An Online Collaborative Biology Simulation Used by Ukrainian Students During the 2022 Russian Invasion

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Abstract: Although the Covid-19 pandemic disrupted learning for students worldwide, the 2022 Russian invasion of Ukraine has more severely impacted education for Ukrainian students. This study was conducted in the context of an educational technology master's thesis (Halchevska, 2022) at the University of Tartu, Estonia. A master's student with Ukrainian background contacted a biology teacher in Ukraine and offered to help teach an online collaborative lesson about genetics and the laws of inheritance. The lesson involved using an innovative computer simulation called the Collaborative Rabbit Genetics Lab. The learning materials were translated into Ukrainian. A quasi-experimental research design compared whether prior experience working with a collaborative seesaw simulation would influence outcomes later with the biology-related collaborative simulation. Data from two classes of 9th-grade students were collected using questionnaire items related to the perception of interdependence, an open-ended question about collaboration, and a focus group interview. The results indicate that prior practice with a collaborative simulation somewhat enhanced perceived collaboration the next time students worked with a similar type of interdependent task but did not affect task performance. The findings suggest that more guidance is needed to support learners in online collaboration when they solve interdependent tasks.

1 INTRODUCTION

A major concern of teachers during the Covid-19 pandemic and the resulting lockdown of schools was maintaining social contact with students during a time of mandatory physical distancing (König et al., 2020). Even when teachers began to use video conferencing platforms for online lessons, many science teachers reported that engaging students in collaborative learning activities was a serious challenge (Rannastu-Avalos and Siiman, 2020). It has been argued that successful online learning requires establishing and maintaining a condition of social presence, that is, the ability of learners to project themselves socially and affectively into a community (Garrison et al., 2000). The Covid-19 pandemic experience suggests that, in general, school teachers require more guidance and support to promote online social interaction effectively.

The Covid-19 pandemic began in March 2020 and led to worldwide quarantine and physical distancing measures. Thanks to the success of mass vaccination programmes, travel restrictions have been lifted in most countries. However, on the morning of 24 February 2022, another event captured worldwide attention. On that day the Russian Federation invaded its neighbour Ukraine. Immediately, all educational institutions were closed in Ukraine, but slowly began to reopen online in mid-March for secondary school students and in April for university students (Lavrysh et al., 2022). By that time, millions of Ukrainian refugees, mostly women and children, had left the country in what has become the largest refugee crisis of the 21st century (UNHCR, 2022).

Many European countries have shown an extraordinary outpouring of support for the Ukrainian people. Since the Russian invasion, the Ukrainian government has been looking for and supporting initiatives for the digitalisation of education (Zinchenko et al., 2022). The government of Estonia has successfully developed many digital solutions for public services and recently signed a cooperation

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agreement with Ukraine to promote a vision of digital transformation focusing on cybersecurity and e-governance (Ministry of Economic Affairs and Communications, 2022). Universities in Estonia have been active in promoting the digitalisation of education. The University of Tartu has offered since 2017 a mostly online master's degree programme in educational technology taught in English[1]. A few Ukrainians have completed it and in 2022 one Ukrainian student in the programme, the second author (Y.H.), chose as her thesis topic collaboration with educational technologies under the supervision of the first author (L.A.S). After the Russian invasion of Ukraine, she decided to plan an online activity with Ukrainian school-age students.

Supporting online collaboration requires learning activities that prompt various collaborative behaviours in students and monitoring their behaviour to provide feedback when necessary. The Programme for International Student Assessment (PISA) developed three general competencies to categorise collaborative behaviours expected of school-age students for the 2015 large-scale assessment of students' collaborative problem-solving skills. The three collaborative problem-solving competencies are (OECD, 2017):

- Establishing and maintaining shared understanding (e.g., discovering the unique knowledge and perspectives of group members);
- Taking action to solve the problem (e.g., identifying and describing subtasks);
- Keeping the team organised (e.g., describing roles and providing feedback on member contributions).

The PISA assessment used different types of collaborative problem-solving tasks to prompt collaborative behaviours, one of which was the jigsaw or hidden-profile task. In this type of task, each group member is given different information, and success with the task depends on pooling together each member's unique information (Aronson et al., 1978; Stasser and Titus, 1985). No single individual can solve this type of task on his or her own because each collaborator has a unique and necessary part of the information, and like solving a jigsaw puzzle, must put the parts together before a solution is found (i.e., seeing the bigger picture of the puzzle).

Another assessment of students' collaborative problem-solving skills was developed by the Assessment and Teaching of 21st Century Skills (ATC21S) project (Griffin and Care, 2015). The tasks developed by ATC21S also required establishing a condition of interdependence in which no student could solve the problem alone. The tasks were created for use online and involved two students working remotely on separate computers while controlling different aspects of a shared simulation. The students could communicate with each other using a chat messenger app. For example, one task involved a simulation of a beam balance in which functionality to place masses on the balance was divided between the two students: i.e., one student could place masses only on the left side and the other student only on the right side of the balance. To explore different combinations of masses that would still keep the beam balanced, the two students had to work together and coordinate their actions.

Based on the ATC21S task design to create simulations where different collaborators have differing control over a shared simulation, Siiman et al. (2020) developed so-called asymmetric simulations to support collaborative scientific inquiry. These collaborative simulations were designed for learning various science topics (photosynthesis, force and balance, electric circuits, genetics and laws of inheritance). They are also freely available on the internet[2], can be integrated into an online digital lesson using the Go-Lab Platform[3], and translatable into different languages. The second author decided that the Collaborative Rabbit Genetics Lab[4] would be a suitable collaborative simulation to use after contacting a Ukrainian biology teacher. The teacher mentioned that the students had learnt this topic, but it would be good to review it in a new and collaborative manner. Prior research with asymmetric simulations has suggested that it is challenging for students the first time they encounter strongly interdependent tasks (Rannastu et al., 2019). Thus, the current study aimed to investigate whether practice with a collaborative simulation task about balancing a seesaw would influence outcomes on the later task about rabbit genetics and the laws of inheritance. We hypothesised that prior experience solving an interdependent task with collaborative simulations would benefit students later when they collaborated again on a similar task but in a different context.

[1] https://ut.ee/en/curriculum/educational-technology
[2] https://leosiiman.neocities.org/simulations.html
[3] https://www.golabz.eu
[4] https://www.golabz.eu/lab/collaborative-rabbit-genetics-lab

2 METHOD

Students aged 14 to 15 from two 9th-grade biology classes at a public school in Dnipro, Ukraine participated in this study. The class sizes were 21 (Class 1) and 28 (Class 2), but due to the ongoing war in Ukraine, only 19 students fully participated. They were either in Dnipro or on the outskirts and close to the city. In case of an air raid siren in the city, the lesson would have to stop immediately, but fortunately for the three sessions in this study, no air sirens rang. A quasi-experimental design was applied, and Class 1 was assigned to the condition of gaining prior experience with an interdependent simulation before completing the main task. The sessions with the students were held online using the Zoom video conferencing software and led by the educational technology master's student (author Y.H.) in mid-April 2022. Each intervention lasted 40 minutes. Students in both classes were randomly assigned to work in pairs. One group in Class 2 worked as a group of three.

2.1 Materials

2.1.1 Asymmetric Collaborative Simulations

Two asymmetric collaborative simulations were used in this study. The main simulation, the Collaborative Rabbit Genetics Lab (see Figure 1), involves a simulation where in version A, a student can select black rabbits to be placed in the "Parents" area for breeding offspring. In Version B, a student has similar functionality over white rabbits. The simulation reacts in real-time simultaneously to changes made by either student as long as the room number which students entered to join the simulation is the same. Initially, both black and white rabbits have a homozygous trait for fur colour. However, if the two students collaborate, it is possible to discover that two black rabbits can produce a white offspring. To do so, it is necessary to generate a second generation of black rabbits bred with white rabbits so that the offspring will have a heterozygous trait for

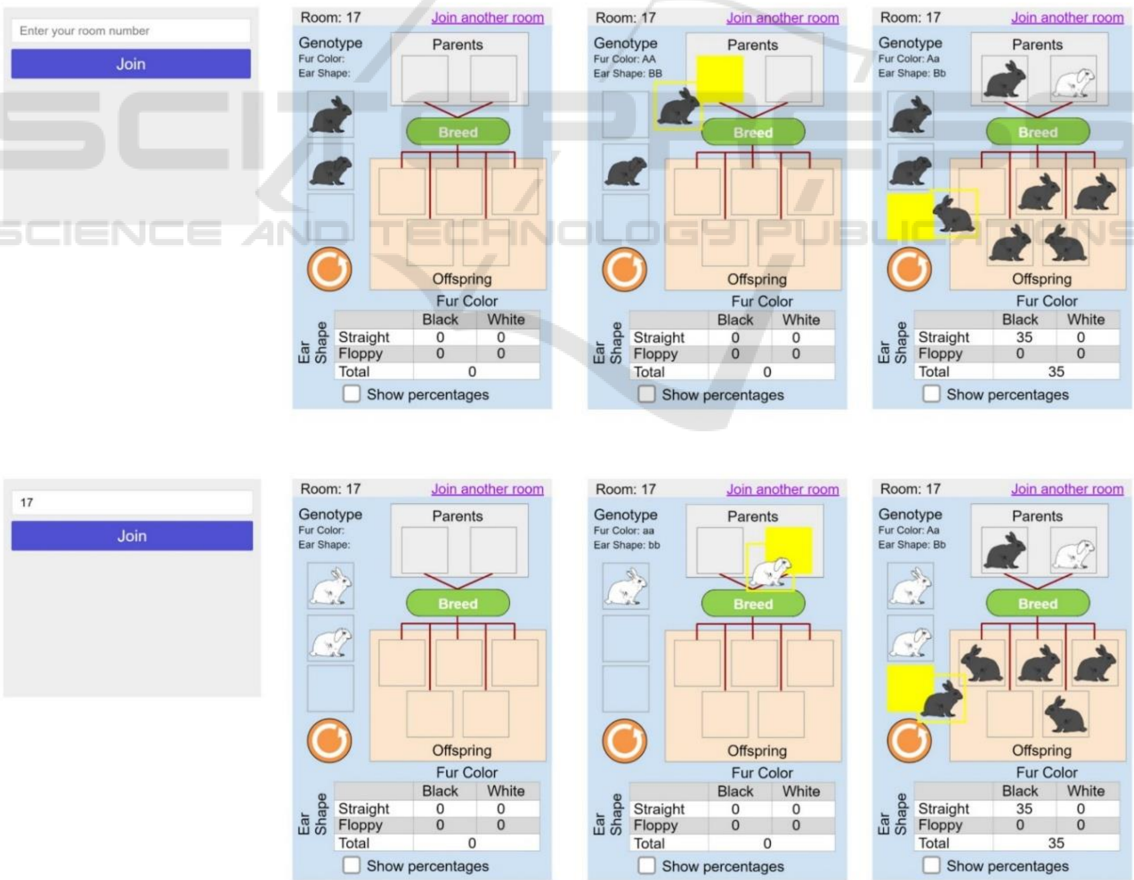

Figure 1: Screenshots of the Collaborative Rabbit Genetics Lab: Version A (Top row) and Version B (Bottom row). The sequence of images from left to right show potential actions students might take in the simulation.

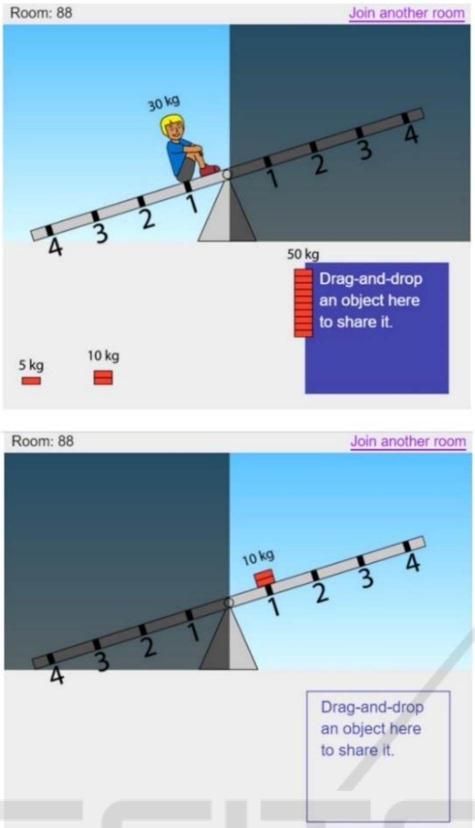

Figure 2: Screenshots of the Collaborative Seesaw Lab: Version A (Top) and Version B (Bottom). It was used with the group of students (Class 1) who received prior experience using a collaborative simulation before working with the rabbit genetics simulation.

fur colour. Then each student saves one of these black offspring into a box provided in the simulation. Finally, when the students reset the simulation so that new parents can be selected, they select the two heterozygous black rabbits they saved and discover that some offspring may now be white in colour.

Besides the main collaborative simulation, we used the Collaborative Seesaw Lab (see Figure 2) with Class 1 to provide them with prior experience solving an online interdependent task. This simulation involves a seesaw where users can place masses only on the left side (Version A) or only on the right side (Version B) of the seesaw. Students do not see the masses or positions of masses on the opposite side. They can only see whether the seesaw is tilted or balanced. A box provided in the simulation allows the students to share masses back and forth with each other. Initially, all of the masses are provided in Version A of the simulation.

2.1.2 The Go-Lab Learning Environment

To collect data and easily translate the learning materials into Ukrainian, we used the Go-Lab learning environment (T. De Jong, Soteriou, and Gillet, 2014). In Go-Lab (https://www.golabz.eu), we could embed the simulations and collect responses from students to the task questions. Figure 3 shows how the collaborative rabbit genetics task appeared in the Go-Lab learning environment.

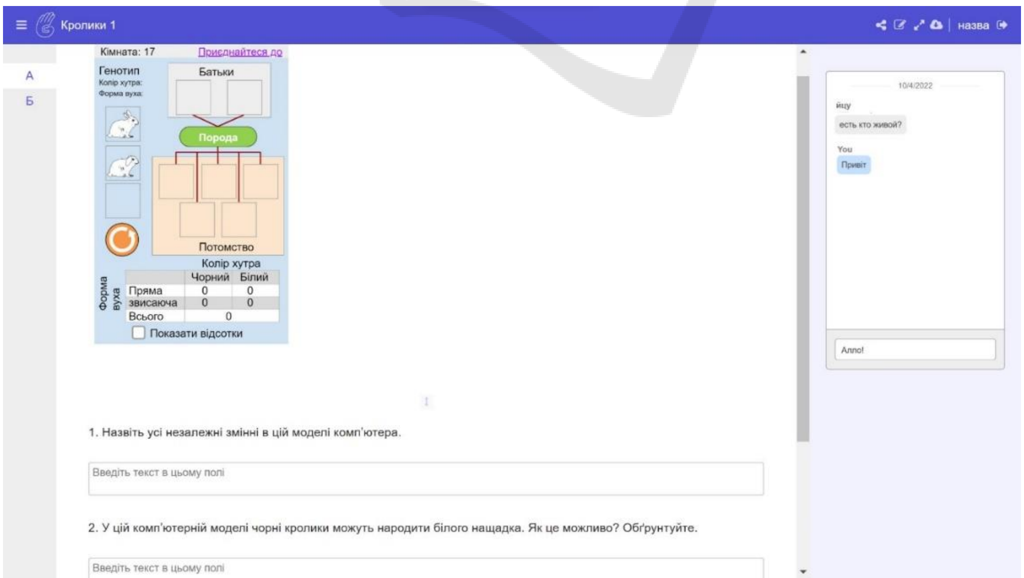

Figure 3: Screenshot of version B of the collaborative rabbit genetics activity after translation into Ukrainian as it appeared in the Go-Lab learning environment on a desktop or laptop computer screen. Note the chat messenger to the right.

In the main task involving rabbit genetics, we asked three questions:

- Q1. Name all the *dependent* (Version A) / *independent* (Version B) variables in this computer simulation.
- Q2. In this computer simulation, it is possible for black rabbits to give birth to a white offspring. Discover how to do this and then explain how.
- Q3. Explain what characteristics two *white* (Version A) / *black* (Version B) rabbits in this simulation should have so that there is an equal probability (50%) of giving birth to an offspring with floppy ears or an offspring with straight ears.

The first question was scored correct if students identified fur colour of the offspring as the dependent variable and parent fur colour or genotype as the dependent variable. The second question was scored correct if students discovered that the parents they have initial access to have dominant (genotype = AA) or recessive (genotype = aa) fur colour traits, whereas it is necessary to mate two heterozygous black rabbits (genotype = Aa) in order to have the possibility of having a white offspring. The third question was scored correct if the students identified that mating a rabbit with recessive genotype for ear shape (genotype = bb) and a heterozygous rabbit (genotype = Bb) would result in a probability of about 50% for the offspring to have straight ears.

For the seesaw task, which was meant to be practice for the students in Class 1 to get familiar with a jigsaw or hidden-profile type of task, we asked only one question:

- Can the seesaw be balanced using a total of *3 objects* (Version A) / *2 objects* (Version B) on the seesaw? If so, then describe exactly how.

Note that questions were not always the same for both students. This was done deliberately so that students would have to clearly communicate what the goals of their collaboration should be.

The way students could communicate in Go-Lab was via a chat messenger app and the sending of text messages. This mode of communication follows the example of collaborative problem-solving tasks designed by ATC21S. It has the advantage of presenting a history of everything that has been written. However, it is usually slower than oral communication and lacks the subtle opportunities to convey emotions using non-verbal signals.

2.2 Measures

Both task performance and collaboration were assessed in this study. The main task involving rabbit genetics consisted of the three questions mentioned above that could be objectively graded. To measure students' collaboration, several indicators were used. Table 1 shows five survey items related to interdependence that were asked of students after they had completed the rabbit genetics task. The collaborative simulation was designed to instil a condition of interdependence between the two students and therefore perception of interdependence was judged to be important for this collaborative activity.

Table 1: Survey items.

Item	Statement or question
Q1	My partner was dependent on me for information and advice.
Q2	I was dependent on my partner for information and advice.
Q3	We agreed on what we wanted to achieve.
Q4	When my partner succeeded, this had a positive impact on me.
Q5	What do you think is most important for successful collaboration?

Note. Items Q1 to Q4 were responded to on a Likert scale with the options: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree. Items 5 was open-ended question.

Two items measuring perceived task interdependence (Q1 & Q2) and two items measuring outcome interdependence (Q3 & Q4) were adapted from the the Team Learning Beliefs & Behaviors Questionnaire (Van den Bossche et al., 2006). An open-ended question (Q5) was used as the fifth survey item to allow students to answer in their own words what is most important for successful collaboration.

A focus group interview with each class separately was also used to gather data about the intervention. It was guided by the question: *"What did you learn from this collaborative experience?"*.

3 RESULTS AND DISCUSSION

Table 2 presents the performance results of the collaborative rabbit genetics task for both classes. This performance score is the result of grading the three questions for this task (e.g., Q1. Identify the dependent/independent variables in this simulation). As can be seen, both classes performed poorly answering the task questions, with responses to the third question barely receiving any credit.

Table 2: Average performance scores (in percentage) for the three questions on the collaborative rabbit genetics task.

Question	Class 1 (n=10)	Class 2 (n=9)
1	38	43
2	20	25
3	1	4

The post-task focus group interview offers possible reasons for the poor task performance. A lack of time to solve all three questions was expressed by students in both classes. But perhaps more importantly, the inconvenience of communicating continuously with a chat messenger app may have slowed down progress. In the interview, one student said, *"I was using Telegram … because it is more comfortable for me to focus on the task."* Then another student said *"I also used Telegram because me and my partner were using voice messages to save some time. Well, it is faster to say something rather than type it."* Telegram is a social media app for instant messaging, voice, and video messaging that is popular in Ukraine. A third student summed up the general opinion by saying, *"If we had a chance to speak to each other it would save us time."* The additional time needed to communicate with a chat messenger may explain why many students did not perform well on the third task question. In addition to a lack of time, students commented that the task was challenging: *"It took some time to try it out, to try to move the rabbits around … to listen to [the] explanation of the lesson and to register … it was challenging"*, *"the task with rabbits is more complicated than the seesaw one"*.

Table 3 shows means and standard deviation values from the survey items measuring perceived interdependence. Compared to Class 2, the students in Class 1 reported higher perceived interdependence on all four of the items, but only item Q1 was found to be statistically significant.

The generally positive responses towards perception of interdependence with the collaborative rabbit genetics task was echoed in the focus group interview. Students said, *"I learned how to work in*

Table 3: Mean and standard deviation values (in parentheses) for survey items Q1 to Q4.

Item	Class 1 (n=10)	Class 2 (n=9)
Q1*	3.8 (0.8)	2.7 (1.3)
Q2	3.9 (1.1)	3.1 (1.4)
Q3	3.9 (0.9)	3.3 (1.7)
Q4	4.4 (0.7)	3.9 (0.8)

*$p < .05$. Two-sample independent t-test.

Table 4 shows student responses to the survey question Q5: "What do you think is most important for successful collaboration?". The responses to item Q5 show that many students perceive successful collaboration to be the result of effective communication and understanding. The collaborative rabbit genetics task certainly presented them with a type of problem where effective communication was essential for success. According to the three dimensions unique to collaborative problem-solving in the PISA framework, effective communication as expressed by the students could be best categorised under the dimension *Establishing and maintaining shared understanding*. The PISA dimension *Taking action to solve the problem* was expressed by students

Table 4: Responses by students to survey item Q5: "What do you think is most important for successful collaboration?".

No.	Class 1 (n=10)	Class 2 (n=9)
1	*A friendly way of talk, and to be a good listener, and to understand the question we work on.*	*Quickly find solutions to questions, the ability to hear different points of view.*
2	*Both people need to listen, understand the topic and look for the answers quickly.*	*They listen to each other and understand why they want from us.*
3	*We need to save time in order to finish the cooperation quickly.*	*Friendship forever like in fairy tales, team spirit.*
4	*To communicate with each other and respect each other.*	*Ability to listen, understand and implement.*
5	*To communicate and keep the friendly way of talk.*	*Team spirit and willingness to work.*
6	*To communicate in a way so that we save time.*	*The ability to negotiate quickly.*
7	*Friendly way of talk and quick respond.*	*An easy transfer of information.*
8	*To discuss and communicate.*	*Communication.*
9	*To listen to my partner.*	*Friendship.*
10	*Understanding quickly.*	-

in statements like *"Quickly find solutions to questions", "look for the answers quickly"*. The third dimension, *Keeping the team organised*, was expressed by students in the sense of acting friendly. They said, *"keep the friendly way of talk", "friendship", "team spirit"*. Thus, all three dimensions were partly expressed by students in their short answer responses to what they think is most important for successful collaboration.

Looking again at the task assignment, we realise that guidance for certain parts would have alleviated the time pressure students felt. Lazonder and Harmsen (2016), in a comprehensive meta-analysis, found that guidance is pivotal to successful inquiry-based learning. For the first question on the collaborative rabbit genetics task, we could have prompted students with text such as *Make sure to work collaboratively since your collaborator may have information in their simulation that you are missing*. Students do not expect to have missing or different information on collaborative tasks. In fact, during the interview, one student said, *"We were surprised when … our questions for the [task] were different … usually it happens when there's a typo, so we tell this to our teachers. But I understand now that it is meant to be like that."* When under time constraints, then providing guidance for students to quickly realise that information is missing or different seems reasonable. Additional guidance could lower the complexity of the task by providing hints about how to perform a certain action or scaffolds to explain more demanding parts of an action.

In this study we measured collaboration using self-report data from students. Future research should explore ways of combining such data with other indicators of collaboration, such as process data, to get a richer picture of the multiple interacting elements involved in collaboration. Triangulating analysis approaches may offer improved validity when assessing the collaborative problem-solving construct (Pöysä-Tarhonen et al., 2022). Ultimately, a practical assessment instrument for teachers should be developed so that students' collaboration skills can be measured and appropriate feedback given about the strengths and weaknesses of their collaboration skills.

Collaboration is a complex construct that is not easily operationalised. Ercikan and Oliveri (2016) make a case for going beyond traditional psychometric analyses of assessment instruments and looking closely at the behaviour and thinking of subjects during real-life learning contexts. This study investigated online student collaboration during a difficult time for the Ukrainian participants. Nevertheless, the students expressed positive aspects when describing successful collaboration and offered constructive remarks for improving this activity. Their responses to the survey item "What do you think is most important for successful collaboration?" mentioned friendship several times and showed their awareness of dealing with people in a friendly way to get along better. The context of this study during the 2022 Russian invasion of Ukraine makes it unique. More data from other contexts would help to identify the potential of online collaborative simulations in developing students' collaboration skills and in suggesting ways of validly assessing those skills.

4 CONCLUSIONS

The aim of this study was for Ukrainian students to participate in an online collaborative activity and investigate whether prior experience with a collaborative simulation benefits students later when they use a similar simulation again. We found that students' collaboration, as measured by perceived interdependence questionnaire items, was higher for the prior experience group. However, students' task performance did not differ significantly depending on whether they received prior experience or not, and was on average poor. A post-task interview revealed that a barrier to effective communication was designing the task with a chat messenger app. Students preferred to communicate orally. In addition, the biology task related to rabbit genetics was challenging and would have benefited from additional guidance for students.

Although interdependent collaborative tasks may be challenging for students, educators need to support students in developing collaboration skills to solve such tasks. The European Digital Competence Framework for Citizens (Vuorikari et al., 2022) provides a common understanding of digital competence and specifically identifies one competence area as *Communication and Collaboration*. Young people need to become proficient at using digital technologies to solve complex problems collaboratively. Furthermore, teachers and educational researchers require evidence-based guidance to create and use well-designed digital collaborative activities while monitoring or measuring the development of students' collaboration skills. More evidence is needed to ensure collaborative activities and tools for measuring collaboration skills are reliable and valid.

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