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Interdependence between Perceived Cooperative Learning, Sense of Belonging, and Generic Skills in Undergraduate STEM Education

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ABSTRACT: The development of sense of belonging and generic skills may be considered important to succeed in higher education and in life and may be enhanced through student group work. For group work to succeed, Social Interdependence Theory and Cooperative Learning suggest that group members need to be positively interdependent. In the present study we conducted a cross-sectional survey in a sample of 401 students in undergraduate Science, Technology, Engineering, and Mathematics education in Norway mapping the students' perceptions of cooperative learning, sense of belonging, and generic skills. By means of Pearson bivariate correlation analyses and standard multiple regression analyses, we found that 1) Cooperative Learning was positively associated with the development of both sense of belonging and generic skills, 2) Sense of belonging and generic skills were positively interrelated, and 3) Interaction was the cooperative learning principle contributing most to the association with both sense of belonging and generic skills.

1 INTRODUCTION

The importance of preparing students for work and life in a fast-paced world is a recurring topic in international position papers (OECD, 2018; UN, 2015). Among the student factors that can be developed to succeed in higher education specifically and life generally are sense of belonging (SoB) and generic skills (GS). In higher education SoB seems to be linked to student retention (Aurlien et al., 2019; Sæthre, 2014; Thomas, 2012; Tinto, 1975, 1993) and GS to employability (Cornford, 2005; Davey et al., 2018; Male et al., 2011). In life, belonging is regarded as a basic human need (Baumeister & Leary, 1995; Maslow, 1968) and SoB may be defined as our experience of being an integral part of our surrounding systems or environment (Hagerty et al., 1992, p. 173). GS may be regarded tools for lifelong learning (Bourn, 2018) and defined as holistic soft skills which operate across wide ranges of contexts (Taber, 2016, p. 226), and often predict success in life (Heckman & Kautz, 2012, p. 2).

The development of SoB and GS in educational settings seems to be related to student interaction, including group work (Allen et al., 2021; Ballantine & McCourt Larres, 2007; Kember et al., 2007; Virtanen & Tynjälä, 2019). However, groups and group tasks may need to be deliberately designed to ensure that students cooperate to fulfill their tasks. One alternative is to make the students mutually interdependent (Gillies, 2014; 2016). Positive interdependence between students in groups makes up the foundation of Cooperative Learning (CL) by Johnson and Johnson (1989). CL is developed from Social Interdependence Theory (SIT) by Deutsch (2012), which postulates that to facilitate desirable student outcomes, e.g., increased SoB and GS, it is important to structure positive interdependence between students in groups (Deutsch, 2012; Johnson & Johnson, 2005).

In this study, we examine how CL in undergraduate Science, Technology, Engineering, and Mathematics (STEM) education in Norway is related to SoB and GS respectively. The relationships are interpreted with the theoretical frameworks of SIT.

Belonging is a human need (Maslow, 1968). If our need to belong goes unfulfilled we may become lonely which in turn may cause health problems and increase mortality (Baumeister & Leary, 1995; Hayley et al., 2017; Holt-Lunstad et al., 2015; Richardson et al., 2017). Thus, according to Baumeister and Leary (1995), belonging may be regarded just as important for our health and survival as basic

physical needs. We fulfill our need to belong by engaging in meaningful interpersonal relationships and social interactions (Baumeister & Leary, 1995). Hence, being a part of groups seems essential to fulfill the need for belonging, in life as in higher education.

Many initiatives may enhance SoB in educational settings. In their review, Allen et al. (2021, p. 91) propose that components such as perceptions of belonging and opportunities to belong reinforce and affect one another continuously in the development of belonging. It seems essential that universities acknowledge that students enter with different perceptions of belonging informed by past experiences. Given this acknowledgement, universities should both strive to add to an existing SoB and create new experiences that may remedy past experiences of alienation. A way to achieve this may be to create learning settings where students are given opportunities to belong on different levels, e.g., with peers, teachers, disciplines, and institutions. These learning settings should be structured so that all students are enabled to fulfill the need for belonging through social interactions and meaningful relationships (Allen et al., 2021; Baumeister & Leary, 1995).

Previous research shows that highly structured groups and group work such as CL in undergraduate STEM education may provide the social interactions and meaningful relationships needed to enhance SoB (Møgelvang & Nyléhn, 2022). In a study in undergraduate mathematics, Furuto (2017) reported that implementing CL methods increased SoB among the students. In an undergraduate biology study, Wilton et al. (2019) introduced structured in-class student-student/student-teacher interactions and peer-led discussions and found that the students reported greater SoB than did students in a similar course with traditional teaching. In these studies, both from the US, CL was implemented to enhance belonging among minority groups to strengthen student diversity in STEM higher education. Taken together they show the potential for a positive association between CL and SoB in undergraduate STEM education. In Norway, student loneliness is on the rise (Knapstad et al., 2018; Sivertsen, 2021) and initiatives to enhance belonging are warranted. Thus, in this study we wish to examine if CL may also be positively related to SoB in a Norwegian undergraduate STEM population.

As the definition in the first paragraph implies, we opt for an extended understanding of GS. GS are also known as "life skills", "21st century skills", and "transferable skills" (UN, 2015; UNICEF, 2021), and according to Binkley et al. (2012, pp. 18-19) GS include a) ways of thinking: e.g. creativity, critical thinking, problem-solving, and meta cognition, b) ways of working: e.g. collaboration and communication, c) tools for working: e.g. Information and Communication Literacy (ICT) and d) living in the world: e.g. citizenship. Since GS may promote lifelong learning opportunities across a range of fields and enable students to navigate in and adapt to an unpredictable future, GS are seen as vital to the question of sustainability. Thus, GS play a substantial role in Goal 4 of *Transforming Our World: The 2030 Agenda for Sustainable Development* (UN, 2015; UNESCO, 2016).

In educational settings, it is generally believed that GS are developed through an integration of content knowledge and active learning methods, and especially collaborative learning methods seem to be a strong predictor of the development of GS (Ballantine & McCourt Larres, 2007; Kember et al., 2007; Smith & Bath, 2006; Tynjälä & Gijbels, 2012; Virtanen & Tynjälä, 2019). By integrating both learning content and collaborative learning methods, it is believed that a dual process occurs: when students use theoretical knowledge to discuss and solve practical problems, they also conceptualize their practical experiences using theoretical concepts (Virtanen & Tynjälä, 2019, p. 882). In CL literature, specifically, Millis and Cottell (1998) suggest that the inherent group and task structures of CL may stimulate the development of GS such as problem-solving and critical thinking.

Previous research in undergraduate STEM education indicates that CL may be linked to the development of GS (Møgelvang & Nyléhn, 2022). Thus, in the US, where numerous calls to address gaps in GS have been issued, studies (Canelas et al., 2017; Carson & Glaser, 2010; Cheruvelil et al., 2020; Ott et al., 2018) have examined if CL may help close these gaps. In undergraduate chemistry, Canelas et al. (2017) compared two similar courses, one employing traditional lectures and one employing several CL methods and found that the students in the latter reported higher learning gains in key transferable skills such as problem-solving and collaboration. Similar results, at least regarding collaboration, was found in yet another undergraduate chemistry course employing CL methods (Carson & Glaser, 2010). In undergraduate biology, Cheruvelil et al. (2020) introduced CL elements such as team contracts, teamwork syllabus objectives, exercises, and reflection and found that the students' collaboration skills improved significantly. In a mix of STEM disciplines, a study implemented CL roles to enhance

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collaborative skills. Although the students reported negative perceptions of the roles, they gained valuable collaboration skills (Ott et al., 2018). Taken together, these studies show the potential for a positive association between CL and GS in undergraduate STEM education, at least in the US. The White Paper "Working Life Relevance" (St.Meld.16, 2020-2021) is a clear testimony to similar gaps in Norway – and specifies the responsibility of higher education to address the question of GS in reducing these gaps. Thus, knowledge on teaching and learning strategies related to GS are warranted and, in this study, we examine if CL may be related to the development of GS in a Norwegian undergraduate STEM population.

2 THEORETICAL FRAMEWORK

2.1 Social Interdependence Theory (SIT)

Social Interdependence Theory (SIT) states that we are socially interdependent when our individual outcomes are influenced by other people's actions and was first introduced by Morton Deutsch in the 1940s (Deutsch, 2012). The premise of SIT is that goals, actions, psychological processes, interaction, and subsequently outcomes of individuals are dependent on how social interdependence in groups is structured. There are three ways of structuring social interdependence: positive interdependence, negative interdependence, and no interdependence (Deutsch, 2012). Negative interdependence primarily leads to negative group processes and outcomes, and no interdependence leads to no group processes or outcomes. Positive interdependence, however, is believed to lead to several positive processes and outcomes (Figure 1).

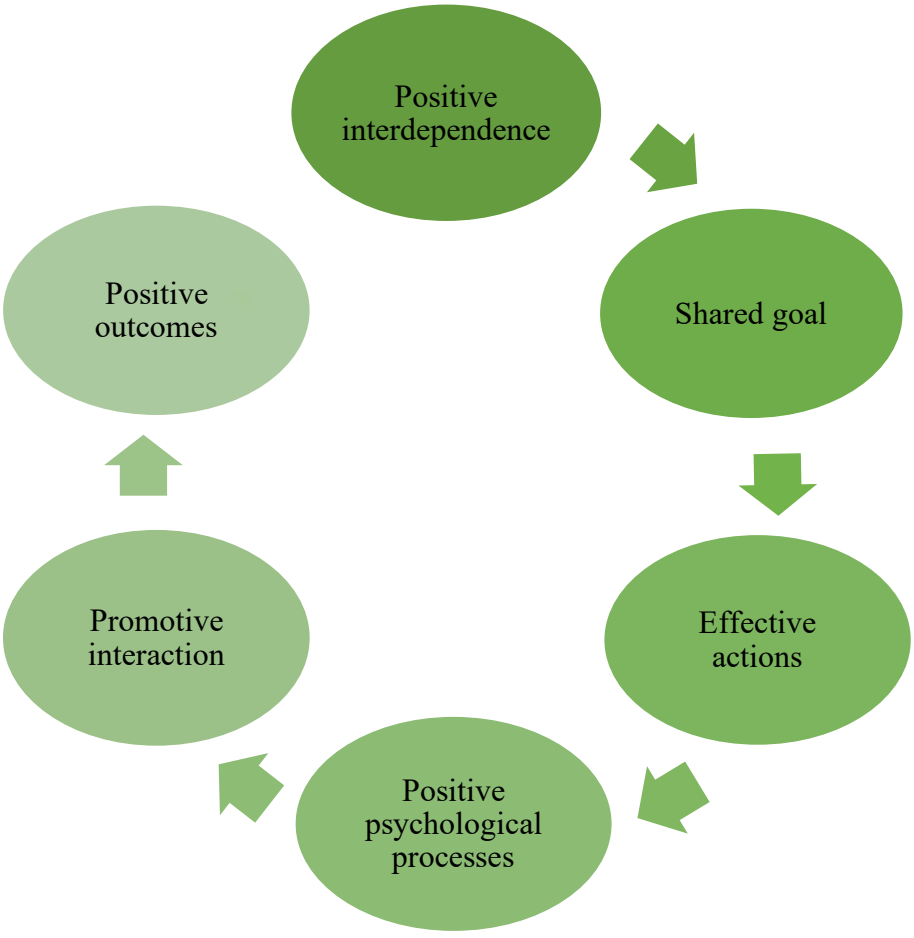

Figure 1. Positive interdependence processes in groups

According to Deutsch, *positive interdependence* arises when individuals in a group think that the only way, they can reach their own goals is if other individuals reach their goals (Deutsch, 1973, p. 20; Johnson & Johnson, 2009, p. 366). Therefore, as shown in Figure 1, when individuals within a group are positively independent and share goals, they engage in *effective actions,* e.g., orientation to task achievement and high productivity, to try to reach their *shared goal*. In the process, they are likely to experience *positive psychological processes* and Deutsch (2012, pp. 5-6) points to three psychological processes: cathexis, substitutability, and inducibility. Cathexis concerns the human innate predisposition to respond positively to stimuli that are beneficial for us and negatively to those that are harmful. Substitutability is a term which is used to describe the degree to which an individual's actions can satisfy another individual's intentions, e.g., division of labor or role specialization. Inducibility refers to the readiness to accept or reject doing what another individual wants us to do. Positive interdependence is likely to affect these three psychological processes in a positive manner and because of that the next step in Figure 1, *promotive interaction* will follow. Promotive interaction is a type of interaction where individuals encourage and ease each other's contributions. Ultimately, the entire process will lead to *positive outcomes* for the individuals in the group. These positive outcomes are characterized by a reciprocal relationship and count high efforts to achieve, positive relationships, and good mental health (Johnson & Johnson, 1989, p. 9). In our study, we relate SoB to positive relationships and good mental health and due to our extended understanding of GS, we relate GS to all three categories: high efforts to achieve, positive relationships, and good mental health.

Deutsch (1973; 2012) stressed that few situations are characterized by purely positive, negative or no interdependence. Thus, to facilitate positive student outcomes, e.g., increased SoB and GS, it may be important to create deliberate structures leading to positive interdependence. Structuring positive interdependence between students in groups is the pillar of the teaching method Cooperative Learning (CL).

2.2 Cooperative Learning (CL)

The premise of SIT has the last forty years been systematically developed into the pedagogy known as Cooperative Learning (CL) by educational psychologists and brothers David and Roger Johnson (Johnson & Johnson, 1989). CL rests on the relationship between SIT, research, and practice - and numerous studies have validated, modified, and extended the theory and the applications of CL (Johnson & Johnson, 2009). Based on SIT, CL underlines positive interdependence in cooperation. In CL, students are not simply assigned to groups and told to work together (Gillies, 2014). Thus, CL tends to be more highly structured than other forms of small-group learning (Millis & Cottell, 1998, p. 10). CL may be defined as: '...a highly structured form of group work' (Millis, 2010, p. 5) and '…the instructional use of small groups so that students work together to maximize their own and each other's learning' (Johnson et al., 1998, p. 14). For true cooperation to occur, both groups and group tasks should be structured according to a set of principles.

Johnson and Johnson (2009) operate with five principles to which CL should adhere. *Positive interdependence* is achieved by structuring the group and the group task in a way that makes group members interdependent and interested in co-working to successfully complete the task (Ballantine & McCourt Larres, 2007, p. 128). *Individual accountability* promotes responsibility and prevents social loafing (Millis & Cottell, 1998). Individual accountability is achieved when the teacher includes a mechanism, e.g., individual tests, for holding group members accountable for learning the material and completing the group task (Ballantine & McCourt Larres, 2007, p. 128). *Promotive interaction* takes place when group members encourage and ease each other's contributions through listening, exchanging ideas, offering explanations, and constructive feedback (Gillies, 2014, p. 131). According to Johnson and Johnson (1990) such reciprocal actions may also lead to group members feeling more accepted and valued. *Appropriate use of social skills* is the explicit training and negotiation of social inclusion, mutual respect, consideration, and assistance within the group (Gillies, 2016). *Group reflection* occurs in two steps: first the group members reflect on which group actions and strategies were useful and which were not and second, they decide which actions and strategies should be maintained and which need altering (Johnson & Johnson, 2009). In addition to the CL principles of Johnson and Johnson (2009), we find other principles or basic elements in CL literature and *Tutoring* is one of these. Tutoring is characterized by the teacher's involvement and support in the group task, process, and product (Atxurra et al., 2015).

Teachers who plan, explain, observe, help, and offer feed-back are invaluable to student success (Hattie, 2012).

3 RESEARCH QUESTION

Most of the previous studies on the proposed relationships between CL and SoB and CL and GS in undergraduate STEM education do not provide an in-depth theoretical rationale for this association and have not been conducted in a European setting (Møgelvang & Nyléhn, 2022). To the best of our knowledge, associations between CL on the one hand and the development of SoB and GS on the other, have yet to be examined in Norwegian undergraduate STEM education.

In this study, we contribute to filling these knowledge gaps. In response to higher education challenges (Knapstad et al., 2018; Sivertsen, 2021) and numerous international and national priorities (OECD, 2018; St.Meld.16, 2020-2021; UN, 2015), we consider it important to identify teaching methods that may enhance SoB and GS in a Norwegian higher education context, and to provide possible and thorough theoretical reasons for such associations. Hence, we pose the following research question:

How is cooperative learning related to sense of belonging and generic skills among students in Norwegian undergraduate STEM education?

4 METHODS

4.1 Sample and Procedure

Data used in this study was based on a cross-sectional survey collected during lectures in the fall 2020. For the analyses, we used a sample of undergraduate STEM students at a major Norwegian university. In total 437 students from six different courses were invited to complete a survey and 401 students participated, resulting in a response rate of 92%. The students were studying the following disciplines: chemistry (n=146; 36%), biology (n=126; 31%), geology (n=92; 23%), engineering (n=22; 6%), and physics (n=15; 4%). Only large undergraduate STEM courses implementing variants of student cooperation were invited to participate. Participants consisted of 244 females (61%), 152 males (38%) and 4 students who did not report gender (1%). Age was divided into three intervals: 20 years or younger (52%), 21-24 years of age (41%), and 25 years or older (8%). Regarding the education level of their parents, 14% of the students had no parents with higher education, 35% had one parent with higher education and 51% responded that both parents had higher education.

The data collection procedures followed the regulation of the General Data Protection Regulation (GDPR) and the advice of Norwegian Centre for Research Data (NSD), and the study was registered in a data protection portal. The participants were informed of the purpose of the study, that their participation was voluntary, and that no personal, sensitive, nor identifiable data was collected. Each student was allowed 15 minutes to complete the survey. Due to the COVID-19 pandemic the data collection was partly digital, using SurveyXact by Rambøll (Rambøll, 2021), and partly physical, depending on course restrictions. The main researcher or research assistants were available for questions throughout the completion.

4.2 Measures

All measures were validated in a pilot survey administered to 253 STEM students at the same university during the spring 2020. The main purpose of the pilot was to validate the translation and the dimensionality of the *Psychological Sense of School Membership* (PSSM) by Goodenow (1993) and the *Cooperative Learning Application Scale* (CLAS) (Atxurra et al, 2015). Based on student comments and the statistical measures from this pilot some of the items were re-translated while others were removed. The individual measures and their validation steps are explained below.

4.2.1 Cooperative Learning (CL)

Validated scales that measure CL in higher education are rare and therefore, this study made use of a rather new scale called the *Cooperative Learning Application Scale* (CLAS) (Atxurra et al., 2015). This

scale consists of 44 items distributed along seven subscales, each responding to a CL principle: Positive interdependence, Interaction, Social skills, Group reflection, Heterogeneity, Assessment, and Tutoring.

Because CLAS was a new scale with little previous validation, we took several steps to validate it in a Norwegian setting before using it in the pilot and main survey. First, we decided to remove two subscales: assessment and heterogeneity. Assessment (six items) was removed as formative assessment has not yet been implemented in all courses at Norwegian universities. Heterogeneity (four items) was removed as our survey was to be administered to large introductory courses where deficient personal knowledge of the students may make the forming of heterogeneous groups a difficult task. Lacking measures of student in-coming preparation analogous to ACT or SAT scores, or GPA in previous classes in Norway adds to this difficulty (Cotner et al., 2020).

As recommended by the International Test Commission (ITC) test translation and adaptation guidelines (Hambleton, 2001), the items were translated from English to Norwegian and then back to English again by two different sets of researchers. After agreeing upon the most suitable translation, each item was discussed with a group of five STEM students to ensure that the students' understanding of the items reflected the meaning of the items. Furthermore, the translation and number of items in the scale were subject to change after student feedback and the statistical findings of the aforementioned pilot study (n=253). Ultimately, the validation process resulted in a final scale consisting of five subscales and 23 items. These five subscales each represented the following principles of CL: positive interdependence, promotive interaction, social skills, group reflection and tutoring.

The items in the selected subscales included statements such as "When we work in groups, we can't fulfill a task unless everybody contributes" (Positive interdependence), "In this subject, we have the opportunity to share our opinions with group members" (Interaction) and "The lecturer guides us and helps us with our group task" (Tutoring). The items were measured on a 4-point Likert-type scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*).

4.2.2 Sense of Belonging (SoB)

To measure the students' SoB in their respective courses, we used the *Psychological Sense of School Membership* (PSSM) by Goodenow (1993). The scale has been validated in international higher education and in some but not all previous studies, the PSSM has resulted in three different subscales equivalent to a sense of social belonging (peer-related), a sense of academic belonging (tutor-related) and a general sense of belonging (institution-related). In these studies, the global scale and subscales have demonstrated good internal consistency (Alkan, 2016; Freeman et al., 2007).

The original scale consists of 18 statements, but due to poor fit we decided to remove two of the items. The PSSM underwent the same thorough validation steps as the CLAS. First, it was translated and back translated in accordance with the ITC (Hambleton, 2001) and second, discussed with a group of five STEM students to ensure that the students' understanding of the items reflected the meaning of the items. Further, based on student feedback in the pilot survey (n=253), we reformulated some of the items before including them in the present study. Examples of select items are "Other students here like me the way I am", "The teachers here respect me" and "I feel like a real part of (name of course)". All items were measured on a 5-point Likert scale from *strongly disagree* (1) to *strongly agree* (5).

4.2.3 Generic Skills (GS)

The students' perceptions of their GS in their respective courses were measured using the subscale "Generic skills" in the *Course Experience Questionnaire* (CEQ) (Ramsden, 1991). The subscale comprises six statements such as "The course helped me to develop my ability to work as a team member" and "The course sharpened my analytical skills" which were measured using a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). In previous publications, including in a Norwegian study, the reliability of the CEQ "Generic skills" subscale has been acceptable (Byrne & Flood, 2003; Espeland & Indrehus, 2003; Jansen et al., 2013) and no translation was needed.

4.3 Data Analyses

All preliminary and primary analyses were performed using IBM SPSS 25 (IBM, 2017). First, to assess factor structure, normal distribution, and internal consistency, we conducted exploratory factor analyses, descriptive analyses, and reliability analyses measured with Cronbach's alpha. Second, to explore potential relationships between CL and SoB and GS, we ran Pearson bivariate correlation analyses.

Third, to determine how much unique variance each of the CL subscales explain in the prediction of SoB and GS, we conducted standard multiple regression analyses. "Exclude cases pairwise" was the chosen strategy in cases of missing data.

5 RESULTS

5.1 Exploratory Factor Analyses

Due to little previous validation of CLAS and the uncertainties regarding dimensionality of PSSM, we ran Principal component exploratory factor analyses (Tabachnick & Fidell, 2014). Because CLAS and PSSM were reported to consist of correlated factors (Atxurra et al., 2015; You et al., 2011), we used Oblimin rotation (Tabachnick & Fidell, 2014). Our exploratory factor analyses (EFAs) showed acceptable factor loadings. An EFA of CLAS resulted in a four-factor solution with eigenvalues above 1, accounting for 64.38% of the variance. The original subscales "Social skills" and "Group reflection" emerged as one factor which we, based on the items, named "Group work reflection". An EFA of PSSM produced three factors, i.e., general sense of belonging, social sense of belonging, and academic sense of belonging, with eigenvalues above 1 which in total accounted for 56.34% of the variance. An EFA of *Course Experience Questionnaire* (CEQ) (Ramsden, 1991) resulted in a one-factor solution with eigenvalues above 1, accounting for 53.01% of the variance. Full overviews of the EFA solutions and their respective factor loadings are presented in the supplementary materials.

5.2 Descriptive Statistics

As illustrated in Table 1, all variables met the assumptions of normal distribution with skewness (Skw.) and kurtosis (Kurt.) well under the absolute limit of -2 to 2 (Field, 2009). Reliability was measured with Cronbach's alpha (α) and exhibited values of around .80 which is considered good and around .90 which is considered excellent (Cronbach, 1951; Kline, 2016).

Table 1. Descriptive statistics for the study variables

	M	Range	*SD*	Skw.	Kurt.	α
Cooperative learning (CL)	2.87	1-4	0.60	-0.47	-0.05	.93
Positive interdependence	3.07	1-4	0.71	-0.76	0.11	.84
Interaction	3.19	1-4	0.68	-0.84	0.16	.84
Group work reflection*	2.42	1-4	0.80	-0.07	-0.78	.88
Tutoring	2.80	1-4	0.73	-0.42	-0.27	.87
Sense of belonging (SoB)	4.10	1-5	0.57	-0.43	-0.53	.88
General sense of belonging	3.86	1-5	0.80	-0.41	-0.51	.81
Social sense of belonging	4.24	1-5	0.62	-0.79	0.03	.80
Academic sense of belonging	4.18	1-5	0.67	-0.85	0.64	.77
Generic skills (GS)	3.62	1-5	0.71	-0.16	-0.17	.81

Note. *M* = Mean; *SD* = Standard Deviation; Skw = Skewness; Kurt. = Kurtosis;
α = Cronbach's alpha.
*"Group work reflection" is a novel combined subscale

5.3 Correlation Analyses

All the Pearson bivariate correlations between the study variables were significant at $p<.01$ as shown in Table 2. Specifically, and marked in bold, CL correlated strongly with SoB and with GS. Further, SoB was strongly correlated with GS. Lastly, the correlation between the CL subscale Interaction and SoB and GS was stronger than the correlations between the other CL subscales and SoB and GS. All effects in bold were large ($r>.50$) in magnitude, except for the correlation between Interaction and GS, which was medium ($r>.30$) in magnitude (Cohen, 2013).

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Table 2. Pearson correlation matrix of the study variables

		1	2	3	4	5	6	7	8	9	10
1	Cooperative learning (CL)	-									
2	Positive interdependence	.73	-								
3	Interaction	.83	.57	-							
4	Group work reflection	.80	.34	.53	-						
5	Tutoring	.89	.51	.64	.68	-					
6	Sense of belonging (SoB)	**.56**	.41	**.57**	.39	.47	-				
7	General sense of belonging	.47	.27	.49	.38	.37	.83	-			
8	Social sense of belonging	.41	.35	.43	.22	.32	.83	.51	-		
9	Academic sense of belonging	.52	.38	.47	.37	.47	.80	.49	.54	-	
10	Generic skills (GS)	**.52**	.33	**.46**	.42	.45	**.56**	.55	.35	.46	-

Note. All correlations were significant (p<.01).

5.4 Multiple Regression Analyses

Multiple regression analyses make several assumptions about the data (Tabachnick & Fidell, 2014) and thus, preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. The overall regression of CL to predict SoB was statistically significant (R^2 = .35, F (4, 36) = 48.36, $p < .001$) and the effect size large in magnitude ($R^2 > .26$) (Cohen, 2013). As marked in bold in Table 3, the only CL subscale to significantly predict SoB was Interaction (β = .40). Group work reflection, Positive interdependence and Tutoring did not significantly predict SoB. The overall regression of CL to predict GS was statistically significant (R^2 = .26, F (3, 36) = 43.01, $p < .001$) and the effect size large in magnitude ($R^2 > .26$) (Cohen, 2013). The following CL subscales, in descending order, significantly predicted GS: Interaction (β = .24), Group work reflection (β = 18), and Tutoring (β = .14). Positive Interdependence did not significantly predict GS, see Table 3.

Table 3. Standard multiple regression results of the subscales of CLAS in predicting sense of belonging and generic skills

	Unstandardized coefficients		Standardized coefficients		95% CI	
Variable	*B*	*SE*	*β*	*t*	*LL*	*UL*
Sense of belonging						
Constant	2.43	.13		19.32	2.19	2.68
Group work reflection	.01	.01	.07	1.25	-.01	.03
Positive interdependence	.02	.01	.09	1.76	-.00	.03
Interaction	.07	.01	**.40*** **	6.68	.05	.09
Tutoring	.01	.01	.11	1.63	-.00	.03
Generic skills						
Constant	11.25	1.02		11.09	9.26	13.25
Group work reflection	.20	.07	**.18** **	2.91	.06	.33
Positive interdependence	.07	.07	.06	.98	-.07	.20
Interaction	.30	.08	**.24*** **	3.63	.14	.46
Tutoring	.14	.07	**.14***	2.00	.00	.28

Note. CLAS = Cooperative Learning Application Scale; CI = Confidence interval; *LL* = lower limit; *UL* = upper limit.
*$p < .05$. **$p < .01$. ***$p < .001$

6 DISCUSSION

The purpose of this study was to examine how perceived CL relates to the development of perceived SoB and GS among a sample of Norwegian students in undergraduate STEM education and three main findings emerged. First, the results suggested that CL is positively related to both SoB and GS respectively. Second, we found that SoB and GS are positively interrelated. Third, Interaction emerged as the strongest of the significant subscales of CL in the prediction of SoB and GS.

6.1 The Relationship between CL and SoB, and CL and GS

Previous studies from the US show that CL may enhance undergraduate STEM students' SoB and GS (Canelas et al., 2017; Carson & Glaser, 2010; Cheruvelil et al., 2020; Furuto, 2017; Ott et. al, 2018; Wilton et al., 2019). Although not inferring any causal relationships, our study supports a positive relationship between CL and SoB and CL and GS in a context not examined previously, i.e., in a sample of Norwegian STEM undergraduates. Further, by providing an explanation based on social interdependence theory (SIT), the study adds value to the existing literature on the relationship between CL and SoB and GS.

When explaining the findings in light of SIT, it is vital to consider one of the principal conditions for positive interdependence in groups, i.e., shared goals. As shown in Figure 1, SIT states that shared goals between students in groups will lead to positive actions, psychological processes, promotive interaction, and subsequently outcomes, such as SoB and GS in our study (Deutsch, 2012; Johnson & Johnson, 2009, p. 366). Shared goals, and the processes they may cause, could provide the conditions Allen et al. (2021) and Baumeister and Leary (1995) claim are necessary for belonging. Not only might a shared goal provide opportunities to belong, positive psychological processes and promotive interaction (Figure 1) might also facilitate positive student perceptions of belonging – and ultimately satisfy the need to belong and prevent student loneliness (Baumeister & Leary, 1995). Shared goals and the actions, processes, and interactions brought about by positive interdependence (Figure 1) may ultimately also train and strengthen the students' GS such as communication, problem-solving, analytical skills, and collaboration. Such a process would be in line with the hypothesis proposed by Millis and Cottell (1998) that the inherent structures in CL groups and group work may lead to various GS.

6.2 A Relationship between SoB and GS?

A strong positive correlation between SoB and GS was found in the present study (Table 2). Although beyond the original scope of this study, this strong correlation may be relevant for the interpretation of the results and of interest to further studies. When SoB and GS are interrelated, it complicates our understanding of the influence of CL on these variables.

Theoretically, it is likely that SoB may lead to increased GS. According to Baumeister and Leary (1995) we will strive to fulfill our need to belong through interaction, and previous research shows that GS are developed by way of student interaction (Ballantine & McCourt Larres, 2007; Kember et al., 2007; Smith & Bath, 2006; Tynjälä & Gijbels, 2012; Virtanen & Tynjälä, 2019). On the other hand, it is also likely that students who master GS at an early stage are inclined to experience an enhanced SoB. Demonstrating solid GS may lead to recognition from peers and faculty alike and is also likely to be reflected in good grades, which in turn may affect SoB positively. A third explanation may be that SoB and GS reinforce each other. This third explanation would be in accordance with SIT which states that there is a reciprocal relationship among efforts to achieve, positive relationships, and good mental health (Johnson & Johnson, 1989, p. 9). To the best of our knowledge research on the relationship between SoB and GS does not exist, and more research is needed on this topic.

6.3 The Relationship between Interaction and SoB, and Interaction and GS

Our results indicate that of the CL principles measured in this study, Interaction is the most important principle in the development of SoB and GS. Which specific CL principles are most important to student outcomes, e.g., SoB and GS, in STEM higher education has - to the best of our knowledge - not been examined previously. Thus, this study may bring new knowledge to the field. The Interaction subscale measured in our study can be considered to reflect the principle of promotive interaction (Gillies, 2014, p. 131), and in SIT promotive interaction is considered an important step leading to positive student outcomes.

The association between the CL subscale Interaction and SoB might support the theoretical assumption in SIT that promotive interaction leads to positive student relationships and good mental health. The findings may also be in compliance with the CL notion that promotive interaction is considered to bring about a feeling of personal acceptance and value among peers (Johnson & Johnson, 1990). Further, our findings may support the belief that interaction - more than other factors and principles, including in CL practices - is key in the fulfillment of our need to belong (Baumeister & Leary, 1995).

The association between the CL subscale Interaction and GS may also support the theoretical assumption in SIT that promotive interaction increases student efforts to achieve, positive relationships, and good mental health. Johnson and Johnson (2002) suggest that promotive interaction in university populations results in cognitive processes involving oral communication, problem-solving, acquisition of concepts, critical thinking and bridging past and present knowledge. We see many parallels between the cognitive processes pointed out by Johnson and Johnson (2002) and today's sought-after GS. In addition, our findings support the hypothesis by Millis and Cottell (1998), specifically that the inherent structures in CL groups and group work may lead to various GS. Promotive interaction as one of the key CL principles may underpin many CL structures which in turn may stimulate the development of GS.

6.4 Limitations and Strengths

Our study is a cross-sectional study and thus, no causal relationships could be claimed. Although our results showed clear associations between CL, SoB, and GS it is not possible to infer any direction to these associations. Self-reported instruments and scales not previously validated in a Norwegian setting may also pose a limitation to the study. Finally, there is a possibility that the COVID-19 pandemic and a high degree of digital teaching have affected the students' perceptions of CL, SoB, and GS.

Despite these possible limitations, this study can point to many strengths. The study was conducted in a sample not previously examined and thoroughly pre-validated scales and design through systematic procedures such as student interviews, an extensive pilot study, and review of previous research. The response rate and the magnitude of the relationships may be considered a strength, and the study provides a theoretical rationale for the studied relationships using SIT. Taken together, this study fills knowledge gaps and contributes with new and valuable information about the relationship between CL and SoB and CL and GS among a sample of Norwegian students in undergraduate STEM education.

7 CONCLUSION

We find positive relationships between CL and the development of SoB and GS, but also between SoB and GS among Norwegian students in undergraduate STEM education. The CL principle contributing most to the relationship between CL and SoB and CL and GS is promotive interaction. Except for the positive interrelationship between SoB and GS, our findings seem to be consistent with previous research and all our findings may be understood through the lens of SIT and the benefits of structuring positive interdependence into student group work (Johnson & Johnson, 2009).

7.1 Implications

Our findings suggest that implementing CL in university STEM courses might be a suitable method to strengthen SoB and GS. Our study underlines the importance of promotive interaction and thus we recommend that faculty provide students opportunities to participate in groups where they can help and support each other, exchange ideas, communicate thoughts, and offer explanations and constructive feedback (Gillies, 2014, p. 131; Johnson et al., 2014). However, it must be stressed that we do not recommend merely "group work". We suggest that teachers increase their competency on which elements contribute to successful group work, to ensure that group work is structured to increase positive interdependence among students. Faculty also need to be aware of and avoid negative interdependence.

We recommend that CL structures are applied in one of the large introductory courses. Such a course can be led by an instructor that is skilled in CL, making a foundation for group work in subsequent courses. However, we recommend that all teachers who apply CL have acquired basic competencies in the method, to ensure that students perform group work in a fruitful way.

Studies examining the relationship between CL on the one hand and SoB and GS on the other in higher education are few, conducted outside Europe, and do typically not offer thorough theoretical frameworks. More research examining and theoretically explaining this relationship and the relationship between SoB and GS is warranted - in Norway, in other countries, and in different types of higher education disciplines.

8 DATA AVAILABILITY

The dataset of the current study is available from the corresponding author on reasonable request.

9 DECLARATION OF CONFLICTING INTERESTS

The authors have no conflicts of interest to disclose.

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REFERENCES

Alkan, N. (2016). Psychological sense of university membership: An adaptation study of the PSSM scale for Turkish university students. *Journal of Psychology, 150*(4), 431-449. https://doi.org/10.1080/00223980.2015.1087373

Allen, K.-A., Kern, M. L., Rozek, C. S., McInerney, D. M., & Slavich, G. M. (2021). Belonging: A review of conceptual issues, an integrative framework, and directions for future research. *Australian Journal of Psychology, 73*(1), 87-102. https://doi.org/10.1080/00049530.2021.1883409

Atxurra, C., Villardón-Gallego, L., & Calvete, E. (2015). Design and validation of the cooperative learning application scale (CLAS). *Revista de Psicodidactica, 20*(2), 339-357. https://doi.org/https://doi.org/10.1387/RevPsicodidact.11917

Aurlien, I., Bjørnsrud, K. M., Haugom, E., & Thrane, C. (2019). Betydningen av målbevissthet og sosial tilhørighet for frafall i høyere utdanning [The importance of goal determination and social belonging for drop out in higher education]. *Uniped, 42*(2), 125-138. https://doi.org/10.18261/issn.1893-8981-2019-02-02

Ballantine, J., & McCourt Larres, P. (2007). Cooperative learning: A pedagogy to improve students' generic skills? *Education & Training, 49*(2), 126-137. https://doi.org/10.1108/00400910710739487

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497-529. https://doi.org/10.1037/0033-2909.117.3.497

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). Springer https://doi.org/10.1007/978-94-007-2324-5_2

Bourn, D. (2018). *Understanding global skills for 21st century professions*. Springer International Publishing. https://doi.org/10.1007/978-3-319-97655-6_3

Byrne, M., & Flood, B. (2003). Assessing the teaching quality of accounting programmes: An evaluation of the Course Experience Questionnaire. *Assessment and Evaluation in Higher Education, 28*(2), 135-145. https://doi.org/10.1080/02602930301668

Canelas, D. A., Hill, J. L., & Novicki, A. (2017). Cooperative learning in organic chemistry increases student assessment of learning gains in key transferable skills. *Chemistry Education Research and Practice, 18*(3), 441-456. https://doi.org/10.1039/C7RP00014F

Carson, K. M., & Glaser, R. E. (2010). Chemistry is in the news: assessing intra-group peer review. *Assessment and Evaluation in Higher Education*, *35*(4), 381–402. https://doi.org/10.1080/02602930902862826

Cheruvelil, K. S., De Palma-Dow, A., & Smith, K. A. (2020). Strategies to promote effective student research teams in undergraduate biology labs. *The American Biology Teacher*, *82*(1), 18–27. https://doi.org/10.1525/abt.2020.82.1.18

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic Press.

Cornford, I. (2005). Challenging current policies and policy makers' thinking on generic skills. *Journal of Vocational Education & Training, 57*(1), 25-45. https://doi.org/10.1080/13636820500200273

Cotner, S., Jeno, L. M., Walker, J. D., Jørgensen, C., & Vandvik, V. (2020). Gender gaps in the performance of Norwegian biology students: The roles of test anxiety and science confidence. *International Journal of STEM Education, 7*(1), 1-10. https://doi.org/10.1186/s40594-020-00252-1

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334. https://doi.org/10.1007/BF02310555

Davey, T., Meerman, A., Galán-Muros, V., Orazbayeva, B., & Baaken, T. (2018). *The state of university-business cooperation in Europe (Final report).* https://www.ub-cooperation.eu/

Deutsch, M. (1973). *The resolution of conflict*. Yale University Press.

Deutsch, M. (2012). A theory of cooperation – competition and beyond. In P. A. M. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), *Handbook of theories of social psychology: volume 2* (Vol. 2, pp. 275). SAGE Publications Ltd. https://doi.org/10.4135/9781446249222.n40

Espeland, V., & Indrehus, O. (2003). Evaluation of students' satisfaction with nursing education in Norway. *Journal of Advanced Nursing, 42*(3), 226-236. https://doi.org/10.1046/j.1365-2648.2003.02611.x

Field, A. (2009). *Discovering statistics using SPSS: (and sex and drugs and rock 'n' roll)* (3rd ed.). SAGE.

Freeman, T. M., Anderman, L. H., & Jensen, J. M. (2007). Sense of belonging in college freshmen at the classroom and campus levels. *The Journal of Experimental Education, 75*(3), 203-220. https://doi.org/10.3200/JEXE.75.3.203-220

Furuto, M. A. (2017). Mathematics pedagogical strategies to create a positive college classroom community. *Malaysian Journal of Mathematical Sciences, 11* (1), 9-21.

Gillies, R. M. (2014). Developments in cooperative learning: review of research. *Anales de Psicología 30*(3), 792-801. https://doi.org/10.6018/analesps.30.3.201191

Gillies, R. M. (2016). Cooperative learning: review of research and practice. *Australian Journal of Teacher Education, 41*(3), 39-54.

Goodenow, C. (1993). The psychological sense of school membership among adolescents: Scale development and educational correlates. *Psychology in Schools, 30*(1), 79-90.

Hagerty, B. M. K., Lynch-Sauer, J., Patusky, K. L., Bouwsema, M., & Collier, P. (1992). Sense of belonging: A vital mental health concept. *Archives of Psychiatric Nursing, 6*(3), 172-177. https://doi.org/10.1016/0883-9417(92)90028-H

Hambleton, R. K. (2001). The next generation of the ITC test translation and adaptation guidelines. *European Journal of Psychological Assessment, 17*(3), 164-172. https://doi.org/10.1027//1015-5759.17.3.164

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning*. Routledge.

Hayley, A. C., Downey, L. A., Stough, C., Sivertsen, B., Knapstad, M., & Øverland, S. (2017). Social and emotional loneliness and self-reported difficulty initiating and maintaining sleep (DIMS) in a sample of Norwegian university students. *Scandinavian Journal of Psychology, 58*(1), 91-99. https://doi.org/10.1111/sjop.12343

Heckman, J. J., & Kautz, T. (2012). Hard evidence on soft skills. *Labour Economics, 19*(4), 451-464. https://doi.org/10.1016/j.labeco.2012.05.014

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and social isolation as risk factors for mortality: A meta-analytic review. *Perspectives on Psychological Science, 10*(2), 227-237. https://doi.org/10.1177/1745691614568352

IBM. (2017). *IBM SPSS statistics for Macintosh, version 25.0.* In IBM Corp.

Jansen, E., van der Meer, J., & Fokkens-Bruinsma, M. (2013). Validation and use of the CEQ in The Netherlands. *Quality Assurance in Education, 21*(4), 330-343. https://doi.org/10.1108/QAE-11-2012-0041

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Interaction Book Company.

Johnson, D. W., & Johnson, R. T. (1990). Cooperative learning and achievement. In S. Sharan (Ed.), *Cooperative learning: Theory and research* (pp. 23-37). Praeger.

Johnson, D. W., & Johnson, R. T. (2002). Social interdependence theory and university instruction - theory into practice. *Swiss Journal of Psychology, 61*(3), 119-129. https://doi.org/10.1024//1421-0185.61.3.119

Johnson, D. W., & Johnson, R. T. (2005). New developments in social interdependence theory. *Genetic Social and General Psychology Monographs, 131*(4), 285-358. https://doi.org/10.3200/MONO.131.4.285-358

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365-379. https://doi.org/10.3102/0013189X09339057

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom* (2nd ed.). Interaction Book Company.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. *Journal on Excellence in College Teaching, 25*(3-4), 85-118.

Kember, D., Leung, D. Y. P., & Ma, R. S. F. (2007). Characterizing learning environments capable of nurturing generic capabilities in higher education. *Research in Higher Education, 48*(5), 609-632. https://doi.org/10.1007/s11162-006-9037-0

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guildford.

Knapstad, M., Heradstveit, O., & Sivertsen, B. (2018). *Students' Health and Wellbeing Study 2018*. SiO. https://www.studenthelse.no/tema/sosiale_forhold

Male, S. A., Bush, M. B., & Chapman, E. S. (2011). An Australian study of generic competencies required by engineers. *European Journal of Engineering Education, 36*(2), 151-163. https://doi.org/10.1080/03043797.2011.569703

Maslow, A. H. (1968). *Toward a psychology of being* (2nd ed.). D. Van Nostrand.

Millis, B. J. (2010). Why faculty should adopt cooperative learning approaches. In B. J. Millis (Ed.), *Cooperative learning in higher education* (pp. 1-9). Stylus Publishing, LLC

Millis, B. J., & Cottell, P. G. (1998). *Cooperative learning for higher education faculty*. American Council on Education/Oryx.

Møgelvang, A., Nyléhn, J. (2022). Co-operative learning in undergraduate mathematics and science education: A scoping review. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-022-10331-0

OECD. (2018). *The Future of Education and Skills 2030.* OECD. https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf

Ott, L. E., Kephart, K., Stolle-McAllister, K. & LaCourse, W. R. (2018). Students' understanding and perceptions of assigned team roles in a classroom laboratory environment. *Journal of College Science Teaching*, *47*(4), 83–91. https://doi.org/10.2505/4/jcst18_047_04_83

Rambøll. (2021). *SurveyXact*. Retrieved 19.10.2021 from https://www.surveyxact.no

Ramsden, P. (1991). A performance indicator of teaching quality in higher education: The Course Experience Questionnaire. *Studies in Higher Education, 16*(2), 129-150. https://doi.org/10.1080/03075079112331382944

Richardson, T., Elliott, P., & Roberts, R. (2017). Relationship between loneliness and mental health in students. *Journal of public mental health, 16*(2), 48-54. https://doi.org/10.1108/JPMH-03-2016-0013

Sivertsen, B. (2021). *Students' Health and Wellbeing Study 2021*. SiO. https://sioshotstorage.blob.core.windows.net/shot2018/SHOT2021.pdf

Smith, C., & Bath, D. (2006). The role of the learning community in the development of discipline knowledge and generic graduate outcomes. *Higher Education, 51*(2), 259-286. https://doi.org/10.1007/s10734-004-6389-2

St.Meld.16. (2020-2021). *Utdanning for omstilling - Økt arbeidslivsrelevans i høyere utdanning [Education for change - Increased work relevance in higher education]*. https://www.regjeringen.no/no/dokumenter/meld.-st.-16-20202021/id2838171/?ch=1

Sæthre, H. Å. (2014). *Å tilrettelegge for at studentene skal lykkes: en verktøykasse for utdanningsledere, studieadministrasjon, studenttillitsvalgte [Facilitating student succes: A toolbox for educational leaders, study administration, student representatives]*. Haas1.

Tabachnick, B. G., & Fidell, L. S. (2014). *Using multivariate statistics* (6th, new international ed.). Pearson.

Taber, K. S. (2016). Learning generic skills through chemistry education. *Chemistry Education Research and Practice Journal, 17*, 225-228.

Thomas, L. (2012). *Building student engagement and belonging in higher education at a time of change.* P. H. Foundation. https://www.heacademy.ac.uk/system/files/what_works_final_report_0.pdf

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research ,45*(1), 89-125. https://doi.org/10.3102/00346543045001089

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). The University of Chicago Press.

Tynjälä, P., & Gijbels, D. (2012). Changing world: Changing pedagogy. In P. Tynjälä, M.-L. Stenström, & M. Saarnivaara (Eds.), *Transitions and transformations in learning and education* (pp. 205-222). Springer Netherlands. https://doi.org/10.1007/978-94-007-2312-2_13

UN. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. Retrieved 20.04.22 from https://sdg4education2030.org/the-goal

UNESCO. (2016). *Unpacking Sustainable Development Goal 4: Education 2030; guide*. Retrieved 15.10.2022 from https://unesdoc.unesco.org/ark:/48223/pf0000246300

UNICEF. (2021). *Adolescent education and skills*. Retrieved 21.04.22 from https://www.unicef.org/education/skills-development

Virtanen, A., & Tynjälä, P. (2019). Factors explaining the learning of generic skills: A study of university students' experiences. *Teaching in Higher Education, 24*(7), 880-894. https://doi.org/10.1080/13562517.2018.1515195

Wilton, M., Gonzalez-Niño, E., McPartlan, P., Terner, Z., Christoffersen, R. E., & Rothman, J. H. (2019). Improving academic performance, belonging, and retention through increasing structure of an introductory biology course. *CBE Life Sciences Education, 18*(4), ar53-ar53. https://doi.org/10.1187/cbe.18-08-0155

You, S., Ritchey, K. M., Furlong, M. J., Shochet, I., & Boman, P. (2011). Examination of the latent structure of the Psychological Sense of School Membership scale. *Journal of Psychoeducational Assessment, 29*(3), 225-237. https://doi.org/10.1177/0734282910379968