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Patterns of situational engagement and task values in science lessons

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ABSTRACT

Situational engagement is a key element in promoting students' maintained interest and focused attention in learning. Most research on students engagement has been variable-centered, and only few studies have examined situational patterns of student engagement. The present study used person-oriented approach (e.g., latent profile analysis with Mplus multigroup comparison and 3-step procedure) to examine patterns of students' situational engagement in science (e.g., situational interest, skills, and challenge), differences in the engagement patterns during regular vs. intervention science lessons, and the extent to which situational expectations and task values (e.g., attainment and utility values) are associated with engagement patterns. Chilean ninth grade students participated in the study using Experience Sampling Method (N = 77 students; 475 situational responses). Three patterns of engagement were identified: a) *medium interest and skills* (21% and 23% of the moments during regular/intervention lessons, b) *high interest and skills* (12% and 16%), and c) *low interest, skills, and challenge* (13% and 15%). Situational task values and expectations were positively associated with high and medium engagement patterns, especially during the regular science lessons.

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In the light of international research findings (OECD, 2007, 2015) fostering students' engagement, motivation, and optimal learning experiences has become a dominant concern due to students' increasing disengagement and boredom at school (Shernoff & Csikszentmihalyi, 2009; Stephan et al., 2011). Concerns about declining engagement have been expressed also in science domains where students' interest has been continuously decreasing (OECD, 2007; Osborne & Dillon, 2008; Zeyer et al., 2013). Similarly, the PISA 2006, 2015, and 2018 results showed that Chilean students' science enjoyment has been declining and performance ranking at the bottom (OECD, 2015, 2016, 2019), increasing concerns about the level of students' engagement in science, and intentions to find new ways to promote students' engagement.

Students' motivation and engagement vary in different classroom situations (Dietrich et al., 2017), emerging as diverse engagement patterns (see also Schnitzler et al., 2020). Hence, in the present study, patterns of situational engagement (e.g., simultaneous experiences of skills, interest, and challenge) (Inkinen et al., 2019; Linnansaari et al., 2015; Schneider et al., 2016) were examined during science class situations. While performing science activities in the classroom, students may experience high skills, interest, and challenge (high engagement), or low skills and interest but high challenge (disengagement). These engagement patterns can be captured by methods typically used in person-oriented approach (e.g., latent profile analysis, LPA) which enable researchers to identify various homogeneous patterns of students' situational experiences (von Eye & Bogat, 2006). Moreover, students who show high task motivation are typically highly engaged while doing their assignments (Martin et al., 2017). However, there is a lack of research examining the patterns of situational engagement, and their associations with concurrent situational motivation (Salmela-Aro et al., 2016). Consequently, the present study focused on examining these research questions. Situational engagement and motivation were measured using experience sampling method (ESM) via smartphones. ESM provides researchers a tool to capture students' experiences and behaviors in the moments they are occurring (Hektner et al., 2007), giving researchers broader insights about the phenomena of interest (see also Ainley & Ainley, 2011).

Because concerns about engagement in science have led to proposals to modify science teaching according to an interdisciplinary approach focused on scientific competencies' pertinence to students' everyday life (U.S. Department of Education, 2016), a secondary goal of this study was to compare patterns of engagement during regular science classes with those carrying out an intervention designed to follow the interdisciplinary science approach.

Situational engagement

Student engagement is a broad construct which exists in different grain sizes and can be conceptualized in multiple ways (Nguyen et al., 2018; Sinatra et al., 2015). The grain

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sizes can vary from microlevel (e.g., engagement in learning situations) to macrolevel (e.g., engagement of students in a class or school) (Sinatra et al., 2015), and often require new conceptualizations of engagement and/or new approaches of measurement (Nguyen et al., 2018). In the microlevel learning situations, students' engagement can be measured through their experiences of interest, skills, and challenge while performing different classroom activities (Linnansaari et al., 2015; Schneider et al., 2016). Research on situational engagement originates in studies on optimal experience, or flow, often described as experiences in which students feel so deeply engrossed in the activity in which they are involved and so enjoying the tasks at hand that other environmental factors and individual needs retreat to the background (Csikszentmihalyi, 1990). While experiencing flow individuals are engaged in challenging activities, which stretch their existing skills neither overstretching nor underutilizing them (Nakamura & Csikszentmihalyi, 2014). Much like Vygotsky's zone of proximal development, most learning occurs in situations where students take just one step beyond the skills they have already mastered (Shernoff & Csikszentmihalyi, 2008). Moreover, besides skills and challenge, concurrent interest plays an important role in students' situational engagement (Linnansaari et al., 2015; Schneider et al., 2016; Shernoff et al., 2014). Situational interest has been described as focused attention and a key element in continuing engagement (Hidi & Renninger, 2006; see also Rotgans & Schmidt, 2011; Shernoff et al., 2014). Using this conceptualization, high situational engagement can be described as moments when students experience high *interest* in their current tasks, combined with high confidence in their own *skills* to accomplish the tasks, which are also perceived as optimally *challenging* (Linnansaari et al., 2015; Schneider et al., 2016).

According to previous research students experience high situational engagement during approximately 15% of the classroom situations (Inkinen et al., 2020), suggesting that during the remaining classroom situations students experience other patterns of engagement (e.g., different combinations of situational interest, skills, and challenge). These different engagement patterns can be examined with person-oriented research (e.g., LPA) which, on the basis of clustering, seeks to identify different homogeneous patterns of students' situational experiences (von Eye & Bogat, 2006). However, to the best of the authors' knowledge, it yet remains to be examined what kind of patterns of skills, interest, and challenge are identifiable in natural settings (e.g., during classroom activities, as opposed to retrospectively).

While engagement research has increased in the past decade, only a small number of studies has examined students' engagement in science, and even a smaller number has focused on situational engagement in science domains (Schmidt et al., 2018). Simultaneously, researchers worldwide have expressed growing concerns about students' declining science interest (Jack & Lin, 2017; Mostafa et al., 2018; OECD, 2007; Osborne & Dillon, 2008; Zeyer et al., 2013), leading to development of a variety of enrichment programs that promote student participation and active learning (Penuel & Fishman, 2012; Valla & Williams, 2012). Previous studies have underscored the need for more engaging science instruction (Schmidt et al., 2018), and shown that interventions may promote students' achievement and self-regulated learning in science (Capraro & Corlu, 2013; Han et al., 2015). Consequently, in the present study the patterns of engagement were examined both during regular and intervention (designed to enhance students' engagement in science) lessons (Appendix).

Situational attainment- and utility values, and expectations

Aside from the way lessons are designed, which should impact students in a relatively homogeneous way, engagement can also be affected by individuals' motivation. According to the expectancy-value model (EVT; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), students' expectancy beliefs and subjective task values play an important role in achievement motivation, and have further consequences on students' persistence or giving up on a task, achievement, engagement, future course selection, and aspirations (Eccles & Wigfield, 2002; Martin et al., 2017; Wigfield & Eccles, 2000). Expectancies are students' assessment of how well they think they will perform in a specific task or domain (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). The value aspect of motivation includes constructs such as importance or attainment, utility value or usefulness of the task (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). Importance to oneself (e.g., attainment value) refers to the importance of doing well at a given task, whereas future importance (e.g., utility value) describes how well accomplishing the task would fulfill one's future plans and goals (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000).

Even according to the EVT task values and expectancies are associated with students' learning, persistence, and engagement (Eccles & Wigfield, 2002), these associations have seldom been tested in actual classroom situations. Research within the EVT (Eccles (Parsons), 1983) framework has typically examined the interindividual differences in students' motivation and learning, however, recent findings have highlighted the importance of examining also situational fluctuation in students' task values, expectations, and engagement (Dietrich et al., 2017; 2019; Tsai et al., 2008). Examining patterns of situational engagement together with task values will help teachers and practitioners to better understand how to support students' engagement during different classroom activities (see also Tsai et al., 2008). Moreover, high situational engagement and task values play a crucial role in skill development, persistence, aspirations, and ultimately, future science career choices (Sinatra et al., 2015; Tytler & Osborne, 2012).

Research questions

The present study sought answers to following research questions:

1. What kind of patterns of students' situational engagement (e.g., situational experiences of skills, interest, and challenge) in science can be identified?
2. Do these patterns reflecting varying levels of situational skills, interest, and challenge differ when regular science lessons are compared to those implementing an intervention?
3. To what extent situational utility and attainment values, and expectations are associated with the patterns of situational engagement during regular and science intervention lessons?

Method

Data collection

To measure students' situational interest, skills, and challenge in science lessons, ESM with smartphone technology was used. With the ESM procedure researchers are able to obtain data in the moment that students' experiences are occurring, thus reducing recall bias, and the potential for giving socially desirable responses (Mulligan et al., 2005). In the present study, the ESM instrument was transferred to the Paco mobile app (www.paco.com) using a web-based dashboard that allowed for instantaneous data uploading in addition to housing the data.

Students received a pre-programmed smartphone for a period of 9 weeks during the spring term 2017. Across the 9-week period, students were signaled during six physics lessons, and they were asked to respond to a set of identical items within a 15-minute window. The duration of each physics class was 90 minutes, and the signals were preprogrammed to occur thrice during each class: once approximately 30 minutes after the beginning, then 30 minutes later, and once approximately 10 minutes before finishing the class. All the students received the beeps simultaneously. On average, it took about 150 seconds to complete the ESM items, which were selected based on their performance in previous ESM studies (see also Schneider et al., 2016). In addition to students, teachers received a briefing of the study procedures. Approximately 54% of the signals occurred during intervention lessons.

Participants

The participants were 77 (N = 475 situational responses) Chilean ninth grade students (15% female, age M = 14.5) from two schools (one physics classroom from each school) in Santiago, Chile. The participating schools represented achievement diversity among Chilean students. Both schools were urban and the family socioeconomical status in one school was mostly middle class (though 9-34% of the students came from lower SES families), and in the other school approximately half of the families were middle class, while 34-52% of the students came from lower SES families. The schools and teachers were selected on a voluntary basis and all students in the physics lessons were asked to participate, on the basis of informed consent of their parents. The project followed the ethical protocol of the host university, which are in accordance with the international guidelines of human rights. The students' parents provided a written consent for students to participate, and students signed assent forms.

Measures

Situational Engagement. When signaled, students answered with a four-point Likert scale (1 = not at all; 4 = very much) to questions concerning their current activity and experiences (How did you feel about the activity you were doing [when you received the signal] skilled"; "interested"; "challenged") (Schneider et al., 2016).

Task Values and Expectancies were examined with three questions ("Was this [main activity] important for you?" (attainment value); "How important was this [main activity] in relation to your future goals/plans?" (utility value); "Were you living up to your expectations?" (expectancies); 1 = not at all; 4 = very much). The questions were based on previous research on EVT (Wigfield & Eccles, 2002), and modified to concern students' situational task values and expectations.

Regular Lessons were coded as 1; intervention lessons were coded as 2.

Analytic plan

The data were analyzed using latent profile analysis (LPA; Muthén & Muthén, 1998–2020) which is a type of finite mixture analysis based on the assumption that homogeneous patterns, i.e. latent classes, can be identified in the observed data, and that the parameters of these patterns can be estimated. Thus, LPA enabled us to examine whether naturally occurring homogeneous latent patterns of students' experiences can be identified according to their levels of situational interest, skills, and challenge (N = 475 situational responses). Compared to traditional cluster analyses, the advantage of LPA is that it is model based and uses statistical criteria for deciding the number of latent classes. The estimation was performed step by step starting from the one-class solution to estimate parameters for 2,3,…, *k*-class solutions.

All the analyses were performed using the Mplus statistical package (Version 8; Muthén & Muthén, 1998–2020). The estimation method was maximum likelihood estimator with robust standard errors (MLR). Because the moments were nested within students, the 'complex' option which adjusts the standard errors for non-independence of observations was used to control for the fact that moments were nested within students. The LPAs were performed for different latent pattern solutions, and the resulting fit indices and class frequencies were compared. Five criteria were used to decide the final number of classes: (a) the Bayesian information criterion (BIC), and (b) the Akaike information criterion (AIC), according to which the model with the smallest value is considered the best model; (c) the Vuong-Lo-Mendell-Rubin (VLMR) test of fit, which compares solutions with different numbers of profiles (a low *p*

value indicates that the *k* model has to be rejected in favor of a model with at leat *k* + 1 profiles); (d) entropy values, which determine classification quality (values close to 1 indicate clear classification) (Celeux & Soromenho, 1996); and (e) the clarity and interpretation of the profiles.

To determine the number of latent patterns and then to compare the final latent pattern solution between regular and intervention lessons the analyses were performed in two steps: First, the patterns were estimated for all the moments regardless of the lesson type (e.g., all the situations without dividing them in regular versus intervention situations) in order to test the feasibility of the latent profile analysis (e.g., where we were able to identify different patterns). Second, the patterns were estimated separately for moments during and outside of the intervention lesson using the multiple group (e.g., knownclass) option with LPA.

Next, to investigate the extent to which situational task values and expectations are associated with different engagement patterns, the two last steps of the manual 3-step procedure were conducted (Asparouhov & Muthén, 2014). In the 3-step procedure, after determining the number of latent patterns (step 1, as described above), the pattern probabilities for each situation in each pattern were saved in a new data set with the covariates (step 2), and using the new data set the role of the antecedents was examined further (step 3; see Asparouhov & Muthén, 2014 for further details of the analyses). The benefit of the 3-step procedure is that the forming of the latent patterns is free from the effect of the covariates.

Results

Patterns of students' situational engagement in science

The means, variances, and correlations between all the variables are presented in Table 1. In order to examine whether different patterns of students' situational interest, skills, and challenge could be identified, LPAs were performed. Table 2 presents the fit indices for the models with different numbers of latent patterns. The results showed that the VLMR test supported a two-pattern solution, whereas the BIC and AIC indices supported the four-pattern solution. The results for the four-pattern solution showed, however, that the only difference with the three-pattern solution was that in the four-pattern model one of the patterns split in two similar patterns, decreasing the clarity and interpretation of the results. Thus, as the clarity and interpretation of the three-pattern solution exceeded those of the other solutions, and also showed relatively good fit, the three-pattern model was chosen as the final latent pattern solution.

Table 1. Correlations between all the variables (N = 475 situational responses).

	1.	2.	3.	4.	5.
1. Skills					
2. Interest	.43				
3. Challenge	−.14	.35			
4. Attainment value	.34	.54	.30		
5. Utility value	.22	.32	.30	.50	
6. Expectations	.27	.36	.24	.52	.44
M	3.17	3.00	2.20	3.10	2.66
Var	.52	.90	.71	.33	.67

Note. All the correlations were significant $p < .001$.

Table 2. Fit indices for the compared latent pattern models (n = 475 situational responses).

Model	BIC	ΔBIC	AIC	Entropy	VLMR	Difference in the number of parameters
One pattern	3904.59	3885.55	3879.61			
Two patterns	3827.17	3795.43	3785.54	0.83	−1933.81	4
Three patterns	3666.65	3622.22	3608.37	0.80	−1826.16	4
Four patterns	3358.32	3301.19	3283.38	0.93	−1664.31	4

Note: BIC, Bayes information criteria; AIC, Akaike information criteria; VLMR, Vuong–Lo–Mendell–Rubin.

The results for the whole sample showed that three patterns could be identified according to students' situational experiences of interest, skills, and challenge in science (Figure 1). The first '*high skills and challenge*' pattern (that occurred during 57% of the moments) was characterized by experiences of low interest, high skills, and high challenge. The second '*low interest, skills, and challenge*' (28%) pattern was characterized by experiences of low interest, skills, and challenge. The third '*high interest and skills*' (15%) pattern was characterized by experiences of high interest and skills, and medium challenge in science situations.

Patterns of situational engagement during regular and science intervention lessons

Next, the multiple group procedure was used to determine whether students' situational experiences during their science lessons differed in regular versus intervention lessons. The results showed, that when the multigroup procedure was applied to the data, the pattern originally described as 'high skills and challenge' slightly changed as a proportion of the situational experiences (13%) which initially belonged to this pattern now belonged to the 'high interest and skills' pattern of engagement. Thus, the remaining content of the

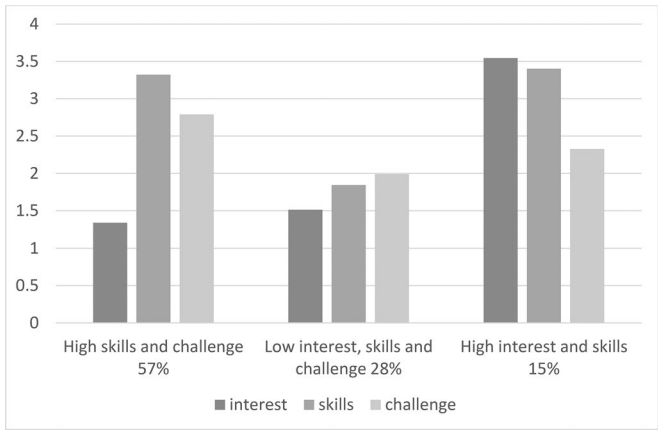

Figure 1. General Pattern without LPA and three patterns of students' situational engagement (e.g., interest, skills, and challenge) in physics with the percentages of the moments they are describing.

first pattern after the multigroup procedure was better described as 'medium interest and skills' pattern which consisted 21% and 23% of the moments during regular and intervention lessons, respectively. The content of the two other patterns remained similar to the initial ones.

Wald tests were then used to further compare the level of interest, skills, and challenge in each pattern during regular vs. intervention lessons (Table 3). The tests confirmed that while experiencing the medium interest and skills (e.g., 'medium') pattern, students' interest and skills were higher, and experiences of challenge were lower during the intervention lessons (in comparison to regular science lessons) (Table 3, Figures 2, 3). Moreover, while experiencing the high interest and skills (e.g., 'high') pattern students' interest was lower and experiences of challenge were higher during the intervention lessons (in comparison to regular science classes). Further, no differences emerged between the components of the low interest, skills, and challenge (e.g., 'low') pattern between regular vs. intervention science lessons.

Associations between situational utility and attainment values, expectations, and engagement patterns

To examine the associations between situational task values, expectancies, and the probability of situational engagement patterns during regular and intervention lessons, the final step of the 3-step procedure (Asparouhov & Muthén, 2014) was conducted. The results showed that when students experienced high situational attainment values, they more often experienced the high engagement pattern rather than the medium pattern during the regular science lessons (Table 4). In addition, when students experienced high attainment values or expectations they were more likely to experience the high or medium engagement pattern rather than the low engagement pattern during regular and the intervention lessons. When students reported high situational utility values, they were more likely to experience the medium rather than the low engagement pattern during regular science lessons. Students reporting high utility values were also more likely to experience the high rather than the low engagement pattern both during regular and intervention lessons.

Table 3. Wald Test Comparisons between the Situational Engagement Components during Regular and Science Intervention Lessons.

	Wald test	Df	*p*
High pattern			
Interest	27.48	1	<.001
Skills	2.39	1	*n.s.*
Challenge	19.01	1	<.001
Medium pattern			
Interest	35.95	1	<.001
Skills	60.42	1	<.001
Challenge	10.95	1	<.001
Low pattern			
Interest	2.72	1	*n.s.*
Skills	0.15	1	*n.s.*
Challenge	2.04	1	*n.s.*

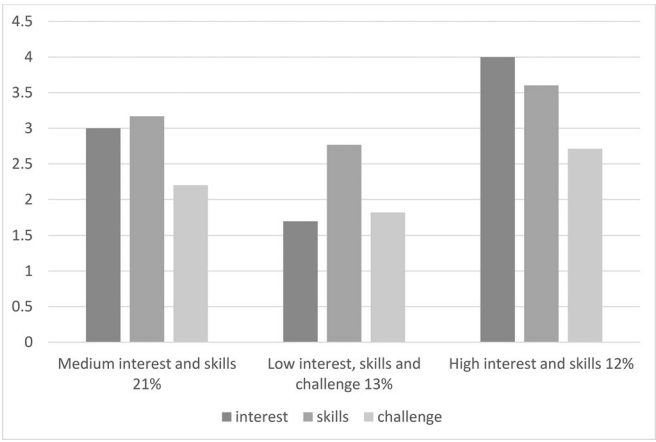

Figure 2. The patterns of students' situational engagement (e.g., interest, skills, and challenge) during regular physics lessons.

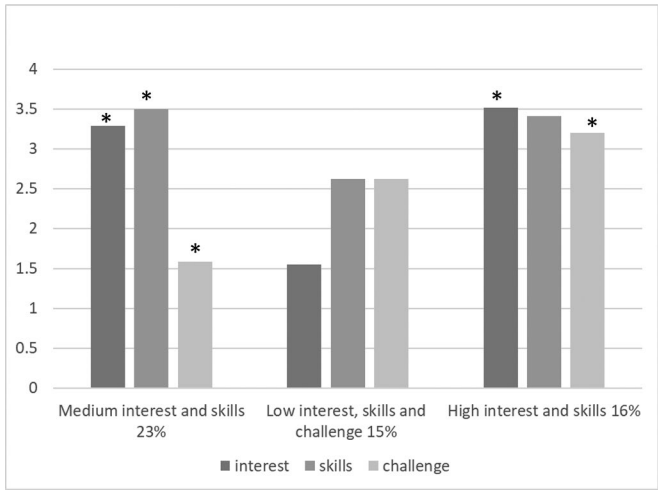

Figure 3. The patterns of students' situational engagement (e.g., interest, skills, and challenge) during the intervention lessons. Note. * = component significantly different compared to the regular science lessons; all differences are p < .001.

Table 4. Logistic Regression Coefficients (Standard Errors in Parenthesis) and Odd's Ratios While Predicting the Patterns of Situational Engagement with Concurrent Attainment and Utility Values, and Expectations during regular and intervention (in italics) lessons.

	Medium vs. High pattern		Medium vs. Low pattern		High vs. Low pattern	
	B	*OR*	*B*	*OR*	*B*	*OR*
Attainment value	−1.02 (.42)*	.36	1.20 (.29)***	3.32	2.23 (.57)***	9.30
	−.35 (.37)	*.70*	*1.52 (.61)**	*4.57*	*1.86 (.69)***	*6.42*
Utility value	−.33 (.22)	.72	.53 (.24)*	1.70	.85 (.31)**	2.34
	−.13 (.27)	*.88*	*.65 (.34)*	*1.92*	*.78 (.36)**	*2.18*
Expectations	−.01 (.24)	.99	1.09 (.24)***	2.97	1.10 (.32)**	3.00
	.11 (.34)	*1.12*	*1.35 (.41)****	*3.86*	*1.46 (.46)***	*4.31*

Note. ***p<.001; **p<.01; *p<.05.

Discussion

This study employed situation-oriented approach (see also von Eye & Bogat, 2006) to examine latent patterns of students' situational engagement in science (e.g., situational interest, skills, and challenge), and differences in these patterns during science intervention versus regular science lessons. Moreover, associations between situational engagement patterns, task values and expectations were explored.

Using situation-oriented LPA, three engagement patterns were identified, namely *high skills and challenge* (57% of the moments), *high interest and skills* (15%), and *low interest, skills, and challenge* (28%) patterns. Multiple group comparisons further revealed that slight differences emerged in the engagement patterns between regular and intervention classes. High situational task values and expectations were associated with students' experiences of high and medium engagement patterns, especially during regular science lessons.

Patterns of situational engagement

Importantly, the present results indicated that students' engagement is malleable, fluctuating from situation to situation (see also Fredricks et al., 2004), and that distinct patterns of situational engagement can be identified during science lessons (Schmidt et al., 2018). Approximately during 57% of the moments in science lessons students' experienced a pattern of high engagement, which was described as students' experiences of high skills and challenge, also resembling experiences of 'flow' (Nakamura & Csikszentmihalyi, 2014). This pattern was relatively large, considering that the results were obtained among Chilean students, whose performance and enjoyment in studying science has been rather low in international comparisons (OECD, 2015, 2016). These results are also promising, as previous studies suggest that the zone of proximal development in learning is reached when students take one step beyond their mastered skills and meet the new challenges while experiencing flow (Shernoff & Csikszentmihalyi, 2008). In addition to the high pattern, situational engagement fluctuated between science class situations, and during 15% and 28% of the remaining situations students experiences high interest and skills, and low interest, skills, and challenge patterns of engagement. These results also indicated diversity in students' engagement, and suggested that even students attend the same lessons and perform the same tasks, their experiences and level of engagement can be substantially different (Schnitzler et al., 2020).

When the patterns of situational engagement were examined by comparing them between the implemented intervention and regular science lessons, slight changes occurred in the 'high skills and challenge' pattern, which was now better described as a 'medium interest and skills' (e.g., 'medium') pattern. The two other ('high' and 'low') engagement patterns remained similar to the initial patterns. In general, students' experiences of interest and skills were slightly higher during the intervention than regular science lessons, which may reflect the fact that, on the whole, interventions motivate students to learn (see also Harris et al., 2015) and increase their interest in the current topic (Hulleman & Harackiewicz, 2009). During the intervention lessons experiences of challenge slightly increased in the 'high' engagement pattern, resembling previously described optimal learning moments (e.g., OLM, experiences of simultaneously high interest, skills, and challenge) which is often associated with positive learning outcomes (Inkinen et al., 2020; Schneider et al., 2016). Students' experienced the 'high' pattern approx. 16% of the situations during intervention lessons, consistent with previous research among Finnish students showing that students experience OLM in approximately 15% of the moments (Inkinen et al., 2020). Thus, the results suggested that the intervention designed to enhance students' science learning and engagement increased experiences of high engagement and OLM, a condition that further promotes students' learning and motivation (Schneider et al., 2016).

During 15% of the situations students experienced the low engagement pattern, even during intervention lessons. Students may experience low situational engagement across a variety of different activities, such as laboratory or individual work (Schmidt et al., 2018). The 'low' engagement pattern may reflect boredom or moments of relaxation in between 'medium' or 'high' engagement (see also Nakamura & Csikszentmihalyi, 2014), and serve as regulatory states between learning (see also Elpidorou, 2018). However, more future research would be needed to better capture the causes leading to low situational engagement. Further, and interestingly, the medium and high engagement patterns increased in their similarity during intervention lessons, suggesting that students' experiences were less differentiated.

Associations between situational task values, expectancies, and engagement patterns

Students with high attainment and utility values were more likely to experience the high or medium patterns rather than the low pattern of situational engagement in science. These results add to previous findings by showing that positive associations between attainment and utility values and engagement (see also Ainley & Ainley, 2011; Lau & Roeser, 2002) emerge also in science classroom situations. These results add to the previous literature by showing that besides the OLM pattern, both high and medium patterns of situational engagement are associated with high concurrent attainment and utility values (see also Schneider et al., 2016). These patterns were alike in that both of them involved average/high situational skills, possibly reflecting students' situational self-concept or perceptions of performance, which are often positively associated with task values (see also Wigfield & Eccles, 2000). Moreover, in previous research, especially utility values promoted students' situational interest and subsequent performance in math (Hulleman et al., 2010). Our results partly support these findings and add to them by showing that situational utility and attainment values are associated with experiences of high situational engagement.

During regular science lessons high situational attainment values were associated with the high rather than the medium pattern, and high situational utility values were associated with the medium rather than the low pattern. During the intervention lessons these differences diminished. These results may reflect the fact during the intervention lessons the high and medium engagement patterns became more alike (e.g., both skills and interest were average/high), and task values

were associated with both patterns equally. Moreover, it is possible that during the intervention students' experiences became less dependent on their situational task values, at least to some extent. It is possible that the implementation of intervention itself was perceived as important task to accomplish (see also Harris et al., 2015), and that the effect of situational task values became less important in predicting students' situational engagement. Further, students who reported high situational expectations more often experienced the high or medium rather than the low pattern both during regular and intervention lessons. These results are in line with previous literature indicating that high teacher expectations are associated with high student engagement (Rubie-Davies, 2010) and show that also students' own expectations contribute to their concurrent engagement in science situations.

Limitations

The study has some limitations. First, the number of participants was relatively small preventing the usage of multilevel models. In future research it would be important to examine the different patterns of situational engagement using larger data sets with science interventions. Second, the majority of the participants (85%) were male students. Thus, it was not possible to examine the possible gender differences in the situational engagement patterns. Third, some variables that were not examined in the present study might have affected the results. For example, concurrent emotions (Sinatra et al., 2015; Winberg et al., 2014) and type of the current activity in which students are involved (Inkinen et al., 2020; Linnansaari et al., 2015) may contribute to their situational engagement in science. In the future, it would be important to examine differences in patterns of situational engagement during varying academic tasks. In a similar vein, more research would be needed examining which patterns of situational engagement would lead to sustained engagement and interest in science domains (see also Linnenbrink-Garcia et al., 2013). Moreover, as engagement is highly influenced by context (Schmidt et al., 2018; Tas, 2016), the results of the present study can be generalized only to students' experiences in science lessons. The subject content (e.g., math, science, languages) influences also the type of activities teachers choose for the classroom, which may further manifest in situational engagement (Nguyen et al., 2018; Parsons et al., 2018). More future research would be needed to examine situational engagement in different subject contents.

Conclusions

The results of the present study add to previous findings on students' situational engagement (Pöysä et al., 2019) by showing that different patterns of engagement emerge while learning science (Salmela-Aro et al., 2016; Schmidt et al., 2018). Simply distinguishing students to engaged and disengaged does not fully describe the complexity of students' learning experiences (Schnitzler et al., 2020), and examining student engagement at different grain levels (Nguyen et al., 2018), such as the microlevel (e.g., situational engagement; Sinatra et al., 2015) may help in identifying different patterns of engagement. Knowledge of engagement at the finer grain levels brings us better understanding on how engagement may change from moment to moment and what other factors are present simultaneously. Importantly, the present study indicated that students experience different patterns of situational engagement during science lessons, and that a large amount of these experiences resemble previously described 'flow' (e.g., experiences of concurrent high skills and challenge) (Nakamura & Csikszentmihalyi, 2014), which may reflect students' active seeking for a subjective balance between their skills and challenges (Engeser & Rheinberg, 2008). In addition to skills and challenges, it would be important for science teachers to create learning situations which promote students' interest in the current task or activity (Schmidt et al., 2018; Singh et al., 2002). Students' success in future achievements depends on their willingness to be learners and on their motivation to seek out challenges which develop new valuable skills (Rege et al., 2020). Our results showed that an intervention in which students were guided to meet challenges and to engage more in learning science produces simultaneous experiences of high skills, challenge, and interest (OLM, high situational engagement), which promote further learning (Schneider et al., 2016). Situational engagement is a core factor of students' educational resilience, which helps students to perform well and maintain attention regardless of the type of the task (e.g., easy, difficult, boring, task) (Torsney & Symonds, 2019). Thus, it is important to encourage students becoming active learners who seek out new challenges and experiences, even it might sometimes be difficult or unpleasant (Rege et al., 2020). When students meet challenges, and use their prior knowledge and skills to solve problems, they acquire new science knowledge and transferable skills which provide important constituents for future human capital (National Research Council, 2012b). Students are sensitive to different learning situations, and by providing elements to support students' perceived importance and future utility of the current task or activity teachers can endorse students' situational engagement and learning (Tsai et al., 2008), and prevent situational and chronic disengagement (Stephan et al., 2011). More studies would be needed in the future examining whether teachers recognize different engagement patterns, how accurately they assess them, and how accurately they can guide students employing different levels of engagement (see also Schnitzler et al., 2020). By supporting students' engagement in science teachers may enhance students' skill development, aspirations, and choices to make science a career (Sinatra et al., 2015; Tytler & Osborne, 2012). Similarly, interventions themselves may motivate students to learn (see also Harris et al., 2015) by increasing students' problem-solving skills and deep understanding of the topic (Han et al., 2016). Finally, the present results indicated that students engage in learning in complex ways (Schmidt et al., 2018), and with ESM it is possible to capture patterns of situational engagement closer to the point of actual occurrence (Sinatra et al., 2015).

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Appendix

Science intervention

The science intervention module[1] was designed in collaboration with science teachers to meet the new vision of scientific competencies known as Interdisciplinary Science Research (U.S. Department of Education, 2016), also emphasized in the current science curriculum in Chile. The intervention focused on optical phenomena, and on learning science research. Special emphasize was paid on students' active use and learning of new knowledge while engaging in scientific and engineering practices, such as design of experiments, interpreting data and solving of technological problems. In a similar way, science curriculum in various countries emphasize the use of knowledge in different situations and students' active engagement (Ford, 2015; National Research Council, 2012a; Osborne, 2014). Thus, in learning, knowing and doing cannot be separated but should be combined in contextualized inquiry, problem solving and decision making situations (Ford, 2015; Osborne, 2014).

The basic principles on which the intervention was based acknowledge that, given the complexities the world we live in, a new set of technical and practical skills are needed to solve problems. Thus, a number of components and competencies were included in the intervention. Some of the central components were: activities that invite to play and take challenges, interdisciplinary approaches flexible and inclusive learning environments and innovative and accessible ways to assess learning. In order to develop competencies, learning experiences should have attributes such as contextualization of problems relevant to the students' lives, incorporation of skills or practices of the research process, and to make connections among disciplines. While designing the module, the knowledge related to student engagement in science learning was taken into account (Inkinen et al., 2020). The intervention covered the physics of light, and included activities to apply laws of reflection from flat mirrors to convex lenses that help improve human vision (e.g., microscope, optical glasses), and to utilize and connect prior knowledge in multiple science related fields. Students were also building and making observations with a telescope collaboratively.