ONLINE COMPUTER-SUPPORTED INQUIRY LEARNING IN STEM-EDUCATION DURING THE COVID-19 PANDEMIC

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Abstract

The Covid-19 pandemic forced educators to go fully online. In most cases, this was a first encounter with online teaching and learning for both teachers and students in secondary education. Student-centred forms of learning are promoted to activate and motivate students during online teaching. In secondary STEM-education, inquiry learning has been advocated for which online learning environments have been developed, introducing Computer-Supported Inquiry Learning (CoSIL). However, in current research collaboration phases during CoSIL mostly takes place face-to-face in the classroom. Via a mixed methods design, online education during the Covid-19 pandemic allowed to investigate the learning effect of CoSIL when students work together online synchronously as well as their perceptions towards the use of online CoSIL during STEM. Results show a significant learning effect of CoSIL on scientific knowledge and scientific inquiry skills. Further focus groups show a strong preference for face-to-face collaboration. Our insights provide important insights for future post-Covid redesign processes in which blended learning scenarios can be explored in depth.

Keywords: inquiry learning, online collaborative learning, STEM-education, Covid-19 pandemic

1 INTRODUCTION

1.1 Inquiry learning in STEM

Many recent educational reform initiatives in secondary education have advocated the use of inquiry-based learning (IBL) for STEM-education. IBL is an instructional approach that provides students with authentic problems and the materials necessary to learn about a topic through self-directed investigations [1]. IBL fits in the larger educational trend of active learning based on the constructivist learning approach whereby students are ought to undertake action and use higher-order thinking skills to master new knowledge and skills [2]. The meta-analysis of Freeman and colleagues [3] supports this shift as it demonstrates that active STEM-learning yields better learning outcomes than a traditional lecturing teaching style. More precisely, IBL within STEM has the potential to attain three interrelated science learning objectives: (1) to develop scientific conceptual knowledge [4], (2) to improve scientific inquiry and reasoning skills [5], [6] and (3) to stimulate interest in science [6].

Nevertheless, the IBL approach for STEM-education is a heavily debated one. Opponents of IBL favour direct instruction that is logically organized and clearly sequenced, which is claimed to be the prerequisite to enhance learning [7]. Furthermore, critics conceptualize IBL as a minimal guided or even unguided learning approach in which teachers are absent and students can only rely on themselves [8]. Nonetheless, the IBL research field acknowledges that unguided IBL is insufficient [9]. Consequently, the IBL research focus shifted to the conditions under which IBL is effective, in which guidance is considered as a fundamental prerequisite to foster IBL learning outcomes [10].

In addition, numerous online learning environments have been developed to facilitate the process of IBL in STEM, introducing Computer-Supported Inquiry Learning (CoSIL). These environments offer possibilities to include software tools, simulations tools, rich content, to visualize abstract scientific concepts and to collect various streams of data that learners produce while working online [11].

1.2 Distance learning

In 2020, 1.5 billion learners stood in front of closed school doors due to the Covid-19 pandemic [12]. All over the world, schools reorganized and set full- or parttime distance education in motion for which digital resources are the driving force [13]. Due to the abrupt shift, researchers refer to the educational circumstances during Covid-19 as emergency distance education [14]. Jarves defines distance
education as “any form of education in which the teacher and the learner are separated in either time or space” [15, p. 171]. Moore and Kearsley [16] expand this definition by adding the requirement of technology to allow communication between teacher and learners. Distance learning is foremost facilitated through connections via the world wide web. As such, commonly used synonyms for distance learning are e-learning, where e- refers to electronic, or online learning [16], [17]. In distance education, a distinction is made between synchronous and asynchronous online learning. Where the first requires simultaneous participation of both learners and teachers who are separated in space, the latter does not. As such synchronous online learning demands technology that supports direct reciprocal communication [18]. Videoconferencing tools and virtual classroom software meet this requirement and subsequently have become widespread during the Covid-19 pandemic.

While university students might already have had experience with some forms of online teaching and learning before the start of the Covid-19 pandemic, this was not the case for the majority of secondary students and teachers [17]. This is reflected in the research literature base wherein most research about online learning is conducted in higher education [19], [20]. However, during the pandemic, digital platforms and other resources were also implemented at the secondary education level of K-12 education [13]. This provides opportunities to scale up research about online education in secondary education.

In the meantime, various researchers jumped at the chance to interrogate students at university level about emergency distance education. Currently study results about students’ online teaching preferences during emergency distance educations are contradictory. Whereas Tümen Akyildiz [21] and Hebebci, Bertiz and Alan [22] report that students seem to hold on to their traditional educational habits from before the pandemic where teachers ‘hand-over’ knowledge and show a preference for online synchronous lectures, Paudel [23] found that students expect an adapted teaching style offering more freedom and handing over responsibility to the students, thus leaning towards a more constructivist teaching style. In general, students think that distance education contributed to the loneliness they experienced during the pandemic. Students are not satisfied with the limited amount of communication and interaction they have with their teacher and fellow students [21]–[23]. Subsequently, students in Paudel’s [23] research add that they only way they see online learning succeed, is if it encourages cooperation and is being supplemented with face-to-face instruction.

Furthermore, specifically about traditional online lectures students mention that they not only fail to meet the need of communication and interaction, they also demand a large amount of self-discipline, motivation and autonomy to process lesson content [21], [23]. Likewise to classroom teaching, student-centered forms of learning are put forward to actively process lesson content and motivate students during online teaching [24]. Albeit digital technology offers the prerequisites to put the abovementioned shift to student-centered learning into practice, often the traditional lecture style persists when using this technology [25].

1.3 Online CoSIL

Online CoSIL could possible form an answer to the aforementioned concerns by higher education students as well as the call to implement more student-centered learning forms. However, collaboration during CoSIL mostly takes place face-to-face when students work together at one computer [6] and not via online videoconferencing tools that have become widespread due to the pandemic. The Covid-19 pandemic brought the opportunity to investigate the learning effect of CoSIL when secondary students work online synchronously together.

Further, the online learning research field is in need of mixed methods research [20], with an emphasis on the quantitative part of the design as in the field of online synchronous learning quantitative results are scarce [19]. Moreover, as most perception research about online learning is situated at a higher education level [21], secondary students’ perspective on online learning and learning results should be explored. Their experiences can be valuable resources to shape future online distance or blended learning.

2 METHODOLOGY

2.1 Research questions

This research will contribute to the research field by answering the following research questions:
1. What is the impact of online CoSIL on scientific knowledge, inquiry skills and motivation for learning sciences?
2. What are the perceptions of students on the use of online CoSIL during STEM lesson hours?

2.2 Context, design and participants

This explorative study took place during the Covid-19 pandemic in Flanders, Belgium. At the time of the study, Flemish secondary students from grade nine on were only allowed to go fifty percent of time to the school campus. The other fifty percent students followed distance education during which they followed lessons online [13]. A mixed methods design was used to examine the impact of online CoSIL on scientific knowledge, inquiry skills and motivation for science learning of secondary students as well as their perspective on online CoSIL. Data was collected by an online pre-post-test and two online focus groups. Originally, 43 students were planned to participate. However, after deleting students who were absent during (a part of) the intervention and consequently their partners who had to work alone because of their absence, a total of 38 students of the 9th and 10th grade participated ($M_{age} = 15.44, SD_{age} = .54$) of which 9 nine girls and 29 boys. Of this total participant population 10 students follow a general track and 28 students a science track. Students were randomized in 13 dyads and 4 triads to collaborate online during the intervention.

After the intervention, two online focus groups took place with 25 participants consisting out of 8 girls and 17 boys of the 9th grade. Out of the 25 participants, 15 students follow a science track and 10 students a general track.

2.3 Intervention

The intervention consisted out of four online lessons about climate change designed on the WISE-platform which is especially developed for science learning by the University of Berkeley [26]. The lessons were structured by the means of an inquiry cycle, derived from a the review study of Pedaste and colleagues [27], and consists out of the following five stages: orientation, conceptualization, investigation, conclusion and discussion. In total, students had to go through four inquiry cycles from which each one focused on another facet of climate change. An extra fifth inquiry cycle was provided for students who finished early. Before the start of the intervention, participants watched an introductory video of the lessons in which the inquiry cycle was shortly introduced and applied.

Groups had to collaborate online via the Bongo Virtual Classroom tool [28]. This virtual classroom tool offers multiple functions like audio and video calling, chat box, screen sharing, white board… One group member had to log into the WISE-unit and share his/her screen. As such, the other team member(s) could follow along and they could collaborate. The person that was screen sharing had to manipulate the simulations and type the answers in WISE. Teams were free to alternate the screen sharing.

Two facilitators, the main researcher and a Masters’ student, were present online during the lessons and mainly had a support function. They could join all the online group sessions at any moment. Students could ask questions to the facilitator via the chat or to join their session. Furthermore, the facilitators could track the answers of the groups via the teacher dashboard tool integrated in WISE. When wrong answers were given or groups drifted off in the wrong direction, facilitators could join the groups online and engage in a conversation about their answers.

2.4 Measurement instruments

Data was collected via an online pre- and post- knowledge test, online pre- and postquestionnaire and two online focus groups.

2.4.1 Pre- and post-test instruments

The pre- and post-test was taken before and after the four lessons. The test consisted out of two parts. The first part measured scientific knowledge about climate change via open questions as well as multiple choice questions by which participants had to explain which answer they chose (e.g. explain the albedo-effect; converted to a total of 20 points). The second part of the test measured scientific inquiry skills (converted to a total of 10 points). The first question entailed a graphic about the global temperature and atmospheric CO2-concentration which students had to interpret. In the second question, they had to read an abstract of a scientific article from which they had to deduce the research question and hypothesis. Next to that, students had to propose a research method to find an answer to their former
research question and hypothesis. Two different scientific articles were used and counterbalanced across two groups to rule out possible effects as a result of a varied difficulty rate.

Students’ open answers on the pre- and post-test were coded by means of a rubric that was designed by the researcher. The rubric contains criteria like correct use of scientific phenomena, completeness of answer, correct relationships between phenomena...

### 2.4.2 Motivational questionnaire

Next to the test, the motivation questionnaire of Sierens and Vansteenkiste [29] was completed by the students before and after the lessons. This questionnaire consists out of 16 5-points Likert scale items. Sierens and Vansteenkiste’s [29] questionnaire makes a distinction between autonomous and controlled motivation. Autonomous motivation arises from personal interest in sciences (intrinsic motivation) or because seeing the benefit of studying sciences (identified regulation). Next to that, controlled motivation can be caused directly by external actors (e.g. parents, teachers, peers). As such, people learn sciences because they want to be rewarded, avoid punishment or meet expectations (external regulation). But people also can impose pressure on themselves and as such experience controlled motivation. In this case people learn sciences to feel proud about themselves or to avoid shame if they don’t (introjected regulation).

Table 1 shows subscales and scales with an example item as well as their internal reliability values (Cronbach’s alpha). The external regulation scale contains three items instead of four. The item ‘I learn sciences because I am supposed to do so’ was excluded to obtain an acceptable reliability.

**Table 1. Cronbach alpha scores motivational questionnaire**

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Items</th>
<th>Cronbach’s Alpha Pre-Test</th>
<th>Cronbach’s Alpha Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled motivation</td>
<td>7</td>
<td>.78</td>
<td>.88</td>
</tr>
<tr>
<td>External regulation</td>
<td>… others oblige me to do so.</td>
<td>3</td>
<td>.79</td>
</tr>
<tr>
<td>Introjected regulation</td>
<td>… I will feel guilty if I don’t do it.</td>
<td>4</td>
<td>.65</td>
</tr>
<tr>
<td>Autonomous motivation</td>
<td>8</td>
<td>.76</td>
<td>.90</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>… I think science is interesting.</td>
<td>4</td>
<td>.74</td>
</tr>
<tr>
<td>Identified regulation</td>
<td>… I want to learn new things.</td>
<td>4</td>
<td>.85</td>
</tr>
</tbody>
</table>

### 2.4.3 Focus group

After the intervention, two online focus groups took place with 25 participants. The first focus group took place with 10 students of a general track [FG 1], the second took place with 15 students of the science track [FG 2]. Each focus group approximately took 30 minutes. The focus groups were semi-structured by the means of five propositions. These propositions questioned students about online CoSIL and online collaboration. Via the mobile response tool Socrative, one proposition at a time was launched and projected. Participants had to answer on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Results were anonymously projected and discussed with all participants.

### 2.5 Statistical analysis

Data from the pre- and post-test, pre- and post-questionnaire and focus groups were analysed via SPSS. To determine the effect of the intervention as well as differences between general and science tracks a one-way ANOVA with repeated measures as well as independent samples t-test was performed (significance level: \( p < .05 \)).

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4
Descriptive statistics are used to analyse the focus group data from Socrative. The focus groups were audio-recorded and transcribed. This qualitative data was used to gain more insight in the quantitative data derived from the focus groups [30].

3 RESULTS

3.1 What is the impact of online CoSIL on scientific knowledge, inquiry skills and motivation for science learning?

The results of the students’ pre- and post-test and pre- and post-questionnaire are summarised in Table 2.

Table 2. Descriptives of pre- and post-test and -questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Pre-test M (SD)</th>
<th>Post-test M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge (/20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General track</td>
<td>2.64 (2.49)</td>
<td>6.77 (3.67)</td>
</tr>
<tr>
<td>Science track</td>
<td>4.61 (2.49)</td>
<td>11.72 (4.53)</td>
</tr>
<tr>
<td>Total</td>
<td>4.09 (2.58)</td>
<td>10.42 (4.81)</td>
</tr>
<tr>
<td>Inquiry skills (/10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General track</td>
<td>2.71 (2.65)</td>
<td>4.29 (1.65)</td>
</tr>
<tr>
<td>Science track</td>
<td>4.95 (2.15)</td>
<td>6.12 (2.42)</td>
</tr>
<tr>
<td>Total</td>
<td>4.36 (2.46)</td>
<td>5.64 (2.37)</td>
</tr>
<tr>
<td>Controlled Motivation (/5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General track</td>
<td>2.11 (.80)</td>
<td>1.96 (.97)</td>
</tr>
<tr>
<td>Science track</td>
<td>1.59 (.56)</td>
<td>1.69 (.58)</td>
</tr>
<tr>
<td>Total</td>
<td>1.73 (.97)</td>
<td>1.76 (0.70)</td>
</tr>
<tr>
<td>Autonomous Motivation (/5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General track</td>
<td>2.60 (.30)</td>
<td>2.37 (.81)</td>
</tr>
<tr>
<td>Science track</td>
<td>3.60 (.53)</td>
<td>3.54 (.52)</td>
</tr>
<tr>
<td>Total</td>
<td>3.33 (.70)</td>
<td>3.23 (.79)</td>
</tr>
</tbody>
</table>

Looking at pre-test results, students’ knowledge about climate change was limited before the lessons (M = 4.09, SD = 2.58). An independent sample t-test shows that participants who follow a science track possess significantly more prior knowledge (M = 4.61, SD = 2.49) than students who follow a general track (M = 2.64, SD = 2.49; t (36) = -2.180, p < .05). Next, results show a main positive effect of time for knowledge (Wilks’ Lambda = .357, F(1, 36) = 64.769, p < .001, ηG² = .643). This implies that students’ knowledge about climate, regardless of study track, significantly improved over time (M = 10.42, SD = 4.81). However, results also show a significant interaction effect between time and study track (Wilks’ Lambda = .888, F(1, 36) = 4.529, p < .05, ηG² = .112). This means that on average science track students improve more than students of a general track (MD = 2.98).

Results of students’ inquiry skills pre-test show that students in general possess limited inquiry skills (M = 4.36, SD = 2.46) before the start of the intervention. Again, students who follow a science track possess significantly better inquiry skills before the intervention (M = 4.95, SD = 2.15) than students who follow a general track (M = 2.71, SD = 2.65; t (36) = -2.658, p < .05). A main effect for time was found for inquiry skills (Wilks’ Lambda = .797, F(1, 36) = 9.152, p < 0.05, ηG² = .203) suggesting that the inquiry skills of students, regardless of study track, significantly increased after the intervention (M = 5.64, SD = 2.37). No significant interaction effect between time and study track was found (Wilks’ Lambda = .995, F(1, 36) = .192, p = 0.664) meaning that on average students of both tracks made similar progression in their inquiry skills.

In the motivational questionnaire a distinction is made between controlled and autonomous motivation. As to controlled motivation, general track students experience significantly higher controlled motivation...


\[ M = 2.11, SD = .80 \] in comparison to science track students \( M = 1.59, SD = .56 \); \( t(36) = 2.23, p < .05 \) before the start of the intervention. No significant effect of time on controlled motivation was found \( (\text{Wilks' Lambda} = .998, F(1, 36) = .080, p = .779) \) as well as no significant interaction effect between time and study track \( (\text{Wilks' Lambda} = .966, F(1, 36) = 1.28, p = .27) \). This implies that on average students, irrespective of their study track, do not experience more or less controlled motivation after the intervention.

Lastly, before the start of the intervention general track students experience significantly less autonomous motivation to learn sciences \( M = 2.60, SD = .30 \) in comparison to science track students \( M = 3.60, SD = .53 \); \( t(36) = -4.935, p < .001 \). No significant main effect for time on autonomous motivation was found \( (\text{Wilks' Lambda} = .906, F(1, 36) = 3.73, p = .061) \) as well as no significant interaction effect between time and study track \( (\text{Wilks' Lambda} = .906, F(1, 36) = 1.28, p = .27) \). Thus on average, regardless of study track, students autonomous motivation score does not change after the intervention.

### 3.2 What are the perceptions of students on the use of online CoSIL during STEM lesson hours?

Table 3 shows the descriptive results of the propositions that were presented to the participants during the focus groups. To gain deeper insights into these descriptive results, the distribution of the participants' answers on the 5-Point Likert scale are displayed as well as quotes from the participants are used.

**Table 3. Descriptives derived from the focus groups**

<table>
<thead>
<tr>
<th>Proposition</th>
<th>M (SD)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>This way of learning science ensures that I am more active in class.</td>
<td>3.28 (.79)</td>
<td>0%</td>
<td>12%</td>
<td>56%</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>This way of science learning kept me focused on the content.</td>
<td>3.42 (1.17)</td>
<td>10.5%</td>
<td>5.3%</td>
<td>31.6%</td>
<td>36.8%</td>
<td>15.8%</td>
</tr>
<tr>
<td>This way of learning science motivates me to learn science.</td>
<td>2.8 (.82)</td>
<td>8%</td>
<td>20%</td>
<td>56%</td>
<td>16%</td>
<td>0%</td>
</tr>
<tr>
<td>I can work better with my team members online compared to physically in the classroom.</td>
<td>2.33 (1.05)</td>
<td>16.7%</td>
<td>50%</td>
<td>25%</td>
<td>0%</td>
<td>8.3%</td>
</tr>
<tr>
<td>I wish I had received more guidance during the classes.</td>
<td>2.9 (1.20)</td>
<td>0%</td>
<td>50%</td>
<td>30%</td>
<td>0%</td>
<td>20%</td>
</tr>
</tbody>
</table>

On the first proposition, ‘This way of learning science ensures that I am more active in class’, focus groups were neutral to agree \( (M = 3.28, SD = .79) \). Compared to classroom learning, participants thought that they were more engaged in lesson activities.

“I choose agree, because now you need to fill in and submit something by the end of the lesson. Otherwise, you just sit in the classroom and you write in your book [FG 2].”

In both focus groups it was mentioned that the amount of prior knowledge someone possesses could be related to the amount of activity they showed during the lessons.

“I already knew a lot about climate. So, I just clicked my way through the lessons and moved on fast. I already searched a lot about climate, so for me, I was not really active during the lessons. If the topic had been more difficult and new, then I would be more active I think [FG 1].”

These results are supported by the answers on the proposition ‘This way of science learning kept me focused on the lesson,’ at which participants also answered neutral to agree \( (M = 3.42, SD = 1.17) \).
self-paced working possibility was mentioned as the driving force behind staying active during the online lessons.

“Yes, otherwise you have to listen constantly and after a while you are lost. So now you can continue the whole time and continue working [FG 1]”.

However, some participants disagreed and thought that sooner or later they also get distracted during CoSiL, just as in the classroom.

“In the classroom you only listen and sit. However, with the online lessons (cfr. the intervention) we got, in the beginning I was working hard, but after I lost my concentration too [FG 1]”.

This limited attention span may be ascribed to the long periods that the participants must spend behind their computer due to emergency distance education. Participants mention that they get tired and hardly can concentrate to study at night after a full day of online learning.

“After a whole day of sitting behind your computer, it is really difficult to study at night. That really did not work for me [FG 2]”.

At the proposition ‘This way of learning science motivates me to learn science,’ students mostly answer neutral to disagree ($M = 2.8, SD = .82$). When analysed on a deeper level, there can be seen that none of the science track students choose for (totally) disagree and none of the general track students choose (totally) agree. So, students’ motivation for learning sciences in general could possibly be hidden in their answers to this proposition as can be assumed that participants who chose to follow a science track will be more motivated to learn sciences and thus also be more motivated to participate in the intervention in comparison with general track students. General track students seem to confirm this assumption as a few times was mentioned during the focus group that regardless of the learning method, they are not interested in learning sciences. However, general track students do think that it was fun to learn sciences in a different way than they are used to.

“I don’t like to learn sciences. I do not find sciences interesting. So, these lessons do not stimulate me to learn sciences. For sure I found it fun to learn sciences different for once. However, I am not more motivated because of these lessons to learn more about science in the future [FG 1]”.

When the discussion expanded to motivation during emergency distance learning in general, there are two voices in the debate. While some students say that they were motivated in the beginning but lost their motivation by now, others say that they now push themselves more because they were not motivated at the start of emergency distance learning.

“In the beginning of online education I was very motivated, but now I am really starting to hate it. ... I find it really hard to concentrate during the lessons and teachers expect always that you hear everything, but that is really hard. In general I am very easy to distract. But in a classroom there I have my teacher who is talking and I can just follow them. In my room with my computer I am very easily distracted [FG 2]”.

“At the start I was very little motivated, but now I start to do more. Because I noticed that when I am not motivated this influences my grades [FG 2]”.

On next proposition ‘I can work better with my team members online than physically in the classroom’, participants answered neutral to not agree ($M = 2.33, SD = 1.05$). As mentioned earlier, students find it hard to spend long periods behind their computer screens. Some participants feel isolated sitting alone at home while following online lessons. As they could work together online during the intervention and talk with each other, they found the lessons a little bit more fun. About the difficulty rate of working online together, opinions are divided. While some see benefits of collaborating online, others only see disadvantages. The most mentioned benefit is less distraction by other groups and subsequently more concentration as groups work in their personal online working space.

“... In the classroom you are being distracted by other groups. You look next to you and so. Online you are really alone with the two of you and you have to work. In the classroom it sometimes gets too loud and you do not hear your teammates [FG 1]”.

Being more active during the CoSiL-lesson in comparison with classroom lessons was the second most mentioned benefit. Remainder benefits are technical ones like screen sharing, but also more practical ones like the possibility to sleep longer and not having to commute to school. However, distraction, poor concentration, and (screen) tiredness are the most cited disadvantages of online collaboration. These
are followed by distance and technical shortcomings like bad Wi-Fi connections. Participants see distance between them and their teammates as an obstacle to a high quality collaboration. They find the collaboration or their team members less tangible and find it harder to explain something to one another. In the end, participants just find it more fun to collaborate in person.

“I think that it is easier to collaborate with in the classroom than online… Because in the classroom you sit physically together next to each other and I think that is more fun [FG 2]”.

“It is harder to make plans with someone when they are further away from you. If you want to collaborate, it is way much better to be close to one another. You can show each other something instead of having to explain it [FG 1]”.

On the last proposition, ‘I wish I had received more guidance during the classes’ (\(M = 2.9, SD = 1.20\)), participants answered on average neutral. Opinions during the focus groups were divided. While some find guidance not necessary or thought the amount of received guidance was ideal, others preferred more help from the facilitators. Some students think that this could be attained by implementing the online lessons in the classroom.

“I did not have any troubles. I could easily do it on my own. I don’t think that guidance was necessary [FG 1]”.

“I think in the classroom things would have runed more smooth… We would have received more guidance because we can always raise our hands and you can see which groups need help. Online we are put into break-out rooms and they say you need to call or send a message, but that is difficult for the teacher to oversee everything. You have questions and suddenly you are stuck and you cannot move on…[FG 2]”.

4 CONCLUSION AND DISCUSSION

The purpose of this explorative mixed-methods study was to examine (1) the effect of online CoSIL on the scientific knowledge, inquiry skills and motivation for learning sciences and (2) the perceptions of students on the use of online CoSIL during STEM lesson hours. In such way there was aimed to contribute to the CoSIL research field by widening the research gaze from face-to-face CoSIL to online CoSIL, as such specific research focus is currently lacking. Moreover, this study contributes to student perception research about distance learning as it explores perceptions of secondary students, while the current research field is focusing on higher education settings.

It was found that online CoSIL has a significant learning effect on scientific knowledge and inquiry skills. No significant effect on both autonomous and controlled motivation was found. Further, focus groups show mixed results as students’ opinions are varied. On the one hand, students think that, compared to traditional science lectures, they are more active and attentive during online CoSIL. On the other hand, they do not feel more motivated during online CoSIL and they think that face-to-face collaboration is more effective and fun. Their preference for collaboration in the classroom over online collaboration could be explained by the Social Presence Theory. This theory states that online communication, and thus online collaboration, may not be sufficient to meet the needs of students during distance education because of key concepts like intimacy and immediacy [31]. Moreover, preference for in-person collaboration could be due to their feelings of isolation as a consequence of the long lasting Covid-19 pandemic, which was also found in earlier research on higher education level [14], [21]–[23]. Additionally, students were ‘screen-tired’ and experienced loss of concentration after a whole day of online learning. These findings point in the direction of a preference for a blended learning environment instead of fully online environment, which was also expressed by higher education students in the research of Paudel [23].

A limitation of this explorative study is the limited number of participants which influences the presented statistical analyses. Therefore, it is recommended to do further research with a larger number of participants in secondary education.

Results of this study call for new studies on blended learning approaches in secondary education. Further, in this study two external facilitators facilitated the CoSIL learning experience but their actions were no subject to the current research. However, future research should focus on the increased workload that teachers may experience. Teaching with technology in the classroom requires a lot of planning and designing of the teacher after regular classroom hours. This heavy workload was widely recorded during the Covid-19 pandemic, regardless of teachers’ experience with technology [13], [25]. We recommend to further inquire instructors and teachers on both secondary and university level,
because momentary research attention is mainly focused on students’ experiences. Teachers’ experiences and concerns need to be taken seriously to benefit from the Covid-19 pandemic wherein an abundance of teaching experience with technology was gained. Finally, our results provide important insights for future post-Covid redesign processes in which blended learning scenarios can be explored in depth.

REFERENCES


