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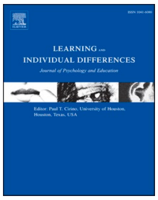

Mutual relationships between the levels of and changes in interest, self-efficacy, and perceived difficulty during task engagement

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ABSTRACT

This study examined how students' interest, self-efficacy, and perceived difficulty change during a task, how those changes relate to each other, and how they predict performance. Sixth-graders ($N = 1024$) rated their interest, self-efficacy, and perceived difficulty repeatedly during a dynamic problem-solving task. Results from the estimated non-linear and piecewise latent growth curve models showed interest and self-efficacy to decrease, and perceived difficulty first to increase, and then to decrease, over time. The levels of and changes in interest and self-efficacy correlated positively with each other, but negatively with perceived difficulty. Task performance was positively predicted by initial interest and less negative change in self-efficacy, and negatively by initial perceived difficulty and steeper increase in it. The results suggest perceived difficulty to have a distinctive role in the dynamics of task-specific motivation, and on-task changes to be relatively independent of more general motivation and competence.

1. Introduction

Situational interest (momentary state of heightened attention and enjoyment during task engagement; Ainley & Hidi, 2002) and self-efficacy (confidence in ability to orchestrate and execute actions required for achieving intended results; Bandura, 1986) are among the most influential motivational factors contributing to students' task processing and performance (Hidi et al., 2007). It has also been acknowledged that students tend to like tasks they are (or think they are) good at (Bandura & Schunk, 1981), and feel efficacious in tasks they are interested in (Ainley, 2012), although empirical studies going beyond such correlative relations are surprisingly scarce. Recently, Eccles and Wigfield (2020) also noted that while interest and self-efficacy have been the center of attention in motivational research, perceived difficulty (subjective evaluation of task difficulty, influenced by situational appraisals; Efklides, 2002) has been, perhaps mistakenly, overlooked by considering it simply as another type of manifestation of self-efficacy or competence perceptions rather than an independent motivational factor. They suggested that through distinctive effects on motivational processes and action, over and above those of self-efficacy, perceived difficulty could potentially have a complementary role in how an individual approaches and processes a task. They did not, however, specify how these effects might become manifested in action. Also other theories (Bandura, 1993; Efklides, 2011) and limited findings (Eccles & Wigfield, 1995; Rodgers et al., 2008) postulate self- and task perceptions as conceptually distinct while tightly connected, but corresponding research on the role of perceived difficulty in students' task motivation and performance is limited.

Available research on the effects of perceived difficulty suggests that while moderate levels of perceived difficulty may boost motivation and performance (Atkinson, 1957; Brunstein & Schmitt, 2010), high levels are likely to impede effective action through increased negative affect and frustration (Steensel et al., 2019). Then again, high situational interest and self-efficacy may buffer against such hampering effects by promoting enjoyment and reinforcing persistence (Fulmer & Frijters, 2011; Malmberg et al., 2013). Hence, to understand better the variety of facilitating and debilitating motivational processes, it seems worthwhile to take a closer look at the role perceptions of difficulty play in students'

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task experiences and actions in various stages of task engagement. This is one of the aims of the present study.

Research on on-task motivation has mostly focused on correlations or predictions (Hidi et al., 2007, 2002; Nuutila et al., 2020) between the above-mentioned motivational factors, while less attention has been paid to their mean-level changes, the mutual relations of those changes, or to their effects on performance during a specific task (see, Chen et al., 2016; Niemivirta & Tapola, 2007; Rodríguez-Aflecht et al., 2018). Given that interest, self-efficacy, and perceived difficulty all reflect dynamic motivational processes that fluctuate over time as a function of the interaction between the individual and the task (Ainley & Hidi, 2002; Efklides, 2001), this would seem particularly relevant.

Some evidence exists of such dynamics between situational interest and self-efficacy, showing their mean levels and changes to be connected, and, even more interestingly, to have differential predictions on task performance (Niemivirta & Tapola, 2007). Less is known about similar relations among situational interest, self-efficacy, and perceived difficulty (see however, Ainley et al., 2009). Although some studies have looked at the associations between perceived difficulty and interest in a task (Fulmer & Tulis, 2013) or a class (Horvath et al., 2006), or between perceived difficulty and competence perceptions in relation to a class (Patall et al., 2018), we are not aware of studies examining the relationships between on-task changes in all these constructs and their predictions on task performance. Thus, we will address this gap in this study by investigating the development of motivation during a dynamic problem-solving task among elementary school students. Such an interactive task seems ideal for capturing motivational processes relevant in virtually all learning and performance contexts. Consequently, we examined i) how situational interest, self-efficacy, and perceived difficulty change during a task, ii) how their levels and changes are related to each other, and iii) how these predict task performance.

1.1. *Situational interest and self-efficacy*

Research shows situational interest to be linked with increased persistence (Ainley et al., 2005, 2002), positive affect (Flowerday & Shell, 2015), higher attention and efficient cognitive processing (Hidi et al., 2004), and, subsequently, enhanced performance and learning (Rotgans & Schmidt, 2018). Similarly, self-efficacy contributes to performance (Talsma et al., 2018) through, for example, higher persistence and effort (Honicke & Broadbent, 2016), and more efficient cognitive processing (Phan, 2014).

As to their mutual connections, it has been postulated that certain level of self-efficacy could be a prerequisite for interest to arise in the first place (Silvia, 2003), and that it may reinforce interest through positive affect (Tanaka & Murayama, 2014) and feelings of satisfaction obtained through performance and sense of mastery (Bandura & Schunk, 1981). Through persistence and effort, self-efficacy engages an individual in the task in a way that could have a positive impact on interest (Hidi & Ainley, 2008), especially in tasks that initially seem boring (Bandura & Schunk, 1981). Yet, highly confident students might lose their interest if the task was too easy (Rotgans & Schmidt, 2014). Interest, in turn, may boost confidence through elevated focus (Hidi et al., 2004), persistence (Ainley et al., 2005), effort (Patall et al., 2016), and positive emotions (Flowerday & Shell, 2015), which, again, may enhance performance, and thereby perceived competence (Talsma et al., 2018).

When looking into the reciprocal relations between the “want” and “can” aspects of motivation and their role in performance, some confusion may arise from studies being conducted at different levels of specificity, and therefore also on different (but not unrelated) constructs. Most evidence seems to come from research on certain school subjects (e.g., mathematics), or in the context of a specific course. In these studies, the focus has been on individual interest or intrinsic value (i.e., enduring interest or enjoyment in relation to a domain; Eccles, 1983; Hidi & Renninger, 2006), on the one hand, and on self-concept, competence perceptions, or expectancies (i.e., more generalised perceptions regarding one's competence or chances of succeeding in a domain; Harter, 1982; Marsh et al., 2005; Wigfield & Eccles, 2000), on the other. Some of these studies suggest interest and competence perceptions to predict each other during courses (Fryer & Ainley, 2019) and over school years (Arens et al., 2019), although the effects may vary depending on the subject domain. Further, compared to interest, competence perceptions appear to be a stronger predictor of achievement (Marsh et al., 2005), although these effects also seem to depend on age, with achievement having a stronger impact on competence perceptions than vice versa in younger students (see, Talsma et al., 2018). Evidence on task-specific relations and predictions still comes mostly from cross-sectional studies (Hidi et al., 2007, 2002) or studies on unidirectional effects (e.g., the effects of interest on efficacy; Ainley et al., 2009). A recent study on reciprocal effects showed interest and self-efficacy to predict both each other and performance during an inductive reasoning task, although the effects were not consistent across task sections (Nuutila et al., 2020). This is in line with studies demonstrating the connections between interest and self-efficacy to depend partly on task characteristics (Ainley et al., 2009).

These reciprocal predictions in both domain- and task-specific contexts also suggest possible connections in the changes in interest and self-efficacy over time. Despite the rather considerable rank-order stability observed both in specific task situations (Ackerman et al., 1995; Rotgans & Schmidt, 2011), and over longer periods of time (Fryer & Ainley, 2019; Nuutila et al., 2018), even substantial mean-level changes may yet take place. For example, several studies show a rather consistent decrease in subject-related interest and self-concept during adolescence and even earlier (Fredricks & Eccles, 2002; Spinath & Steinmayr, 2008). However, less is known about whether such changes are linked with each other. As an exception, Jacobs et al. (2002) examined changes in self-concept and task value (i.e., interest, importance, and usefulness) in various school subjects and found these to decrease over the 12 years (although the rate of decline varied across domains) and the changes to be associated with each other.

Mean-level fluctuations seem particularly likely in task contexts, due to the unfolding interaction (Ainley & Hidi, 2002) between the individual (e.g., motivational beliefs) and task characteristics (e.g., novelty). Indeed, research shows such changes, for example, in situational interest during a task (Fulmer & Tulis, 2013) and across tasks (Rodríguez-Aflecht et al., 2018), and in self-efficacy over one or two semesters (Phan, 2011, 2012). In a study examining change in sixth-graders' situational interest during a ten-day science intervention, Chen et al. (2016) found the overall decrease in interest to be predicted by self-efficacy (higher initial self-efficacy being predictive of less steep decline in interest), and the change in interest, in turn, to predict later self-efficacy. In one of the few studies investigating simultaneous task-specific changes in interest and self-efficacy, Niemivirta and Tapola (2007) found ninth-graders' self-efficacy to increase, on average, during an exploration task, and, while no overall increase or decrease in situational interest was observed, changes in it correlated positively with changes in self-efficacy. Task performance was predicted by the initial level of self-efficacy and, more interestingly, by the change in situational interest, demonstrating how the levels and changes in motivation during a task may differentially contribute to task processing and outcomes.

1.2. *Perceived difficulty*

In Efklides' (2011) model of metacognition, motivation, and affect, perceived difficulty is considered as an online metacognitive experience comprising different interpretational processes during a task. Importantly, in this model, perceived difficulty is seen as distinct from self-efficacy: while self-efficacy concerns self-related knowledge and feelings (about oneself and the domains in which one is strong or weak), perceived difficulty, in turn, refers to knowledge and feelings related to the task (beliefs about the difficulty, effort demands, and sense of fluency or lack of fluency).

Compared to research on situational interest and self-efficacy, perceived difficulty has nevertheless received less attention, with most studies being conducted in non-educational contexts and among adults (Silvia, 2003). In line with Efklides' theorising (2011), Bandura's (1993) self-efficacy theory states that high perceived difficulty is not to be considered as equivalent to low self-efficacy. Instead, it suggests that individuals with high self-efficacy are likely to maintain their confidence even when tasks are considered difficult and view such situations as challenges and opportunities for growth. Another justification for the relevance of perceived difficulty comes from the view advocating the inclusion of "undermining" factors in addition to "affirming" (e.g., intrinsic motivation, perceived competence) factors in the study of task-specific motivation (Guthrie et al., 2009) – presence of debilitating does not equal to absence of facilitating, and vice versa. A few studies have explicitly examined whether self-efficacy and perceived difficulty, or their effects on motivation and performance, can be distinguished from each other (Eccles & Wigfield, 1995; Efklides, 2001; Kraft et al., 2005; Rodgers et al., 2008; Steensel et al., 2019; Watt, 2004). Findings have shown, for example, that self-efficacy and perceived difficulty load on separate factors, their association varies in strength across activities, they display different patterns of change across school years, and have independent effects on performance (e.g., reading fluency). Yet, it remains unclear whether the role of perceived difficulty in students' on-task processing and motivation differs from that of self-efficacy.

While it would intuitively seem plausible that increases in perceived difficulty would hamper students' motivation and willingness to engage in a task, some early theories on achievement motivation suggested that an amount of perceived difficulty could even be beneficial. Already Atkinson's risk-taking model (1957) proposed effort to be highest in moderately difficult tasks with greatest level of uncertainty about the outcome; in easy tasks, success is guaranteed, and in very difficult tasks, success is likely impossible, making effort not worthwhile (see also, Brehm & Self, 1989; Brunstein & Schmitt, 2010). Yet, the available recent studies suggest more linear connections between perceived difficulty and unfavourable task experiences (e.g., negative affect, frustration, anxiety; Fulmer & Tulis, 2013; Steensel et al., 2019), inferior performance (e.g., lower course grade; Andres, 2019; Power et al., 2020; Steensel et al., 2019), and lower interest, enjoyment and ability perceptions (Eccles & Wigfield, 1995).

The function of perceived difficulty may also vary depending on the students' motivational dispositions, states, or experiences during a task. High perceived difficulty has been linked with higher situational interest when students' prior knowledge is high (Durik & Matarazzo, 2009), and with higher engagement and performance when the task is considered interesting (Fulmer et al., 2015). Higher situational interest also seems to buffer against negative effects of excessive challenge by helping to maintain enjoyment in the task (Fulmer & Frijters, 2011). Although higher perceived difficulty is often associated with lower self-efficacy (Patall et al., 2018), the relationship may also vary across individuals. For example, Malmberg et al. (2013) found that in subjectively difficult tasks, students who generally perceived their ability higher also expected to do better than students who generally perceived their ability lower, thus aligning with Bandura's (1993) assertion that perceived difficulties do not necessarily hinder efficacious students' confidence, as they tend to view difficulties as challenges and opportunities for learning.

Similar to situational interest and self-efficacy, perceived difficulty likely varies during a task as a function of the person-task interaction (Efklides et al., 1999). Judgements of difficulty depend on central cues, such as objective difficulty and task properties, and peripheral cues, such as perceptions of one's performance or feelings of fatigue (Koriat, 1997; Vangsness & Young, 2019). Thus, on-task perceived difficulty can be seen as a fluctuating metacognitive experience influencing a person's self-regulation and online awareness as the tasks unfold (Efklides, 2001). However, as there is virtually no research on changes in perceived difficulty during a task, our understanding of how those fluctuations might influence performance, and how they would relate to parallel changes in other task-specific motivational factors, is limited. To our knowledge, the only study so far with such repeated measures of interest, self-efficacy, and perceived difficulty is by Ainley et al. (2009), who found generally positive relations between self-efficacy and interest as well as their role in the evaluation of success to depend on perceptions of task difficulty.

1.3. Present study

The aim of the present study was to examine (Q1) whether and how situational interest, self-efficacy, and perceived difficulty change during a task, (Q2) how their levels and changes are mutually related, and (Q3) how both the levels and changes predict task performance. Research on these dynamics, particularly on how perceived difficulty connects with the fluctuation of younger students' interest and self-efficacy during a demanding task, is still sparse. Given that the role of perceived difficulty in this context has recently attracted increasing attention (Eccles & Wigfield, 2020), this would seem particularly relevant.

As to the first question (Q1) concerning change in students' on-task motivation, it is fairly difficult to assume certain overall change, either increase or decrease, to take place over time. The task here is rather extensive and increasingly challenging (Greiff et al., 2012), and the students need to interact constantly with the system (i.e., acquire and apply knowledge) in order to complete it (see below). Students gradually "build knowledge" through testing and exploration, due to which the task seems particularly suitable for bringing about fluctuation in students' on-task motivation. As students' interaction with task characteristics partly influences the fluctuation of situational motivation (Ainley et al., 2009), students' progress with the task, perceived or actual, is likely to contribute to the activity becoming engaging or disengaging, and their motivational appraisals becoming more positive or negative over the course of the task. Previous research using a similar complex problem-solving environment (Niemivirta & Tapola, 2007) reported a significant overall increase in participants' self-efficacy, but not in interest. Significant individual differences were, however, found in both trajectories of on-task motivation. Given that the students in the present study are younger and the task more challenging, we hypothesise no overall change in self-efficacy, situational interest, or perceived difficulty, but expect significant variation in each slope during the task.

As to the second question (Q2), we anticipate both the initial levels and change in situational interest and self-efficacy to be positively associated with each other during the task, thus echoing previous, albeit very limited findings (Chen et al., 2016; Niemivirta & Tapola, 2007). Although moderate levels of perceived difficulty may sometimes enhance motivation (Silvia, 2003), most evidence suggests perceived difficulty to be negatively connected with self-efficacy and interest (Fulmer & Tulis, 2013; Horvath et al., 2006; Patall et al., 2018), and this is also what we expect. We further extend this assumption to changes during the task, meaning that we anticipate change in perceived difficulty to be associated with parallel changes in self-efficacy and interest.

Regarding the third question (Q3), we expect, based on previous findings (Niemivirta & Tapola, 2007; Nuutila et al., 2020; Rotgans & Schmidt, 2018; Talsma et al., 2018), the initial levels of situational interest and self-efficacy to be predictive of task performance. Similarly, in line with both direct and indirect evidence (Andres, 2019; Guthrie et al., 2009; Power et al., 2020; Steensel et al., 2019), we presume the level of perceived difficulty to have a negative effect on performance, beyond and above the effects of self-efficacy and interest. The potential effects of changes in each construct on performance remain more speculative. However, given the characteristics of the task (e.g., challenge and novelty) and sparse evidence from previous work (Niemivirta & Tapola, 2007), we would expect increases in self-efficacy and interest and decreases in perceived difficulty to facilitate performance.

On-task motivation is also likely influenced by the more stable motivational tendencies and beliefs the students bring into the task situation (Ainley, 2010). For example, individual interest and value beliefs in a specific domain may be a source for situational interest (Hulleman et al., 2008; Rotgans & Schmidt, 2018), and prior achievement is known to be a significant predictor of both motivation and performance (Köller et al., 2001; Talsma et al., 2018). To control, in part, for such individual differences, we included in our analyses students' mathematics-related intrinsic value (Eccles et al., 1993) and achievement. As findings show gender differences in task- and domain-specific interest and self-efficacy (e.g., boys displaying higher confidence than girls in a math task; Ainley et al., 2005; Jacobs et al., 2002; Nuutila et al., 2018), and domain-specific perceived difficulty (e.g., girls experiencing more increase in their perceived difficulty in mathematics over the school years than boys; Watt, 2004), gender was also included as a covariate. Despite the limitations associated with these variables,[1] we expect intrinsic value to be predictive of the level of interest, and previous achievement to predict both self-efficacy and perceived difficulty as well as task performance.

2. Method

2.1. Participants and procedure

The participants were 1024 Hungarian sixth-graders ($M_{age} = 13.05$, $SD = 0.53$; girls = 51,90%). Altogether, 70 classes from 48 elementary schools in different regions were involved in the study. The assessments providing data for this study were integrated parts of the educational processes of the participating schools. Data collection was conducted in the schools' ICT labs. The 45 min task session was supervised by teachers thoroughly trained in task administration. The result from the no-stakes assessment was disclosed after task completion only to students and their teachers as immediate feedback regarding the total score. The coding system for the online platform masked students' identity. Ethical approval was not required in accordance with the Hungarian national and institutional guidelines. Due to anonymity and no-stakes testing, it was not required or possible to request and obtain written informed parental consent. The guidelines of the Finnish Advisory Board on Research Integrity were also followed at different stages of the study.

2.2. Measures

2.2.1. Task

The dynamic problem-solving (DPS) task and questionnaire were administered online via the eDia platform (Csapó & Molnár, 2019). The 10 problems (20 items) of the DPS task were developed in accordance with the MicroDyn approach (see, Greiff et al., 2012), containing up to three input variables and up to three output variables with different fictitious cover stories. In the beginning, students were provided with instructions about the usage of the user interface and problem scenarios, and a trial (warm-up) task with immediate feedback. Subsequently, students had to explore, describe, and operate unfamiliar systems in the MicroDyn approach. Participants' problem-solving performance was automatically scored as DPS performance indicators (i.e., knowledge acquisition and knowledge application). In the first phase of the task, in each of the problems (for an example, see, Appendix A), students had to find out how the variables were interconnected by exploring the system (Molnár & Csapó, 2018), then to represent their knowledge in a concept map (knowledge acquisition; Funke, 2001). In the second phase of the problem-solving process, they had to control the system by reaching given target values (knowledge application; see, Greiff et al., 2012). The complexity of the problems increased gradually.

2.2.2. On-task motivation

The questions reflecting the students' situational interest, self-efficacy, and perceived difficulty were embedded in the DPS task. Students received the first set of questions after the warm-up tasks, before the actual DPS problems. The second set appeared after the first eight problems, and the third set at the very end of the task. Students' situational interest (e.g., "*This task seems interesting*"), self-efficacy (e.g., "*I believe I'm going to do well in this task*"), and perceived difficulty (e.g., "*This task seems difficult*") were thus measured three times. Single items with a 7-point Likert-scale ranging from 1 (*Not at all true*) to 7 (*Very true*) were used in order to interfere with the actual task as little as possible.

2.2.3. Covariates

In the background questionnaire, the students disclosed their gender, rated their intrinsic value in mathematics (Eccles et al., 1993) with one item (i.e., "*I like mathematics*") on a 5-point Likert-scale ranging from 1 (*Not at all true*) to 5 (*Very true*), and reported their last semester grade in mathematics with a 5-point scale reflecting Hungarian grading system (1 = Lowest grade – 5 = Highest grade).

2.3. Analyses

Latent growth curve models (LGCMs) within the structural equation modeling framework were used for the analyses of change over time (see, Duncan et al., 2006). As some minor indications of clustering across classes were detected by means of intraclass correlations (e.g., design effects being slightly above 2; see, Muthén & Satorra, 1995), we took this into account by using a more proper estimation (i.e., through the TYPE = COMPLEX specification as implemented in the Mplus statistical software; Muthén & Muthén, 1998–2020). In this approach, the standard errors using a sandwich estimator and chi-square test of model fit are calculated in a manner that takes into account the non-independence of observations due to clustering of the sample.

The analyses were carried out in three steps (see, Bollen & Curran, 2006). First, univariate LGCMs were estimated separately for situational interest, self-efficacy, and perceived difficulty. Next, a multivariate model was estimated to examine how the parameters of change for all three constructs were related to each other. Finally, a full model with covariates (i.e., intrinsic value and achievement in mathematics, gender) and task performance as a distal outcome was estimated.[2] To do this, all latent and auxiliary variables were set to predict knowledge acquisition, which was then set to predict knowledge application. Additional paths were added according to the modification indices if considered relevant.

All analyses were performed using the M*plus* statistical software (Muthén & Muthén, 1998–2020). To evaluate the model fit, we used the Comparative Fit Index (CFI; cutoff-value close to >0.95; Bentler, 1990), Root Mean Square Error of Approximation (RMSEA; cutoff-value close to <0.06; Steiger, 1990), and Standardized Root Mean Square Residual (SRMR; cutoff-value close to <0.08; Hu & Bentler, 1999) along with the chi-square statistics. All solutions were generated using maximum likelihood estimation with robust standard errors (MLR), and missing data were handled with full-information maximum likelihood method (e.g., Dong & Peng, 2013).

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[1] Note that the present study was embedded in a larger evaluation project, due to which we had limited influence on the included variables beyond those utilised in the actual task. Of these variables, students' reports of their intrinsic value and previous achievement in mathematics were considered most pertinent.

[2] Although our specific goal was to investigate the connections and predictions of the different constructs in a joint model (i.e., examining independent effects of each construct while taking into account the effects of the other constructs), we also estimated separate univariate models for each construct with covariates and outcomes to evaluate the extent to which the predictive effects of these isolated models differed from the ones in the multivariate full model (see Appendix B in Supplementary material).

3. Results

3.1. Mean-level changes

To examine our first research question, univariate LGCMs were estimated separately for situational interest, self-efficacy, and perceived difficulty. The initial inspection of item means (see, Table 1) suggested a non-linear change for all of the constructs, and the inadequate fit of the linear models for situational interest, χ^2 (1, N = 1024) = 15.625, $p <$ 0.001, CFI = 0.99, RMSEA = 0.120, SRMR = 0.30, self-efficacy, χ^2 (1, N = 1024) = 83.126, $p < 0.001$, CFI = 0.92, RMSEA = 0.28, SRMR = 0.06, and perceived difficulty, χ^2 (1, N = 1024) = 41.940, $p < 0.001$, CFI = 0.96, RMSEA = 0.20, SRMR = 0.05 confirmed this to be the case.

Consequently, non-linear models, in which the second measurement point was freely estimated, and first and third measurement points fixed to zero and one, respectively, were specified for situational interest and self-efficacy. This approach allowed us to capture the shape of the growth curve over the three measurement points more flexibly as their item means suggested a steeper decrease between the first and the second measurement point, after which the decline appeared to flatten out (see, Bollen & Curran, 2006). The models fit the data well for both situational interest, χ^2 (1, N = 1024) = 1.027, p = 0.31, CFI = 1.00, RMSEA = 0.01, SRMR = 0.01, and self-efficacy χ^2 (1, N = 1024) = 0.064, p = 0.80, CFI = 1.00, RMSEA = 0.00, SRMR = 0.00. The results (see, Table 2) revealed a significant overall decrease in situational interest (M = −0.46) and self-efficacy (M = −0.77), with most of it occurring between the first and the second measurement point (see, Fig. 1). Significant individual differences were also observed in both the initial levels and the slopes, demonstrating considerable variation in the trajectories.

The pattern of means for perceived difficulty was slightly different, with an increase from the first to the second measurement point, followed by a minor decrease from the second to the third measurement. Due to the poor fit of a linear model, and the non-convergence of a non-linear model with one freely estimated measurement occasion, a piecewise model (Flora, 2008) with two slopes instead of one was specified (the first slope representing the change between Time 1 and Time 2, and the second slope representing the change between Time 2 and Time 3) and estimated. Note that since the model specified in this manner is just-identified, no fit indices are available (Kamata et al., 2013).[3] The results indicated a significant increase in perceived difficulty between the first and the second measurement point (M = 0.42), and a somewhat less steep decrease between the second and the third measurement point (M = −0.19). Again, significant individual differences were observed in both the initial level and slopes.

3.2. Relationships between levels and changes

To examine how the initial levels and changes in situational interest, self-efficacy, and perceived difficulty were related, we estimated next a multivariate model in which the three univariate models from the first step were included in the same model (see, Table 2), with an excellent fit to the data χ^2 (13, N = 1024) = 40.01, $p < 0.001$, CFI = 0.99, RMSEA = 0.05, SRMR = 0.01. Several significant latent correlations were observed: the initial levels of situational interest and self-efficacy were positively correlated (r = 0.44, $p < 0.001$), whereas the initial level of perceived difficulty was negatively correlated with the initial levels of situational interest (r = −0.14, $p < 0.001$) and self-efficacy (r = −0.48, p < 0.001). Higher initial self-efficacy was associated with steeper increase in perceived difficulty (or a lower initial self-efficacy with less steep increase in perceived difficulty; r = 0.22, $p < 0.001$), and higher initial perceived difficulty was associated with less steep decrease in self-efficacy (or a lower level of initial perceived difficulty with steeper decrease in self-efficacy; r = 0.12, p = 0.010). As to the connections between the changes, slopes of situational interest and self-efficacy were highly correlated (r = 0.54, $p < 0.001$), indicating that a change in situational interest was associated with a parallel change in self-efficacy. Also the slope of perceived difficulty correlated with the slope of self-efficacy, but not with the slope of interest. That is, steeper increase in perceived difficulty was linked with steeper decrease in self-efficacy (r = −0.28, $p < 0.001$), but unrelated to changes in interest.

3.3. Predictions on task performance

As our last research question, we examined the predictive effects of the level of and change in self-efficacy, situational interest, and perceived difficulty on performance, while controlling for the effects of intrinsic value and achievement in mathematics, and gender (see, Table 3). Our model provided an excellent fit to the data: χ^2 (33, N = 1024) = 126.674, p = 0.00, CFI = 0.98, RMSEA = 0.05, SRMR = 0.03. As the modification indices suggested an additional direct path from achievement in mathematics to knowledge application (i.e., the second phase in performance), we revised the model accordingly, χ^2 (32, N = 1024) = 91.025, p = 0.00, CFI = 0.99, RMSEA = 0.04, SRMR = 0.03. The results (see, Fig. 2) showed knowledge acquisition to be positively predicted by initial situational interest (β = 0.15, $p < 0.001$), less steep decrease in self-efficacy (β = 0.13, p = 0.038), and math achievement (β = 0.38, $p < 0.001$), and negatively by initial perceived difficulty (β = −0.16, $p < 0.001$) and steeper increase in it (β = −0.10, p = 0.023). Knowledge application, in turn, was predicted positively by knowledge acquisition (β = 0.47, $p < 0.001$), and math achievement (β = 0.19, $p <$ 0.001).

Of our covariates, intrinsic value was found to predict initial situational interest (β = 0.32, $p < 0.001$) and self-efficacy (β = 0.18, $p <$ 0.001), and math achievement to predict initial self-efficacy (β = 0.13, p = 0.006). Compared to boys, girls reported lower initial situational interest (β = −0.09, p = 0.013) and self-efficacy (β = −0.18, $p < 0.001$), higher initial perceived difficulty (β = 0.11, p = 0.011), and somewhat inferior performance (β = −0.06, p = 0.087).

4. Discussion

In this study, we examined how sixth-graders' interest, self-efficacy, and perceived difficulty change during a task, how those changes relate to each other, and how they predict performance. Results showed (i) significant individual variation and overall changes in all constructs, (ii) interesting associations between the levels and changes – particularly between situational interest and self-efficacy, and self-efficacy and perceived difficulty –, and (iii) levels and changes in on-task motivation to be predictive of task performance.

Students did a rather extensive and increasingly challenging dynamic problem-solving task, which was thought to bring about fluctuation in students' on-task motivation. Confirming our expectations, the results revealed significant individual differences in the levels of and changes in situational interest, self-efficacy, and perceived difficulty, thus demonstrating variation in students' initial motivation and how it fluctuated during the task. More importantly, the findings showed students' situational interest and self-efficacy to decrease during the task (mainly between the first and second measurement), while perceived difficulty first increased and then slightly decreased. Also, the findings provide evidence on the distinctive role of perceived difficulty.

The shapes of the trajectories (see, Fig. 1) suggest that, on average, the students' anticipated the task to be easier and more interesting than what it turned out to be. A previous study using a similar task showed an

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[3] Although it would have eventually been possible to find a converging solution by tweaking the model excessively, we considered such an approach inappropriate, and chose to specify a piecewise model instead, even at the expense of limited information on model fit. However, the piecewise model worked well as part of the full model, thus clearly retaining relevant information on individual differences in the changes in perceived difficulty.

Table 1
Descriptive statistics and correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Situational interest t1	–												
2. Situational interest t2	0.55**	–											
3. Situational interest t3	0.57**	0.78**	–										
4. Self-efficacy t1	0.33**	0.23**	0.28**	–									
5. Self-efficacy t2	0.25**	0.41**	0.40**	0.48**	–								
6. Self-efficacy t3	0.27**	0.41**	0.50**	0.46**	0.72**	–							
7. Perceived difficulty t1	−0.11**	−0.11**	−0.13**	−0.35**	−0.24**	−0.24**	–						
8. Perceived difficulty t2	−0.06	−0.11**	−0.12**	−0.21**	−0.28**	−0.24**	0.52**	–					
9. Perceived difficulty t3	−0.03	−0.09**	−0.08*	−0.17**	−0.23	−0.19**	0.48**	0.74**	–				
10. Knowledge acquisition	0.14**	0.22**	0.21**	0.12**	0.25**	0.19**	−0.14**	−0.19**	−0.11**	–			
11. Knowledge application	0.14**	0.20**	0.21**	0.13**	0.24**	0.20**	−0.12**	−0.17**	−0.14**	0.55**	–		
12. Math intrinsic value	0.27**	0.18**	0.23**	0.18**	0.22**	0.19**	−0.06*	−0.08**	−0.04	0.18**	0.16**	–	
13. Math achievement	0.04	0.04	0.06*	0.15**	0.15**	0.09**	−0.06	−0.05	−0.01	0.39**	0.37**	0.35**	–
M	4.07	3.65	3.59	4.04	3.26	3.27	4.04	4.48	4.27	23.9	29.4	3.33	3.55
SD	3.57	4.84	4.74	2.85	3.18	3.41	4.24	4.51	4.80	6.74	4.12	1.53	1.13
Range	1–7	1–7	1–7	1–7	1–7	1–7	1–7	1–7	1–7	1–100	1–100	1–5	1–5
Skewness	−0.11	0.24	0.22	−0.08	0.44	0.45	0.02	−0.23	−0.14	1.11	0.37	−0.37	−0.24
Kurtosis	−0.97	−1.34	−1.33	−0.72	−0.75	−0.79	−1.28	−1.31	−1.38	0.13	−0.09	−0.78	−0.78

Note. t1–t3 = Time 1–Time 3.
* $p < 0.05$.
** $p < 0.01$.

Table 2
Means, variances, and bivariate latent correlations for initial levels and slopes.

				Situational interest		Self-efficacy		Perceived difficulty		
		M	*S*	Initial level	Slope	Initial level	Slope	Initial level	Slope 1	Slope 2
Situational interest	Initial level	4.07**	2.71**	1.00						
	Slope	−0.46**	1.91**	−0.20**	1.00					
Self-efficacy	Initial level	4.04**	1.82**	0.44**	−0.04	1.00				
	Slope	−0.77**	1.33**	−0.07	0.54**	−0.31**	1.00			
Perceived difficulty	Initial level	4.04**	3.26**	−0.14**	−0.06	−0.48**	0.12*	1.00		
	Slope 1	0.42**	2.28**	0.08	−0.09	0.22**	−0.28**	−0.37**	1.00	
	Slope 2	−0.19**	0.52*	0.08	0.08	0.12	0.08	−0.09	0.00	1.00

Note. Perceived difficulty Slope 1 = change t1-t2; Perceived difficulty Slope 2 = change t2-t3.
* $p < 0.01$.
** $p < 0.001$.

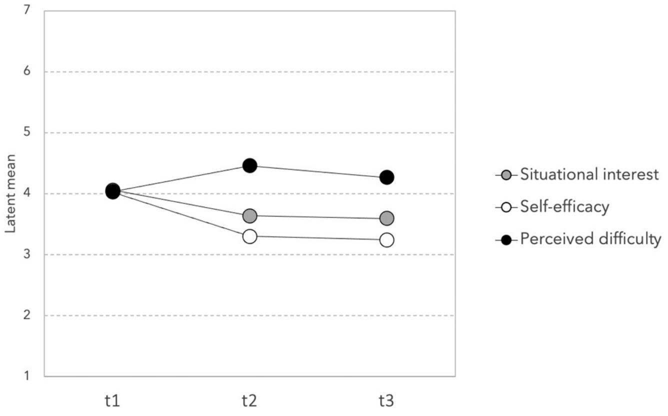

Fig. 1. Slopes of situational interest, self-efficacy, and perceived difficulty.

overall increase in students' self-efficacy during the task (Niemivirta & Tapola, 2007). Given the nature of the task, it was assumed that advancing with the task provided the students with some sense of accomplishment, which, in turn, translated into higher self-efficacy. As the task here was relatively more difficult, it seems that the students did not experience similar initial progress with the task, which then resulted in a re-calibration of their self-evaluations. The fact that perceived difficulty slightly decreased towards the end of the task, while self-efficacy and interest remained the same, might suggest that the students became more familiar with the task (Vangsness & Young, 2019), but this did not influence their further on-task motivation.

As to the second question, both initial interest and self-efficacy and their changes were strongly correlated, thus confirming our assumptions. Given previous findings (Niemivirta & Tapola, 2007), this implies that, regardless of the pattern of change in interest and self-efficacy (negative or positive), they tend to follow a similar trajectory and to be intertwined. However, the results do not allow for making inferences about causality, that is, whether changes in interest follow changes in self-efficacy or vice versa, or whether they just occur simultaneously. Evidence on the predominance of the relations between interest and self-efficacy is still inconclusive, mostly coming from studies on domain-specific motivation and relying on predictions based on cross-lagged panel models (Arens et al., 2019), and even then, the mixed findings suggest the effects to depend on the domain (e.g., school subject) and the characteristics or stages of the task (Nuutila et al., 2020). Nevertheless, given the present and previous evidence on changes over time (Jacobs et al., 2002; Niemivirta & Tapola, 2007), it seems clear that self-efficacy and interest are temporally related in a way that goes beyond mere correlations.

With respect to the role of perceived difficulty, we expected it to be negatively connected with situational interest and self-efficacy (e.g., Guthrie et al., 2009). In support of this, higher initial perceived difficulty was related to lower initial interest and self-efficacy. Despite the

Table 3

Standardized predictive effects from the multivariate model with covariates and outcome.

	Interest				Self-efficacy				Perceived difficulty						Performance			
	Level		Slope		Level		Slope		Level		Slope 1		Slope 2		Acquisition		Application	
Predictor	β	t	β	t	β	t	β	t	β	t	β	t	β	t	β	t	β	t
Gender	−0.09	−2.47*	−0.04	−1.04	−0.18	−4.59***	0	−0.01	0.11	2.54*	−0.05	−1.20	0.04	0.59	−0.06	−1.71†		
Intrinsic value	0.32	7.13***	−0.05	−1.05	0.18	3.69***	0.06	1.21	−0.04	−1.04	−0.04	−0.84	0.08	0.97	−0.03	−0.78		
Prior achievement	−0.06	−1.43	0.05	1.12	0.13	2.75**	−0.05	−0.89	−0.05	−1.33	0.03	0.66	0.08	0.97	0.38	12.67***	0.19	6.36***
Interest level															0.15	4.14***		
Interest slope															0.07	1.03		
Self-efficacy level															−0.03	−0.63		
Self-efficacy slope															0.13	2.07*		
Difficulty level															−0.16	−4.01***		
Difficulty slope 1															−0.10	−2.28*		
Difficulty slope 2															0.13	1.73†		
Acquisition																	0.47	14.3***
R^2	0.10***		0.01ns.		0.09***		0.00ns.		0.02ns.		0.00ns.		0.02ns.		0.26***		0.33***	

† $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

relatively high negative correlation between perceived difficulty and self-efficacy, the result nevertheless shows them to be partly independent motivational appraisals (Rodgers et al., 2008). Covariance is expected, since increasing difficulty logically decreases the likelihood of success, thus also influencing one's confidence. Then again, one may also hold high efficacy beliefs even when evaluating the task to be challenging, which, indeed, is one of the facilitating functions of self-efficacy (Bandura, 1993). Despite the relatively weak negative correlation between perceived difficulty and interest, some connection between these motivational experiences nevertheless exists, although its sources may be various. Lower likelihood of success presumably reduces interest, either directly or through increased anxiety (Steensel et al., 2019), and in case this poses a threat to one's self-esteem (Eccles & Wigfield, 1995), reporting lower interest might also represent a self-serving strategy.

Interestingly, increase in perceived difficulty was associated with decrease in self-efficacy, and vice versa, but it was independent of changes in interest. This further suggests that the experiences of confidence and perceptions of difficulty do indeed covary during task engagement, but, more importantly, that perceived difficulty does not simply mirror self-efficacy; they may have different task processing functions (Efklides, 2011). Another reason why perceived difficulty was not associated with the change in interest could be that their relationship is non-linear (e.g., their connection depending on the level of self-efficacy). However, investigating such dynamics would require studying interactions within a different analytical design.

Further clarity on these dynamics comes from the connections between the onsets and changes over the course of the task. The results showed higher initial self-efficacy to be associated with steeper increase in perceived difficulty, and higher initial perceived difficulty to be associated with less steep decline in self-efficacy. More specifically, when the initial self-efficacy was high, the initial perceived difficulty was lower, and thus there was simply more “room” to calibrate perceptions of difficulty upwards. Similarly, there was less downwards adjustment in self-efficacy among those whose initial perceived difficulty was higher. Given the unfamiliarity of the task, some students may have had unrealistically high confidence in the beginning, perhaps leading to a discrepancy between expectation and task reality, and this mismatch (Ainley et al., 2009; Nuutila et al., 2020), in turn, resulting in a need for recalibrating (Alexander, 2013) one's perceptions. Conversely, if high difficulty was expected initially – perhaps corresponding more realistically to the objective difficulty – self-efficacy may have been already “accurate” enough, thus requiring less recalibration. This interpretation is further qualified by the similar connections between each construct's initial level and change. Future studies should investigate the extent to which both the mismatch between expectations and reality, and the recalibration of task appraisals, influence the fluctuation of student's on-task motivation and performance (Ainley et al., 2009).

As to our third question, we found task performance to be positively predicted by the initial situational interest and positive change in self-efficacy, and negatively by the initial level and steeper increase in perceived difficulty, thus partly confirming our assumptions and previous findings (e.g., Andres, 2019; Nuutila et al., 2020; Talsma et al., 2018). These effects suggest that the way students initially connected with the task and their ability to maintain their confidence during the task contributed to performance. Given that this pattern of predictions is interestingly different from the one found in a previous study using a similar design and task, where task performance was positively predicted by initial self-efficacy and increase in interest (Niemivirta & Tapola, 2007), it would seem that the extent to which the level and changes in interest and self-efficacy do or do not contribute to performance may partly depend on whether the overall changes in motivation during the task are positive (facilitating) or negative (debilitating). Note that in the above study, an overall increase in self-efficacy was found, but no overall change in interest. The authors concluded the findings to imply that becoming gradually more involved with the task had an

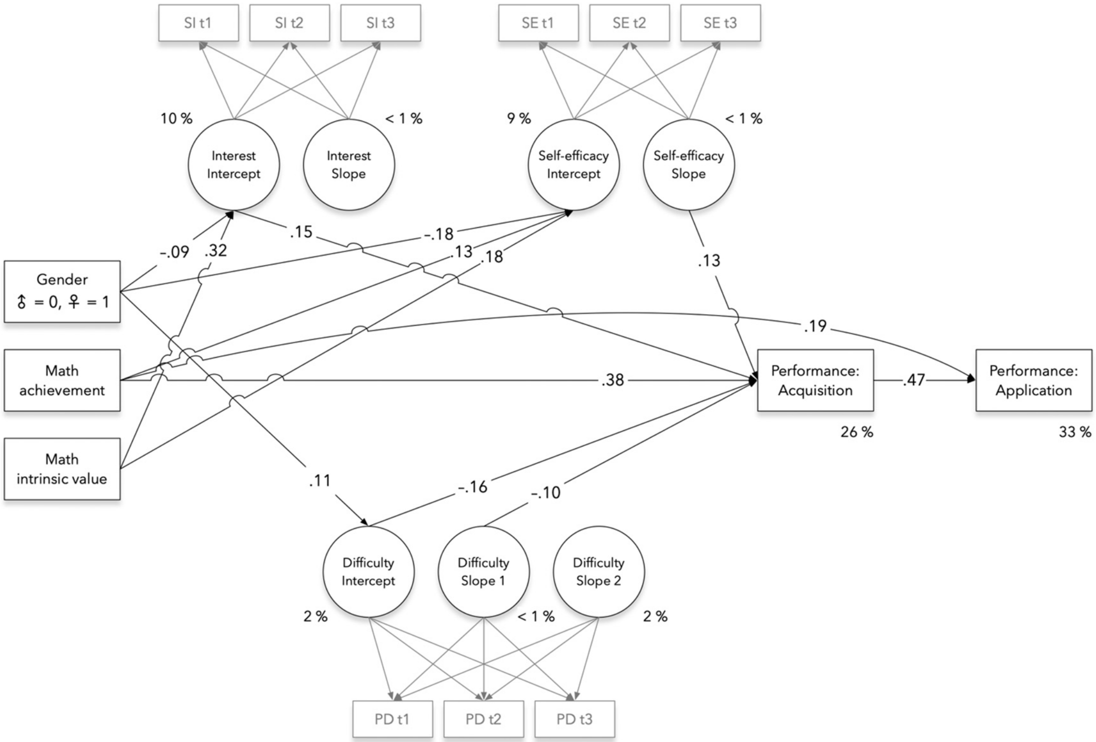

Fig. 2. Predictions within the full multivariate growth model.
Note. Only significant effects included ($p < 0.05$).

added value in terms of performance, given sufficient level of confidence in the beginning of the task. In this study, instead, it seems that maintaining confidence played a more significant role, given sufficient level of interest in the beginning. This implies that students' involvement with the task did not develop in the same way in the present study, possibly because the challenging task did not engage the students adequately, or provided limited sense of accomplishment or self-satisfaction, which may be necessary for triggering further interest (Bandura & Schunk, 1981; Silvia, 2003). Naturally, other sources might also contribute to the differences, as the studies included different covariates and the students were of different age.

Another possibility is that there are some undetected non-linear effects of interest and self-efficacy on performance. Relatively recent studies (Guo et al., 2017; Trautwein et al., 2012) within the expectancy-value framework point to the importance of considering interactive effects of interest and competence perception on performance. Also the early theories on perceived difficulty (Atkinson, 1957) suggested its effects on performance and motivation to depend on the interaction between perceived difficulty level and a person's tendency to avoid failure or aim to succeed, thus conveying similar needs. However, studying such dynamics would be rather challenging within the latent growth curve framework (see however, Duncan et al., 2006).

The observed effects of perceived difficulty on performance concurred with our expectations, and demonstrate that perceived difficulty is not just another aspect of perceived competence, but has a separate, predictive role partly independent of self-efficacy (Eccles & Wigfield, 2020). It is plausible that the increase in perceived difficulty to some extent reflects the increase in the objective difficulty of the task, which, naturally, translates into performance. Also, high perceived difficulty might have made effort in the task seem less useful, thus leading to reduced effort and engagement (Atkinson, 1957). Studying the connections of self-efficacy and perceived difficulty with performance-related processes such as effort could shed light into their different influences on performance.

Given the above, future studies should clearly pay more attention to how various task characteristics influence the fluctuation of students' self-efficacy and interest as well as their mutual relations and effects on performance, while also taking into account students' subjective perceptions of task difficulty. A look at early studies on achievement motivation (e.g., Kukla, 1974) investigating how different levels of difficulty (perceived or objective) moderate a person's actions during a task (e.g., effort exertion) might prove useful in this regard. Parameters such as learning-oriented feedback, systematically increasing complexity, and even rewards could be easily implemented as an integral function in the application used here, which would then permit some control over the variation in the task. This would also enable the manipulation of interest, self-efficacy, and perceived difficulty, thus allowing the possibility to investigate the effects those manipulations have on their temporal relations. In addition, direct manipulations may facilitate studying more complex dynamics such as the interactive effects of interest, self-efficacy, and perceived difficulty on performance. Further, given the significant individual variation found in all initial levels and slopes, investigating possible subgroups of students displaying similar changes in their interest, self-efficacy, and perceived difficulty, and whether these are differently related to students' motivational tendencies and task performance, could be fruitful.

Our control variables, intrinsic value and prior achievement in mathematics, significantly predicted the initial levels of interest and self-efficacy, thus showing that domain-specific motivation and competence may influence students' task-related expectations even if the task itself does not exactly reflect the given domain (Nuutila et al., 2020). However, they did not contribute to the changes in self-efficacy and interest during the task, implying the fluctuations in task experiences were influenced more by the situational person x task transactions (Ainley & Hidi, 2002). This echoes other studies (Knogler et al., 2015; Rotgans & Schmidt, 2018) suggesting that situational interest is influenced both by situation-specific and person-specific factors, but the degree to which one of these sources is more prominent may vary across situations and depend on task characteristics such as familiarity. For example, it seems that the effect of individual interest on situational interest varies across different phases of a task, possibly as a function of the match between the individual interest domain and task domain (Nuutila et al., 2020). Also, domain-specific interest often only predicts situational interest in the beginning of the task, suggesting that it affects the initial connection with the task, while further engagement depends more on the situational cues and the person-task dynamics (Rotgans & Schmidt, 2018; Tapola et al., 2014). While covariates here predicted motivation only in the beginning of the task, the observed individual variation in the changes in motivation suggests that personal factors played a role in them too.

Interestingly, neither initial perceived difficulty nor changes in it were predicted by prior math achievement and intrinsic value, thus not only demonstrating its dependency on task-related experiences, but also further evidencing its distinction from self-efficacy. When the task is unfamiliar, students may have challenges in estimating its difficulty, and their pre-existing dispositions incorporating their prior task experiences may have lesser role than in more familiar tasks. Perceived difficulty thus seems to be more influenced by task- than self-related beliefs and knowledge (Efklides, 2011), although other motivational dispositions such as achievement goal orientations (Pintrich, 2000) or self-concept (e.g., in mathematics; Marsh et al., 2005) could have been more influential.

As to gender effects, girls displayed lower interest and self-efficacy, and higher perceived difficulty in the beginning of the task compared to boys. Yet, their task performance was only marginally inferior. These differences seem rather stereotypical, only applying to the beginning of the task, thus implying that compared to boys, girls' perceptions of the task, and consequently also their motivational expectations, may have been less positive than their actual on-task experiences. This pattern of differences again speaks for designing studies with more attention to task contents.

4.1. Limitations

Some limitations need to be acknowledged with respect to our measures and the task design. Single items were used for both on-task measures and covariates, which certainly narrows the scope of the measures and limits variation. However, since such measures have been used successfully in previous studies (Ainley & Patrick, 2006; Gogol et al., 2014), we do not consider this to be a major threat to the validity of the findings. Note that the main reason for this operationalisation was to minimise interference with the actual task (see also, Footnote 1). Naturally, more comprehensive measures would be preferable, given that responding to them would not become counterproductive. Perhaps it would also be beneficial to include a measure of topic interest (instead of a more distal measure of intrinsic value in a domain) that matched the contents of the cover stories included in the task. This would enable a more precise prediction of the onset of students' situational interest. Nevertheless, while our independent variables were less than optimal both in terms of the content and operationalisation, we believe the current setup was useful and informative (as evidenced by the results), and complemented the design. Another important question concerns the number of measurement points during the task. Although we do not consider our current design to be inferior as such, our challenges with the modeling suggest that more than three measurements would help capture task-related dynamics better, and also allow for more complex and accurate modeling of non-linear trajectories. Yet, too many repeated interruptions could interfere with students' task engagement.

4.2. Conclusion

This study showed situational interest, self-efficacy, and perceived difficulty as well as their changes during a task to be mutually connected and partly predictive of task performance. These findings add to previous research by demonstrating the intriguing temporal connections between self-efficacy and interest, and also support the view of perceived difficulty having a complementary role in students' task engagement and performance that goes beyond perceived and actual competence (Eccles & Wigfield, 2020). Overall, the outcomes of our study align with the notion that the functional relationships between interest, self-efficacy, and perceived difficulty are not independent of task characteristics, and cannot be completely detached from students' expectancies regarding the task (Ainley et al., 2009). While the onset of a student's interaction with the task seems to be set by their more general motivational beliefs, inclinations, and achievement, the fluctuation of that interaction is more situational and task-dependent, in-the-moment. Disentangling the sequences of these effects would be of particular interest in future research. Also, while the findings imply students' motivation during the task to have been more task dependent, potentially due to unfamiliarity of the task, the observed individual variation in the trajectories suggests that exploring whether certain patterns of change are typical for certain groups of students could be relevant. Regarding educational implications, a more thorough understanding of the motivational dynamics during students' task engagement not only helps educators to recognise relevant individual differences better and become more sensitive to different types of struggles in learning, but also provides valuable input for designing motivationally supportive tasks.

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Declaration of competing interest

None.

Appendix A

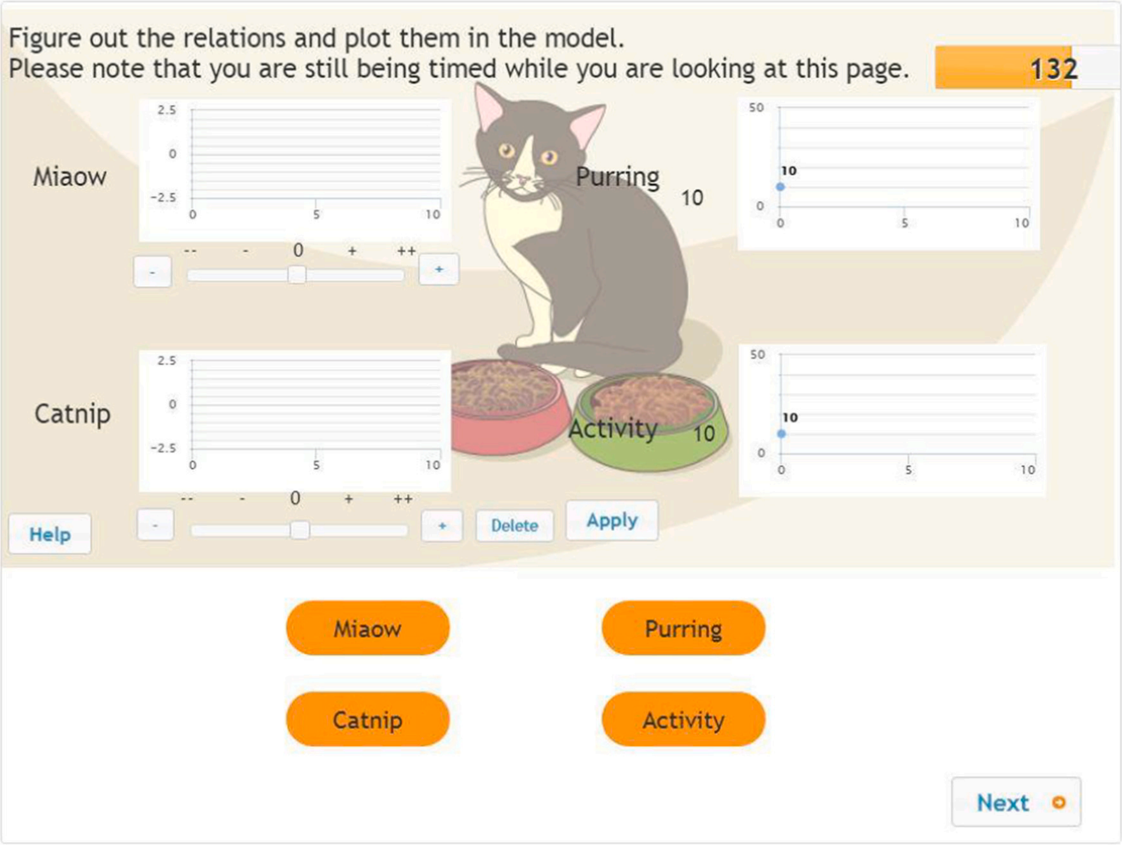

Figure out the relations and plot them in the model.
Please note that you are still being timed while you are looking at this page.

Screenshot of the “Cat” task during the first phase of the problem-solving process, in the knowledge acquisition phase. Students can manipulate the sliders on the left side (input variables: miaow, catnip) and observe the changes on the right side (output variables: purring, activity). The relations must be depicted in the concept map at the bottom.

Appendix B. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.lindif.2021.102090.

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