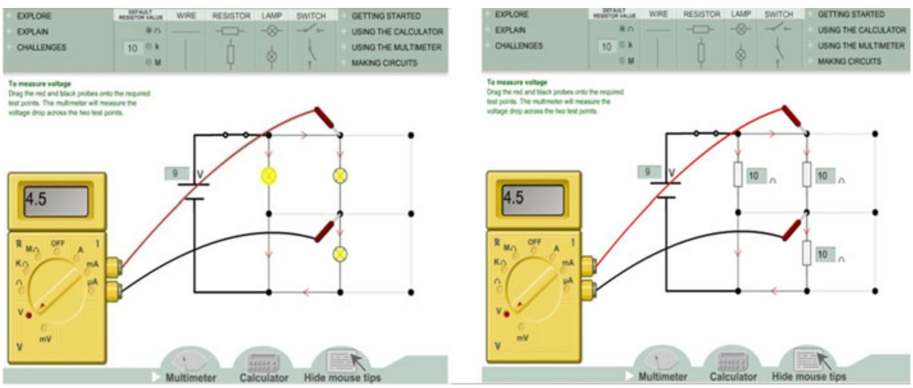

Fig. 1 The EET with bulbs (*left*; the concrete version) and resistors (*right*; the concreteness fading version)

Procedure

A couple of days before the learning task, the students were asked to complete a self-report questionnaire on their personal achievement goal orientations and subject-specific interest in certain school subjects. A test measuring students' prior knowledge on the principles of electric circuits was administered to students immediately after they had answered the motivational questionnaire.

The students were divided into *concrete* (n = 26) and *concreteness fading* (n = 26) task conditions. Pairs of students were matched on their prior knowledge test scores and allocated randomly to either of the groups. The teacher of the class formed the working-pairs within each group. This procedure was to mimic the normal practice of utilizing pair work in the classroom.

The students worked with the simulation in the school's computer class, where they had 2 hours to go through as many worksheets as possible. The paper-and-pencil worksheets included instructions and assignments to be performed with the simulation. Even though students worked in pairs, each student filled out their own worksheets. There were 10 worksheets in total with assignments that became gradually more difficult. The students had to complete each worksheet correctly until proceeding to the next one. In the assignments students were asked to construct different kinds of circuits and to conduct various electrical measurements, starting with very simple tasks and proceeding to more challenging ones. The assignments in both conditions included similar circuits to be constructed and tested with the simulation, but in the *concrete* condition they were represented with bulbs and in the *concreteness fading* condition with resistors.

Students' post-task performance was measured one day after the simulation task.

Measures

Achievement goal orientations

For assessing achievement goal orientations, we used an instrument (Niemivirta 2002) that was in line with our conceptualization of dispositional achievement goal orientations. It distinguishes five types of orientations, and it has been validated in several studies showing consistent factorial structure and meaningful patterns of associations with criterion variables (Niemivirta 2002; Tuominen-Soini et al. 2008, 2011). Besides assessing performance-approach, performance-avoidance, and work-avoidance orientations—commonly studied in this line of research—the instrument also distinguishes between mastery-intrinsic and mastery-extrinsic orientations (see also Grant and Dweck 2003). It has been suggested that mastery goals could be differentiated according to the *criteria* (intrinsic or extrinsic) students use for judging their success in goal attainment (Niemivirta 2002). Students endorsing mastery-intrinsic goals would evaluate mastery and learning based on self-set, intrinsic standards (e.g., feeling of understanding), while those pursuing mastery-extrinsic goals would rely on absolute and extrinsic referents for success (e.g., grades). Evidence supporting this differentiation demonstrates distinctive patterns of relations with other motivational variables as well as with variables linked to students' emotional subjective well-being (Tuominen-Soini et al. 2008, 2011).

The items in the *mastery-intrinsic scale* reflect students' desire to learn new things and gain knowledge according to self-set standards (e.g., "To acquire new knowledge is an important goal for me in school"), whereas the *mastery-extrinsic scale* measures students' emphasis on mastery and success according to absolute (but extrinsic) standards (e.g., "My goal is to get good grades"). The scale for *performance-approach orientation* includes items assessing students' desire to perform better than others (e.g., "An important goal for me in school is to do better than other students"), while the *performance-avoidance scale* comprises of items reflecting students' aim of avoiding public failure (e.g., "I try to avoid situations in which I might fail or make mistakes"). The *work-avoidance orientation scal*e consists of items assessing students' concerns with minimizing effort and avoiding work in achievement situations (e.g., "I try to do my schoolwork with as little effort as possible"). Each orientation scale includes three items that the students rated on a 7-point *Likert*-scale ranging from 1 (*not true at all*) to 7 (*very true*). Structural validity was confirmed and reliability coefficients were estimated as a part of the PLS-analysis (see Analyses), and composite scores for the correlational and descriptive analyses were constructed accordingly. Based on inter-item correlations, one item from both performance-approach and performance-avoidance orientation scales was excluded from subsequent analyses.

Prior knowledge

The test of prior knowledge included two tasks (consisting of 14 and 11 items, respectively) where different kinds of circuits were presented varying from simple concrete illustrations (mimicking the real bulbs and wires) to more complex constructions and schematic drawings (e.g., circuits with several bulbs). In the tasks students were asked to reason out and compare the voltage of the bulbs in different circuits. One point was given for each correct answer. An average composite score of the items ($\alpha = .77$) was created for the descriptive and correlational analyses.

Subject-specific individual interest

As the simulation included some basic calculations and thus required the utilization of mathematical reasoning, mathematics was considered a relevant school subject with regard to the topic of the simulation.[1] Students were thus asked to rate how interested they were in mathematics on a single scale with five face icons (see Appendix A, item 1) representing a response continuum from 1 (*not at all interested*) to 5 (*very interested*). This was done in order to match the operationalization with the measure of situational interest (see below) and to keep the item as unambiguous as possible.

Situational interest

During the simulation students' subjective experience of their situational interest was assessed with one item in three different phases of the working period. The item was modified from a scale assessing students' ongoing motivational appraisals by Niemivirta and Tapola (2007). The format of the scale (see Appendix A) was similar to the measure of students' subject-specific interest: students were presented with a statement "I find working on these tasks…" and asked to mark one face icon on a continuum ranging from

[1] At the time of the data collection the fifth-graders had not yet had classes of physics taught as a separate school subject (in Finland, "environmental and natural sciences" covers physics instruction until the 5th grade). We therefore made an attempt to assess students' interest in physics by referring to "environmental and natural sciences". However, this item turned out to be overly confusing to the students, due to which it was omitted from further analyses.

not at all interesting (coded as 1) to *very interesting* (coded as 5). The use of face icons in the scale was adopted from Ainley and Hidi (2002).

After the general instructions, the students filled the first worksheet with the researcher who was guiding the session, in order to grasp the idea and operation of the program and be able to work independently from then on. The first situational interest item was presented on the other side of this "rehearsal worksheet" and was formulated to measure students' aroused situational interest according to the initial impression they had at that point (see Appendix A, item 2). The subsequent items were located after worksheets 4 and 7 (see Appendix A, item 3).

Post-task performance

Students' post-task performance was measured with a test consisting of the same two tasks as the prior knowledge test. An average composite score of the items ($\alpha = .87$) was created for the descriptive and correlational analyses.

Analyses

In order to answer the first research question, that is, to examine the change in situational interest in the groups using different simulation version, we conducted a repeated measures analysis of covariance on situational interest measures with gender, prior knowledge, interest in mathematics and achievement goal orientations as covariates. By testing the effects of the between-subjects factor (task condition), and the within-subject factor (situational interest) as well as the interaction between them, we examined change in interest over time as such and as a function of the task condition.

As to the predictive effects implied by our second research questions, we used partial least squares (PLS) path modeling (Chin 1998) to test our assumptions. Like any structural equation model (SEM), a PLS model consists of a structural part, which reflects the relationships between the latent variables, and a measurement part, which shows how the latent variables and their indicators are related. However, unlike covariance-based structural equation modeling, which seeks to minimize the difference between the sample covariances and those predicted by the theoretical model, PLS modeling focuses on maximizing the variance of the dependent variables explained by the independent ones. In general, PLS modeling, as compared to covariance-based SEM, is considered as a more exploratory (as opposed to confirmatory) and prediction-oriented (as opposed to parameter-oriented) approach to SEM, as it can handle complex models with numerous indicators and correlated variables. Moreover, the PLS approach imposes few or no demands on the sample size, scale type, and variable distribution, which makes it especially suitable for the present purposes (for an empirical example, see Aunio and Niemivirta 2010).

The specification of the model was based on our assumptions presented at the introduction (see Present Study). In the tested model, achievement goal orientations, prior knowledge, and post-task performance were specified and estimated as latent factors with respective indicators. As to the predictive relationships, the observed measure of interest in mathematics was set to predict the latent factor of prior knowledge, and both these factors were regressed on the five latent factors of achievement goal orientations. The successive situational interest measures were regressed on the latent factors of achievement goal orientations, interest in mathematics, prior knowledge and the observed measure of task condition. These factors, in turn, were set to predict the latent factor of students' post-task performance. The composite reliability estimates (Chin 1998) for the latent factors of mastery-intrinsic, mastery-extrinsic, performance-approach, performance-avoidance, and work-avoidance goal orientations were .91, .79, .95, .87, and .88, respectively.

Results

Descriptive statistics and correlations

To obtain an overview on the mean level of and relationships between the variables, descriptive statistics and zero-order correlations were examined (see Table 1). The correlations between achievement goal orientations replicated findings from previous studies (Niemivirta 2002; Tuominen-Soini et al. 2008, 2011). The tendency to value learning and knowledge as such was also reflected in the moderately high correlations of both mastery-intrinsic and mastery-extrinsic orientations with students' interest in mathematics. Although the correlations of mastery-intrinsic and mastery-extrinsic orientations with the situational interest at the beginning of the task were positive as expected, they were not significant. Students' prior knowledge on electricity did not correlate with students' interest in mathematics but it was positively related to students' post-task performance.

As to the overall gender differences, boys' interest in mathematics as a school subject was higher than that of girls', $t(50) = -2.07$, $p < .05$, while there were no significant gender differences in either prior knowledge, $t(50) = -1.14$, $p = .26$, or post-task performance, $t(50) = -1.20$, $p = .24$.

The change in students' situational interest

The results showed a significant interaction effect of task condition and situational interest across the task, $F(2, 84) = 6.50$, $p = .002$, $\eta^2 = .13$, indicating that interest in the two conditions evolved differently over time; although the initial level of situational interest was relatively high in both conditions ($M = 3.60$, for *concrete* and $M = 3.94$ for *concreteness fading*, respectively), it increased among those in the *concrete* condition, while the opposite was true for students in the *concreteness fading* condition (see Fig. 2). Of the covariates, only interest in mathematics showed marginally significant effect on the change in situational interest over time, $F(2, 84) = 2.79$, $p = .067$, $\eta^2 = .06$.

There was also a between-subjects effect for gender, $F(1, 42) = 5.10$, $p = .029$, $\eta^2 = .11$, meaning that on average, boys' ($n = 20$) situational interest ratings remained higher than girls' ($n = 32$) throughout the task.

Predictive relationships between individual characteristics, task condition, situational interest, and post-task performance

Our model explained 35 % of the variance in students' interest in mathematics (see Fig. 3). As expected, students' mastery-intrinsic ($\beta = .30$, $p < .05$) and work-avoidance orientations were the strongest predictors, although the effect of work-avoidance orientation was only marginally significant ($\beta = -.26$, $p < .10$); students emphasizing mastery-intrinsic goals and not work-avoidance goals were more likely to be interested in mathematics.

Student and task characteristics explained 21 % of the variance in students' situational interest at the beginning of the task, but interest in mathematics was the only significant predictor ($\beta = .38$, $p < .01$).

Table 1 Correlations and descriptive statistics for all variables

Measures	1	2	3	4	5	6	7	8	9	10	11	M	SD
Goal orientations													
1. Mastery-intrinsic	–											5.71	1.04
2. Mastery-extrinsic	.51**	–										6.08	.82
3. Performance-approach	.04	.30*	–									3.05	1.51
4. Performance-avoidance	.03	.34*	.40**	–								4.46	1.53
5. Work-avoidance	−.25	−.30*	.24	.10	–							4.37	1.51
6. Interest in mathematics	.42**	.40**	.23	.21	−.35**	–						3.07	1.07
7. Prior knowledge	−.03	.11	.10	.14	−.05	.18	–					11.85	4.70
Situational interest (SI)													
8. SI measurement 1	.17	.17	.10	−.02	.05	.33*	.18	–				3.75	1.06
9. SI measurement 2	.04	.12	.10	.04	.08	.16	.15	.80**	–			3.69	.95
10. SI measurement 3	.08	.13	.03	.01	.01	.23	.21	.74**	.84**	–		3.70	.95
11. Post-task performance	.07	.07	.08	.08	−.16	.21	.36*	.10	.16	.14	–	17.47	5.14

* $p < .05$; ** $p < .01$

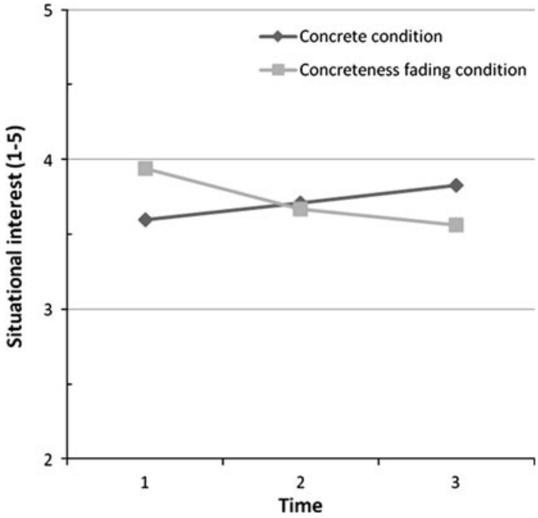

Fig. 2 Change in situational interest over time as a function of task condition

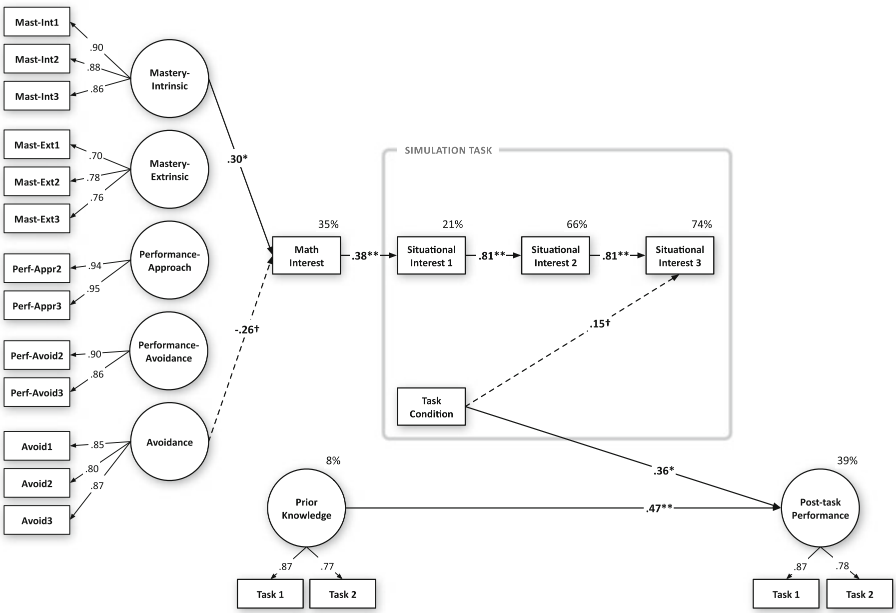

Fig. 3 The empirical model illustrating direct effects (standardized regression coefficients) between variables of the study. *Continuous lines* represent significant effects (*$p < .05$, **$p < .01$) and *dashed lines* represent marginally significant effects ($p < .10$)

Interest in mathematics was not related to students' prior knowledge on electricity, which, in turn, did not predict situational interest at the beginning of the task. Students' situational interest measures were predicted by one another ($\beta_{T1T2} = .81$, $p < .01$; $\beta_{T2T3} = .81$, $p < .01$, respectively), indicating high rank-order stability in students' ratings over time. Only a marginal direct effect ($\beta = .15$, $p < .10$) was found from task condition to the last measure of situational interest, which reflects the increasing difference in students' situational interest in the two task conditions observed earlier.

Neither students' interest in mathematics nor situational interest during the task predicted students' post-task performance, but, as expected, prior knowledge did ($\beta = .47$, $p < .01$). Also, the effect of task condition on post-task performance was significant ($\beta = .36$, $p < .05$), indicating that students in the *concrete* condition outperformed those in the *concreteness fading* condition. Altogether, the model explained 39 % of the variance in students' post-task performance.

Discussion

The first objective of this study was to examine the level of and change in students' situational interest during a science learning task in an authentic classroom setting. The fluctuation of situational interest was captured using repeated measures during the task. To examine the role of task in the development of students' situational interest, two different simulation versions with varying level of concreteness were used. The present study thus extends previous research by investigating the change in students' situational interest over time as a function of task characteristics.

The second objective was to investigate in more detail the effects of different individual characteristics and task on both situational interest and post-task performance. Using sophisticated statistical modeling, we were able to investigate the stability of situational interest over time as well as the predictions of motivation (in terms of achievement goal orientations and individual interest), prior knowledge, and task condition on the initial level of situational interest and learning (in terms of post-task performance). Until now, only few studies have examined the simultaneous effects of task and student characteristics on situational interest within a predictive design and with repeated measures.

The results showed that the changes in students' situational interest were different in the two task conditions, and that students' motivational tendencies contributed to the arousal of situational interest at the beginning of the task.

The level of and change in students' situational interest

The overall level of students' situational interest across the task conditions was reasonably high. Thus, most students found the simulation itself rather interesting right at the onset of the working. It would seem that the novelty related to both the topic of the simulation and the mere use of a simulation program was interest-arousing, especially at the beginning of the task (cf. Chen et al. 2001; Mitchell 1993; Palmer, 2009). The fact that the level of situational interest remained relatively high throughout the task in both conditions, even despite the decrease in the *concreteness fading* condition, suggests that some features of the task (e.g., interactivity, possibilities for choices, decision making, and social involvement) might have contributed to the maintenance of students' situational interest (Ronen and Eliahu 2000; Tsai et al. 2008).

The significant interaction between task condition and change in situational interest nevertheless highlights the importance of capturing the flow of students' interest experience as a task proceeds. In a sense, then, the three sequential measures of students' situational interest can be taken to reflect the stages from aroused to maintained interest presented in the four phase model of interest (Hidi and Renninger 2006). While, on average, the situational interest of students in the *concrete* condition seemed to develop towards a maintained state of interest, students in the *concreteness fading* condition experienced a drop from their aroused level of situational interest. That is, for young students with relatively low prior knowledge on the topic, the more concrete simulation seems likely to maintain and enhance their situational interest during the task.

This result is in line with suggestions of several possible ways the concreteness of a task may contribute to students' situational interest. Concreteness of the material fosters the comprehensibility of the content, which can be considered as a precondition for interest arousal in the content itself (Sadoski 2001; Sadoski et al. 2000). The concrete elements in the task are also likely to activate students' own experiences or prior knowledge on the content, which in turn may create feelings of familiarity, meaningfulness and utility value of the learning material (Hulleman et al. 2010; Wade 2001). In the present study, the bulbs in the illustrations of electric circuits were likely to be a more familiar element than the resistors, and thus made the task and assignments easier to approach and comprehend. Also, the utility value of learning about electricity might have been more salient in the *concrete* condition, as the function and use of bulbs are a part of students' everyday-life experiences.

Consequently, it is most probable that one factor affecting the different development of situational interest in the two conditions was the fact that all students were "novices" with regard to the topic of the simulation. Prior knowledge or familiarity with the content being low, learners have been found to be more interested in and benefit from concrete (vs. abstract) and less complex learning material (Kluge 2007; Mikk and Kukemelk 2010; Sadoski et al. 2000). In our study, the unfamiliarity of the topic might, then, partly explain the decline in students' situational interest in the *concreteness fading* condition, which represented a less concrete task type.

As to the gender differences, our results paralleled previous findings in mathematics and science learning (Hoffman 2002; Smith et al. 2007). While there were no differences in knowledge, girls' interest in mathematics was lower than boys' and they did not find working with the simulation as interesting as boys did. It is also probable that the topic and the way it was presented contributed to the differences in girls' and boys' experiences. In science instruction, girls have been shown to prefer topics dealing with "human functioning" or examples illustrating practical applications of the theoretical concepts (Hoffmann 2002; Krapp and Prenzel 2011). Thus, simulations and worksheets with technical drawings may not be attractive enough for girls.

Predictors of situational interest

The finding of mastery-intrinsic and work-avoidance achievement goal orientations predicting students' individual and situational interest echoes previous results, which suggest that students with mastery orientation are positively "tuned" to learning and find intrinsic satisfaction in gaining new knowledge in learning situations (Ainley and Patrick 2006; Harackiewicz et al. 2002, 2008; Pintrich 2000). In contrast, with work-avoidance goal orientation, the preferred end (i.e., to get away with least effort) is in conflict with what is required from a student in a learning situation, which is likely to hinder personally meaningful and enjoyable involvement with tasks and school subjects. These notions were supported by our findings suggesting that the influence of mastery-intrinsic and work-avoidance goal orientations on students' situational interest was mediated by subject-specific interest.

As in previous studies examining the relation of students' individual interest and situational motivational states (Ainley et al. 2002, 2005), a positive effect was found;

students' interest in mathematics facilitated the arousal of situational interest at the beginning of the task. According to Tsai and colleagues (2008), individual interest in a certain domain can be considered as a "motivational resource", which, once activated, is likely to support the emergence of situational interest during everyday classroom situations. An existing individual interest seems to make it easier for the student to establish and maintain a meaningful connection to a learning task in a related subject (Renninger et al. 2002).

Unlike expected, however, interest in mathematics was not related to students' level of prior knowledge, which, in turn, did not predict the arousal of situational interest either. In previous studies, the relation of individual interest and related content knowledge has been found to characterize especially a well-developed individual interest, more often found among older students who also already posses more differentiated fields of individual interests (Hidi and Renninger 2006; Krapp and Prenzel 2011). Accordingly, considering the age of the students in this study, and the fact that they had little or no experience of electricity or physics as a school subject in general, the result seems reasonable.

The predictive chain from the first measurement point of students' situational interest onwards highlights the importance of the initial motivational reaction at the beginning of a task that has also been observed in previous studies (Ainley et al. 2005; Vollmeyer and Rheinberg 2000). Students' level of aroused situational interest predicted their subsequent state of interest during the task, thus implicating considerable stability over time. It seems that once a particular affective connection to the task has been formed, it also characterizes students' later engagement with it (Ainley and Patrick 2006). In this respect, the nature of that initial connection that may lead either to engagement with or disengagement from the task is of relevance.

Predictors of post-task performance

Of the individual factors, students' prior knowledge on electricity predicted post-task performance, while interest in mathematics did not. The effect of prior knowledge indicates moderate stability in the rank order of students' level of performance before and after the simulation task. The somewhat unexpected non-significant effect of interest in mathematics on performance might be explained by the lack of exact correspondence between the interest measure (i.e., mathematics) and contents of the knowledge measure (i.e., electricity).

Students' situational interest was not related to their post-task performance either. Although unanticipated, this is not surprising, considering that some earlier studies have also reported weak effects between situational interest and academic performance or learning gains (e.g., Harackiewicz et al. 2008; Zhu et al. 2009). It is noteworthy that the performance outcome was not a part of the task itself or measured right after the task, as usually is the case when studying performance effects of situational interest (Ainley et al. 2002; Durik and Matarazzo 2009; Vollmeyer and Rheinberg 2000). As the advantage of situational interest with regard to learning is attributed to certain immediate cognitive and affective processes, it is plausible to expect the gains to be most effective close to the experienced state of interest.

However, it must be noted that students in the *concrete* condition performed better in the post-task than students in the *concreteness fading* condition. Thus, when reflecting upon the results from our repeated ANCOVAs, students who experienced an increase in their interest during the simulation also performed better in the post-task. In other words, it would seem that the added value for subsequent performance came from the positive *change* in interest rather than the level of interest as such (for a similar finding, see Niemivirta and Tapola 2007).

There are some limitations to this study. First, the use of single-items for measuring subject-specific and situational interest excludes the possibility to evaluate the reliability of the scales in terms of internal consistency. However, the intention here was to ensure consistent interpretation of the items and to focus directly on students' experience of interest by using a single word that explicitly represents the given construct, whether in relation to a school subject or a specific task. This logic follows the common practice in emotion research, where it is argued that virtually any emotion term, interest included, can anchor a single-item scale (Larsen and Fredrickson 1999). Moreover, as pointed out by Ainley and colleagues (2006), single-item self-reports represent ecological means for measuring students' transient states by minimizing interference to the state itself as it occurs. Second, due to the small sample size, the presented empirical model lacks statistical power, and thus warrants replication. Finally, in order to better tease out the possible experimental effects, the conditions used could include more accentuated differences. In the present study, the focus was explicitly on the potential influence of rather subtle variations in the concreteness of certain aspects of the task, which, in turn, might have deflated the potential effects on students' experiences. In future studies with larger samples, more emphasis should be given to the interaction of students' individual motivational factors and more distinct task characteristics.

Conclusions

Our results suggested that the changes in students' situational interest may partly depend on the task characteristics. The results further emphasized the contribution of students' motivational tendencies (achievement goal orientations and subject-specific interest) to the level of situational interest at the beginning of the task, which, in turn, seemed to be influential for the students' subsequent engagement. Taken together, the results suggest that despite the relative (rank-order) stability of students' situational interest over time, task characteristics may contribute to the change in the level of students' evolving situational interest. Put in another way, while students begin the task with different level of situational interest depending on their motivational basis, it may be possible to support the maintenance of or even increase that level by manipulating the task characteristics.

Our study extends previous research most importantly by showing that the task elements and students' individual characteristics may have a different function in the formation of students' situational interest. Although some previous studies have investigated the development of students' situational interest during a specific learning episode, the novelty of our approach was in the examination of that change as a function of task characteristics. Also by analyzing the joint effects of multiple factors associated with situational interest, we were able to advance our understanding of those mutual relations. We argue that the study of individual differences and task elements simultaneously is necessary, not only to learn more about the origins of students' subjective reactions to the task, but also to avoid too narrow a view of the underlying motivational system.

As to the practical implications, it seems that for fifth- and sixth-grade students a more concrete science simulation is likely to lead to better learning and more positive motivational outcomes. However, it should be kept in mind, especially when planning instructional designs, that students' interpretations of tasks vary, and that they are partly influenced by students' motivational tendencies. Future research might further investigate how the use of other technological advancements (e.g., learning with hypermedia) could help to increase students' sense of autonomy and interest by providing possibilities for choosing an individual "instructional path" (see Moos and Marroquin 2010) or alternative ways of participation (Veermans and Tapola 2004). More gender-sensitive designs when planning activities for science learning might also be of relevance (Murphy et al. 2006; Smith et al. 2007).

It still remains for the future studies to examine how to best support students with difficulties in creating a meaningful connection with a learning task right at the onset. As situational interest is taken to be a potential "pathway" for the development of a more stable interest, the microlevel study on such processes holds it place.

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Appendix A

1. Question format of students' subject-specific interest

How interested are you in…					
mathematics					

2. Question format of students' situational interest (measurement 1)

Working on these tasks seems to be…						
Not at all interesting						Very interesting

3. Question format of students' situational interest (measurements 2 and 3)

I find working on these tasks…						
Not at all interesting						Very interesting

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