



## Peer selection and influence: Students' interest-driven socio-digital participation and friendship networks

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*Article received 6 February 2019 / Article revised 26 February 2020 / Accepted 9 March / Available online 10 June*

### Abstract

*Digital technologies have been increasingly embedded in students' everyday lives. Interest-driven socio-digital participation (ISDP) involves students' pursuit of interests mediated by computers, social media, the internet, and mobile devices' integrated systems. ISDP is likely to intertwine closely with young people's social networks that has been scarcely studied quantitatively. To close this gap, the present paper investigated students' peer selection and influence effects of the intensity of their ISDP and friendship networks. We collected two-wave data by administering a peer nomination to trace students' friendship networks with peers and a self-reported questionnaire to examine students' ISDP. Participants were 100 students in Finland (female: 53%; mean age = 13.48, in grade 7 in the first wave). Through stochastic actor-oriented modelling, the results showed that the students' friendship ties with peers influenced the intensity of their ISDP practices to become more similar. Yet, students did not select peers as friends based on similar intensity levels of ISDP. Utilizing influence effect found in students' ISDP and their peer networks, we suggest that connected learning (Ito et al., 2013) should be promoted to integrate students' informal and formal learning in order to bridge the gap between students' informal interest-related digital practices and formal educational practices.*

**Keywords:** interest-driven socio-digital participation; peer friendship; peer selection and influence; social network analysis



## 1. Introduction

The purpose of the present investigation was to examine peer selection and influence effects over time in interest-driven socio-digital participation (ISDP). Adolescents' everyday practices are increasingly embedded with socio-digital technologies (e.g., computers, social media, the internet, and mobile devices' integrated systems), and they socialize using such technologies from the very beginning of their lives (Palfrey & Gasser, 2011). Yet, there appears to be a gap between young people's digital and educational practices (Kumpulainen & Sefton-Green, 2012; Salmela-Aro, Muotka, Alho, Hakkarainen, & Lonka, 2016) in terms of students who prefer digital learning becoming less and less engaged in school. Students who prefer to apply digital technologies to developing their interests by learning in virtual communities outside of school appeared to disengage in traditional schools. These out-of-school interests mediated by digital technologies are not well recognized (Rajala, Kumpulainen, Hilppö, Paananen, & Lipponen, 2016). Informal learning and knowledge obtained outside of school are different from those within the school environment so that there is a mismatch between learners and the formal learning contexts (McFarlane, 2015). Thus, there is an urgent and vital need to research students' digital practices for pursuing their interests.

Ubiquitous socio-digital technologies have blurred the boundaries between the time and space of interactions as well as between the virtual and real worlds (Baym & boyd, 2012). The increasing use of socio-digital technologies enables young people to pervasively network with their peers (Conti, Passarella, & Das, 2017) in three qualitative genres (Ito et al., 2010): 1) friendship-driven participation by connecting with their friends on social media (e.g., chatting with friends), 2) interest-driven participation by seeking interest-relevant knowledge and socializing with peers on the internet who share similar interests and hobbies (e.g., searching information, sharing knowledge and discussing about interests), and 3) creative participation that involves participating in creative production and developing associated digital competences (e.g., creating and modifying media artifacts) with a network of more capable peers, which can assist to develop their career tracks. Most Finnish young people are engaged in friendship-driven socio-digital participation that often represents a rather shallow use of socio-digital technologies (e.g., chatting with friends on social media) (Hietajärvi, Salmela-Aro, Tuominen, Hakkarainen, Lonka, 2019). Although there is not a large group of youth who participates in the creative use of technologies through the internet (Hietajärvi, Seppä, & Hakkarainen, 2016), expanding such learning supportive socio-digital practices across out- and in-school contexts appears to be important for meeting challenges of the emerging innovation-driven society (Ito et al., 2010; Hakkarainen, Hietajärvi, Alho, Lonka, & Salmela-Aro, 2015). On the other hand, in order to pursue interests, adolescents may participate in either closely or loosely bound social networks for discussing and sharing experiences of their hobbies (e.g. discussing about sports in online virtual communities). Cultivating interests by building such extended social networks beyond immediate social community enables adopting a role of local expert sharing knowledge and competences with peers. By this way, adolescents' interest-related activities are embedded on social networks and involve seamless possibilities of socially sharing interests and intellectual efforts. Interest-driven socio-digital participation, in this regard, may be seen as a transition zone that highly intertwines with social networks between the genres of friendship-driven and creative participation. Thus, interest-driven practices may be an important prerequisite for students to engage in creative participation that may possibly lead to further academic and even career opportunities (Ito et al., 2010). In the present study, we focused on examining the influence and selection processes related to students' social networks with peers that involve in their ISDP.

Because young people spend much of their time with their peers (Subrahmanyam & Greenfield, 2008), the norms and characteristics of peer groups have become increasingly important indicators for fitting in. Interest-driven digital activities involve both direct contacts between peers (i.e., what they say) and the social modelling of young people's digital activities (i.e., how they behave) (Ito et al., 2010). Although research confirms that young people within the same peer groups are inclined to be similar across an array of behavioural outcomes (Li, Lynch, Kalvin, Liu, & Lerner, 2011), a number of extant studies examine students' disruptive behaviours (Delay, Laursen, Kiuru, Salmela-Aro, & Nurmi,



2013), academic achievements (Fortuin, Geel, & Vedder, 2016), and school engagement (Wang, Kiuru, Degol, & Salmela-Aro, 2018). Rigorous studies of peer effects on ISDP remain scarce, and the processes that underlie peer similarity in ISDP are unclear. Peer effects in social networks are not easy to estimate, and causal interpretations should be undertaken with caution, as individuals choose whom they will associate with (Kremer & Levy, 2008). Accounting for peer selection effect is suggested because such effect reveals to what extent individuals tend to seek peers as friends based on similar intensity level of interest-related digital activities (Manski, 1993). On the other hand, peer influence (Christakis & Fowler, 2013) causes a distinct shift in the intensity of young people's interest-related digital participation, making these more similar with those of their connected peers. Thus, we simultaneously examined whether adolescents actively selected their peers based on sharing similar levels of intensity in their interest-driven digital activities (i.e., selection effect) and whether youths' friendship connections with peers contributed to adolescents' adjusting their ISDP to become more similar to their peers' ISDP over time (i.e., influence effect).

### 1.1 Peer Selection and Peer Influence

Establishing and maintaining friendships are vital in adolescence because young people spend much more time with their peers during this period than any other phase in their life spans (Witkow & Fuligni, 2010). Especially after the transition from elementary to secondary school, it is important for youth to have peers as friends and to be with them in their school lives (Haynie, 2001). Students' interactions, friendship negotiation, and their peer groups develop mostly with peers in school (Farmer, Lines, & Hamm, 2011). These interactions and negotiations emerge as a tendency for students to become friends with similar peers. Such a phenomenon of similarity among friends is typically known as homophily (McPherson, Smith-Lovin, & Cook, 2001), with a variety of similar characteristics, for instance, regarding adolescents' use of tobacco and alcohol (Cruz, Emery, & Turkheimer, 2012; Kiuru, Burk, Laursen, Salmela-Aro, & Nurmi, 2010) and their academic orientation (Shin & Ryan, 2014, Wang et al., 2018). There are two processes that can underlie homophily among peers: peer selection and peer influence (Kandel, 1978; Veenstra & Steglich, 2012). Peer selection refers to the procedure by which people select peers according to pre-existing similar characteristics (Byrne, 1971). For instance, early adolescents are likely to interact with peers of the same gender (Wang & Degol, 2017), as well as with whom they collaborate in and out of school (Juvonen, Espinoza, & Knifsend, 2012; Li, Palonen, Lehtinen, Hakkarainen, 2018). Peer influence, in contrast, refers to the procedure by which peers become more similar over time because of indirect and direct social influence (Kandel, 1978). Reinforcement may be one of the main mechanisms in the process of peer influence (see Kindermann, 2016, for a comprehensive summary). Because friendship is, in nature, reciprocal and dyadic (Bagwell & Bukowski, 2018), young people attempt to achieve common grounds or establish intimacy with friends by reinforcing certain behaviours of their friends'. Research on peer influence has revealed that adolescents' behaviours are remarkably similar to those of their friends due to peer influence (see a review by Christakis and Fowler [2013]). Because peer selection and influence indicate relationships between peers' friendship ties and their behaviours in two opposite directions (i.e. students select peers based on similar behaviours as selection effect while peer ties influence behaviours to become more similar as influence effect), researchers have suggested that the two procedures work complementarily to explain the similarity of students' behaviours with their peers' (Svensson, Burk, Stattin, & Kerr, 2012).

Adolescents may select peers as friends who are at a similar intensity level of ISDP, perhaps because it is consistent with their prior behavioural tendencies (Farmer et al., 2011). Alternatively, it could be because of a similar intensity of using interest-driven socio-digital technologies that provides youth with a seamless channel to remain connected with peers. Whether or not students select friends with a similar intensity of ISDP, connected friends may become more similar due to peer influence over time. Adolescence is a developmental period characterized by the desire to fit in with one's peers (Hamm, Farmer, Lambert, & Gravelle, 2014). Peer influence not only occurs through modelling or imitation, but it also occurs through the social comparison and behaviour approximation effects.



Adolescents increasingly invest in their peers as primary sources of social and emotional support while simultaneously using feedback and acceptance from their peers to achieve a sense of their selves. Young people thus engage in behaviours that match the social norms of a valued or desired peer group (Brechwald & Prinstein, 2011). Youth's interest-driven socio-digital participation occurs in a social sphere in which their practices are immediately visible to their peers. In most cases, young people's socio-digital practices are ultra-social in nature in terms of calling for the engagement of peers. How intensively young people engage in ISDP may, thus, be related to their friendship networks with peers. Adolescents often attempt to fit in to peer groups in which members share similar activity patterns for interest pursuits, as mentioned above. Hence, peer groups may often reach high levels of similarity in their ISDP through selection and influence processes. Because the selection and influence processes occur complementarily (Svensson et al., 2012), it is critical to estimate selection and influence effects simultaneously within behavioural and network dynamics (Steglich, Snijders, & Pearson, 2010). Yet, there is scant research examining the selection and influence effects between youths' peer friendship networks and their ISDP interest-driven use of digital technologies. Most extant research shows qualitatively that young people's pursuit of their interests is highly embedded in their social networks with peers (e.g., Penuel, DiGiacomo, Van Horne, & Kirshner, 2016; Wernholm, 2018). However, these previous studies have not distinguished particularly peer selection from peer influence. Instead, they merely examine the extent to which students' interest-driven digital practices are related to their participation in social communities. Our paper attempts to close this gap.

It is noteworthy that peer academic support online is likely to embed in the co-evolution of students' ISDP and their peer social networks (van Rijsewijk, Snijders, Dijkstra, Steglich, & Veenstra, 2019). The concept of connected learning (Ito et al., 2013) elaborates this issue theoretically. Connected learning integrates three contexts for learning: peer-supported, interest-driven and academically oriented. Peer-supported collaboration enables young people to use skills acquired in both formal and informal learning contexts. In turn, interest-driven digital learning practices may elicit the inspiration to learn related competences in schools. Connected learning appears to link students' practices related personal interests with formal learning to empower academic achievements and even career possibilities (Ito et al., 2013). As indicated by connected learning research (e.g., Deng, Connelly, & Lau, 2016), peer academic support online intertwines with students' interest-driven socio-digital participation. Therefore, present study considered peer academic support online as an influencing function in the co-evolution of students' friendship and their ISDP. In addition, we also treated gender and being in the same classroom as the other influencing factors in this co-evolution process because previous research posits that early adolescents are likely to interact with peers of same gender (Wang & Degol, 2017) in the same classroom (Gremmen et al., 2019) over time.

## 1.2 Objectives

The present study aimed at providing insights into possible selection and influence processes among peers related to ISDP within grade networks. We selected the school period of grade 7 as the starting measurement point because it falls at the beginning of secondary education in Finland, when students enter into new peer environments. Many young people must establish new friendships and find places in the new peer ecology, which we assumed would serve as an ideal context for examining selection and influence effects (Altermatt & Pomerantz, 2003). The following research questions were addressed:

1. Do young people select their friends according to similar intensity of ISDP over time (i.e., selection effect)?
2. Do adolescents' friendship network dynamics influence the intensity of their ISDP to become more similar with that of their peers (i.e., influence effect)?



## 2. Methods

### 2.1 Participants and Procedure

Students from five classes at a school in a city in southern Finland participated in the present study in the spring of 2013 (time 1 [T1]) and 2014 (time 2 [T2]). At T1, participants were in grade 7 at the average age of 13.48 (SD = 0.55). We simultaneously administered a peer nomination (using the grade roster) and a self-reported questionnaire for all participants during their ordinary class time at both time waves. A total of 103 students were in the grade roster in both time waves. Three students, who were nominated by grade peers but did not agree to participate in the present study, were removed from the list when we created friendship networks for both time waves (Shin, 2018). Hence, 100 students (male: 47, 47%; female: 53, 53%; mean age = 13.48, SD = 0.55) were in two-wave networks in this research. The grade included five classes with numbers of students ranging from 15–25 in each classroom. Sixteen students (16%) appeared only in T2 and not in T1, whereas fifteen students (15%) were present only in T1 and not in T2. Altogether, 84 (84%) and 82 (82%) participants responded to self-reported questionnaire in the two waves, respectively.

### 2.2 Measures

#### 2.2.1 Friendship Networks (T1 and T2)

We collected the friendship networks within the grade in two waves through peer nomination using a grade roster (Scott, 2000). In practice, each respondent received a list of names in the grade, and the respondents could not add any participants outside of this name list. Additionally, participants could nominate as many or as few peers as they wished within the grade roster (for similar methods, see Cillessen & Borch, 2006). We asked the respondents to indicate the existence of each networking relation of “who you spend time with” by marking the name with an “X.” We imputed all the responses from the peer nomination into adjacency matrices, altogether yielding one matrix for a peer friendship network for each time wave respectively. We coded “1” for linked ties and “0” to represent situations in which two participants lacked a tie between them. Further, we used “NA” to code the cells in the matrices to indicate friendship relations for participants who did not appear (Ripley, Snijders, Boda, Vörös, & Preciado, 2018).

#### 2.2.2 Interest-driven Socio-digital Participation (T1 and T2)

We examined students’ ISDP during both time waves by using a self-reported questionnaire. Rather than students’ experiences of interest pursuits (Maul et al., 2017), we were interested in young people’s digital practices mediated in their interest pursuits. We relied on earlier measurements of adolescents’ various ISDP (e.g., Hakkarainen et al., 2000); we also used new items that Hietajärvi et al. (2016) developed representing the relatively recent emergence of internet-related activities in the Finnish context. Accordingly, the questionnaire included 5 items using a Likert-type scale from 1 (“never”) to 7 (“all the time”) to assess the intensity of various interest-driven digital activities (see constructs in appendix, Li, Hietajärvi, Palonen, Salmela-Aro, & Hakkarainen, 2017), including “How often do you search or follow new information about your hobbies or things that interest you?”, “How often do you read blogs or forums?”, “How often do you write and comment in forums?”, “How often do you share pictures and picture updates that you took with your phone?”, and “How often do you share music or ‘mix tapes’ you have made?” In addition, these five items anchored on qualitative findings of (ISDP) by Ito and colleagues (2010) that involved one-year long ethnographic investigation on students’ socio-digital participation. The Cronbach’s alphas of these items in two waves were 0.69 and 0.75, respectively. It is notable that there were 21% (n = 21) and 18% (n = 18) missing values of ISDP in T1 and T2, respectively. Because RSiena statistical package (Ripley et al., 2018) for modelling network dynamics requires categorical dependent behavioural variables, we used the mean values of ISDP rounded to the nearest integer.



### 2.2.3 Covariates

Because connected learning integrates three contexts for learning (i.e., peer-supported, interest-driven and academically oriented) that we mentioned above, in the self-reported questionnaire for T1, we considered students' peer academic support as controlled variable in the process of interest-driven digital practices. Thus, we also asked participants the following: "How often do you ask for help from friends on school work-related issues?" and "How often do you give help to your friends on school work-related issues?" with Likert scales from 1 "never" to 7 "all the time." Seventy-seven students (77%) replied to each question, respectively. We used the mean values of these two items as a measure of participants' engagement in peer academic support ( $M = 2.86$ ,  $SD = 1.52$ ). On the other hand, we coded gender as 1 = female and 2 = male. We had no missing value for the gender variable. We used whether participants came from the same classroom (1 = Yes, 0 = No) as another covariate.

## 2.3 Analytic Strategy

We applied multiple imputation (Rubin 1987, 1996) for missing data of individual variables to impute 20 data sets (van Buuren, 2018) (see section of missing data treatment). We used the imputed data and original friendship networks to estimate 20 stochastic actor-oriented models (SAOMs). Finally, we combined the results of these 20 models.

## 2.4 Treatment of Missing Data

A total of 10–20% of the data were missing in the self-reported questionnaire mentioned above, creating difficulty in obtaining model convergence and good model estimates in further dynamic network modelling (Ripley et al., 2018, p. 32). Multiple imputation is one of the most efficient methods for handling incomplete data in which missing data occur in more than one variable in a data set (van Buuren & Groothuis-Oudshoorn, 2011). We utilized the Mice (multivariate imputation via chained equations) 3.3.0 package (van Buuren & Groothuis-Oudshoorn, 2011) in R 3.5.1 (R Development Core Team, 2011) to impute our data on ISDP (T1 and T2) and peer academic support online (T1). Mice assumes that the missing data are "missing at random" (MAR) meaning that the probability that a value is missing depends only on other observed values and can be predicted by using these values based on their linear or correlation relationship. Because of the correlation and linear relationships found between adolescents' social use of digital technologies and their mathematic achievements (Qing & Xin, 2010) as well as between youths' social use of digital technologies and their digital competences (Hargittai, 2010), we included digital competences (T1) and mathematic achievements (T1) to impute ISDP (T1 & T2).

We assessed students' digital competences through 23 items with a Likert-type scale from 1 ("not at all") to 7 ("proficient") in a self-reported questionnaire. We adapted measures developed by Hakkarainen and colleagues (2000) by adding items that emerged due to recent technological developments. The measures included basic (e.g., "Use a text-processing program to search for information on the internet"), moderate (e.g., "Edit and modify digital photos"), and advanced skills (e.g., "Set up a desktop with components (e.g. processor, sound card, graphic card)" and "programming"). Seventy-five participants (75%) responded to all the digital competences items; the Cronbach's alpha of these items was 0.91. Further, we obtained information on students' mathematic achievements in the T1 self-reported questionnaire. The grades were from 4 (lowest) to 10 (highest). Self-reported academic achievement had a correlation coefficient of 0.96 with actual achievement among Finnish students at the secondary level (Holopainen & Savolainen, 2005).

We used items measuring the sharing of academic materials online (T1) and discussing schoolwork issues online (T1) to impute peer academic support (T1) due to their correlation: sharing academic materials online and asking for schoolwork help online (Pearson: 0.36,  $p < 0.001$ ), sharing academic materials online and giving school work help online (Pearson: 0.44,  $p < 0.001$ ), discussing



schoolwork issues and asking for schoolwork help online (Pearson: 0.52,  $p < 0.001$ ), discussing schoolwork issues and giving school help online (Pearson: 0.66,  $p < 0.001$ ). Although these correlation values are not too high, this might not matter in this case because the amount of imputed missing data is relatively small. For sharing academic materials online, participants responded to the item “How often do you share materials you have created related to your schoolwork (homework, notes, essays) online with your peers?” We used the item “How often do you discuss school work-related issues with your peers online?” to measure students’ discussion of schoolwork online. Both items used a Likert-type scale from 1 (“never”) to 7 (“all the time”) in the T1 self-reported questionnaire. Van Buuren (2018) suggested 5–20 imputations “will be enough under moderate missingness”. Hence, we imputed 20 sets of ISDP (missing values in T1:  $n = 20$ , 20%; T2:  $n = 18$ , 18%) and peer academic support (T1 missing values:  $n = 23$ , 23%).

## 2.5 Stochastic Actor-Oriented Model (SAOM)

Our primary analyses included SAOM (conducted in RSiena 1.2-12) representing network-behaviour dynamics that Snijders (2005) and Snijders, van de Bunt, and Steglich (2010) developed. The model consisted of parameters representing friendship changes (i.e., network dynamics) and changes in individual ISDP (i.e., behavioural dynamics). We applied a continuous-time Markov chain Monte Carlo procedure to model the sequence of individual events with the highest probability of describing the total amount of change in friendship networks and individual ISDP behaviours observed between the two time points (Snijders, 2005; Snijders et al., 2010). We included 20 imputed ISDP data sets in the model (see the treatment of the missing data above). In addition, we included the imputed peer academic support online, gender and whether coming from the same classroom as controlled variables. The indicator for model convergence—the absolute value of the t-ratio for an individual parameter—was less than 0.1, and the overall t-ratio was less than 0.2, both of which statistically confirmed the model’s convergence (Ripley et al., 2018). We applied the pool function in Mice to combine the 20 model outcomes.

## 2.6 Model Parameters

We described the parameter estimates of the model (see Table 1) based on terminology that Snijders and colleagues (2010) applied. The model primarily examined selection (the extent to which students selected peers as friends based on their similar levels of ISDP) and influence (whether students’ peer friendship influence their levels of ISDP to become more similar) with the covariates of peer academic support, gender, and being in the same classroom. We assessed both the selection and influence effects in regard to ISDP in the models (see de la Haye, Green, Kennedy, Pollard, & Tucker [2013] for more details on these co-evolution models).

Selection effect was represented by “ISDP similarity”—that is, the extent to which adolescents selected new connected peers at T2 based on similar level of ISDP at T1. In other words, whether similarity in ISDP predicted the formation of new ties. We also estimated “ISDP alter” and “ISDP ego” effects. “ISDP alter” was the effect of being nominated by peers based on ISDP; a positive effect meant a higher likelihood of receiving peers’ friendship nominations when adolescents had a higher level of ISDP. “ISDP ego” was the effect of nominating other peers as friends based on ISDP; a positive effect meant that the students with higher values of ISDP were more likely to nominate more peers as friends. We also considered the variation that adolescents nominated their grade peers as friends (“peer academic support ego”) and were nominated as friends (“peer academic support alter”) as a function of their academic support with peers. In addition, we used “peer academic support similarity,” “same gender,” and “same class” to estimate whether students became friends with peers with similar levels of peer academic support, with the same gender, and who were in the same class.

We used the parameter of “average similarity” as the influence effect instead of other potential specifications of friend influence because Ripley et al. (2018) suggested that it consistently converged



well across models. “ISDP average similarity” was the tendency of adolescents’ ISDP level to become more similar with that of their peers over time. We included the effect of change in ISDP as a function of peer academic support, gender and being in the same classroom (“effect from”). Moreover, we controlled for important network structural effects that are suggested to be the basic effects included in SAO models (Veenstra & Steglich, 2012): outdegree (density), which is the general tendency of adolescents to selectively nominate their peers as friends; reciprocity, which is the tendency to make reciprocated friendship nominations, and transitive reciprocated triplets, referring to the tendency to reciprocate the nomination of friends of their friends. Effects of out-degree (or density) and reciprocity are those always included in a model of RSiena package while effects of transitive triplets and transitive reciprocated triplets attempt to capture the tendency to network closure and they contribute to a good fit of the model (Ripley et al., 2018). Table 1 shows the effects we included in the RSiena model; for detailed effect descriptions, see Ripley et al. (2018). The observed networks’ various measures excluded from the model (i.e., indegree, outdegree, and triad census) were found to be within the distributions of those measurements within 100 simulated networks with the same density of observed networks. This indicated that the model presented in this study was able to capture and represent the observed networks.

Table 1

*Explanation of Parameters in the RSiena Model*

Effect (Short Name in RSiena)	Representation	Explanation
Out-degree ( <i>density</i> )		Basic tendency to have ties
Reciprocity ( <i>recip</i> )		Tendency toward reciprocation
Transitive triplets ( <i>transTrip</i> )		Tendency to nominate friends of friends
Transitive reciprocated triplets ( <i>transRecTrip</i> )		Tendency to reciprocate the nominations of friends of friends
Gender ( <i>sameX</i> ); Class ( <i>sameX</i> )		Tendency for participants to make nominations based on same gender or same class
Peer academic support—similarity ( <i>simX</i> )		Tendency for participants to make nominations based on similar frequency of peer academic support
Peer academic support—ego ( <i>egoX</i> )		Tendency for participants with higher frequency of peer academic support to make more nominations
Peer academic support—alter ( <i>alterX</i> )		Tendency for participants with higher frequency of peer academic support to receive more nominations
ISDP—similarity ( <i>simX</i> )		Tendency for participants to make nominations based on similar ISDP over time ( <i>selection effect</i> )
ISDP—ego ( <i>egoX</i> )		Tendency for higher-ISDP participants to make more nominations over time
ISDP—alter ( <i>alterX</i> )		Tendency for higher-ISDP participants to receive more nominations over time
Friendship network—average similarity ( <i>avSim</i> )		Tendency of participants to have similar ISDP to those of friends over time ( <i>influence effect</i> )

*Note.* ISDP = interest-driven socio-digital participation





### 3. Results

#### 3.1 Descriptive Statistics

##### 3.1.1 Friendship Networks (T1 and T2)

The descriptive results of the developmental networks are shown in Table 2. Both the density and the average number of ties per participant increased from T1 to T2 within friendship networks, meaning that the students had more friends over time. The friendship networks in the two waves thus showed density values of 8.0% and 10.0%, respectively. The Jaccard index between the two-wave networks was 0.36, showing that peer networks did not change rapidly or abruptly (value > 0.30), as per Ripley et al. (2018, p. 20).

##### 3.1.2 Interest-driven Socio-digital Participation (T1 and T2)

There were 65 participants (65%) who responded in both time waves. Twenty-eight students (28%) reported higher frequencies of ISDP in T2 than in T1, whereas 11 participants' (11%) frequencies of ISDP decreased in T2 compared to T1. Twenty-six students (26%) reported having the same level of ISDP in the two-time waves. Table 2 shows descriptive statistics in detail.

Table 2

*Descriptive Statistics of Friendship Network Structure and Interest-Driven Socio-Digital Participation*

Descriptive Statistics	Grade 7 (T1)	Grade 8 (T2)
Network structure		
Density of the network	8.0%	10.0%
Average number of ties per student	7.96	9.98
Total number of ties	796	998
Number of reciprocated pairs	188	239
Number of triangles	3910	6183
Number of isolated students who did not have any ties	6	3
Number (%) of ties between students of the same gender	630 (79.1%)	756 (75.8%)
Number (%) of ties between students in the same class	469 (58.9%)	457 (45.8%)
Interest-driven socio-digital participation		
1 (never)	23 (23%)	11 (11%)
2	36 (36%)	44 (44%)
3	10 (10%)	17 (17%)
4	8 (8%)	5 (5%)
5	2 (2%)	4 (4%)
6	0 (0%)	0 (0%)
7 (all the time)	0 (0%)	1 (1%)
Missing	21 (21%)	18 (18%)
Mean/SD	2.06/1.00	2.46/1.01

#### 3.2 Selection and Influence Related to Friendships and ISDP

Table 3 shows the model of peer selection and the influence effects related to peer friendships and ISDP. As one of the primary effects of this model, students did not select peers as friends within the same grade based on their similar levels of ISDP with peers (“ISDP similarity”), meaning that we found no selection effect for ISDP in friendship dynamics. By contrast, the model showed that students’



friendship ties influenced each other’s intensity of ISDP over time (positive “ISDP average similarity”). Students’ ISDP appeared to become more similar with that of their peers across time. In other words, peers’ ISDP contributed to the increase or decrease of the intensity of students’ ISDP.

On the other hand, students with a higher intensity of ISDP were likely to nominate more peers as their friends (positive “ISDP ego”), whereas ISDP did not affect the number of receiving friendship nominations from peers (no significance in “ISDP alter”). In terms of controlling peer academic support online, adolescents who engaged more in peer academic support online were likely to receive fewer friendship nominations from their peers (negative “peer academic support alter”). Moreover, students were likely to have friendships with peers of the same gender and of the same class as per the positive significant “same gender” and “same class” parameters in the model.

The negative “out-degree” parameter indicated that there are in general costs to establishing ties; that is, young people typically would not nominate an infinite number of peers as friends. Adolescents were also tended to reciprocate the nominations they had (“reciprocity”), meaning that connections between two participants were likely to be reciprocal. Young people were inclined to form hierarchical triadic relationships with the friends of their friends (positive “transitive triplets” and negative “transitive reciprocated triplets”) in the grade, indicating that a nested structure was statistically significant in adolescents’ friendship networks with peers.

Table 3

*Dynamic Model of Selection and Influence in Friendship Networks: Estimates and Standard Errors (SEs) for Interest-Driven Socio-Digital Participation*

<b>Model Parameters</b>	<b>Estimates</b>	<b>SEs</b>
Friendship network dynamics		
Rate parameter	23.17***	1.73
Effects of network structure		
Outdegree (density)	-2.59***	0.12
Reciprocity	1.78***	0.19
Transitive triplets	0.30***	0.03
Transitive reciprocated triplets	-0.34***	0.05
Effects of covariate		
Peer academic support—ego	0.01	0.03
Peer academic support—alter	-0.08*	0.03
Peer academic support—similarity	0.05	0.21
Same gender	0.58***	0.08
Same class	0.47***	0.09
Selection effects on friendship		
ISDP—ego	0.28*	0.12
ISDP—alter	-0.01	0.10
ISDP—similarity	0.18	1.05
Behaviour dynamics		
Rate	3.66**	1.72
Linear shape	0.09	0.16
Quadratic shape	0.02	0.10
Effect from peer academic support	0.10	0.10
Effect from gender	-0.01	0.22
Effect from classrooms	-0.06	0.10
Influence effect on ISDP		
Friendship network—average similarity	7.78*	3.30

*Note.* Gender coded: female = 1, male = 2. \*\*\*p < .001, \*\*p < .01, \*p < .05



## 4. Discussion

Within a school in Finland, we exploratorily examined selection and influence effects in co-evolution of students' friendship dynamics and the intensity of their ISDP, controlling for student gender, being in the same classroom and peer academic support online, as well as several network and behavioural tendencies. By applying stochastic actor-oriented modeling, we found out that the levels of students' ISDP became more similar with that of their peers over time, whereas young people did not select peers as their friends based on their similar levels of ISDP. One explanation for the lack of selection effect could be that the data was collected from classrooms that provided already constrained social contexts with limited possibilities of selecting peers as friends. Peer influence is a process where a young person affects or is affected by another. Influence in behaviours occurs when an adolescent acts in ways that he or she may not otherwise act; it is an effect that is attributed to joint experiences with friends. In particular, mechanism of reinforcement (Bagwell & Bukowski, 2018) may be able to explain the influence effect between young people's friendship with peers and their ISDP. Mutual friendship may have a powerful reinforcement effect over time on behaviours mediated digitally by mutual interest-driven activities among young people. Within friendships, norms for expected behaviours (e.g., mastering digital activities, pursuing shared interests) are created and friends actively push their peers to engage in activities that are in accordance with the shared norms and expectations. In this way, they attempt to achieve common ground of shared interests, deepen their mutual relations or even develop intimacy with friends (Gottman, 1983). Generally, influence is considered to be "a reflection of engagement" (Laursen, 2018). Peers who are intensively engaged in activities that interest the young person are likely to have greater influence than those who are not, especially if the engagement is collaborative (Brechwald & Prinstein, 2011). Interest-driven socio-digital activities are collaborative in nature. Various interest-driven digital practices (e.g., seeking for information, producing and sharing knowledge with connected peers) enable young people to engage in exerting great influence effect among peers. As young people work to strengthen their friendship ties with their peers, similarity might increase fastest in the early stage of the relationship (Laursen, 2018). Participants in present study were at grade 7 at the first measure while they were at grade 8 at the second measure time. Grade 7 is the first year of lower secondary school in Finnish educational system, right after finishing elementary school. Therefore, similarity among present participants is likely to increase rapidly during their Grade 7 and Grade 8 and it also contributes to explain why influence effect between students' friendship and ISDP was found. In terms of selection, previous research posits that demographic attributes (e.g., gender for early adolescence) appear to play primary role when young people select networking partners in initial friendship interaction (McPherson et al., 2001). While friendship develops closer, similarity might continue to increase in private domains (e.g., those related to interests) that were not part of initial social interactions (Laursen, 2018). This would explain why we did not find early adolescents select peers as their friends based on their similar level in ISDP.

There has been little research examining peer selection and influence effects related to the intensity of adolescents' ISDP and their friendship network dynamics. Our results on peer influence effect are partly in line with previous studies that did not simultaneously estimate peer selection and influence effects. Escardíbul et al. (2013) found that the intensity of Spanish youth playing video games was similar with that of their peers. More recently, Amialchuk and Kotalik (2016) reported similar results among US male adolescents that students' intensity of playing games is influenced by their peers to become more similar. While these two investigations examined peer influence on the intensity of young people's video game playing, our study simultaneously focused on peer selection and peer influence regarding interest-driven activities. Present study is unique in terms of examining selection and influence effects at the same time in co-evolution of young people's friendship with peers and their interest-driven socio-digital practices. Yet, we found out that adolescents within a school in Finland are not likely to select peers as friends based on their aligned ISDP. It is critical to understand young people's influence on the ISDP of their peers as well as how ISDP affects the selection of friends in a context where ample knowledge and information are available for students' learning.



Educational activities are increasingly mediated by digital practices and social learning with peers, and require students having increasingly more sophisticated socio-digital competences, especially in relation to academic studying and creative production (Hietajärvi et al., 2016; Li et al., 2017). The fact that students are able to influence their peers' interest-driven socio-digital activities through their informal interactions provides an option for teachers to capitalize on students' social, peer-to-peer learning resources. Students who are competent in digital technologies could be engaged in tutoring their peers as part of computer-supported collaborative learning activities (Riikonen, Seitamaa-Hakkarainen, & Hakkarainen, 2018). Social learning and peer tutoring play important roles in the type of computer-supported collaborative learning that is becoming more commonplace in Finnish educational institutions (Korhonen & Lavonen, 2017; Niemi, Kynäslahti, & Vahtivuori-Hänninen, 2013). Through such pedagogies, similar social learning resources that appear to be involved in ISDP could be also harnessed for supporting school learning.

## 5. Educational implications and limitations

More importantly, because students' friendship-based peer networks influence their interest-driven socio-digital participation to become more similar, connected learning (Ito et al., 2013) should be promoted to integrate informal interest-related activities and formal learning to bridge the gap between students' informal interests and educational practices. Digitally mediated connected learning can be seen as "a social construct that emerges in interaction while learners engage in various social practices mediated by different artefacts" (Kumpulainen & Sefton-Green, 2012); as we mention above, it integrates interest-driven, peer-supported and academically oriented learning contexts. Such multi-contextual settings enable students' learning practices to be production-centered and sharing-grounded across various networked borders. For instance, Penuel and colleagues (2016) illustrated a case that Jerome (pseudonym) participated in a programme of a science museum for a ninth or tenth grader and served as a docent for the museum visitors; he had opportunities, with peers, to contribute to science investigations by resident scientists. During such connected learning programmes, students are able to engage in interest-driven, peer-supported and academically oriented knowledge practices across multiple contexts (i.e., out of school and in school). As some reviews have summarized, such "border crossing" (Akkerman & Bakker, 2011) knowledge practices between formal and informal learning (Bronkhorst & Akkerman, 2016; Rajala et al., 2016) are simultaneously interest- and network-based. The fact that students' friendship networks with peers influence their interest-driven digital practices suggests that educational institutions should foster students' competences in the interest-driven and academic use of digital technologies so that academic and out-of-school knowledge flows and peer-supported communities expand from students' daily lives to schools and vice versa. In this way, rather than a closed, undialectical or immobile space, school becomes an open, dynamic and multifaceted learning community with different connections (e.g. knowledge, social relationships, learning artefacts) to students' everyday practices and learning.

The limitations of the present study warrant consideration. Participants' self-reports on the intensity of their ISDP may have been biased to some extent by being overestimated or underestimated due to errors in memory or a lack of awareness of the actual frequency with which they used socio-digital technologies for their interests. In addition, we examined the intensity of students' interest-driven participation. Future studies could qualitatively examine youths' ISDP to obtain comprehensive knowledge about what students actively do related to their interests mediated by socio-digital technologies. Finally, the present study addresses results from a school in southern Finland; the small sample size provided relatively small pool for students to possibly connect with peers of similar level of ISDP. Additionally, results may be different in other contexts due to possible diverse patterns of young people's friendship with peers and their ISDP in other cultural contexts. Future studies should expand the sample to other areas of Finland. After collecting the present data, the Finnish matriculation examination that is the only high-stake test in Finland, has been digitalized together with nation-wide efforts of supporting digitalization of schools; this is likely to have a significant impact on school use of



digital technologies for learning and instruction. Consequently, it will be critical to obtain more detailed information of young people's within school practices of using socio-digital technologies and associated pedagogical approaches; actually we have developed refined self-report instruments for that purpose, including also collecting social networking data from larger sample of students. Similar instruments are being administered to a sample of teachers to have their perspectives to complement student data.

## 6. Conclusions

Pervasiveness of socio-digital technologies has been incredibly increasing and young people's socio-digital practices are constantly transforming from one cohort to another. By applying stochastic actor-oriented modelling upon two-wave students' social network with peers and their intensity of ISDP, we examined peer selection and influence between early adolescents' friendship with their peers of the same grade and their intensity of ISDP in a school in Finland. The findings indicated that students did not appear to select peers as friends based on their similar intensity level of ISDP. Yet, students' friendship ties with peers enable their intensity of ISDP to become more similar with that of their friends. In order to bridge the gap of students' socio-digital participation outside school and the educational practices, the results suggested that schools should utilize connected learning (Ito et al., 2013) to take into consideration the interests pursued by students outside of school when designing formal learning contexts. Toward that end, the phenomenon-based pedagogy, which characterizes the Finnish national curriculum and calls for inviting even primary students to participate in co-designing open-ended technology enhanced study projects, provides opportunities for connected learning.

## Keypoints

- Students' friendship ties influenced their intensity of interest-driven socio-digital participation to become similar as that of peers'.
- Students did not select peers as friends based on similar intensity levels of interest-driven socio-digital participation.
- Young people with a higher intensity of interest-driven socio-digital participation were likely to nominate more peers as their friends.
- Intensity of interest-driven socio-digital participation did not affect the number of receiving friendship nominations from peers.
- Connected learning should be promoted to integrate informal and formal learning.

## Acknowledgements

This study was supported by: Finnish Cultural Foundation (Shupin Li, 00172381), the Academy of Finland project "Bridging the gaps: Affective, cognitive, and social consequences of digital revolution for youth development and education" (Katariina Salmela-Aro, PI, 308351), the Academy of Finland project "Co4-Lab" (Kai Hakkarainen, PI, 286837) and, the Strategic Research Council project of the Academy of Finland "Growing Mind: Educational transformations for facilitating sustainable personal, social, and institutional renewal in the digital age" (Kai Hakkarainen, PI, 312527).



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