Contemporary Educational Psychology 49 (2017) 175–184

Contents lists available at ScienceDirect

Contemporary Educational Psychology

journal homepage: www.elsevier.com/locate/cedpsych

Empirical study

Interest development: Arousing situational interest affects the growth trajectory of individual interest

Jerome I. Rotgans [a,*], Henk G. Schmidt [b]

[a] Nanyang Technological University, Singapore
[b] Erasmus University Rotterdam, The Netherlands

ARTICLE INFO

Article history:
Available online 9 February 2017

Keywords:
Four-phase model of interest development
Individual interest
Situational interest arousal
Problem-based learning

ABSTRACT

Interest has become a central topic in the educational-psychology literature and Hidi and Renninger's (2006) four-phase model of interest development is its most recent manifestation. However, this model presently enjoys only limited empirical support. To contribute to our understanding of how individual interest in a subject develops in learners, two studies were conducted with primary school science students. The first study (N = 187) tested the assumption that repeated arousal of situational interest affects the growth of individual interest. Latent growth curve modeling was applied and the results suggest that the arousal of situational interest has a positive effect on the development of individual interest and significantly influences its growth trajectory. The second study tested the assumption that engaging students with interest-provoking didactic stimuli, such as problems, is critical to triggering situational interest and increasing individual interest. To test this assumption, four classes of primary school students (N = 129) were randomly assigned to two conditions in a quasi-experimental setup. The treatment condition received four situational-interest-inducing science problems as part of a course whereas the control condition did not, all other things being equal. The results of latent growth curve modeling revealed that only the group receiving problems experienced repeated arousal of situational interest and its related growth in individual interest. Implications for, and amendments to, the four-phase model of interest development are proposed.

1. Introduction

Interest in interest research is growing in educational psychology (Ainley, 2006; Hidi, 2006; Krapp, 1999; Schraw & Lehman, 2001). One of the possible explanations for this surge in curiosity is that interest is a construct that oddly seems to manifest itself through two quite different identities. Interest is sometimes considered a semi-stable construct representing the dispositional tendencies of a person to engage with a subject over time, or, alternatively, a transient phenomenon that is temporarily aroused by contextual stimuli in the learning situation. The latter is referred to as *situational* interest, whereas the former is generally referred to as personal or *individual* interest (Bergin, 1999; Hidi, 2006; Schraw, Flowerday, & Lehman, 2001; Schraw & Lehman, 2001). Of particular importance is the question how interest develops from fleeting situational interest into stable individual interest (Hidi, 2006; Hidi & Renninger, 2006). An answer to this question is useful because if more would be known about the mechanism of interest development, teachers would be in a better position to influence students' interest in subjects for which many have little affinity.

A model describing how individual, stable, interest emerges out of situational interest was proposed by Hidi and Renninger (2006). According to Hidi and Renninger, interest develops over four sequential phases. The first phase is called "triggered situational interest" and entails that a person's situational interest for a particular topic can be sparked by presenting features such as novelty or surprising information (Renninger & Hidi, 2016). These features can be induced by activities of the teacher or presented by means of texts or other learning resources. The second phase is referred to as "maintained situational interest." The third phase marks a transition to individual interest and is referred to as "emerging individual interest." This phase is characterized by a dispositional internalization of a person's interest for the topic in question and a tendency to seek out more frequent engagements with the topic without much external support. According to Hidi and Renninger, the last phase is referred to as "well-developed individual interest"

* Corresponding author at: Nanyang Technological University, Lee Kong Chian School of Medicine, Novena Campus HQ, 11 Mandalay Road, Singapore 308232, Singapore.

E-mail address: rotgans@gmail.com (J.I. Rotgans).

http://dx.doi.org/10.1016/j.cedpsych.2017.02.003
0361-476X/

and signifies a person's deep-seated interest for the topic, manifesting itself by a dispositional tendency to reengage with the topic over longer periods of time and without external support.

Skimming through the interest literature published after the Hidi and Renninger article appeared in 2006, it seems that there is hardly any paper that does not refer to the four-phase model of interest development in one way or the other. Looking at the model more closely it is easy to see why. The model suggests that (a) situational interest can be aroused in students and that (b) maintained situational interest leads to changes in a student's dispositional preference and liking for a particular school subject. Hence, if a student does not like science initially, a teacher's focus on the triggering of situational interest may in the long run lead to an increase in individual interest in the particular topic, possibly even influencing future course selection and career choice. Some researchers believe that the arousal of situational interest by appropriate precipitating events, such as puzzles or problems, is hard-wired and therefore—in principle—affecting every individual (Berlyne, 1954, 1962, 1978; Kang, Scharmann, Kang, & Noh, 2010; Kang et al., 2009; Loewenstein, 1994; Rotgans & Schmidt, 2014b). Thus, in theory at least, every student's interest can be aroused for any subject and may subsequently (if reinforced) lead to the development of a long-lasting dispositional interest for the subject. Needless to say, if this is indeed true, it has significant implications for education.

Despite the intuitive logic behind the model and its general acceptance, it has been subjected to limited empirical testing. A reason for this may be that the model is underspecified in at least three ways. First, a psychological mechanism explaining under which conditions situational interest is triggered is missing, as the authors themselves agree elsewhere (Renninger & Hidi, 2011). Second, the model states that situational interest once triggered needs to be "maintained," without clearly postulating what is meant by maintenance of situational interest. Third, Hidi and Renninger provide no information about the duration of the four phases and how changes between the phases occur. Is the transition from one phase to the other a matter of weeks, of months, of years? When and how does the transition from situational interest to individual interest occur? Is this a gradual transition or, as the model seems to suggest, a rather sudden shift from state to trait? What marks the transition from emerging to well-developed individual interest?

Several researchers have made attempts to test elements of the developmental process described by Hidi and Renninger. Most studies concentrated on the influence of task characteristics on the emergence of situational interest. Tapola, Veermans, and Niemivirta (2013), for instance, demonstrated that the extent to which a task is concrete (rather than abstract) positively influences situational interest. Providing texts that contain surprising, incongruent, and unexpected information also seems to have a positive effect on situational interest (Iran-Nejad, 1987). More recently, Høgheim and Reber (2015) conducted a study to examine how example choice (having a choice which text to study) and context personalization (in which features of a text are customized to the learners' out-of-school interests) affect situational interest (see also Flowerday, Schraw, & Stevens, 2004). Both example choice and context personalization had a positive effect on triggering students' situational interest. In addition, much research effort has been invested to determine whether seductive details (information that is interesting but irrelevant to understanding a text) have a positive effect on situational interest and text comprehension. Although the findings of earlier studies were inconclusive—some suggested that seductive details have a positive effect (Schraw, 1998) whereas others suggested it has no positive effect on situational interest and learning (Garner, Gillingham, & White, 1989)—recent studies that experimentally manipulated the cognitive load participants experience during the task suggest that seductive details have a positive effect on students' situational interest and learning if cognitive load is kept low (Park, Flowerday, & Brünken, 2015; Park, Moreno, Seufert, & Brünken, 2011).

Rotgans and Schmidt have tried to tackle the mechanism underlying the arousal of situational interest (Rotgans & Schmidt, 2011b, 2014b). They have demonstrated that situational interest is *only* aroused when students lack knowledge of a topic at hand. Only when students become aware that there is a gap between what they know about a topic and what needs to be known, situational interest increases. In their view, therefore, aroused situational interest signifies a need for knowledge. However, if the need for knowledge is satisfied, for instance through instruction or self-study, situational interest necessarily decreases. A logical consequence of this theory is that situational interest cannot be "maintained," but has to be aroused repeatedly with new instructional events introduced for this purpose. This "knowledge-deprivation theory of situational interest" may be a suitable candidate explaining why precipitating events such as puzzles, classroom experiments, or problems arouse this type of interest. (See also Berlyne, 1978; Kang et al., 2009; Loewenstein, 1994.)

Others have concentrated on the relationship between situational interest and individual interest. Linnenbrink-Garcia et al. (2010), for instance, have demonstrated that the level of situational interest measured at the beginning of a course predicts the level of individual interest at the end of that course. They were however not able to demonstrate a significant relationship between what they called "maintained situational interest" and individual interest. Harackiewicz, Durik, Barron, Linnenbrink-Garcia, and Tauer (2008) conducted a longitudinal study to explore how interest develops in an introductory psychology course. Individual interest was measured as continued interest in the topic and operationalized as students' course choice after completion of the introductory course and whether they majored in psychology. Situational interest was measured at the beginning and during the course (the latter was considered "maintained" situational interest). A path model was tested and the results suggest that situational interest predicted maintained situational interest, which in turn was associated with course choice and whether students took up a major in psychology. Harackiewicz et al. (2008) interpreted the findings in light of the four-phase model and proposed that the first two situational interest measures corresponded with the first two phases in the model, course choice with the emerging individual interest phase, and majoring in psychology with the well-developed individual interest phase.

Although the above studies provide important insights in how elements of the model function, studies that tested the model in its entirety are largely missing. In addition, the studies that did examine the four-phase model more extensively, applied correlational analyses that have significant methodological limitations in exploring the actual developmental growth trajectory of interest over time. The purpose of the studies reported in the present article was twofold. First, we wished to demonstrate that individual interest increases over time, and that it does so under the influence of repeatedly aroused situational interest. To demonstrate that aroused situational interest influences individual interest it is not sufficient to correlate these variables measured at various points in time, such as Linnenbrink-Garcia et al. (2010) and Harackiewicz et al. (2008) have done. What one has to demonstrate is that aroused situational interest determines how individual interest *changes* under its influence. Latent growth curve (LGC) modeling within the structural equation framework seems an adequate approach to study such changes in particular variables over time (Duncan, Duncan, & Strycker, 2013), since it allows the researcher to directly observe the influence of situational interest on the *slope* of the growth trajectory of individual interest. If the slope is positive, and significantly different from zero, this would indicate that individual interest is increasing over time. If we would then be able to show that the arousal of situational interest significantly influences the slope of this growth trajectory, we would have direct evidence of the effect of situational interest on the growth of individual interest. To allow for LGC modeling, situational and individual interest have to be measured several times over the course of time, an approach we have previously labeled micro-analytical measurement (Rotgans & Schmidt, 2011b, 2014b) following a suggestion by Zimmerman (Cleary, Callan, & Zimmerman, 2012; DiBenedetto & Zimmerman, 2010). Like Zimmerman and Kitsantas (2005) we believe that, generally, micro-analytical measurement is a *conditio sine qua non* for the study of situational and individual interest and how they change over time. A second purpose of the present paper was to demonstrate that it is the instructional *problems*, and not some unspecified other elements of the learning environment, that causes situational interest to be aroused.

To test the influence of repeated arousal of situational interest through instructional problems on the growth trajectory of individual interest, we conducted two studies. In both studies LGC modeling was applied. Each study was conducted over the duration of four weeks. The subject of interest was primary school science, "properties of light." Research has demonstrated that students lose interest in school subjects over their study career starting in primary school (Harter, Whitesell, & Kowalski, 1992; Wigfield, 1994). Consequently, we selected primary school students as our sample to examine if this predicted downward trend can potentially be reversed at that early stage in their school career. Students met twice a week for one hour (i.e., 8 h in total over 4 weeks). Four instructional problems were used as stimuli to repeatedly arouse students' situational interest in the science topic. To measure both students' situational and individual interest at four points in time, short self-report measures were administered.

2. Study 1: A latent growth curve modeling approach to interest development

The objective of the first study was to investigate how repeated arousal of situational interest influences the change in individual interest over a four-week period. This study was considered a direct test of the central workings of interest development: How does triggered and "maintained" (here defined as repeated arousal) situational interest develop into emerging individual interest?

2.1. Participants

In this study, 187 Primary 4 school science students (43% female) from one school in Singapore participated. Their mean age was 10 years (*SD* = 0.07). The participants were nested in five classes. Two sessions were conducted each week over the duration of four weeks. Three teachers, with the same years of teaching experience and training background, taught the classes. To assure that all classes received the same instructions, the teachers strictly followed a detailed protocol prepared by the researchers (and available upon request from the corresponding author).

2.2. Materials

2.2.1. Individual interest measure

Individual interest was measured by means of the *Individual Interest Questionnaire* (Rotgans, 2015), which has been validated for different subject domains and with students in different age groups ranging from primary education to high school. The Individual Interest Questionnaire (IIQ) consists of seven items (e.g., "*I always look forward to my science lessons because I enjoy them a lot,*" "*Outside of school I read a lot about science,*" and "*Later in life I want to pursue a career in science or a science-related discipline*"). All items were scored on a 5-point Likert scale, ranging from 1 (*not true at all*) *to* 5 (*very true for me*). Hancock's coefficient *H* was calculated as a reliability measure. The coefficient *H* is considered a more accurate measure of reliability than the much-used Cronbach's alpha (Hancock & Mueller, 2001; Sijtsma, 2009). Its recommended cut-off value is 0.70. In this study, the coefficient *H* ranged from 0.78 (week 1) to 0.87 (week 3) with an average value of 0.83, which suggest adequate reliability of the measure.

2.2.2. Situational interest measure

To measure students' situational interest, the *Situational Interest Questionnaire* was administered (Rotgans & Schmidt, 2011a, 2011b, 2014b). The instrument consists of six items (e.g., "*I want to know more about this topic*" and "*I am fully focused on this topic and not distracted by other things*"). All items were scored on a 5-point Likert scale, ranging from 1 (*not true at all*) *to* 5 (*very true for me*). The coefficient *H* for this measure ranged from 0.91 (week 1 and 2) to 0.94 (week 4) with an average of 0.92, which suggests high reliability of the measure.

2.3. Procedure

At the beginning of the study, the students were informed that we would like to find out more about how students learn during science class and that we will ask them to provide us with their feedback by responding to several questionnaires. Each week, students met on two different days for a one-hour session. During the first session, the problem of the week was introduced and during a second session the students conducted self-study to find answers to the problem. The topic students engaged with during the four weeks was "properties of light." For example, the first problem constituted a scenario in which a group of friends was about to enter a cave and a discussion erupted as to whether they had to bring a torchlight to see in the dark. One friend claimed that they do not need it because their eyes will adjust to the darkness and they will be able to see without the torchlight (see Appendix A for the four problems presented). The sessions were conducted over four weeks. The data collection was identical for each week. At the beginning of the first session, the Individual Interest Questionnaire was administered to measure students' general individual interest in science as well as a situational interest measure to determine their situational interest in the properties-of-light theme before they encountered the problem. Subsequently, the problem was presented, which was immediately followed by the administration of the second situational interest measure. Students then generated learning goals—that is, identify what they do not understand about the problem and would like to find out. To eliminate teacher influence on situational interest, the teachers were not allowed to engage with the students. Instead, students had to fill in a form that guided them in generating learning goals. The form consisted of three columns the students had to fill in: (1) What do I know about the problem?; (2) What do I not know?; and (3) What do I need to find out? The latter constituted the learning goals (Schmidt, Van der Molen, Te Winkel, & Wijnen, 2009). Then, students engaged in a first round of self-study to find information that would address their learning goals. The study materials consisted of texts from a physics textbook and some Internet resources on the topic. Each student received the same learning materials for each week. In the second session, students continued their self-study and at the end of the session they shared their findings with the class. Only at this stage the teacher acted as a facilitator by asking standardized questions that addressed the key ideas of the topic (e.g., "could somebody explain how using a torchlight in a dark cave enables me to see?"). This procedure was repeated for each of the remaining three problems over subsequent weeks.

2.4. Analysis

All analyses were conducted using Mplus 7.3 (Muthén & Muthén, 1998–2012). First a missing-data analysis was conducted. There were two types of missing data: (1) missing data for individual items (e.g., failed to respond to one or more items) and (2) missing data due to absence of students at one or more lessons (e.g., illness). The first type of missing data constituted less than 2% for the individual interest measurements and less than 1% for the situational interest measurements and therefore did not constitute a problem (Graham, Cumsille, & Elek-Fisk, 2003). The magnitude of the second type of missing data was as follows: Week 1 = 1%, week 2 = 5%, week 3 = 4% and week 4 = 2%. To deal with this type of missing data we used the robust maximum likelihood (MLR) and mean-adjusted χ^2 statistics in Mplus (Byrne, 2012). As students are nested within their classes, we applied the "complex" option in Mplus. This option considers the extent to which the data are nested and corrects for this. A LGC model approach was used to examine how individual interest changes over time and the extent to which the arousal of situational interest influences the growth trajectory of individual interest (Duncan et al., 2013). The LGC analyses were carried out in two steps (Byrne, 2012). We first tested an unconditional growth model for individual interest alone to model intraindividual and interindividual differences in change over time. Two latent factors were defined to represent the intercept (initial level of individual interest) and the slope of the growth trajectory (see part A of Fig. 1). The factor loadings of the four observed measures and the intercept factor were fixed to 1 to define the starting point of the growth trajectory. The factor loadings of the observed measures and the slope factor were fixed at 0, 1, 2, and 3 respectively, to model an expected linear trend over the four measurement points. The means of the two latent factors (initial level and slope) were freely estimated. The mean estimate of the intercept factor (*Mi*) represents the mean initial level of the growth trajectory, and the estimate of the intercept variance (*Di*) represents the degree of individual variability at the initial level. Similarly, the mean estimate of the slope factor (*Ms*) represents the mean slope of growth trajectory, and the slope variance (*Ds*) represents inter-individual variability in the rate of change over time (for more detailed explanation see Byrne, 2012).

For the second test, we developed a hypothesized covariate model in which we examined to what extent mean situational interest arousal influenced the growth trajectory (i.e., intercept and slope) of individual interest (see part B in Fig. 1). Situational interest *arousal* was calculated by subtracting the situational interest measure taken *before* a problem was presented from the measure taken *after* the problem was presented. Thus, this variable represents the amount of arousal each student experienced when being presented with the problem stimulus. The four arousal scores for each problem were then aggregated and we regressed the initial level and slope of individual interest on the mean aroused situational interest. This enabled us to directly assess the contribution of arousal of situational interest to the increase of individual interest.

To examine the goodness-of-fit for both models, we generated the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI) along with the χ^2 statistic. Cutoff values of 0.06 (RMSEA), 0.09 (SRMR) and 0.95 (CFI) were used in the analysis (Hu & Bentler, 1999).

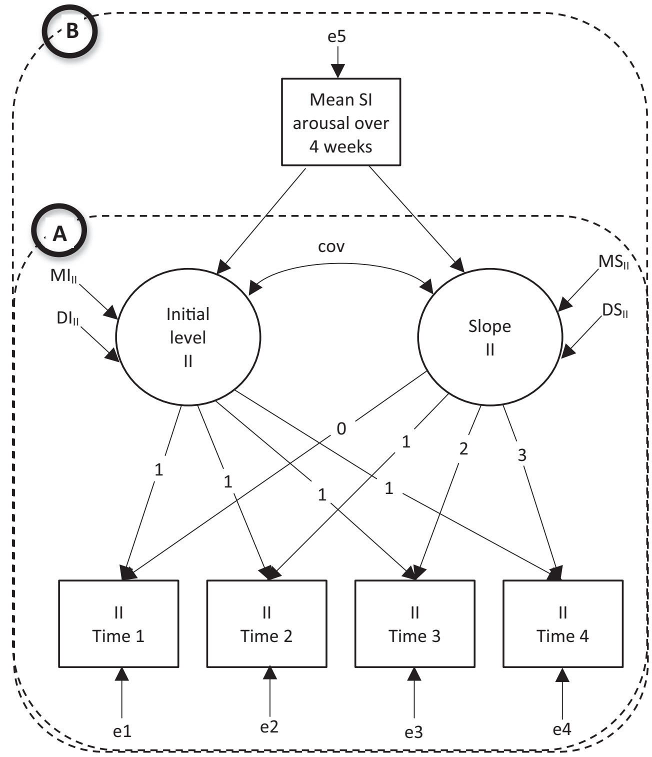

Fig. 1. Study 1, hypothesized LGC model representing the different steps in the analyses: Part A: An unconditional growth model of individual interest (II) and part B: LGC model with mean situational interest arousal as a predictor variable.

2.5. Results and discussion

See Table 1 for the zero-order correlations between the individual interest measures and the mean situational interest arousal score and their descriptive statistics.

The unconditional growth model for individual interest fitted the data well (see part A in Fig. 1): $\chi^2(5) = 5.30$, $p = 0.38$; CFI = 1.00; RMSEA = 0.02 (90% CI: 0.00–0.14); SRMR = 0.03. The mean and variance of the initial level were significantly different from zero ($Mi_{\text{individual interest}} = 3.43$, $p < 0.0001$; $Di_{\text{individual interest}} = 0.42$, $p < 0.0001$), as were the mean and variance of the slope ($Ms_{\text{individual interest}} = 0.09$, $p < 0.0001$; $Ds_{\text{individual interest}} = 0.03$, $p = 0.013$). The correlation between initial level and slope was not significant ($r_{is} = -0.03$, $p = 0.18$). The results of this analysis show that there was a significant overall increase in participants' individual interest over the four-week period.

As a next step, we tested the extended LGC model in which individual interest was regressed on situational interest to investigate whether situational interest arousal is a significant predictor of the observed variability in the initial level and slope of individual inter-

Table 1
Study 1: Zero-order correlations between mean situational interest arousal (SIa) and individual interest measurements (II1–II4) as well as descriptive statistics (N = 187).

Variable	Mean SIa	II1	II2	II3	II4
II1	−0.20*				
II2	−0.21*	0.67**			
II3	−0.09	0.49**	0.66**		
II4	−0.11	0.42**	0.65**	0.82**	
Mean	0.16	3.28	3.43	3.43	3.51
(SD)	(.83)	(.77)	(.84)	(.85)	(.82)

Note:
** $p < 0.01$ level.
* $p < 0.05$ level.

est (see part B in Fig. 1). This is considered a crucial test of the hypothesized mechanism of the model of interest development: repeated arousal of situational interest should be responsible for the observed growth in individual interest for the model to be true.

The extended model fitted the data well: $\chi^2(7) = 4.89$, $p = 0.67$; CFI = 1.00; RMSEA = 0.000 (90% CI: 0.00–0.09); SRMR = 0.04. Examination of the regression coefficients suggests that mean situational interest arousal significantly predicted the initial level of individual interest ($\gamma = 0.25$, $p < 0.001$) and had a significant effect on the slope parameter ($\gamma = 0.10$, $p = 0.02$). This outcome can be considered empirical evidence in support of the Hidi and Renninger model of interest development: repeated triggering of situational interest has a significant positive effect on individual interest development.

3. Study 2: The role of problems in arousing situational interest and enabling interest development

The objective of the second study was to replicate and extend the findings of Study 1 by examining the extent to which didactic problems are instrumental in arousing situational interest, and, hence, an increase in individual interest. Despite of the findings of Study 1 and results of previous studies (Rotgans & Schmidt, 2011b, 2014c), this is not entirely self-evident. Although we could establish a direct relationship between the amount of arousal and the increase in individual interest in Study 1, there is always the possibility that the learning materials studied during the four weeks contributed to an increase in individual interest as well. A quasi-experimental approach was therefore chosen to compare a group of participants who received problems to arouse their interest as a starting point of their learning, with another group of participants who did not receive these problems (all else being equal). If the presence of didactic problems is to be held responsible for situational interest arousal and the subsequent change in individual interest, we expect to replicate the findings of Study 1 for the treatment condition, but not for the control condition. Most theories see the triggering of situational interest as the main determinant of the development of individual interest (Hidi, 2006; Hidi & Renninger, 2006). Therefore, if situational interest is not aroused, individual interest cannot be expected to increase. However, if elements of the learning situation other than problems *also* arouse situational interest, we would expect similar results of the LGC modeling in the no-problems group.

3.1. Participants

Hundred and twenty-nine Primary 4 school science students (49% female) from one school in Singapore participated. Their average age was 9.5 years ($SD = 0.49$). In total, there were four classes of which two were randomly assigned to a treatment condition and two to a control condition. There were no significant differences between the two groups in terms of gender distribution, age, and prior knowledge. Two teachers, with the same years of teaching experience and training background, taught the classes. To assure that both groups received the same instructions the teachers strictly followed a detailed protocol prepared by the researchers (available upon request from the corresponding author).

3.2. Materials

3.2.1. Individual interest measure

The same Individual Interest Questionnaire (Rotgans, 2015) was administered as in Study 1. The coefficient H ranged from 0.70 (week 1) to 0.86 (week 3) with an average value of 0.80, which suggests adequate reliability of the measure.

3.2.2. Situational interest measure

The *Situational Interest Questionnaire* was the same as in Study 1. The coefficient H for ranged from 0.82 (week 1) to 0.89 (week 3) with an average of 0.85, which suggests adequate reliability of the measure.

3.3. Procedure

The study was conducted over four weeks and for each week the procedure was identical. The science topic was the same as in Study 1: Properties of light. Before the study commenced, the Individual Interest Questionnaire was administered. Students in the treatment condition were presented a problem, which was preceded and followed by the administration of the Situational Interest Questionnaire. Students in the control condition did not receive a problem but the teacher provided the same information as in the problem. For instance, as a replacement for problem 1 the instructions were as follows: "*During this week, you will find out why you need a light source to seen in the dark. For instance, if you go into a dark cave you cannot see without a light source, such as a torchlight or a flare. Moreover, you will learn what the difference is between light sources, such as the sun or a torchlight and non-light sources. Finally, you will find out how light enables you to see in the dark—how that actually works*." Before and after this introduction, the situational interest measure was administered. After administration of the situational interest measure, students in the treatment group generated learning goals and subsequently engaged in self-study. The control group received the learning goals from the teacher and then engaged in self-study using the reading materials provided. In the second session, students in both conditions continued doing self-study and at the end of the session they shared their findings with the class. In both conditions, the teacher acted as a facilitator. The Individual Interest Questionnaire was administered at the beginning of each week followed by the sequence of events described above.

3.4. Analysis

As with Study 1, all analyses were conducted using Mplus 7.3 (Muthén & Muthén, 1998–2012). First a missing-data analysis was conducted. There were two types of missing data: (1) missing data for individual items (e.g., failed to respond to one or more items) and (2) missing data due to absence of students at one or more lessons (e.g., illness). The first type of missing data constituted less than 2% for the individual interest measurements and situational interest measurements and the magnitude for the second source of missing data due to absence was as follows: Week 1 = 9%, week 2 = 14%, week 3 = 10% and week 4 = 5%. To deal with this type of missing data we used the robust maximum likelihood (MLR) and mean-adjusted χ^2 statistics in Mplus (Byrne, 2012). As students are nested within their classes, we applied the "complex" option in Mplus.

As with Study 1, we applied a LGC model approach to examine (1) how individual interest changes over time and (2) the extent to which the arousal of situational interest influences the growth trajectory of individual interest. To assess whether there are significant differences between the treatment group and the no-problems group, we examined whether the LGM models were significantly different. For the treatment group, we expected the unconditional growth model to reveal similar model fit characteristics as observed for Study 1. In addition, regressing the slope and intercept of the mean individual interest scores on mean level of situational interest arousal would also lead to adequate fit, showing the positive contribution of aroused situational interest to the growth of individual interest.

However, for the no-problems group, in the absence of problems to arouse situational interest, we did not expect an increase in individual interest and no positive contribution of situational interest. Therefore, the LGC must not fit for this group.

3.5. Results and discussion

Two unconditional growth curve models for individual interest were tested for the treatment and the no-problems group. See Tables 2 and 3 for an overview of the descriptive statistics, and Table 4 for an overview of the model fit statistics for both groups.

From the model fit statistics, one can see that only the LGC model of the treatment group resulted in an adequate model fit. The data for the control group, not receiving the problems over the 4-week period, did not fit the model and resulted in a significantly worse model fit ($\Delta\chi^2 = 19.27$, $p = 0.0001$). This outcome suggests, that only for the treatment group a growth curve model describes the data adequately.

This finding is further strengthened when examining the means for the slopes for both groups. The means of the slopes represent the intraindividual changes over four weeks (see Table 4). Although the means for the slopes for both groups were significantly different from zero (treatment $Ms_{\text{individual interest}} = 0.03$, $p < 0.001$ and control $Ms_{\text{individual interest}} = -0.03$, $p < 0.001$), growth was negative for the control group. This outcome suggests that whereas the treatment group experienced a positive growth in individual interest over the four-week period, it was (slightly) negative for the control group not receiving the problems. In other words, not receiving problems resulted in a significant decrease in individual interest for science over time.

Following the two-step approach of Study 1, we tested an extended LGC model for the treatment group in which individual interest was regressed on situational interest to investigate whether situational interest arousal is a significant predictor of the observed variability in the initial level and slope of individual interest.

The extended model fitted the data very well: $\chi^2(7) = 3.07$, $p = 0.88$; CFI = 1.00; RMSEA = 0.000 (90% CI: 0.00–0.08); SRMR = 0.02. Examination of the regression coefficients suggests that situational interest arousal did not significantly predict the initial level of individual interest ($\gamma = 0.03$, $p = 0.78$). However, situational interest arousal had a significant effect on the slope of individual interest ($\gamma = 0.18$, $p < 0.001$). Thus, the findings of Study 2 largely replicate those of Study 1, and provide evidence to suggest that problems are crucial to the arousal of situational interest, leading to a significant growth in individual interest. However, while the treatment group formulated its own learning goals, the control group did not. This additional difference between the two conditions (necessary because of the ecological validity of our study conducted in the actual classroom setting) possibly limits the generality of our conclusion. We will discuss this limitation as part of the General Discussion in the next section.

Table 2
Study 2: Zero-order correlations between mean situational interest arousal (SIa) and individual interest measurements (II1–II4) as well as descriptive statistics for the control group (N = 61).

Variable	SIa	II1	II2	II3	II4
II1	−0.03				
II2	0.23	0.73**			
II3	0.07	0.77**	0.84**		
II4	0.17	0.71**	0.83**	0.85**	
Mean	−0.28	3.05	2.94	2.90	2.92
(SD)	(1.02)	(.69)	(.81)	(.89)	(.88)

** Note: $p < 0.01$ level.

Table 3
Study 2: Zero-order correlations between mean situational interest arousal (SIa) and individual interest measurements (II1–II4) as well as descriptive statistic for the treatment group (N = 68).

Variable	SIa	II1	II2	II3	II4
SIa	1.00				
II1	0.03	1.00			
II2	0.06	0.85**	1.00		
II3	0.04	0.82**	0.88**	1.00	
II4	0.12	0.76**	0.78**	0.81**	1.00
Mean	0.11	3.39	3.47	3.52	3.51
(SD)	(.94)	(.60)	(.66)	(.71)	(.76)

** Note: $p < 0.01$ level.

Table 4
Study 2: Model fit statistics and intraindividual and interindividual means and variances for the treatment (T problems) and control (C no problems) groups.

Model fit statistics	Treatment group (N = 68)	Control group (N = 61)
$\chi^2(5)$	2.73	22
p-value	0.74	<0.001
CFI	1.00	0.92
RMSEA (90% CI)	0.00 (0.00–0.12)	0.24 (0.14–0.34)
SRMR	0.07	0.14
$Mi_{\text{individual interest}}$	3.34, $p < 0.001$	3.03, $p < 0.001$
$Ms_{\text{individual interest}}$	0.03, $p < 0.001$	−0.03, $p < 0.001$
$Di_{\text{individual interest}}$	0.31, $p < 0.001$	0.38, $p < 0.001$
$Ds_{\text{individual interest}}$	0.01, $p = 0.09$	0.01, $p = 0.19$

4. General discussion

The question how interest can be aroused and cultivated in students is as old as it is elusive. Dewey (1913) devoted an entire book to the topic; "*Interest and Effort in Education*" describing how important raising interest (catch) and its development (hold) is for student learning. Hundred years down the road it appears we have only moved to a limited extent beyond the descriptive mode; empirical data providing insight in how interest emerges and develops over time are still not abundantly available. This is somewhat disappointing, in particular in view of the potential benefits of such knowledge for education.

The objective of the present studies was to contribute to our understanding of this issue. The first study examined the very premise of the developmental theory that situational interest—if triggered—leads to increased individual interest (Hidi & Renninger, 2006; Krapp, 2002; Renninger & Hidi, 2011). To that end we presented primary school students over a period of four weeks with four problems on the properties of light. Students were required to formulate learning goals for themselves and engage in self-study. Over the period, measures of situational and individual interest were taken. We hypothesized that individual interest would show a positive change over time, and that the arousal of situational interest was responsible for this growth trajectory. This hypothesis was tested by means of latent growth curve modeling. The results suggest that the repeated arousal of situational interest did have a direct influence on the growth trajectory of individual interest. These findings thus support the idea that the increase of individual interest is due to recurrently inducing situational interest in students, as suggested by various notions on the development of individual interest (Ainley, 2012; Alexander, Johnson, Leibham, & Kelley, 2008; Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002; Linnenbrink-Garcia et al., 2010; Renninger & Hidi, 2011).

In Study 2, we tested a second hypothesis of the model, namely that didactic interventions are critical in arousing situational interest in students. We considered this issue important because, according to the four-phase model, if one does not succeed in triggering situational interest, there is little hope for individual interest development to occur; triggering situational interest is a necessary condition for individual interest to emerge. To test this assumption, we had two groups of students engage in learning activities similar to those in Study 1. One of these groups however did not receive the four problems and was not asked to formulate learning goals for themselves. Their teacher instructed them about the goals of the learning exercise directly. Measures of situational and individual interest were taken over a period of four weeks. The findings of a LGC model comparison between both groups lent support to our hypothesis; only students who were confronted with problems reported a significant growth in individual interest over the four-week intervention. Participants who did not receive the problems reported a slight decrease in individual interest. If the lack of positive change in the control group generalizes to run-of-the-mill school environments in which direct instructional practices typically prevail, it is to be feared that these practices often do not contribute to the development of individual interest. However, a potential shortcoming of our second study is that, in addition to the introduction of problems in the classroom, students in the treatment group formulated learning goals for themselves whereas students in the control group did not. We will discuss this methodological problem in the shortcomings section below.

How do our findings contribute to the literature on interest development in general and the four-phase model in particular? The studies presented here provide in our view a direct empirical test of some of the assumptions underlying the four-phase model and were designed to cast light on how interest develops in authentic school settings. First, we have demonstrated that the growth of individual interest over time can be ascribed to the repeated arousal of situational interest caused by the problems presented to students and not to other elements of the learning environment. Study 2 suggested that when problems aimed at arousing situational interest are absent, no such change in individual interest occurs; under such circumstances individual interest remains at its starting position. The fact that this study replicated the outcomes of Study 1 attests, in our view, to the stability of our findings.

Second, we believe to have clarified the issue of the "maintenance" of situational interest as a precursor of the emergence of individual interest. Elsewhere, we have argued that situational interest, as an indicator of need for knowledge, cannot be maintained over time as it is satisfied when new knowledge is acquired (Rotgans & Schmidt, 2014b). In the studies presented in this paper we have proposed an alternative to the idea of maintenance of situational interest more in line with this interpretation of what this type of interest is about: Individual interest increases when students' situational interest is repeatedly reinforced by *new* instructional events designed for this purpose. Of course, this does not preclude the possibility that there are other means to keep situational interest going. The present formulation of the four-phase model does however not contain clues as to how that may happen. Finally, some authors seem to identify "maintained situational interest' with Dewey's "hold" phase in his "catch" and "hold" conception of interest (Dewey, 1913). Since Dewey does not distinguish between situational and individual interest, his "hold" may very well refer to individual interest rather than to situational interest.

Finally, another difficulty with the four-phase model as it stands, is that it is hard to differentiate between phase 3 (emerging individual interest) and 4 (well-developed individual interest). What makes individual interest well developed? The level of individual interest attained? Stability of individual interest over time? Maintenance independent of further stimulation? A combination of the three? Although we implicitly assumed that the measurement time frame of both our studies was too short to allow for measurement of well-developed individual interest, taking a post hoc look at our data, it appears that there are signs that at least some students had already reached the stage of well-developed individual interest. Inspecting the changes at item level over the four-week period, we observed a significant increase in the score on the item "*Outside of school I read a lot about science*" ($p < 0.05$). Some researchers would agree that engaging in activities related to the topic outside of school without external support can be considered a sign of well-developed individual interest. On the other hand, the item "*Later in life I want to pursue a career in science or a science-related discipline*" did not show significant differences over time. This may lead others, who see only the development of long-term career aspirations related to the topic as a sign of well-developed individual interest, to conclude that phase 4 has not yet been reached by our students.

The difficulty of conceptually and empirically differentiating between emerging and well-developed individual interest may be a reason why Krapp (2003), who proposed an earlier version of the model of interest development, only differentiates between three phases or stages: (1) triggered situational interest, (2) stabilized situational interest, and (3) individual interest. Krapp does not make a distinction between different phases of development of individual interest. Although investigating how individual interest develops over a longer timeframe (e.g., one semester, an academic year, a school career) is in our view essential for a better understanding of interest development, the above points raise the question whether it is possible, desirable, and of any practical value to distinguish conceptually between numerous phases in interest development. Maybe less is more here?

5. Shortcomings of the present studies and future research

The reader may have noticed that, in this article, we do not report on relations between measures of situational and individual interest and learning outcomes.[1] Why study interest if not for its effects on learning? First, disentangling the complex relationship between situational and individual interest is a necessity in its own right. Theories in this domain, such as Hidi and Renninger's, deal with the nature of this relationship exclusively, without postulating any influence on learning (such influence is only implicitly assumed). Second, we have published several other studies in which the influence of situational interest on learning outcomes was in fact the focus of attention. In these studies, we could demonstrate that situational interest once aroused directly influences the extent of learning, while arousal fades over time (Rotgans & Schmidt, 2011b, 2014b). A yet unpublished study attempted to relate both individual and situational interest to learning outcomes. This study showed that, unlike situational interest, individual interest has no direct influence on learning (Rotgans & Schmidt, submitted for publication). A final series of studies demonstrated that individual interest should be considered a byproduct of learning outcomes rather than a causal factor (Rotgans & Schmidt, in press). Taken together, these studies seem to support Patricia Alexander's model of domain learning (Alexander, Jetton, & Kulikowich, 1995). Alexander and her coworkers assume that at the beginning of a learning event situational interest is high and individual interest is low. While learning progresses, situational interest decreases whereas individual interest increases.

[1] In Study 2, we included in fact a pre- and a post-measure of knowledge. Students who were confronted with the problems learned significantly more than those who were not. This is in line with other findings in the problem-based learning literature (e.g. Loyens, Jones, Mikkers, & van Gog, 2015). However, a model including all three variables became too complex to interpret. Data of this part of the experiment can be obtained from the first author.

A second limitation of our studies is related to the previous one. Since interest and knowledge development are so closely intertwined, it would have been helpful if we would have included a measure of prior knowledge of our students as well. Since situational interest can only be aroused if students lack to some extent knowledge, we would have been in a better position to explain *why* the problems used triggered situational interest in these students.

We already pointed at another shortcoming of our second study that potentially limits our conclusions regarding the role of problems as instigator of situational interest. The treatment group received the problems *and* was allowed to formulate learning goals; in the control group students did not formulate learning goals because under direct instruction conditions it is the *teacher* who formulates these. Since our studies were carried out in actual classroom settings, asking students who did not receive problems to nevertheless formulate learning goals would have been highly artificial. Theoretically, the possibility exists that the presence or absence of student-generated learning goals rather than (or in addition to) the presence or absence of problems was responsible for the triggering of situational interest in the treatment group. However, the measurements of situational interest in the treatment group, from which aroused interest was computed, were always administered *before* students were asked to formulate learning goals. It is highly unlikely that an event later in time (formulating learning goals) would retroactively influence an event occurring earlier in time (arousal of situational interest). Therefore, we stand by our conclusion that the problems were responsible for situational interest arousal. This does not preclude the possibility that, having the opportunity to generate one's own learning goals may have influenced individual interest directly (i.e., not through situational interest arousal). In conclusion, we believe that we have demonstrated that problems as the source of situational interest influence the growth of individual interest. We have failed however in excluding the generation of learning goals by the treatment group as an additional influence on individual interest development. Further research is necessary here.

Our findings suggest that individual interest already shows some development over the relatively short period of four weeks. We did not investigate however how stable the change is in individual interest over a longer period of time. Therefore, future research needs to be conducted to clarify how much reinforcement through situational interest arousal is needed before individual interest stabilizes sufficiently to be considered a true disposition of a person. A further shortcoming of the present study is that we only covered one discipline and age group (i.e., primary school science). It is possible that qualitative differences between subject domains need to be taken into account. The possibility cannot be excluded that for some subject domains (e.g., mathematics: Frenzel, Goetz, Pekrun, & Watt, 2010; Freudenthal, 1981; Rotgans & Schmidt, 2014a) it is more difficult to develop individual interest than for others. Why is this so? Is it because of inherent characteristics of the subject domain, such as its perceived difficulty; or do cultural values in the student population play a role?

Finally, the four-phase model of interest development assumes that students are more or less "blank slates" in terms of their individual interest when they initially engage with a task at hand: situational interest comes first and then develops into individual interest. But is this a reasonable assumption? One can easily imagine that whatever new task students engage in, some level of individual interest pre-exists. This is a position supported by Alexander's model of domain learning (Alexander, Kulikowich, & Schulze, 1994; Alexander et al., 1995). One cannot exclude beforehand the possibility that pre-existing individual interest and perhaps other dispositional factors will influence the initial level of situational interest to a certain degree when a person engages with a new task (Ainley, Hidi, & Berndorff, 2002; Ainley, Hillman, & Hidi, 2002; Knogler, Harackiewicz, Gegenfurtner, & Lewalter, 2015; Tapola et al., 2013; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). How strong such influence of pre-existing individual interest is on situational interest at the beginning and *during* a learning task is a topic for future research.

Acknowledgment

This study was partially funded by the National Institute of Education (Nanyang Technological University) Singapore (ERFP Grant No: OER56/12IJR).

Appendix A. Problems for primary school science "properties of Light

A.1. Problem 1: The secret cave of Pulau Ubin

Not many people know this, but there is a hidden cave on Pulau Ubin, which was used during the Japanese occupation in WWII as a secret hideout. After the war most people forgot about it and since it is so well hidden nobody found it ever since.

Two good friends, Elaine and Teck Seng, who heard stories about the cave from Elaine's grandpa decided to go out and find the cave. According to their grandpa there are some treasures hidden in it—left behind by the people who were hiding from the Japanese.

After a long and very exhausting search through the mangrove forests of Pulau Ubin, Elaine and Teck Seng finally found it (see picture).

At first, Teck Seng is a bit scared to go in because it is a very deep cave and he does not know what they will find, but in the end his curiosity wins and he is determined to explore the cave.

Just when he wants to enter, Elaine says: "wait a minute Teck Seng, did you bring the torchlight, without it we cannot see in the dark cave!"

Teck Seng replies: "No need a torchlight our eyes will get used to the dark and we will be able to see, no worries."

Elaine protests: "without a torchlight we will not be able to see; I will not enter the cave without it!"

Who do you think is right?

A.2. Problem 2: Mysterious moonlight

Sometimes at night you can observe a full moon, shining bright in the sky lighting up the landscape.

Isn't it surprising that the moon, which is NOT a light source itself, can shine so bright at night so that we can see all the things around us? Where is the light coming from?

A.3. Problem 3: Keep the rays out

As we all know, Singapore is a hot place to be. As a result of it, there are many efforts to keep the sun out of buildings to keep it cool inside.

You may be surprised to find out how many different materials can be used to prevent sunrays from entering buildings through the windows. A key feature to consider is of course not to seal off the windows entirely so that it is too dark inside and you need to switch on the lights to be able to see.

What kind of materials do you think would be best suited to keep it cool inside and have sufficient light to see?

A.4. Problem 4: Amazing shadows

After dinner, you are on your way home from the local food court. It is already dark and you are on your bicycle. While cycling on the street you notice that when you approach a street lantern, your shadow gets first longer, then shorter when you close in and longer again when you passed the lantern.

You wonder how is this possible?

(Students are then shown a video that exemplifies the above description of the phenomenon).

References

Ainley, M. (2006). Connecting with learning: Motivation, affect and cognition in interest processes. *Educational Psychology Review, 18*(4), 391–405.

Ainley, M. (2012). Students' interest and engagement in classroom activities. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 283–302). New York, NY, US: Springer Science + Business Media.

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*(3), 545–561.

Ainley, M., Hillman, K., & Hidi, S. (2002). Gender and interest processes in response to literary texts: Situational and individual interest. *Learning and Instruction, 12*(4), 411–428.

Alexander, P. A., Jetton, T. L., & Kulikowich, J. M. (1995). Interrelationship of knowledge, interest, and recall: Assessing a model of domain learning. *Journal of Educational Psychology, 87*(4), 559–575.

Alexander, J. M., Johnson, K. E., Leibham, M. E., & Kelley, K. (2008). The development of conceptual interests in young children. *Cognitive Development, 23*(2), 324–334.

Alexander, P. A., Kulikowich, J. M., & Schulze, S. K. (1994). How subject-matter knowledge affects recall and interest. *American Educational Research Journal, 31*(2), 313–337.

Bergin, D. A. (1999). Influences on classroom interest. *Educational Psychologist, 34*(2), 87–98. http://dx.doi.org/10.1207/s15326985ep3402_2.

Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology, 45*(3), 180–191.

Berlyne, D. E. (1962). Uncertainty and epistemic curiosity. *British Journal of Psychology, 53*(1), 27–34.

Berlyne, D. E. (1978). Curiosity and learning. *Motivation and Emotion, 2*(2), 97–175.

Byrne, B. M. (2012). *Structural equation modeling with mplus: Basic concepts, applications, and programming*. New York: Routledge.

Cleary, T. J., Callan, G. L., & Zimmerman, B. J. (2012). Assessing self-regulation as a cyclical, context-specific phenomenon: Overview and analysis of SRL microanalytic protocols. *Education Research International, 2012*(1), 1–19. http://dx.doi.org/10.1155/2012/428639.

Dewey, J. (1913). *Interest and effort in education*. Cambridge: Riverside Press.

DiBenedetto, M. K., & Zimmerman, B. J. (2010). Differences in self-regulatory processes among students studying science: A microanalytic investigation. *The International Journal of Educational and Psychological Assessment, 5*, 2–24.

Duncan, T. E., Duncan, S. C., & Strycker, L. A. (2013). *An introduction to latent variable growth curve modeling: Concepts, issues, and application* (2nd ed.). Mahwah, NJ: Routledge Academic.

Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *Journal of Experimental Education, 72*(2), 93–114.

Frenzel, A. C., Goetz, T., Pekrun, R. H., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence, 20*(2), 507–537. http://dx.doi.org/10.1111/j.1532-7795.2010.00645.x.

Freudenthal, H. (1981). Major problems of mathematics education. *Educational Studies in Mathematics, 12*(2), 133–150.

Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of 'seductive details' on macroprocessing and microprocessing in adults and children. *Cognition and Instruction, 6*(1), 41–57.

Graham, J. W., Cumsille, P. E., & Elek-Fisk, E. (2003). Methods for handling missing data. In A. Schinka & W. F. Veliecer (Eds.). *Handbook of psychology: Research methods in psychology* (2, pp. 87–114). New York: Wiley.

Hancock, G. R., & Mueller, R. O. (2001). Rethinking construct reliability within latent systems. In R. Cudeck, S. d. Toit, & D. Sörbom (Eds.), *Structural equation modeling: Present and future - A festschrift in honor of karl jöreskog* (pp. 195–216). Lincolnwood, IL: Scientific Software International.

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100*(1), 105–122. http://dx.doi.org/10.1037/0022-0663.100.1.105.

Harter, S., Whitesell, N. R., & Kowalski, P. (1992). Individual differences in the effects of educational transitions on young adolescent's perceptions of competence and motivational orientation. *American Educational Research Journal, 29*(4), 777–807.

Hidi, S. (2006). Interest: A unique motivational variable. *Educational Research Review, 1*(2), 69–82.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111–127.

Høgheim, S., & Reber, R. (2015). Supporting interest of middle school students in mathematics through context personalization and example choice. *Contemporary Educational Psychology, 42*, 17–25.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55.

Iran-Nejad, A. (1987). Cognitive and affective causes of interest and liking. *Journal of Educational Psychology, 79*(2), 120.

Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. T. Y., & Camerer, C. F. (2009). The wick in the candle of learning: Epistemic curiosity activates reward circuitry and enhances memory. *Psychological Science, 20*(8), 963–973.

Kang, H., Scharmann, L. C., Kang, S., & Noh, T. (2010). Cognitive conflict and situational interest as factors influencing conceptual change. *International Journal of Environmental and Science Education, 5*(4), 383–405.

Knogler, M., Harackiewicz, J. M., Gegenfurtner, A., & Lewalter, D. (2015). How situational is situational interest? Investigating the longitudinal structure of situational interest. *Contemporary Educational Psychology, 43*, 39–50.

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education, 14*(1), 23–40.

Krapp, A. (2002). Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction, 12*(4), 383–409.

Krapp, A. (2003). Interest and human development: An educational-psychological perspective. Development and Motivation. *British Journal of Educational Psychology, Monograph Series II* (2), 57–84.

Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement, 70*(4), 647–671. http://dx.doi.org/10.1177/0013164409355699.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin, 116*(1), 75–98.

Loyens, S. M. M., Jones, S. H., Mikkers, J., & van Gog, T. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction, 38*, 34–42. http://dx.doi.org/10.1016/j.learninstruc.2015.03.002.

Muthén, L. K., & Muthén, B. O. (1998–2012). *Mplus statistical analysis with latent variables*. User's guide Los Angeles: Muthén & Muthén.

Park, B., Flowerday, T., & Brünken, R. (2015). Cognitive and affective effects of seductive details in multimedia learning. *Computers in Human Behavior, 44*, 267–278.

Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior, 27*(1), 5–10.

Renninger, K. A., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist, 46*(3), 168–184.

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement*. New York: Routledge.

Rotgans, J. I. (2015). Validation study of a general subject-matter interest measure: The Individual Interest Questionnaire (IIQ). *Medical and Health Science Education, 1*(1), 57–65.

Rotgans, J. I., & Schmidt, H. G. (in press). The relationship between individual interest and knowledge acquisition. *British Educational Research Journal*. http://dx.doi.org/10.1002/berj.3268.

Rotgans, J. I., & Schmidt, H. G. (submitted for publication). How individual interest influences situational interest and how both are related to knowledge acquistion. *The Journal of Educational Research*.

Rotgans, J. I., & Schmidt, H. G. (2011a). The role of teachers in facilitating situational interest in an active-learning classroom. *Teaching and Teacher Education, 27*(1), 37–42. http://dx.doi.org/10.1016/j.tate.2010.06.025.

Rotgans, J. I., & Schmidt, H. G. (2011b). Situational interest and academic achievement in the active-learning classroom. *Learning and Instruction, 21*(1), 58–67. http://dx.doi.org/10.1016/J.Learninstruc.2009.11.001.

Rotgans, J. I., & Schmidt, H. G. (2014a). Interest in subject matter: The mathematics predicament. *Higher Education Studies, 4*(6), 31–42.

Rotgans, J. I., & Schmidt, H. G. (2014b). Situational interest and learning: Thirst for knowledge. *Learning and Instruction, 32*(August), 37–50.

Rotgans, J. I., & Schmidt, H. G. (2014c). Situational interest and learning: Thirst for knowledge. *Learning and Instruction, 32*, 37–50. http://dx.doi.org/10.1016/j.learninstruc.2014.01.002.

Schmidt, H. G., Van der Molen, H. T., Te Winkel, W. W. R., & Wijnen, W. H. F. W. (2009). Constructivist, problem-based learning does work: A meta-analysis of curricular comparisons involving a single medical school. *Educational Psychologist, 44*(4), 227–249.

Schraw, G. (1998). Processing and recall differences among seductive details. *Journal of Educational Psychology, 90*(1), 3–12. http://dx.doi.org/10.1037//0022-0663.90.1.3.

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review, 13*(3), 211–224.

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*(1), 23–52. http://dx.doi.org/10.1023/a:1009004801455.

Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's Alpha. *Psychometrika, 74*(1), 107–120.

Tapola, A., Veermans, M., & Niemivirta, M. (2013). Predictors and outcomes of situational interest during a science learning task. *Instructional Science, 41*(6), 1047–1064. http://dx.doi.org/10.1007/s11251-013-9273-6.

Tsai, Y., Kunter, M., Lüdtke, O., Trautwein, U., & Ryan, R. M. (2008). What makes lessons interesting? The role of situational and individual factors in three school subjects. *Journal of Educational Psychology, 100*(2), 460–472. http://dx.doi.org/10.1037/0022-0663.100.2.460.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review, 6*(1), 49–77.

Zimmerman, B. J., & Kitsantas, A. (2005). The hidden dimension of personal competence: Self-regulated learning and practice. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 509–526). New York: The Guilford Press.