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ORIGINAL PAPER

The relationship between secondary school students' situational interest and their collaborative learning interactions

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Abstract

Situational interest can be a prominent driver for learning, but little is known about how it is connected to the type of interactions students engage in during collaborative learning. To address this gap, we collected data from 94 secondary school students who worked on collaborative tasks during a five-session science course. Students reported their situational interest before and after every collaborative task. The collaborative sessions were videotaped. Based on the differences in situational interest variation, the students were assigned to three situational interest clusters. The differences in the level and trend of interactions were then statistically examined between the clusters. The results showed that the students whose situational interest increased had a higher level of cognitive interaction ($U=6704.5$, $p=0.04$) and more rapid growth in cognitive (t (196)$=-2.42$ and -3.62, $p<0.01$) and socio-emotional (t (196)$=-1.81$ and -3.48, $p<0.05$) interaction than other students. Instead, those students whose situational interest decreased showed more rapid growth in off-task interaction (t (196)$=2.59$, $p=0.01$). To maintain an optimal level of situational interest, the findings also suggest paying attention to off-task interactions during collaboration, in addition to cognitive interaction.

Keywords Interest in learning · Situational interest · Cognitive interaction · Socio-emotional interaction · Collaborative learning

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Introduction

The extent to which students are interested in a task makes a difference. Research has systematically shown that more interested students engage more in learning (Azevedo 2013; O'Keefe and Linnenbrink-Garcia 2014; Patall et al. 2016; Steinhoff and Buchmann 2017; Thomas and Kirby 2020), better regulate their behaviour (Neitzel et al. 2016; Renninger and Hidi 2019; Sansone et al. 2015; Thoman et al. 2017) and are more motivated to pursue goals (Harackiewicz et al. 2008; Renninger and Hidi 2019). They are also more persistent in the face of challenges (Endres et al. 2020; Thoman et al. 2011; Tulis and Fulmer 2013) and prone to apply the concepts learned at school in their everyday life (Heddy et al. 2021). Students who initially lack interest, however, can still cultivate it through the learning process and, therefore, increase their educational opportunities (Renninger and Hidi 2020).

Whether students' interest will change during a lesson greatly depends on the learning environment (Renninger and Hidi 2019, 2020). For example, novelty (Bergin 1999; Palmer 2004, 2009; Tapola et al. 2013), context personalisation (Bernacki and Walkington 2018; Harackiewicz et al. 2016; Walkington and Bernacki 2019), the usefulness of a task (Harackiewicz et al. 2016; Hulleman et al. 2017) and the use of technology (Niels Bonderup Dohn and Dohn 2017; Fryer et al. 2019) have all been associated with enhancement of interest. Also, the roles of a supportive climate (Dorfner et al. 2018; Xu et al. 2012), group work (Mitchell 1993; Palmer 2004; Renninger et al. 2019) and social interaction (Bergin 1999, 2016; Fryer et al. 2016, 2021a, b; Palmer 2009; Thoman et al. 2007) in interest development have been argued for, making researchers wonder whether collaborative learning, which involves working in groups and continuous interaction towards a shared goal (Dillenbourg 1999; Laal and Laal 2012), could be a supportive context for student interest.

Collaborative learning has taken a solid place in both learning research and practice, with a strong justification that it can motivate and engage students' learning (Järvenoja et al. 2018). Accordingly, earlier research has found connections between interaction qualities in collaborative learning and individual situated emotional experiences (Mänty et al. 2020). However, the empirical findings on collaborative learning as a context for interest development have been mixed. Although we would expect collaborative learning to promote student interest, several studies have shown otherwise (Lavonen et al. 2021; Loukomies et al. 2015). Exploring the relationship between students' interactions during collaboration and their interest changes could bring new insights into increasing student interest in school subjects because the decline in interest during school, especially in science, has been a great concern (Drymiotou et al. 2021; Krapp and Prenzel 2011; van Griethuijsen et al. 2015). Thus, the present study aims to understand the relationship between students' interactions and their interest during collaborative learning.

Situational interest and how it manifests in a learning task

Interest is a psychological state inclusive of cognitive and affective components; it is typically manifested in a learning environment through student engagement with content (Hidi and Renninger 2006; Renninger and Hidi 2011). According to the four-phase model of interest development, interest represents a developmental process tied to deepening knowledge and value, which can progress in a linear or nonlinear way (Renninger and Hidi 2011, 2022). Interest development starts when students respond with heightened attention and arousal to certain environmental stimuli, meaning that their situational interest is triggered. Given that students' engagement with content continues, which is especially likely when content is meaningful to them (Harackiewicz et al. 2000; Mitchell 1993), their triggered situational interest evolves into maintained situational interest. With further engagement and a growing personal connection to the content, situational interest emerges before then leading to well-developed individual interest.

In the present study, we have focused on the initial phase of interest development, that is, situational interest. Even though situational interest represents an infancy phase of more durable individual interest, its role should not be underestimated. Situational interest has been found to facilitate conceptual change (Nieswandt 2007; Thomas and Kirby 2020) and knowledge acquisition (Romine et al. 2020; Rotgans and Schmidt 2011, 2018). More than individual interest, situational interest has appeared to impact affect, learning perceptions and engagement in an authentic science classroom (Beymer et al. 2020). Compared with individual interest, it has also been noted as a more powerful predictor of learning outcomes (Potvin et al. 2022).

In line with the theoretical conceptualisation of situational interest, empirical studies have shown that situational interest fluctuation highly depends on the surrounding learning context (Hidi and Renninger 2006; Renninger and Hidi 2011, 2020). For instance, in a study of 706 UK undergraduate students, Quinlan (2019) confirmed the hypothesis that situational factors had a major effect on situational interest compared with personal factors. Moreover, using a sample of 327 German high school students, Knogler et al. (2015) tested 'how situational is situational interest' (p. 39), concluding that situation-specific factors had a strong effect on students' situational interest, while their pre-existing individual interest was not a significant predictor.

The strong link between situational interest and the learning context, as well as the malleability of situational interest (Renninger and Hidi 2020), shows the need for researchers to observe situational interest changes during a task, which can be positive (Endres et al. 2020), negative (Albert et al. 2022; Nuutila et al. 2021), mixed (Rotgans and Schmidt 2011) or not happen at all (Shubina et al. 2021).

Even though negative or mixed changes in situational interest have been less reported in the literature, studies show that they are not rare. For instance, Fulmer and Tulis (2013) reported a decline in middle school students' situational interest over four measurement points, while Rotgans and Schmidt (2011) identified situational interest decreases and increases throughout the day based on five measurement points.

Moreover, stimulating learning designs do not guarantee that significant changes in situational interest will occur (e.g. Shubina et al. 2021; Tapola et al. 2013). For

example, in Tapola et al.'s research (2013), fifth and sixth graders in Finland participated in a computer-based science stimulation settled in two learning conditions and were asked to report their situational interest three times during the task. Surprisingly, the results showed that students' situational interest stayed at a stable high level during the task, despite the learning condition.

Frequently, students' situational interest does not change during a task because the initial level of such interest often defines its subsequent levels (Ainley et al. 2005; Fryer et al. 2021b; Knogler et al. 2015). For instance, with a sample of postgraduate students in Hong Kong, Fryer et al. (2021a, b) identified strong interconnections between proximal situational interest levels during an introductory teaching course. Also, in Dohn's (2021) research conducted with upper secondary students in Denmark in a collaborative science context, there was evidence of the interdependence of situational interest measures.

Therefore, when we observe situational interest fluctuations, it is important to uncover what learning environment features they can be associated with. To use the full potential of situational interest for better learning, researchers and educators are challenged to find and design learning contexts that can not only trigger situational interest, but also maintain it.

Situational interest and collaboration: the role of social interaction

In their systematic review, Potvin and Hasni (2014) mentioned collaboration as a way to improve students' interest in science and technology. Indeed, the social component of collaborative learning looks promising for situational interest enhancement because social interactions during learning give opportunities to share values and create a sense of relatedness to the content (Azevedo 2015a, b; Linnenbrink-Garcia et al. 2013). For instance, Bergin (2016), as well as Järvelä and Renninger (2014), noted how students' social experiences and social interactions are particularly important for their interest development at school. Empirically, with a sample of Australian secondary school students, Palmer (2009) identified social involvement as the main source of situational interest.

However, the answer to the question of how social interaction relates to students' situational interests is not crystal clear. For example, Lai (2021) recently investigated the relationships between Taiwanese university students' interest, peer interaction, and engagement in a group-based flipped learning context. Interestingly, the results of a moderated multiple regression showed a significant positive link between interest and engagement, as well as between peer interaction and engagement, but they found no significant relationship between interest and engagement under the condition of high peer interaction.

Another issue is that the research on interest in the collaborative learning context is somewhat limited, even though it appears to have increased in recent years (Huysken et al. 2019; Shubina et al. 2021; Toli and Kallery 2021). For example, in qualitative research, Huysken et al. (2019) interviewed teachers who reported an increase in their undergraduate students' situational science interest after a collaborative science project. In contrast, Lavonen et al.'s (2021) findings for Chilean and Finnish sec-

ondary school students indicated that collaborative learning did not predict Chilean students' situational interest and had a negative effect on Finnish students' situational interest.

The limited and sometimes contradictory research on collaborative learning may reflect the challenges that collaborative learning settings imply. Productive collaboration might not occur because some students feel uncomfortable when they have to socialise with others (Isaac et al. 1999). For example, in Thoman et al.'s (2007) study, only half of the college students chose to work on a task in groups. Renninger and Hidi (2019) noted that working in a group is not a universal interest trigger, especially for students who are less social. Moreover, a high level of interaction during collaboration is not always a sign of productive work. During collaboration, students can be distracted by off-task conversations, which is one of the reasons why group work does not always catch their interest (Renninger et al. 2019). These issues highlight the importance of understanding the interaction processes in collaborative learning that facilitate or hinder interest development. Specifically, research has used the concepts of cognitive and socio-emotional interaction to understand shared cognitive and emotional processes during collaborative learning (Bakhtiar et al. 2018; Isohätälä et al. 2020; Järvelä et al. 2016; Järvenoja et al. 2020a, b). Socio-emotional interaction refers to students' expressions of their emotions and motivation, reflecting the socio-emotional climate in a group (Bakhtiar et al. 2018; Isohätälä et al. 2020; Mänty et al. 2020; Rogat and Linnenbrink-Garcia 2011); it plays an important role in establishing the feeling of social relatedness to other group members (McMillan 1996), which has been noted as an interest-increasing intervention (Bergin 1999). Cognitive interaction includes verbalisations about goals, task content and knowledge construction processes (Hmelo-Silver and Barrows 2008; Isohätälä et al. 2020; Järvelä et al. 2016). It is typically task focused and facilitates student regulation processes, leading to more productive collaboration (Hadwin et al. 2017; Isohätälä et al. 2020).

However, the relationship between these different interaction processes and interest development in collaborative learning remains unexplored. With this rationale, we aim to investigate how individual students' engagement in different types of interactions during collaborative learning is connected to the changes in their situational interests. Specifically, we have addressed the following research questions:

RQ1 What are the differences in the level of interaction during collaborative learning between students with different situational interests?

RQ2 What are the differences in the trend of interaction during collaborative learning between students with different situational interests?

Methods

Participants and procedure

The participants were seventh graders ($N = 94$; 62% female) in a public secondary school in northern Finland. The students were approximately 13 years old and had similar socio-economic backgrounds. Based on previous grades, four of the school's science teachers divided the students into 30 homogeneous three–four-member groups. In these groups, the students participated in five once-a-week 90-minute collaborative learning sessions dedicated to light and sound topics. The science context was chosen because students often lack interest in scientific disciplines (Maltese et al. 2014; Maltese and Tai 2010). The collaborative session design is illustrated in Fig. 1 (for more detailed information, please see Järvenoja et al. 2020a, b).

The collaborative learning design was based on the idea of a flipped classroom, which is a structure that requires students to actively participate in learning both before and during sessions (Erbil 2020; Jovanovic et al. 2019). Accordingly, the students' homework was to familiarise themselves with the topic beforehand. The flipped classroom structure and collaborative work were supported by the Qridi® technology-based environment (Qridi 2018), which is available on students' tablets. The Qridi® tool was also used to access students' situational interest.

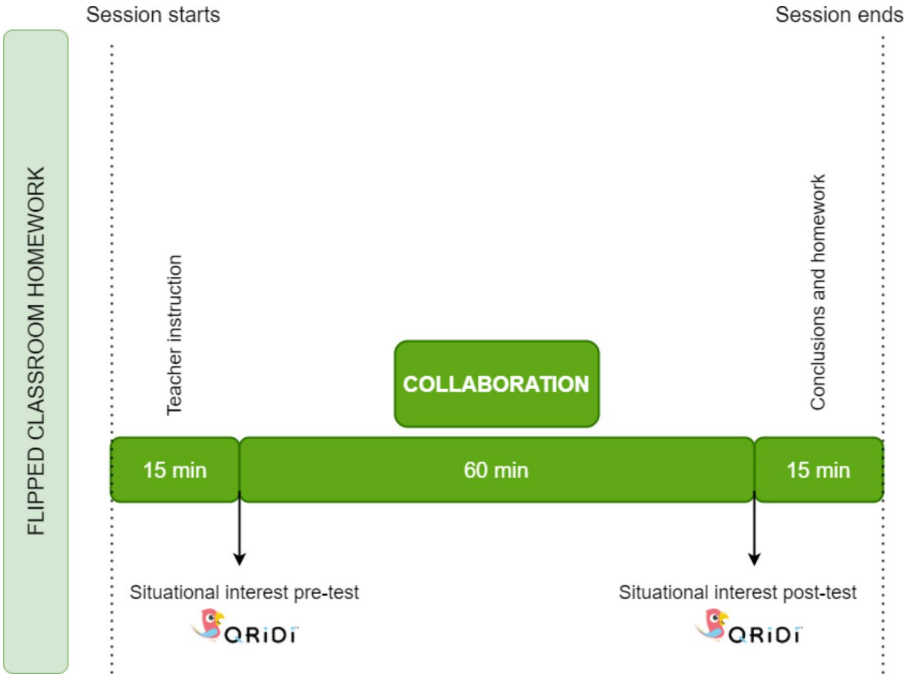

Fig. 1 Illustration of collaborative session design. The figure was created in Diagrams.net

Ethical issues

This study followed the research ethics guidelines of the Finnish Advisory Board on Research Integrity (2019). The study had a data management and security plan that made clear how the data would be handled according to the relevant laws and regulations in every phase of the study. Participation was voluntary, and the students could withdraw from the study at any point.

The Finnish Advisory Board on Research Integrity (2019) requires researchers to comply with the principle of informed consent; therefore, written consent was asked from the students and their guardians. Both consent forms were required for participation. Before signing the consent form, participants and guardians received an information letter explaining the details of the study. Hence, the students and their guardians were properly informed about data sources, data collection methods, personal data processing, storage of the data and transfer and destruction. We also met the students in person prior to the actual research period, and we explained the research focus and procedure while providing them with a chance to ask questions from the research team. When giving permission, the participants could indicate whether they allowed videos and photos to be used in research articles or conference presentations.

The participants' anonymity was guaranteed by the use of ID numbers during data processing. In the numerical data (self-reports), students' names were replaced with these numbers at the very beginning of the data analysis, and the numbers were also used while analysing the video data.

The data collection was part of normal school activities and, hence, did not require extra effort or time from the participants outside of the regular school day. If a student did not participate in the study, it was arranged so that the student could still participate in normal classroom activities.

Data channels

To answer our research questions, we chose a multichannel, process-oriented approach because it allows us to track real-time fluctuating students' interactions and assess the overall shift in their situational interest (Azevedo and Gašević 2019; Järvelä et al. 2019). In addition, we believe that our variables (situational interest and students' interactions) necessitated two different data channels. Situational interest is difficult to capture through video data, while students' interactions are best tracked through video data. Even with these challenges (i.e., synchronisation), we think that bringing self-report and video data sets together gave us an advantage in having a more in-depth look at the learning process.

The benefits of the multichannel approach compared with single-channel approaches have been quite widely recognised (for a review, see Sharma and Giannakos 2020). For instance, it has allowed us to see the learning process from both the students' and teachers' perspectives (Prieto et al. 2018), to give more insights into complex learning situations (Järvenoja et al. 2020a, b) and to identify processes that would not be possible to see otherwise (R. Azevedo 2015a, b). Moreover, a multichannel, process-oriented approach has been successfully implemented in similar collaborative learning settings (e.g., Dindar et al. 2019; Malmberg et al. 2019), show-

ing that it can be especially suitable for our context. Next, we discuss the specific data channels used in the study: situational interest self-reports and students' interaction video data.

Students' situational interest during collaborative learning sessions

The students used the Qridi® tool on their tablets to evaluate their current situational interest (Tapola et al. 2013) using a 100-point slider at the beginning and end of each collaborative learning task (Fig. 2). It was explained to the students that their responses did not affect their grades.

Situational interest was assessed with a single-item measurement because of our desire for a brief, nonintrusive procedure. A single-item measurement interferes less with the actual learning process and has been recognised as an appropriate instrument for measuring situational constructs (Ainley et al. 2002; Goetz et al. 2016). Additionally, the measurement of interest at the task level was chosen to represent both triggered and maintained situational interest, following the developmental (Hidi and Renninger 2006; Krapp 2002) theoretical framework (for the empirical evidence, see also Knogler et al. 2015).

Test–retest reliabilities were calculated to assess the reliability of the self-report instrument. Interclass correlation coefficient (ICC) estimates and 95% confidence intervals were computed using SPSS 25.0 (IBM Corp. 2017) based on an absolute agreement, two-way random effects model. The test evidenced a high degree of reli-

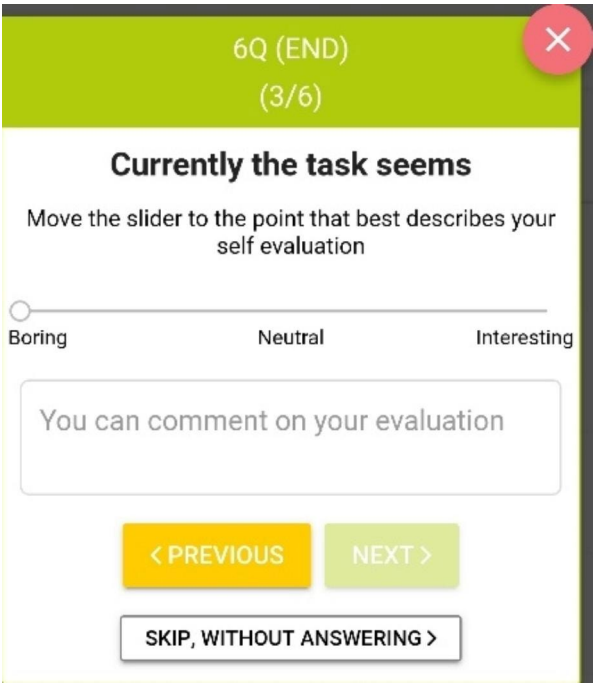

Fig. 2 Interface of situational interest measurement in the Qridi® application. The screenshot was taken from the Qridi software

ability. Specifically, the average measured ICC for situational interest was 0.882, with a 95% confidence interval from 0.816 to 0.932 ($F(36,324)=9.493$, $p<0.001$).

Student interactions during collaborative learning sessions

Student interactions during sessions were recorded with microphones and Insta 360 Pro 360-degree cameras. Because of the authentic school setting, three to nine groups were simultaneously present in the observed science classroom. The groups' compositions remained the same throughout the science course, even though they were occasionally affected by student absences. Altogether, 225 h of video data were collected.

Data analysis

Student interaction during collaborative learning

Video data (225 h) were analysed with a coding scheme that was developed through several phases. First, preliminary coding categories were identified according to previous research on student interactions in collaborative learning (Bakhtiar et al. 2018; Järvelä et al. 2016; Rogat and Linnenbrink-Garcia 2011). Student interaction was defined as a reciprocal verbal exchange between two or more group members. Second, the coding protocol was discussed multiple times and further adjusted after viewing the videos. After the final testing, student interaction was coded according to the following categories: (1) cognitive, (2) socio-emotional and (3) other interaction. Cognitive interaction included, for example, a discussion about task understanding, task goals, prior knowledge and ways to solve the problem. Socio-emotional interaction was represented by emotional expressions with indicators of affect. Other interactions involved off-task discussions, such as conversations about other coursework and personal life stories.

A time-based analysis was conducted using Observer XT12 software (Noldus 2014). The data were segmented into 30 s events and coded according to the three interaction categories. The time frame of 30 s was chosen because it is long enough to allow valid judgements of behaviour and make detailed observations. The coding categories were not mutually exclusive. Examples of the coding categories are presented in Table 1.

To ensure reliability, 10% of the data were coded by a second researcher. Both researchers were involved in qualitative discussions regarding specific codes. Cohen's kappa value was calculated to measure inter-rater agreement for coding the cognitive ($\kappa=0.72$), socio-emotional ($\kappa=0.77$) and other ($\kappa=0.87$) interactions. Cohen's kappa values reached a commonly used threshold of 0.70, indicating that the analysis was conducted reliably (Landis and Koch 1977).

Table 1 Video coding scheme interaction examples

Type of interaction	Examples
Cognitive	*'Okay, what are our goals?'* *'Isn't this the first task? About volume?'* *'No, it is this way. We did this yesterday in math'.* *'I don't think that we have time to do that. [The teacher] is already writing down the homework'.*
Socio-emotional	*'You sound like a hamster!' *laughter** *'How are you able to draw such straight lines without a ruler? Look! She didn't even use a ruler to draw this line!'* *'Can he be quiet? The mic doesn't like it when he does that all the time'.*
Other	*'Maybe [the teacher] was talking about who will be in our group during home economics class'.* *'What grade did you get on the health education exam?'* *'I have to make [mug phones] with Jenny, so we can talk to each other from our balconies'.*

Table 2 Descriptive statistics of change in situational interest across clusters

Clusters	*N*	*M*	*Mdn*	*SD*
Positive	60	41.18	36.5	13.48
Moderate	269	1.82	0	11.43
Negative	41	–43.76	–38	17.1

Note. *N* = number of cases; *M* = mean value of change; *Mdn* = median value of change; *SD* = standard deviation of change

Establishment of situational interest clusters

Students' reports on their situational interest over five collaborative learning sessions were pooled into a single dataset, resulting in a sample of 470 cases used in the data analysis. In 53 cases (approximately 11%), the students were absent, and in 47 cases (approximately 10%), the students were present in class but did not report their interest. Subtraction of the students' pretest scores from their posttest scores was performed. The outcome difference was not normally distributed, with a median (*Mdn*) of 1 and a median absolute deviation (*MAD*) of 12.5. The MAD was selected to divide interest difference data into three clusters because of the data distribution and its robustness to outliers (Elamir and Ao 2012; Lee et al. 2007). Specifically, the students were assigned to the *positive cluster* if the value was positive and fell beyond two median absolute deviations (values ≥ 26). Unless otherwise stated, the positive cluster included students with an exceptional increase in situational interest. In the opposite case, the students were allocated to a *negative cluster* (values ≤ −24). All the other students who reported their situational interests were marked in the *moderate cluster*. The Kruskal–Wallis H test demonstrated a statistically significant difference in situational interest change values between clusters ($H(2) = 226.154$, $p < 0.001$), with a mean rank score of 344.5 for positive, 178 for moderate and 21 for negative. Table 2 shows the descriptive statistics for each cluster.

Table 3 Descriptive statistics of interaction types across clusters

		Interaction								
		Cognitive			Socio-emotional			Other		
SI clusters	*N*	*M*	*Mdn*	*SD*	*M*	*Mdn*	*SD*	*M*	*Mdn*	*SD*
Positive	60	49.42	47.5	23.69	34.92	27.5	25.77	12.4	6.5	14.7
Moderate	269	42.6	40	21.54	32.44	27	25.17	14.29	8	17.27
Negative	41	44.1	45	20.57	35.83	36	25.79	16.68	9	21.03

Note. SI stands for situational interest; *N* = number of cases; *M* = mean of interaction level; *Mdn* = median of interaction level; *SD* = standard deviation of interaction level.

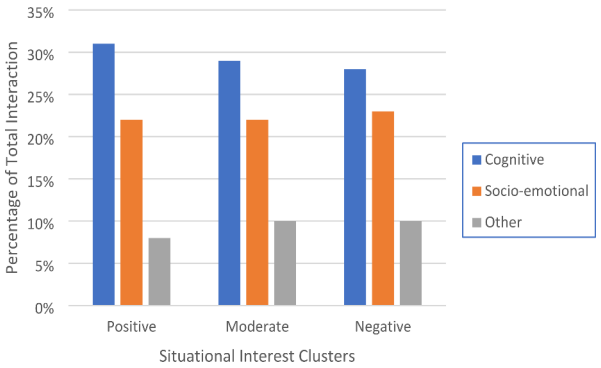

Fig. 3 Distribution of interaction types across situational interest clusters. The figure was created in Microsoft Excel

Final analysis phase

After the data from the two data sources had been processed separately, the analysis proceeded to its final phase. To answer the first research question, the sum of interactions (cognitive, socio-emotional and other) during collaborative learning for each of 370 cases was calculated. Table 3 presents the descriptive statistics for these variables for each situational interest cluster. Kruskal–Wallis H and Mann–Whitney U tests were conducted to examine the differences in the level of interaction between situational interest clusters. Nonparametric tests were used because not all the data were normally distributed. However, all clusters were similar in distribution shape.

To answer the second research question, the original data of the students' interactions were divided according to the three clusters. The mean interaction value for each 30 s segment was calculated for each cluster separately and plotted on the timeline in the Tableau programme. The timeline started from the 20th minute and stopped at the 70th minute of the task because approximately the first and last 20 min of the task were mainly teacher-led and involved few student interactions. The trend slopes were built based on linear regression models and compared using a test of the difference between two independent slopes (Howell 2010, pp. 273–5).

Results

RQ1: What are the differences in the level of interaction during collaborative learning between students with different situational interests?

The results showed that all situational interest clusters were similar in terms of how the level of interaction types was distributed: during collaborative learning, the students across all clusters engaged the most in the cognitive (28–31%) and socio-emotional (22–23%) interactions, followed by about 8–10% of other interactions. Figure 3 shows the levels of interaction types across the situational interest clusters. The most evident difference was for students in the *positive cluster*; who had the highest level of cognitive interaction (31%) and lowest level of other interactions (8%) compared with the students in other clusters.

However, the Kruskal–Wallis H and Mann–Whitney U tests showed no statistically significant differences in the level of students' interaction across situational interest clusters, with one exception. Specifically, the results of the Mann–Whitney U test indicated that the students in the *positive cluster* ($Mdn = 47.5$) had significantly more cognitive interactions compared with the students in the *moderate cluster* ($Mdn = 40$), $U = 6704.5$, $p = 0.04$, with a small effect size ($z = 0.11$). Table 4 summarises the results of the Mann–Whitney U test on cognitive interaction across situational interest clusters.

RQ2: What are the differences in the trend of interaction during collaborative learning between students with different situational interests?

Figure 4 presents the mean level of cognitive, socio-emotional and other interactions over time across situational interest clusters and includes the trend lines built on linear regression models.

The results showed a similar growing trend for cognitive, socio-emotional and other interactions during collaborative learning across all situational interest clusters. However, the test of the difference between two independent slopes (t) indicated that the students in the *positive* cluster had significantly more rapid cognitive ($t\ (196) = -2.42$, $p = 0.008$ and $t\ (196) = -3.62$, $p < 0.001$) and socio-emotional ($t\ (196) = -1.81$, $p = 0.035$ and $t\ (196) = -3.48$, $p = 0.003$) interaction growth compared with students in the *negative* and *moderate* clusters, respectively. In addition, students in the *negative cluster* exhibited significantly more rapid other interaction growth compared with students in the *moderate cluster*, $t\ (196) = 2.59$, $p = 0.01$.

Table 4 Difference in cognitive interaction across situational interest clusters

Cluster comparison	*N*	*Mdn*	*Mean rank*	*Mann–Whitney U*	*p*	*z*
Positive and Moderate						
Positive	60	47.5	187.76	**6704.5**	**0.04**	**0.11**
Moderate	269	40	159.92			
Negative and Moderate						
Negative	41	45	163.8	5174	0.524	0.04
Moderate	269	40	154.23			
Positive and Negative						
Positive	60	47.5	53.39	1086.5	0.321	0.09
Negative	41	45	51.83			

Note. Significant differences are shown in bold. *N* = number of cases; *Mdn* = median of interaction level; *z* = effect size of the difference in interactions.

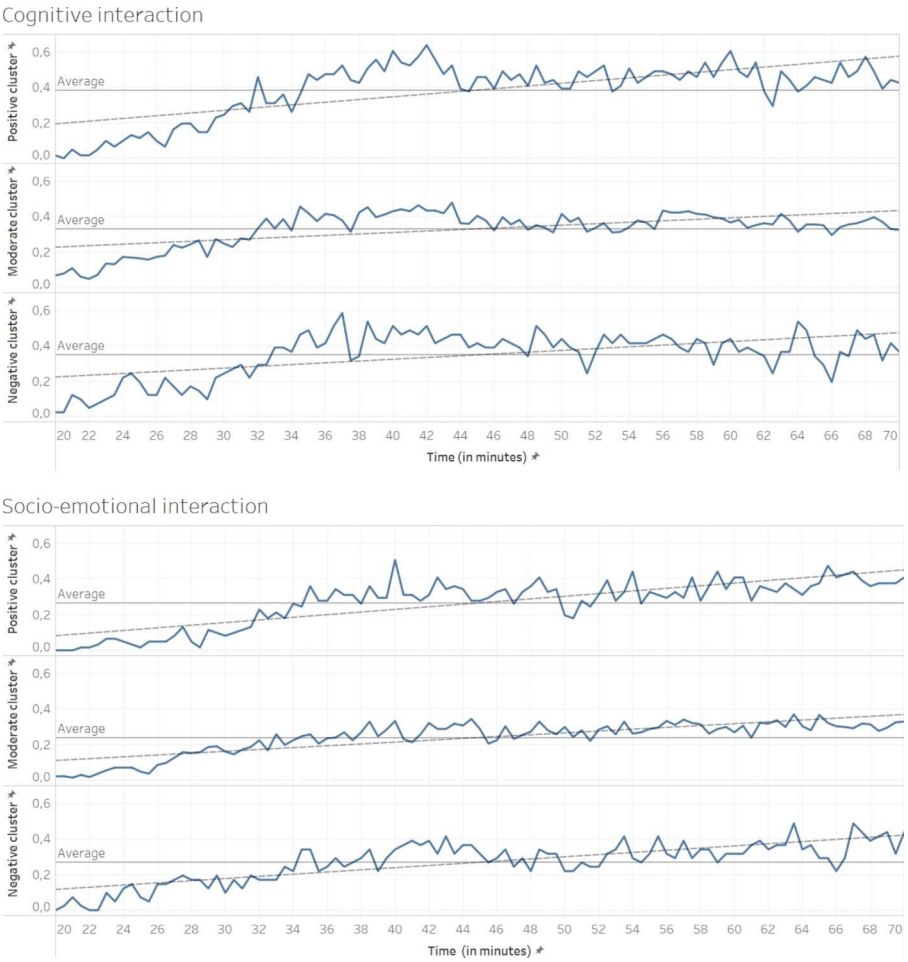

Fig. 4 Student interaction fluctuation across situational interest clusters during collaborative learning. The figure was created in Tableau programme

Discussion

In the present study, we have explored how secondary school students' situational interest was related to the way they engaged in interactions with their group members during collaborative learning tasks. Particularly, we were interested in finding out whether students whose situational interest changed during a collaborative learning task differed in their cognitive, socio-emotional and off-task interactions during the task.

Overall, the results show the interconnections between the students' situational interest and their participation in collaborative interactions. Generally, the results are in line with those of earlier empirical studies, confirming, albeit in rather different contexts, a positive relationship between situational interest and social interaction. For instance, Thoman et al. (2007) found that the more psychology undergraduates

discussed the attended group task, the more interesting the task appeared to them, irrespective of their choice to participate in group work. Moreover, their participation in dyads revealed that peer talk about a computer game with an attentive listener played a crucial role in their interest in the activity. Similarly, Fryer et al. (2021a, b, 2021) showed how participation in social discussion tasks made a significant contribution to university students' subsequent interest. Comparing the experimental and control groups of high school students, Toli and Kallery (2021) concluded that whole-class discussions during science lessons stimulated student interest.

Our findings add to the literature by showing that the relationship between situational interest and social interaction is more complex than it might seem at first glance. That is, the overall level of interaction was not a good indicator of the changes in situational interest in the collaborative learning context, but it was the trend of interaction. Specifically, there was only one case of a significant difference in the overall level of interaction, indicating that students who reported a considerably higher situational interest after collaboration had a higher overall level of cognitive interaction during collaborative learning. Instead, more rapid growth in cognitive and socio-emotional interaction characterised those students who reported a considerably higher situational interest after collaboration, while more rapid growth in off-task interaction during collaborative learning characterised those students who reported considerably lower situational interest after collaboration.

Therefore, the results showcase how the temporal perspective can make a difference in understanding changes in situational interest. Moos and Azevedo's (2008) research represents another example of the importance of the temporal perspective. The authors measured undergraduate education students' situational interest before and three times during a task; they found a significant effect of time on situational interest. Specifically, the students' situational interest increased significantly throughout the task in both learning conditions. In line with this, several researchers have highlighted the importance of a process-oriented approach in collaborative learning contexts (Järvenoja et al. 2018; Nguyen et al. 2021).

In addition, our findings emphasise that we need to pay attention to the types of interaction during collaboration, especially to the role of cognitive interactions, because the results of the present study illustrated that situational interest enhancement was associated with the overall level of cognitive interaction only. This result supports Krapp's (2002) statement that the process of interest development is integrated with cognitive processes, such as goal setting. Likewise, Alexander (2003) noted that interest deepens together with deepening cognitive strategies. Empirically, Seidel et al. (2016) reported that cognitive activation fostered student interest in mathematics, while in Quinian's (2019) study, cognitive activation was a predictor of the students' situational interest in university lectures. Inversely, investigating conceptual change among U.S. university students, Thomas and Kirby (2020) found situational interest as having a significant direct effect on cognitive engagement.

In addition to the role of cognitive interaction in situational interest enhancement, a negative association between situational interest and the process of increasing off-task interaction was found. As illustrated in Pugh's (2004) qualitative examples, in contrast to students who were genuinely interested in learning content, some students become interested mainly in the opportunity to interact with peers. This is in line

with the well-known 'seductive details effect', when students' interest is triggered by entertaining stimuli, which ultimately results in them remembering only the stimuli, not the learning content (for a review, see Rey 2012).

The differences in how different types of interactions relate to the changes in situational interest might explain why, in some studies, collaboration is associated with students' situational interest and in others not. For example, in an experimental study by Toli and Kallery (2021), high school students in the experimental group who participated in a collaborative intervention showed significantly higher situational interest in physics. In contrast, Dohn (2021) found that students' contributions to a collaborative science project had only a small effect on their situational interest.

Finally, we would like to discuss some practical implications. The findings have indicated that, to hold an optimal situational interest level, practitioners should pay attention to how students interact during collaboration, for instance, whether off-task interactions are rapidly increasing. The effort put into monitoring the conditions that are favourable for students' situational interest will pay off. At the school level, Xu et al. (2012) demonstrated that scaffolding situational interest in science through various practices resulted in increased motivation to learn science among low-income students. At the educational policy level, Liu et al. (2022) reported how the integration of situational interest enhancement strategies into mathematics textbooks resulted in the successful implementation of Chinese curriculum reform in China. This evidence encourages educators and researchers to see interest development and how it can aid in learning.

Limitations

The present study also has some limitations. Although we were able to observe the process of evolving students' interactions over time, we could not monitor their situational interest fluctuation in the same way because this interest was measured only at the beginning and end of the task. Therefore, we cannot be sure if and how the changes in situational interest occurred during collaboration. One way to approach this issue would be to increase the frequency of the situational interest assessment (e.g., Loukomies et al. 2015); however, doing so has drawbacks, such as the interference the frequent assessment can have in students' work. Another way would be to use more process-oriented instruments for situational interest assessment, such as physiological (for a review, see Babiker et al. 2021) and observational (Loukomies et al. 2015) measures. Besides process-oriented approaches, qualitative methods might also be beneficial for gaining more insights into the social interactions and situational interest relationships in collaborative learning. For example, Kuo (2010) reported that the quality—but not the quantity—of mother–child interactions was associated with children's interest in science. Similarly, the application of a single-item measurement used in the present study has received both recognition (Ainley et al. 2002; Goetz et al. 2016) and criticism (Potvin et al. 2022). For instance, some researchers have argued that a single-item measurement cannot capture all dimensions of situational interest dimensions (Romine et al. 2016). Finally, the students' interaction

trend was represented by a mean, not individual value, because the individual value was dichotomous, not continuous.

Conclusion

Despite the limitations of the present study, the findings can be useful in understanding the relationship between situational interest and different types of interactions in a collaborative learning context. Overall, the current study supports the argument that interest development is complicated and that understanding it requires a closer look at the qualities of interaction processes in collaborative learning. Exploring them in greater detail in future research may provide insights into how collaborative learning interactions can be facilitated to maintain or increase student interest.

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Author contributions Järvenoja Hanna and Mänty Kristiina contributed to the study design and data collection. Material preparation and analysis were performed by Tatiana Shubina. The first draft of the manuscript was written by Tatiana Shubina and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability Restrictions apply to the availability of these data, because the dataset includes personalized data from minor participants, and so are not publicly available. The metadata are however available from the Etsin, Finnish Fairdata services: https://etsin.fairdata.fi/dataset/2dc7f39a-c849-41a2-8094-59247161b767.

Code Availability Not applicable.

Declarations

Ethical approval The study was approved by the Ethics Committee of Human Sciences, University of Oulu, Finland. This study followed the research ethics guidelines of the Finnish Advisory Board on Research Integrity (2019). The study had a data management and security plan that made clear how the data would be handled according to the relevant laws and regulations in every phase of the study. Please, see more details in the Ethical issues section.

Consent to participate Participation was voluntary. An information letter and a written consent were asked from the students and their legal guardians. Both were required for participation. Students could decline to participate and also stop the experiment at any point.

Consent for publication Not applicable.

Conflict of interest We have no financial interest or benefit arising from the direct applications of our research.

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