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High school students' optimal learning moments: A network analysis approach

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Abstract

Word counts: 118 / 120

The present study examined the emotional and motivational correlates of optimal learning moments (OLM) by using the co-occurrence network analysis and by including data in and outside of school settings. Two first-year high school samples were measured using the experience sampling method. The first sample consisted of 282 students and was assessed in science lessons only. The second sample consisted of 59 students and was assessed over two weeks in and outside of school. The results, in general, were consistent across the situations, which shows OLM co-occurred highly with positive emotions and motivations (e.g., enjoyment, concentration, success). However, OLM only co-occurred moderately with epistemic emotions such as curiosity and inquisitiveness, but those co-occurrences were higher in school settings.

Word counts: 1640 / 2000

Introduction

Optimal learning moments (OLM) refer to the experienced engagement of a task that an individual feels interested, be challenged and capable to finish it (Schneider et al., 2016). The concept of *optimal learning moment* is built upon the idea of “flow” defined by Csikszentmihalyi (2008) as situation-specific instances when an individual is deeply engaged in a task that time loses its temporal boundaries and human needs are suspended. During these moments, an individual experiences higher than average levels of challenge and skill; but neither challenge nor skill overtakes the other, meaning that a particular task is within the boundaries of mastery and not overwhelmingly difficult in terms of one's current skills. Schneider et al. (2016) added a new component – interest – to challenge and skill, to constitute the optimal experience of learning in that a student must have a positive pre- and post- dispositional affection, i.e., interest, towards the learning objects. Thus, the OLM is operationalized as the reported high level of challenge, skill, and interest in task engagement. When an individual is in OLM, Schneider et al. (2016) argue, he/she may simultaneously experience the high level of positive emotions, including happiness, enjoyment, confidence and success, as well as the low level of negative emotions (e.g., boredom and confusion). OLM has previously been studied using the experience sampling method (ESM) in science lessons (Hendolin, 2016; Inkinen et al., 2019; Schneider et al., 2016) and in other academic subjects lessons (Schneider et al., 2016). It has been shown that students reported more feelings of enjoyment, success and happiness, and less feelings of confusion, stress and anxiety, and better attitude towards science (Schneider et al., 2016), and higher course grades (Hendolin, 2016) when they reported more OLM.

However, previous studies have at least three limitations. First, empirical studies on OLM are scarce, and most have focused on OLM in school settings and particular in science lessons (Hendolin, 2016; Inkinen et al., 2019; Schneider et al., 2016). Therefore, the relationships between OLM and its motivational and emotional correlates outside of school are largely unknown. Second, though the relationships between OLM and emotions (e.g., enjoyment, happiness, boredom, confusion) have been examined previously (Schneider et al., 2016), few important epistemic

emotions such as surprise and curiosity (Pekrun, Vogl, Muis, & Sinatra, 2017), motivations such as grit (Duckworth, Peterson, Matthews, & Kelly, 2007; Tang, Wang, Guo, & Salmela-Aro, 2019) and expectation are missing. In other words, a comprehensive understanding between OLM and emotional and its motivational correlates are still needed. Third, the common approach used (Hendolin, 2016; Schneider et al., 2016) in examining OLM-correlates relationships is the correlation analysis, which may not capture the comprehensive relationships among those variables. The co-occurrence network analysis, which aims to show how often (or rarely) two variables co-occur at high levels, can have few strengths over correlation analysis (Moeller, Ivcevic, Brackett, & White, 2018; Trampe, Quoidbach, & Taquet, 2015). First, co-occurrence analysis avoids misinterpretation of correlations. Typically, when interpreting high positive correlations between two variables (e.g., A & B), researchers conclude that variable A is “high” when variable B is “high”, even though in the reality both A and B might be rated at a low level on the original scale. Because correlations only denote how the ratings of two variables are aligned consistently, how these two variables occur together at a high level is not necessarily revealed in correlation analysis. Second, a frequent co-occurrence may occur even if two variables correlate negatively, which could only be detected using co-occurrence analysis. Thus, the purpose of this study is to examine OLM and its motivational and affective correlates, using both co-occurrence network analysis and correlation analysis, and data in and outside school.

Method

Samples and measures

This study used two samples. Both samples’ situational emotions and motivations were obtained using ESM questionnaires delivered via smartphones.

The first sample consisted of 282 first-year high school students from nine classes in three different schools in Helsinki, Finland. Data were collected from the fall of 2018 to the spring of 2019. The students were participating in a project-based learning (PBL; Krajcik & Shin, 2014) module that consisted of six lessons. This module focused on the basics of Newtonian mechanics and aimed to engage students in solving real-world scientific problems by exploring and participating in collaborative inquiry. In each lesson (about 75 mins), the ESM questionnaire alerted the students three times: at the beginning, middle, and end of the lesson. Therefore, each student received 18 signals. Overall, the first sample data comprised 3882 responses.

The second sample comprised 59 first-year high school students from four classes in three schools in the fall of 2017. The topic of the lessons were same as in previous data-collection. In this sample, data were collected during science lessons and other situations in and outside of school. The phones were programmed to alert the students randomly 3-4 times per day (at least once when they had science lessons) over a period of two weeks. In total, the data comprised 1689 responses/situations (average response per person was 28.88). Of these, 154 (9%) responses occurred during science lessons and 1535 (91%) occurred outside science lessons. In addition, 872 (51.6%) responses occurred in the school, whereas 817 (48.4%) occurred outside of the school.

In both samples, the students were signaled to answer an ESM questionnaire in which they first had to indicate what kinds of activities (e.g., listening, discussion) they were doing. Then they were asked to report their academic emotions and motivations when they received the signal. Examples of the questions used are: Do you feel curious (curious)? How well did you focus (concentrate)? Did you cope with your work (control)? Did your performance meet the expectations of others

(other-expect)? A full list of items can be found in the appendix. All the items were rated on a scale of 1 (not at all) to 4 (very much).

Data analysis approach

This study conducted two types of network analyses. The first was the co-occurrence network analysis and the second, in a supplementary way, was the correlation-based network analysis. In this study, to perform co-occurrence analysis, we dichotomized situational emotions and motivations at the scale midpoint.

Preliminary findings

Table 1 and Figure 1 show the co-occurrence and correlation-based network of OLM for Sample 1, in which only science lessons were measured. In total, OLM occurred 475 times. When OLM occurred, feelings of concentration (edge=434; 91.37%), enjoyment (edge=422; 88.84%), inquisitiveness (edge=418; 88%), success (edge=415; 87.37%), meeting self-expectations (edge=414; 87.16%), examining the activity at hand (edge=413; 86.95%), meeting others' expectations (edge=411; 86.53%), feelings of control (edge=411; 86.53%), happiness (edge=409; 86.11%), and grit (edge=405; 85.26%) were the top ten co-occurring emotions and motivations. The results also showed that the general within-level correlations between OLM and other motivations were low (max = 0.17), although most of them were significant.

Table 2 and Figures 2 show the co-occurrence and correlation-based network of OLM for Sample 2, in which half of the responses were reported outside of school. In general, for the full sample, OLM occurred 282 times and when it occurred, feelings of enjoyment (edge=255; 90.43%), control (edge=255; 90.43%), concentration (edge=248; 87.94%), importance to self (edge=248; 87.94%), success (edge=243; 86.17%), meeting self-expectations (edge=239; 84.75%), meeting others' expectations (edge=234; 86.53%), grit (edge=231; 81.91%), happiness (edge=228; 80.85%), and examining the activity at hand (edge=214; 75.89%) typically occurred at the same time. Again, the within-level correlations of OLM networks were low (max = 0.34). The results for the in-school and out-of-school situations showed slightly but interesting differences. In school situations, OLM occurred more frequently with epistemic emotions such as inquisitiveness (edge=132; 82.5%) and curiosity (edge=119; 74.38%) than situations outside of school (63.11% and 50.82% respectively for inquisitiveness and curiosity). Whereas for out-of-school situations, more grit (edge=104; 85.25%) co-occurred with OLM than in-school situations (79.38%).

Discussion and Implications

The results from the two samples (one focusing on science lessons and the other on situations in and outside of school), in general, were highly consistent across the situations. When students indicated that they were in OLM, they were most likely concentrating on what they were doing, experiencing positive emotions and success, feeling in control, doing things important to them, and fulfilling both their own and others' expectations. Moreover, the students in OLM reported rarely being bored, lonely or anxious, and were unlikely to give up on what they are doing. OLM did not co-occur often with curiosity, question-asking, and exploring, but they co-occurred more often in school than outside of school. In sum, our findings corroborate with and expand on those of Schneider et al. (2016) and show that OLM co-occurs with positive emotions and motivations in situations both during and outside science lessons. The findings also remind us that epistemic emotions and motivations such as feeling curious, surprised, question-asking, and exploring, do not necessarily accompany OLM, though the co-occurrences among them are more pronounced in school settings.

Studies (Lamnina & Chase, 2019; Vogl, Pekrun, Murayama, & Loderer, 2018) shown that epistemic emotions like curiosity and surprise can serve as a trigger to other academic emotions (pride or shame depend on the successfulness of task doing) and knowledge learning (fail or success), but those emotions are not guaranteeing to help you succeed in task learning. Thus, curiosity and exploring may serve as the initial drive for OLM, but to achieving OLM requires more.

This study has significant implications. First, this study extends the study of optimal learning moments outside of school settings. Given the consistent results between in- and out- school situations, the OLM model could be extended into daily learning situations and has general implications to motivation and learning process. Second, our findings highlight that epistemic emotion like curiosity and inquisitiveness can serve as an important enhancer of OLM in school learning situations. Finally, this study also highlights the unique value of co-occurrences network analysis apart from the commonly used correlation analysis.

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Table 1. Co-occurrences of OLM-emotion and motivation pairs in the Sample 1

Rank	Node1	Node2	Edge weight	% of all edges	% of OLM edges ¹ as reference	Situational-level correlation	Person-level correlation
	OLM	<i>Emotions</i>					
18		curious	374	3.26%	78.74%	0.10*	0.45*
9		happy	409	3.56%	86.11%	0.11*	0.42*
15		excited	390	3.40%	82.11%	0.10*	0.49*
35		anxious	74	0.64%	15.58%	0.01	0.01
28		competitive	188	1.64%	39.58%	0.10*	0.40*
36		lonely	40	0.35%	8.42%	0.02	-0.01
31		stress	130	1.13%	27.37%	-0.01	-0.03
25		proud	277	2.41%	58.32%	0.16*	0.49*
11		cooperative	404	3.52%	85.05%	0.09*	0.30*
34		bored	89	0.78%	18.74%	-0.09*	-0.23*
16		confident	384	3.35%	80.84%	0.11*	0.45*
30		confused	132	1.15%	27.79%	0.04*	0.06
12		active	400	3.49%	84.21%	0.14*	0.45*
29		surprised	163	1.42%	34.32%	0.12*	0.29*
33		frustrated	99	0.86%	20.84%	-0.03	-0.06
3		inquisitive	418	3.64%	88.00%	0.09*	0.43*
		<i>Motivations</i>					
32		give up	102	0.89%	21.47%	0.07*	0.04
1		concentrate	434	3.78%	91.37%	0.09*	0.37*
2		enjoy	422	3.68%	88.84%	0.12*	0.50*
7		control	411	3.58%	86.53%	0.06*	0.30*
4		success	415	3.62%	87.37%	0.11*	0.41*
14		important to you	393	3.42%	82.74%	0.03	0.48
19		important to future	363	3.16%	76.42%	0.08*	0.42*
7		other expect	411	3.58%	86.53%	0.08*	0.34*
5		self expect	414	3.61%	87.16%	0.09*	0.31*
21		time	333	2.90%	70.11%	0.13*	0.41*
10		grit	405	3.53%	85.26%	0.15*	0.52*
17		effort	376	3.28%	79.16%	0.17*	0.51*
23		imagination	317	2.76%	66.74%	0.17*	0.45*
24		solutions	280	2.44%	58.95%	0.14*	0.45*
22		exploring	327	2.85%	68.84%	0.17*	0.49*
20		ideas	342	2.98%	72.00%	0.13*	0.53*
27		context	231	2.01%	48.63%	0.11*	0.35*
26		questions	246	2.14%	51.79%	0.14*	0.42*
13		know more	394	3.43%	82.95%	0.09*	0.44*
6		examination	413	3.60%	86.95%	0.10*	0.42*

Note. ¹Number of OLM self-edges is 475

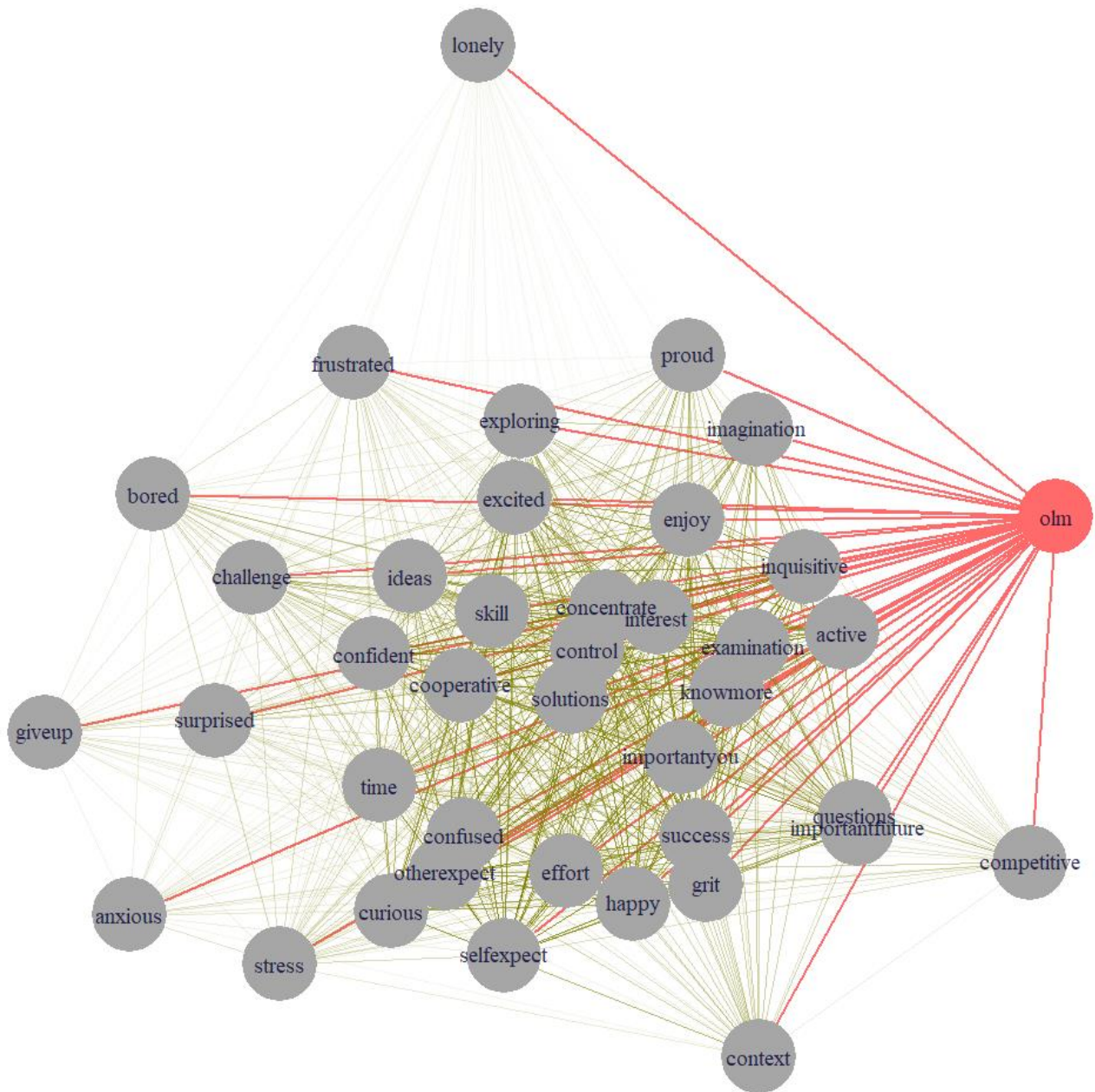


Figure1. Co-occurrences networks between variables in Sample 1

Table 2. Co-occurrences of OLM with emotion and motivation pairs in Sample 2

Node1	Node2	in-school situations				out-of-school situations				Full sample data					
		Rank	Edge weight	% of all edges	% of OLM edges ¹ as reference	Rank	Edge weight	% of all edges	% of OLM edges ² as reference	Rank	Edge weight	% of all edges	% of OLM edges ³ as reference	Situational-level correlation	Person-level correlation
OLM	<i>Emotions</i>														
	curious	15	119	3.38%	74.38%	22	62	2.49%	50.82%	19	181	3.01%	64.18%	0.18*	0.27*
	happy	10	128	3.64%	80.00%	8	100	4.01%	81.97%	9	228	3.79%	80.85%	0.15*	0.45*
	excited	18	116	3.30%	72.50%	12	89	3.57%	72.95%	15	205	3.41%	72.70%	0.21*	0.40*
	anxious	32	24	0.68%	15.00%	33	12	0.48%	9.84%	33	36	0.60%	12.77%	-0.04	-0.19
	competitive	29	47	1.34%	29.38%	27	41	1.65%	33.61%	28	87	1.45%	30.85%	0.17*	0.23
	lonely	34	20	0.57%	12.50%	34	11	0.44%	9.02%	34	31	0.52%	10.99%	-0.04	-0.15
	stress	28	48	1.36%	30.00%	29	29	1.16%	23.77%	29	77	1.28%	27.30%	0.02	-0.10
	proud	25	80	2.27%	50.00%	24	61	2.45%	50.00%	24	142	2.36%	50.35%	0.20*	0.33*
	cooperative	20	110	3.13%	68.75%	19	69	2.77%	56.56%	20	179	2.98%	63.48%	0.10*	0.24
	bored	33	21	0.60%	13.13%	32	16	0.64%	13.11%	32	37	0.62%	13.12%	-0.17*	-0.27*
	confident	17	117	3.32%	73.13%	10	92	3.69%	75.41%	13	209	3.48%	74.11%	0.13*	0.42*
	confused	30	44	1.25%	27.50%	31	18	0.72%	14.75%	30	62	1.03%	21.99%	0.04	-0.03
	active	16	118	3.35%	73.75%	15	79	3.17%	64.75%	18	197	3.28%	69.86%	0.23*	0.44*
	inquisitive	8	132	3.75%	82.50%	17	77	3.09%	63.11%	13	209	3.48%	74.11%	0.20*	0.29*
	<i>Motivations</i>														
	give up	31	25	0.71%	15.63%	30	25	1.00%	20.49%	31	50	0.83%	17.73%	0.04	0.01
	concentrate	3	144	4.09%	90.00%	4	105	4.22%	86.07%	3	248	4.12%	87.94%	0.21*	0.37*
	enjoy	1	146	4.15%	91.25%	2	109	4.38%	89.34%	1	255	4.24%	90.43%	0.16*	0.39*
	control	2	145	4.12%	90.63%	1	110	4.42%	90.16%	1	255	4.24%	90.43%	0.09*	0.33*
	success	6	135	3.84%	84.38%	3	108	4.34%	88.52%	5	243	4.04%	86.17%	0.08*	0.39*
	important to you	3	144	4.09%	90.00%	6	103	4.13%	84.43%	3	248	4.12%	87.94%	0.21*	0.43*
	important to future	8	132	3.75%	82.50%	15	79	3.17%	64.75%	11	211	3.51%	74.82%	0.19*	0.53*
	other expect	7	134	3.81%	83.75%	8	100	4.01%	81.97%	7	234	3.89%	82.98%	0.13*	0.18
	self expect	5	138	3.92%	86.25%	7	101	4.05%	82.79%	6	239	3.97%	84.75%	0.11*	0.23
	time	19	115	3.27%	71.88%	12	89	3.57%	72.95%	15	205	3.41%	72.70%	0.20*	0.22

	grit	11	127	3.61%	79.38%	5	104	4.18%	85.25%	8	231	3.84%	81.91%	0.26*	0.52*
	effort	14	121	3.44%	75.63%	11	90	3.61%	73.77%	11	211	3.51%	74.82%	0.34*	0.49*
	imagination	24	83	2.36%	51.88%	22	62	2.49%	50.82%	23	145	2.41%	51.42%	0.15*	0.07
	solutions	26	70	1.99%	43.75%	25	55	2.21%	45.08%	26	125	2.08%	44.33%	0.18*	0.20
	exploring	22	87	2.47%	54.38%	20	68	2.73%	55.74%	21	156	2.59%	55.32%	0.26*	0.23
	ideas	21	90	2.56%	56.25%	21	63	2.53%	51.64%	22	154	2.56%	54.61%	0.18*	0.18
	context	27	63	1.79%	39.38%	28	31	1.24%	25.41%	27	94	1.56%	33.33%	0.19*	0.31*
	questions	22	87	2.47%	54.38%	26	47	1.89%	38.52%	25	134	2.23%	47.52%	0.21*	0.44*
	know more	13	124	3.52%	77.50%	18	76	3.05%	62.30%	17	200	3.33%	70.92%	0.22*	0.19
	examination	12	126	3.58%	78.75%	14	88	3.53%	72.13%	10	214	3.56%	75.89%	0.26*	0.28*

Note. ¹Number of OLM self-edges among in-school data is 160; ²Number of OLM self-edges among out-of-school data is 122; ³Number of OLM self-edges among full data is 282

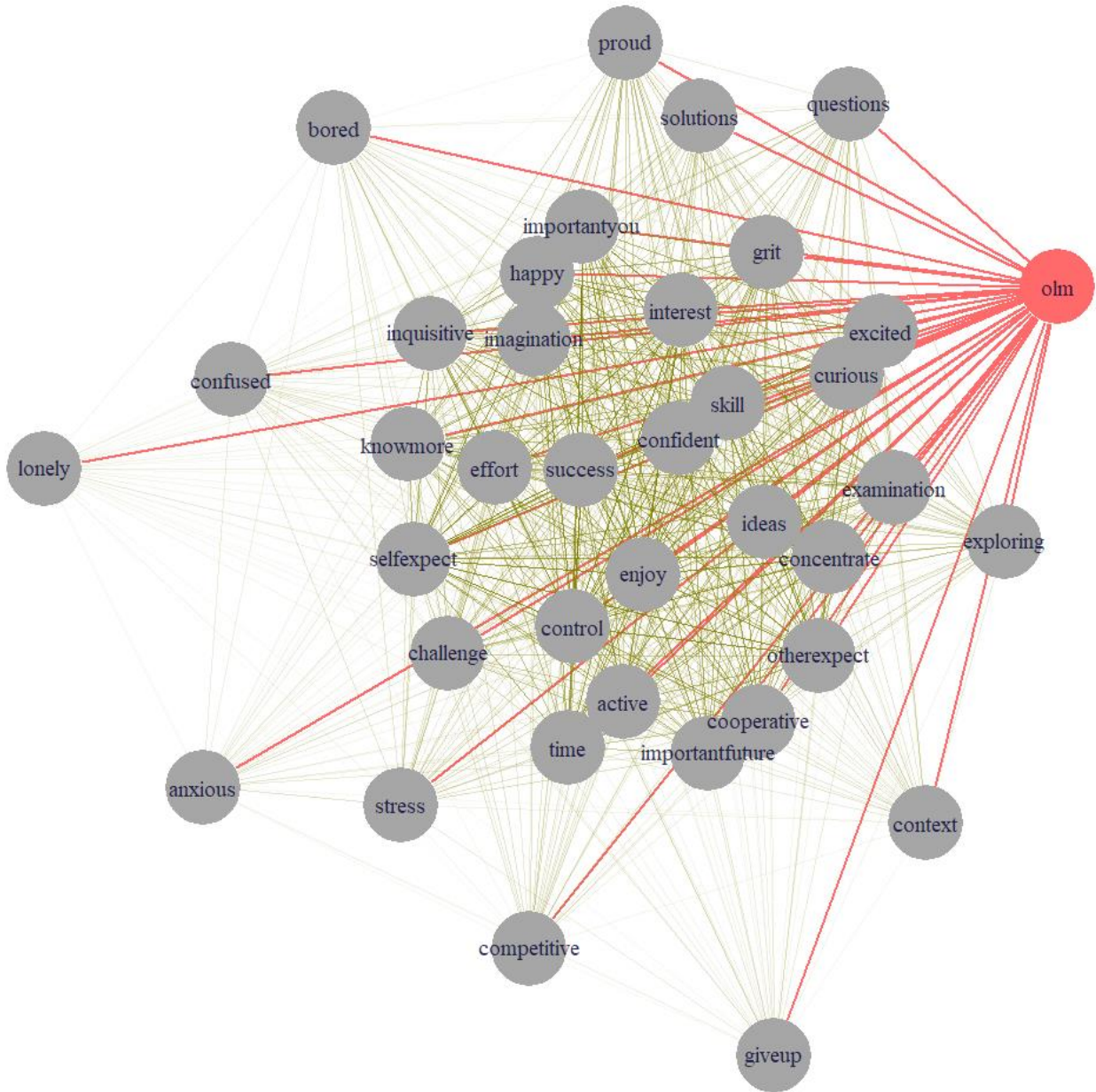


Figure 2. Co-occurrences networks between variables in Sample 2.

Appendix

Emotions and motivations items measured in the study

What do you feel and think about the activity you did (1 Not at all 4 Very Much)

- Do you feel happy?
- Do you feel excited?
- Do you feel anxious?
- Do you feel competitive?
- Do you feel lonely?
- Do you feel stress?
- Do you feel proud?
- Do you feel cooperative?
- Do you feel bored?
- Do you feel confident?
- Do you feel confused?
- Do you feel active?
- Do you feel surprised?
- Do you feel frustrated?
- Do you feel curious?
- Do you feel inquisitive?
- Are you interested in what you did? (interest)
- Did you feel skilled in what you did? (skill)
- Was your work challenging? (challenge)
- Did you feel that you wanted to give up? (give up)
- How well did you focus? (concentrate)
- Did you like what you did? (enjoy)
- Did you manage your work? (control)
- Did you succeed? (success)
- Was it what you did important to you? (important to you)
- Was it what you did important for your future? (important to future)
- Did your performance meet the expectations of others? (other expect)
- Did you do follow your own expectations? (self expect)
- Were you immersed in what you did not notice the passage of time? (time)
- How persistent are you while working? (grit)
- How many efforts did you put when working? (effort)
- While working... I used my imagination (imagination)
- While working... solving problems with multiple answers (solutions)
- While working... I tried different solutions for exploring (exploring)
- While working got new ideas (ideas)
- While working... I combined the contents of different subjects in context (context)
- When I was working... I asked a lot of questions (questions)
- While working... I wanted to know more/do more (know more)
- While I was working ... I studied and examined what I did (examination)