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Bringing Science to the Periphery Through Distance Learning: Barriers and Opportunities

Eilat Chen Levy [1], Gilad Ravid [1], Yael Shwartz [2] and Noa Avriel-Avni [3,*]

[1] Department of Industrial Engineering and Management, Ben Gurion University of the Negev, Beer Sheba 8410501, Israel; eilatlevy@012.net.il (E.C.L.); rgilad@bgu.ac.il (G.R.)
[2] Weizmann Institute, Rehovot 7632706, Israel; yael.shwartz@weizmann.ac.il
[3] Dead Sea & Arava Science Center, Neve Zohar 86910, Israel
* Correspondence: noa@adssc.org

Abstract: Students in peripheral areas often score lower in the sciences than those in urban areas. This study explores the feasibility of distance learning in making quality science education accessible everywhere. In 2016, the Israeli government established technological infrastructure in southern peripheral schools, but these resources remained largely unused. From 2018 to 2019, we interviewed school principals and education department directors, and surveyed teachers and students about distance learning. The findings showed hesitance among educators to implement distance learning for expanding science subjects, despite their confidence in using it when necessary. After the mandatory shift to distance learning during the COVID-19 pandemic in 2020, attitudes towards technology in remote schools improved. Barriers to implementing distance learning were found to be mainly due to internal factors like preconceived notions, which limited the development of necessary skills among teachers and students. We recommend addressing internal resistance to distance learning in teacher training programs.

Keywords: distance learning; ICT; periphery; rural schools; science learning

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1. Introduction

Providing students living in the periphery with high-level lessons in the sciences poses an international challenge (Macintyre & Macdonald, 2011; Nilsen et al., 2023; Sasson, 2019). Limited exposure to the world of science hinders the professional and academic development of students in the periphery (Yogev, 2008) and increases gaps between the academic achievements of students living outside and within urban centers (Chesters & Cuervo, 2021; Haisraeli, 2021). Distance learning (DL) (DL in the periphery was introduced before the COVID-19 pandemic as a means of enhancing science learning in remote regions, through dedicated computerized centers) could enable students in the periphery to connect with remote science centers and enhance their science literacy (Rao et al., 2011; Novotná & Demkanin, 2024; Chesters & Cuervo, 2021). However, until recently, DL had hardly been implemented in peripheral education systems (Clark, 2008; Rundel & Salemink, 2021).

The aim of this study is to understand what prevents the adoption of DL in the periphery. The southern periphery of Israel served as a case study. It was chosen in light of the significant government investment in technological infrastructure in 2016, which largely remained unused. The first phase of the study was held in 2018–2019. In 2020, further data were collected to examine the impact of forced DL (during the COVID-19 lockdown) on the attitudes of students, teachers, and principals.

1.1. The Educational Challenge in the Periphery

Isolated communities suffer from inequalities regarding education options and quality compared to urban populations (Macintyre & Macdonald, 2011; Nilsen et al., 2023; Rao et al., 2011; Sasson, 2019). Students and teachers in the periphery are less exposed to the sciences and to expert science teachers (Weininger, 2014; Davidson & Poor, 2019). It is often difficult for students in the periphery to participate in educational frameworks outside of their living area, making the geographical periphery also a social one (Haisraeli, 2021; Miller et al., 2019). The distance between peripheral schools and science centers, alongside insufficient public transport, pose a logistic challenge (Gökdaş & Kayri, 2005; Hwang, 2008). Thus, local solutions are often difficult to implement (Ayalon et al., 2008). Such barriers limit access to quality education, resulting in lower academic achievements (Nilsen et al., 2023), difficulty developing cultural capital (Haisraeli, 2021), and less chance of being accepted into higher education, compared to urban students (Chesters & Cuervo, 2021).

1.2. The Potential and Challenges of Distance Learning

Distance learning (DL) is achieved through information and communication technologies (ICT), and provides a flexible learning environment (Spiteri & Chang Rundgren, 2020). As such, DL develops higher learning skills, such as independent learning (Zhou et al., 2020). In the periphery, DL overcomes geographical and social barriers, enabling students from isolated schools to partake in various educational projects and courses (Ortagus, 2017; Bryant, 2021). DL offers interesting, interactive, and fast learning options (Ness & Lin, 2015). When combined with ICT, DL can exemplify complex or abstract scientific processes (Geer & Sweeney, 2012) using a wide range of tools and methods (Demkanin & Sands, 2023).

Computerized environments have been shown to enhance all aspects of the learning experience (Hsu, 2016; Luterbach & Brown, 2011), and diverse technological tools have promoted changes in teaching methods (Walan, 2020). Thanks to the digital footprints made by students and teachers (Kent et al., 2019), analysis of the strengths and weaknesses of various methods can be used to fine-tune lessons to suit the needs of individual students (Ferguson, 2012).

However, to integrate DL and ICT in education systems, conceptual and practical challenges regarding organization, pedagogy, and technology must first be identified (Lassoued et al., 2020; Shamir-Inbal & Blau, 2021; Schleicher, 2020). The Technological Pedagogical Content Knowledge Model (TPACK; Mishra, 2019) demonstrates these complex challenges in detail. The TPACK model is based on three critical knowledge components necessary for enhancing teaching quality (Figure 1): content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK), which together create pedagogical content knowledge (PCK) and technology content knowledge (TCK). Numerous TPACK tools developed by researchers and teachers (Graham et al., 2009; Willermark, 2018) enable teachers to constantly improve their TPACK skills, resulting in coherent lessons that are appealing and motivating for the students (Koehler et al., 2011).

Studies show that teachers with experience using technology do so differently than inexperienced teachers, thereby improving their teaching quality (Ertmer et al., 2012; Fraillon et al., 2020a; Lachner et al., 2021; Levy et al., 2016; Lin et al., 2013; Wang et al., 2022). A positive correlation has been found between TPACK and teachers' attitudes toward change, as well as a positive correlation between teachers' attitudes toward change and their perception of school as a learning organization (Avidov-Ungar & Eshet-Alkalai, 2011).

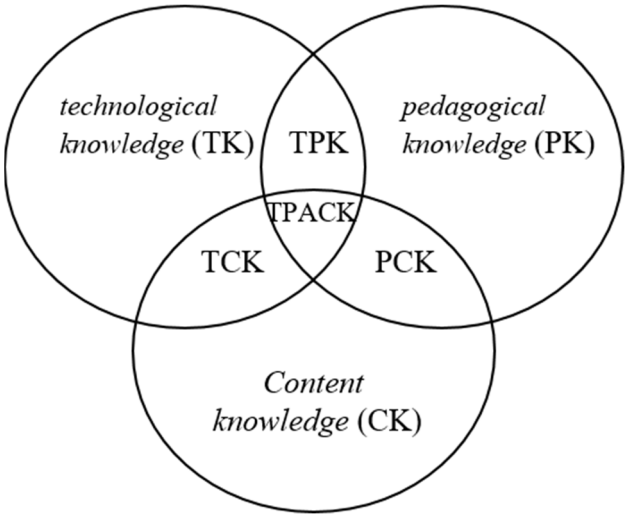

Figure 1. TPACK Components. Source: Koehler and Mishra (2009).

Before implementing a DL program, teachers and students must have access to technological infrastructure (computers, etc.) at school and home, thereby overcoming the digital gap. However, teachers often have to deal with technophobia, i.e., the fear of using advanced technological means and other internal barriers (Novotná & Demkanin, 2024). In a study on science teachers in South Africa, researchers found that the teachers' use of ICT was hindered mainly by internal factors, such as their perceptions of the ease or usefulness of such technologies, rather than external factors, such as the quality and availability of the technology (George & Ogunniyi, 2016). Similar findings were seen in an earlier study conducted in the United States and Singapore (Hew & Brush, 2007), whereby almost half of the inhibitory factors that prevented teachers from utilizing ICT tools were internal. Novotná and Demkanin (2024) found that physics teachers who favor inquiry-based learning are more likely to incorporate advanced technology into teaching than teachers who favor systematic knowledge transfer. Additionally, a study on chemistry teachers (Eidelman et al., 2014) revealed that most participants used first-tier technologies, such as Word documents, existing presentations, and videos. However, they described themselves as feeling comfortable with technology. Few teachers used second-tier technological aids, such as Google Docs or Moodle. During COVID-19 lockdowns, students' difficulties in understanding material were found to stem from teachers' insufficient technological knowledge and skills needed for distance teaching (Carrillo & Flores, 2020), insufficient allocation of learning time, and inadequate infrastructure (Hebebci et al., 2020; Zhao & Watterston, 2021).

The Technology Accepted Model (TAM) developed by Davis (1989) predicts when new data systems will be used, and suggests that their perceived usefulness and ease of use, as viewed by teachers, are central components. The model was developed to differentiate between users who object to using information systems and those who do not object (Davis et al., 1989). Moreover, as seen in Figure 2, perceived usefulness and ease of use directly and indirectly impact attitudes regarding using information technology (IT), behavioral intentions (i.e., acceptance), and actual use. TAM assessment tools have been found to be reliable and valid (Mathieson et al., 2001). A meta-analysis conducted by Scherer et al. (2019) found that TAM explained the relation between technology acceptance and teachers' training and technological capabilities.

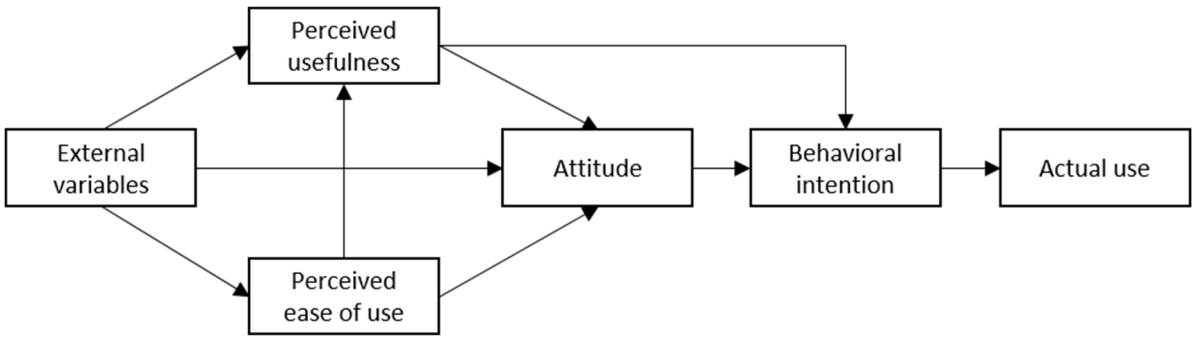

Figure 2. TAM components (source: (Davis, 1989)).

In addition to technological and perceptual challenges, DL also poses pedagogical ones (Mishra, 2019), as the shift is not simply a matter of transitioning from traditional teaching methods in the classroom to conveying materials through online media (Carrillo & Flores, 2020; Yates et al., 2021).

In a meta-analysis, Hattie (2009) found that the best predictors of students' achievements following DL are related to teachers' activities, not to the technology used. In order to benefit from the advantages of DL, teachers must adapt their study models and student–teacher relations, rather than convey predefined knowledge to students (Blau & Shamir-Inbal, 2017). The constructivist theory, based on the recognition that significant learning occurs through learners' internal processes, should provide the foundation for DL (Ambrose & Lovett, 2014). According to this learning theory, new information can be conveyed, but whether new concepts will (or will not) be absorbed by students depends on additional factors, such as students' prior knowledge and perceptions, habits, culture-related perceptions (Ziguras, 2001), emotional state, and values (Davis & Sumara, 2002). As such, teachers become mentors and mediators for students' independent learning (Koehler et al., 2011), and must address students holistically when planning and executing curriculum programs (Ambrose & Lovett, 2014). Accordingly, DL emphasizes flexibility and problem-solving capabilities, rather than striving to develop specific knowledge among students (Himmetoglu et al., 2020; Novotná & Demkanin, 2024; Paas et al., 2004).

An additional challenge of implementing DL relates to the students themselves, who must develop new skills, such as independent learning, creative thinking, personal responsibility, the ability to retrieve relevant and reliable information, and most importantly, digital literacy (Feerrar, 2019; Njenga, 2018; Pangrazio et al., 2020; Le et al., 2022). When examining four factors that positively impact learners' attitudes towards DL (the course environment, learners' characteristics, learners' success, and the institution's functioning), Tallent-Runnels et al. (2006) found a more positive attitude towards DL among students with prior ICT knowledge and experience. In this aspect, too, there is a difference between the center and the periphery, as inequality in digital literacy has been demonstrated between students from central regions versus peripheral ones (Ganayem et al., 2009).

Moreover, while the benefits of simple access to endless information via ICT are clear, students may face cognitive challenges due to the overload of new information, affecting their ability to absorb extensive data (Paas et al., 2004). Self-regulating learning skills are seen as a major requirement for implementing ICT in a DL environment (Tsai, 2011). Self-regulated learners who are motivated and active participants are perceived as metacognitive; they must plan, set goals, organize, and self-evaluate several times during the learning process (Zimmerman, 2008). These are important traits, as research indicates a positive correlation between self-regulated learning and academic achievements (Eidelman & Shwartz, 2021). Thus, integrating DL and ICT in schools presents students

with significant cognitive challenges and requires pedagogical changes among teachers and administrators (Carrillo & Flores, 2020; Thurlings et al., 2014).

Teachers and students must possess suitable technological and pedagogical skills for DL and ICT to become integral to school routines (Blau & Shamir-Inbal, 2017; Novotná & Demkanin, 2024). Therefore, it is unsurprising that many teachers refrain from using ICT when teaching, even when it is readily available, thereby undermining its importance (Fraillon et al., 2020b). Research has indicated that teachers and principals frequently reject innovative pedagogical and organizational changes within the education system, such as the use of educational technologies designed to enhance teaching, learning, and instruction (Avidov-Ungar & Eshet-Alkalai, 2011; Levin & Fullan, 2008).

2. Methodology

2.1. Research Questions

This study's main research question was as follows: What obstacles hinder the implementation of distance learning (DL) technologies in the periphery? We also defined the following specific questions:

RQ1: How do educators and students in southern Israel perceive DL as a means of fostering science literacy in the periphery?

RQ2: How do educators and students define the challenges that DL poses?

Following the forced use of DL in winter 2020, a third research question was added:

RQ3: Has forced use of DL changed the interviewees' perceptions regarding RQ1 and RQ2, and if so, how?

Hypothesis: Q1 and Q2 are qualitative questions. Although it is not customary to formulate hypotheses for qualitative questions (Q1 and Q2), we hypothesized that since our case study in the peripheral south of Israel has available technological solutions, the main obstacles to implementing DL are internal-organizational and perceptional. Regarding Q3, we hypothesized that using technology for learning would transform students' and teachers' perceptions of DL.

2.2. Research Field

The study was conducted in the southern periphery of Israel (the Negev Desert), an area encompassing 10,500 km^2 (Figure 3). This region is home to 115,700 residents living in settlements with 300–10,000 inhabitants. The communities are either urban or rural, and Jewish or Bedouin-Muslim. Lessons in Jewish schools are taught in Hebrew, while lessons in Bedouin schools are taught in Arabic. Town schools are subject to municipal jurisdiction; regional schools, where students from small villages study, are subject to regional jurisdiction. Schools in this region are relatively small (150–300 students), and as such, are unable to offer students a wide range of subjects, teaching methods, and Bagrut credits (in Israel, the Bagrut Certificate confirms that the student has successfully completed the high school matriculation examinations in a range of subjects, and is a prerequisite for higher education). The closest urban center is Beer Sheba, home to a university and a science education center. Yet the distances between this city and most villages (black dots in Figure 3) prevent students and teachers from utilizing these resources (Central Bureau of Statistics, 2019).

According to a report by the Central Bureau of Statistics (Central Bureau of Statistics, 2019). The Face of Society in Israel: Gaps Between Center and Periphery. Report No. 11 https://www.cbs.gov.il/he/publications/DocLib/2019/rep_11/accessibility.pdf (accessed on 5 January 2025) [Hebrew]) of Israel, in 2017, 20.5% of high school students in the country's center were studying advanced mathematics, compared to a mere 10.3% in the periphery. Among high school graduates, 47.5% of students from the center enrolled

in university, compared to 36.5% from the periphery. Additionally, students from the periphery were more likely to study humanities or social sciences than science, medicine, or technology.

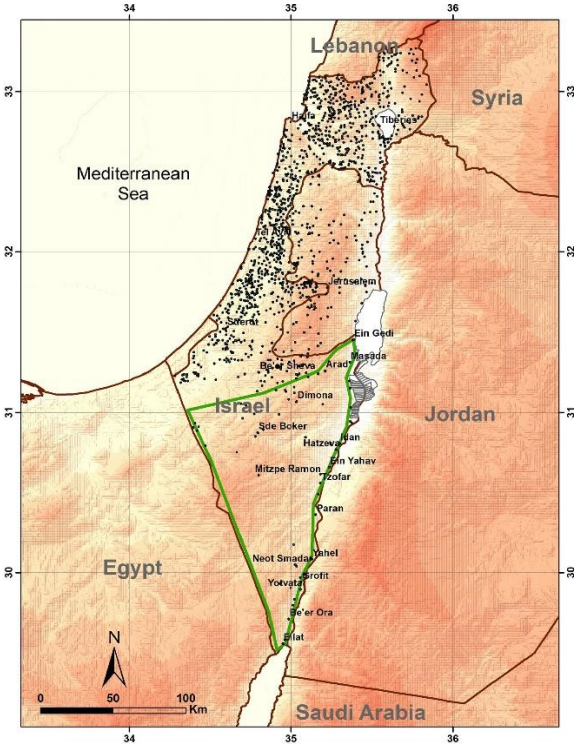

Figure 3. The research area is within the green triangle. The black dots indicate settlements in Israel.

The reasons for these gaps are numerous. It is hard for schools in the geographical periphery to hire and retain good science teachers. Residents of the periphery, many of whom are of low socioeconomic status, cannot fund tutoring for their children (Blass, 2020). In addition, parents with a low socioeconomic status tend to encourage their children to study practical subjects rather than academic subjects (Haisraeli, 2021).

In 2016, DL was recognized as a possible solution to close this gap, and well-equipped computer labs and dedicated DL centers were built in most settlements in the region (East Negev site). However, these were hardly used, as schools preferred to maintain traditional learning methods.

The research participants included education department directors in the local and regional councils, school principals, high school science teachers, and high school students from south Israel. The 15–18-year-old students were at the stage when they had to choose electives for their Bagrut matriculation exams.

COVID-19 restrictions forced schools to close intermittently. When this state of emergency became long-term, teachers, students, and parents had to use DL to maintain teacher/student contact and provide lessons according to the pre-determined syllabi. Although some teachers were already familiar with the asynchronous platform, most lacked formal training and experience in DL teaching. Many teachers found remote teaching difficult, and many students did not have sufficient access to a home computer (Donham et al., 2022). Teachers were immediately required to use digital platforms such as Zoom, recommended by the Israel Ministry of Education. Zoom lessons imitate a face-to-face (F2F) encounter, in which the teachers instruct, and the students listen and (hopefully) internalize the information (Serhan, 2020).

Shortly after embarking on DL, the various parties voiced their concerns about DL via public media. We therefore conducted an additional series of interviews with department directors and school principals, and asked teachers and students to complete an additional questionnaire regarding their attitudes towards DL after they were forced to use it. These findings were then compared to those gathered at the onset of our research.

2.3. Data Collection and Analysis

We used a mixed methods approach (Driscoll et al., 2007) to analyze our data. To answer RQ1 and RQ2 using qualitative data, we conducted semi-structured interviews (Appendix A.1) in 2018–2019 with six education department directors in Jewish and Bedouin towns and regional councils, and ten Jewish and Bedouin school principals. The interviews took place in face-to-face meetings in the interviewees' offices. The interviews lasted between 40 and 60 min. In 2020, we conducted the same semi-structured interviews, but telephonically due to the limitations of the pandemic, with two education department directors in Jewish and Bedouin towns and regional councils, and with five Jewish and Bedouin principals. The interviews were then analyzed using the Content Analysis Approach (Elo & Kyngäs, 2008) to extract central themes from the data.

The main insights achieved from the interviews then served as the basis for two closed-ended and structured Likert-type questionnaires for teachers and students (Appendices A.2 and A.3). Different questionnaires were used for the teachers and the students. The respondents were asked to rate items on a scale of 1 (strongly disagree) to 5 (strongly agree). The questionnaires were validated through a pilot study that included teachers and students outside the research region. Responses were gathered via telephone in Hebrew or Arabic, and participants were compensated for their time with a food voucher. The number of participants in each survey was as follows:

Stage I: In 2019, 70 teachers and 36 students completed the questionnaires.

Stage II: In 2020, 70 teachers and 40 students completed the questionnaires.

The telephone survey was ineffective among the Bedouin population, and printed questionnaires could not be circulated due to frequent lockdowns in Israel. Therefore, only the Jewish participants were included in the second survey. The data were analyzed through ANOVA with R. The study design was full factorial, with 2×2 groups: students vs. teachers, and 2019 vs. 2020.

3. Results

In 2018–2019, the interviews and surveys indicated a lack of enthusiasm and even objection to distance learning (DL) as a means of expanding the Bagrut topics offered to students and increasing the Bagrut success rate of students in the periphery. Teachers were found to be confident in their ability to implement DL if needed.

The later survey indicated a change in the attitudes of teachers and students towards DL. Some teachers and principals perceived the COVID-19 crisis as an opportunity to improve technological infrastructure. They stated that using ICT in remote schools, combined with F2F encounters, could benefit teachers and students. The difference in perceptions between the two research stages sheds light on the obstacles that hinder the use of DL, particularly bringing science to the periphery through DL.

Table 1 presents the Cronbach's alpha reliability of the different blocks in the questionnaire. Alpha values greater than 0.7 are considered reliable. It is evident that all the blocks in the teachers' surveys, apart from ICT usage in 2020, have an alpha greater than 0.7. The use of ICT during the second survey has a low alpha, because the necessity of using ICT tools created many variations in teachers' use of ICT. Coordinated use, as in the first survey, became uncoordinated after the forced use of ICT. The students' responses to the statements

about the usefulness of distance learning show marginal reliability (alpha of 0.65 and 0.626). At the outset, while constructing the questionnaire, this block of statements was intended to test different aspects of the opportunities in distance learning. Since this context was multidimensional, we did not expect a high alpha coefficient. The students' responses to the statements may have been coordinated differently among different students.

Table 1. The Cronbach's alpha reliability of the questionnaire.

6	**4**	**3**	**2**	**Questions**
ICT usage	Facilitating conditions items	UTAT items	Distance Learning Attitude	Block
Teachers 2018–2019				
64	64	65	68	Number of responses
5	3	9	7	Number of items
0.785	0.816	0.804	0.803	Cronbach's alpha
Teachers 2020				
70	70	70	70	Number of responses
5	3	9	7	Number of items
0.21	0.894	0.794	0.795	Cronbach's alpha
Students 2018–2019				
38		39	39	Number of responses
5		8	6	Number of items
0.843		0.689	0.656	Cronbach's alpha
Students 2020				
40		40	40	Number of responses
5		8	6	Number of items
0.958		0.879	0.626	Cronbach's alpha

3.1. Findings Relating to RQ1

The examination of how educators perceived DL as a means for developing high-quality, varied science learning in the periphery showed that before the pandemic, educators were unenthusiastic about this option; most principals doubted DL or completely rejected it. Their reasons included organizational and pedagogical aspects, as expressed by one principal: "*Our school is small, if our students participate in DL Bagrut tracks, we won't be able to offer in-school Bagrut tracks and I won't be able to provide teachers with full-time jobs*". Another principal explained that "*[we are] very concerned about the [small] number of students [at our school]. We don't allow external tracks because it will harm the existing [in-school] tracks*". An additional obstacle expressed by principals related to difficulties in providing ongoing support for students in DL programs, which could prevent them from achieving a complete Bagrut certificate.

Directors of education departments in the more remote regional councils had a positive opinion of DL; some perceived DL as an opportunity for offering additional electives to students. The principals of Bedouin schools (which are usually larger than the Jewish schools in the area, and therefore offer a greater range of Bagrut subjects) perceived DL as an opportunity for Arab and Jewish students to meet and study together on equal footing.

In general, technological infrastructure and teachers' DL experiences were not perceived as significant problems by most principals. However, many did mention that the lack of technical-support employees hindered the implementation of DL, in addition to

teachers' lack of training. One Bedouin principal explained: "*In a town with lots of students. . . there are many teachers. Plenty of budgets allocated to education in the Bedouin sector. [The town's educational vision is] practicing and developing DL capabilities from a young age*". Another principal explained the difficulty in training teachers in the periphery to use ICT: "*Teachers don't participate in trainings. . . If there is a teacher who's crazy about it, then we can open a* DL *track. But there isn't. . . The more veteran teachers don't have the skills, and there isn't a next-generation. . .*" Yet another principal added: "*The issue of distance is significant. Training requires traveling to the center of the country [2–4 hours' drive]. Teachers don't feel that they have to go to training because they have a job either way. Teachers aren't competing over their jobs*".

3.2. Teachers' Attitudes Towards Distance Learning in 2018–2019

In the following subsection, we will describe the responses to the questionnaire. For each response, the mean (M) of the answers is indicated. The responses are also presented in Table 2; significant differences are shown in bold. The responses are on a Likert scale, with 1 being 'strongly disagree' and 5 being 'strongly agree'.

Table 2. Attitudes of teachers and students in the periphery regarding the use of distance learning. Note the changes between 2018–2019 and 2020, before and during the COVID-19 lockdowns. A graphical representation of these findings can be found in Appendix B.

Students 2020	Students 2018–2019	Teachers 2020	Teachers 2018–2019	Statements (1 = Strongly Disagree, 5 = Strongly Agree)	
		1.87	1.64	School electives must be closed to increase students' success rate in Bagrut exams.	q1_1
		2.67	3.51	Additional electives must be opened to increase students' success rate in Bagrut exams.	q1_2
3.33	4.13	3.30	3.74	My students would like more electives to be offered.	q1_3
3.15	3.54	2.84	3.27	Students should be encouraged to enroll in a regional science virtual/blended learning elective that does not exist at their school.	q1_4
		1.60	1.71	Non-science electives should be closed at school (for example, communication) to enable additional science electives to be opened.	q1_5
		2.97	3.19	The lack of Bagrut matriculation teachers is the main barrier to opening unique electives.	q1_6
2.68	3.18	2.29	2.67	In my opinion, if my students had a choice, they would choose to enroll in a regional virtual/blended learning elective for matriculation instead of another elective at school.	q1_7
		2.79	2.97	The lack of computers and internet at school is a barrier to opening distance learning electives for Bagrut matriculation.	q2_1
		3.00	3.35	The lack of ICT and computing skills workshops for teachers is a barrier to opening distance learning electives for Bagrut matriculation.	q2_2
		2.90	3.10	The lack of an ICT support technician at school is a barrier to opening distance learning electives for Bagrut matriculation.	q2_3

Table 2. *Cont.*

Students 2020	Students 2018–2019	Teachers 2020	Teachers 2018–2019	Statements (1 = Strongly Disagree, 5 = Strongly Agree)	
		3.39	3.50	The lack of a computer room (including computers with an internet connection and a comfortable and quiet learning space) is a barrier to opening distance learning electives for Bagrut matriculation.	q2_4
2.65	2.87	3.00	2.96	The school and management fully support students who wish to participate in distance learning by providing computers and an internet connection.	q2_5
2.00	2.56	2.41	2.40	The school and management fully support students who wish to participate in distance learning by providing a late ride (school bus) to his/her city/town.	q2_6
2.53	3.03	2.87	2.88	The school and the management fully support students who wish to participate in distance learning by providing technical support.	q2_7
3.10	3.95	3.60	3.31	The distance learning system supports my study needs.	q3_1
		3.30	3.15	If I use the distance learning system, I will be able to work additional hours.	q3_2
2.70	3.51			If I use the distance learning system, I will increase my chances of completing my Bagrut matriculation with high grades.	q3_1b
2.93	3.82	2.91	3.60	I assume that using the distance learning system will allow me to teach material faster.	q3_3
2.85	3.77	4.10	3.82	I assume that I will easily reach a high skill level of using the distance learning system.	q3_4
3.45	4.03	4.06	4.08	I assume that I will find the distance learning system easy to use.	q3_5
4.10	4.26	3.20	3.42	My students think I should use the distance learning system.	q3_6
3.15	3.72	3.57	3.31	My friends think I should use the distance learning system	q3_7
		3.50	2.97	The school's management assists teachers in using the distance learning system.	q3_8
3.68	3.56	3.74	3.31	Generally, the school's management supports the use of the distance learning system.	q3_9
		3.01	3.34	I intend to teach using the distance learning system.	q4_1
		2.87	3.09	I intend to use the distance learning system during the evening hours to support my students.	q4_2
		3.00	2.84	I am planning to use the distance learning system for the next few months.	q4_3
				How often do you use the following tools? (1—multiple times a day; 5—rarely)	

Table 2. *Cont.*

Students 2020	Students 2018–2019	Teachers 2020	Teachers 2018–2019	Statements (1 = Strongly Disagree, 5 = Strongly Agree)	
1.23	1.26	1.09	1.28	Browsing the internet	q6_1
1.25	1.37	1.27	1.33	Apps on my smartphone	q6_2
1.55	1.47	1.27	1.44	Search engines	q6_3
1.45	1.76	2.64	2.31	Social media (Facebook, Instagram)	q6_4
1.30	1.21	1.1	1.30	WhatsApp (messaging software)	q6_5

Most teachers did not believe that Bagrut electives should be limited to increase Bagrut success rates in the south (M = 1.64), or that additional Bagrut subjects should be offered for the same reason (M = 3.51). Although most teachers agreed that certain electives should not be closed (rated 1, strongly disagree), opinions about offering additional electives varied. The teachers believed that their students would want additional options for Bagrut subjects (M = 3.74). When asked whether teachers should encourage their students to enroll in regional science study programs (rather than their school's Bagrut electives), agreement was moderate (M = 3.27). The teachers did not believe that non-science electives should be closed to make room for science electives (M = 1.71). The teachers believed to a moderate degree that a shortage of teachers posed an obstacle to opening unique Bagrut electives (M = 3.19), and that students would choose the regional distance learning Bagrut programs if offered (M = 2.67). When examining which factors posed an obstacle to opening regional DL Bagrut programs, the teachers highly agreed that the reasons were a lack of ICT rooms (M = 3.50), followed by a lack of teacher training (M = 3.35), a lack of technical support staff (M = 3.10), and insufficient computers and internet connections (M = 2.97). The teachers only slightly agreed that students who wished to study regional DL courses could obtain full support for transportation (M = 2.40), but agreed moderately that they did receive adequate technical support (M = 2.88).

Most teachers expressed indifferences towards learning management systems (LMSs). In addition, most stated that students would not want to study a regional distance learning Bagrut elective, rating this possibility lower than the students did. The teachers perceived themselves as technologically capable. The teachers tended to agree that LMSs could be useful (M = 3.31), as they would enable them to increase their salary (M = 3.15) and teach faster (M = 3.60). Moreover, the teachers stated that it would be easy for them to acquire control of these LMSs (M = 3.82), and they would find them easy to use (M = 4.08). Teachers beliefs that students thought LMSs should be implemented were only slightly above average (M = 3.42). The teachers also stated that LMSs should be used (M = 3.31), but did not believe that the school principal expected them to use them (M = 2.97). In general, the teachers believed that the school's management was not very supportive of using DL (M = 3.31). Finally, the teachers stated that they intended to use LMSs to a moderate degree (M = 3.34), even during the evenings (M = 3.09), but that they would use LMSs over the next few months to a low degree (M = 2.84).

Finally, 2 of the 64 teachers stated that they did not own a smartphone, 5 that they did not have a computer at home, and 7 that they did not have a computer or internet connection at school. Moreover, 60 teachers stated that they used the internet at least once a day and used smartphone applications at least once a day; and 57 teachers sought information via Google and used text-messaging applications; however, only 41 teachers stated that they used social media.

3.3. Students' Attitudes Towards Distance Learning in 2018–2019

Unlike the teachers (M = 2.67), the students expressed a desire to participate in regional DL Bagrut electives (M = 3.18). Students expressed a higher desire to choose an ICT Bagrut elective than their teachers perceived them to. Like the teachers, however, the students perceived themselves as being technologically oriented and as having adequate access to technological infrastructure.

When summarizing the main findings among the teachers and students in 2019, the teachers were hesitant or unwilling to use DL, and expressed a lack of relevant pedagogical training or ICT tools for conducting DL. The teachers did not perceive LMSs as a useful tool, while the students did. Both teachers and students believed they could easily become proficient in the system, and they similarly rated their perception of the system as easy to use.

3.4. Findings Relating to RQ2

Our findings show that for most teachers and students, DL was a foreign concept in 2018–2019 in relation to teacher training, school organization, and teacher and student experience. In addition to difficulties maintaining learning routines without access to a computer, tablet, or smartphone for every family member, DL was perceived as incapable of enabling meaningful learning. The participants also believed that students would not join DL classes or complete their given assignments, and would eventually quit school. The teachers' ability to evaluate the students' performance was also expected to be harmed by implementing DL.

3.5. Findings Relating to RQ3

In response to COVID-19 lockdowns, education was conveyed via DL. This unexpected change allowed us to re-collect data and examine participants' attitudes towards DL after experiencing it. Eight of the sixteen principals who participated in the first stage were interviewed again; they expressed very different attitudes towards DL this time.

The principals now believed that DL should play a more central role in the education system in the southern periphery, with some even hoping that the pandemic would accelerate this process. One principal of a Bedouin school stated that the school's internet site should be used more (i.e., asynchronous learning) as a means for preparing for all types of emergencies: "*. . . a state of war or Coronavirus situation, we live in a country where things can change. [Emergency states] offer a good direction for thinking about things that the education system can develop and lead. I'll give you a simple example: The school website contains all of the learning materials. . . enabling students to access the site through their phones and prepare for exams. This is good for the child and the teacher. All you need is a bit of good will to do such things*". This principal also added that teacher–parent ties have been beneficial for adapting DL to individual students.

Unlike perceptions in 2018–2019, whereby teachers had adequate training and access to advanced ICT, the principals now stated that in-depth change was needed. One principal said: "*Very intense training is needed for the education teams. . . as well as support that includes both technical training and innovative pedagogical perceptions: How can teachers let go of their place in the classroom to become mentors and mediators instead, with students transitioning and becoming independent learners. Training needs to occur at all levels: principals, teachers, students, and even parents*".

Another principal described the changes, emphasizing that DL should not replace F2F learning, but the two should be combined: "We were in a really bad way regarding ICT, really bad, the school hardly has any budgets. . . I mean, there were objections to all this. . . technology. We preferred human contact with each other, and we didn't really deal with

technology. But now, suddenly, this is a chance for us to discover a whole new world... we let go of our objections to technology because we had no choice. Even those who are technologically challenged had no choice. It's not like everyone now wants only to use technology but it is definitely something complementary".

Another principal explained that teachers not only need to overcome technological gaps, but also must receive pedagogical support and training, to enable the combination of conventional and DL: "*Teachers should be trained, helped... we would be happy to revert to conventional learning because, with all due respect, conventional learning has a lot of advantages. But in my opinion, combining ICT is very important!*".

3.6. Changes in Attitudes Towards Distance Learning in 2020

Teachers (M = 3.30) and students (M = 3.32) wanted additional Bagrut electives to be offered via DL, yet both averages were lower in the 2019 surveys. No significant differences were found between students and teachers in their responses to the following two questions: Would schools provide a computer and internet connection for students who want to participate in DL? Would students who want to participate in DL receive support from the school regarding transportation after school hours? However, students felt that if they participated in DL, they would not receive the school's support regarding transportation (M = 2.56 on 2019 and M = 2.0 in 2020), while teachers rated this perception higher at both stages (M = 2.40 in 2019 and M = 2.41 in 2020). Regarding technical support for those participating in DL Bagrut electives, no significant decrease was found among teachers at the second stage (M = 2.88 compared to M = 2.87 in 2020). On the other hand, a significant decrease was seen among students who believed they would not receive technical support from the school: M = 3.03 in 2019, compared to M = 2.53 in 2020.

An interesting finding relates to the question of whether DL is useful. As seen in Figure 4, there was an increase in the teachers' ratings regarding the usefulness of DL, from M = 3.31 to M = 3.60 from 2019 to 2020; on the other hand, there was a decrease in the students' ratings, from M = 3.95 to M = 3.10.

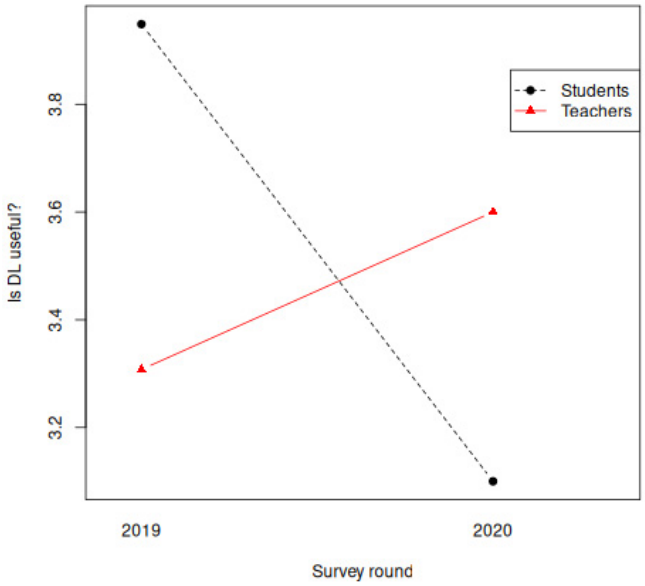

Figure 4. Perceived usefulness of distance learning.

On the other hand, no differences were found between teachers and students regarding the following perception: "*If I use the distance learning system, I will increase my chances of completing my Bagrut matriculation with high grades*"; the perceptions of both groups decreased at the second stage. Regarding the claim that DL would increase learning speed,

students and teachers changed their rating from M = 3.60 and M = 3.82, to M = 2.91 and M = 2.93, respectively. A change in trend was seen regarding the ability to achieve strong capabilities in using DL, with teachers and students rating this statement similarly in the first stage (M = 3.82 and M = 3.77, respectively). However, in the second stage, students significantly reduced their agreement (from M = 3.77 to M = 2.85). On the other hand, an increase was seen in the teachers' rating of this item, (from M = 3.82 to M = 4.10) following their actual use of this tool (Figure 5).

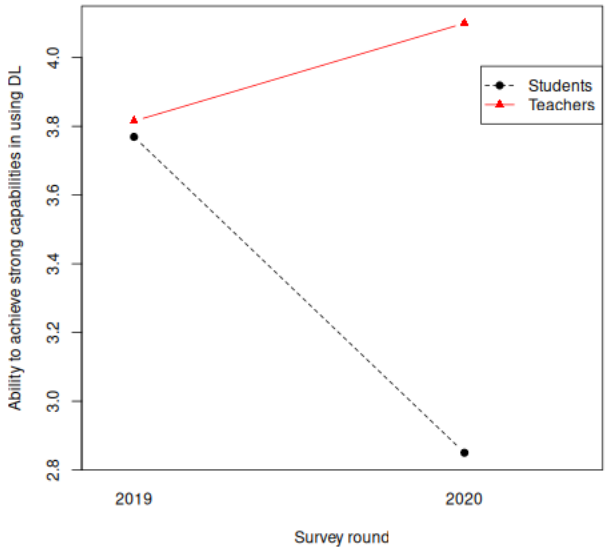

Figure 5. Perceived skills and capabilities in using distance learning.

Teachers and students both lowered their perceptions regarding ease of use of DL; this decrease was greater among students (from M = 4.03 to M = 3.45) than among teachers (from M = 4.08 to M = 4.06) (Figure 6).

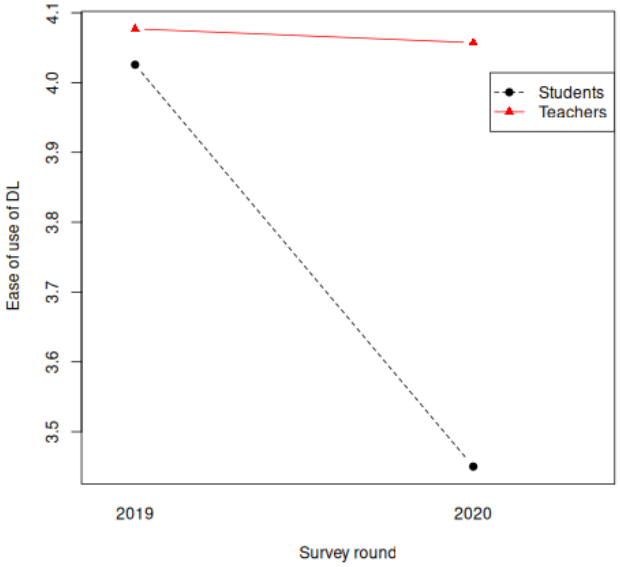

Figure 6. Perceived ease of use of distance learning.

Regarding the item "*Do my friends think I should use the distance learning system*?", students exhibited a small but significant decrease (from M = 3.72 to M = 3.15), while teachers exhibited an increase (from M = 3.30 to M = 3.57). Regarding the statement, "*My school has adequate computers and internet connections for me to use*", an increase was seen among students (from M = 1.03 to M = 1.18), while little change was seen among teachers

(M = 1.11 and M = 1.10), from the first to second phase. Regarding their use of social media, a significant difference was observed between teachers and students, who were asked to rate their use on a scale of 1 (a number of times a day) to 5 (rarely). In general, teachers used social media less than students did. Yet, in 2020, there was a decrease (a higher score indicates less usage) in teachers' use of social media (from M = 2.31 in 2019 to M = 2.64 in 2020), compared to an increase in the students' use (from M = 1.76 to M = 1.45).

Finally, a *t*-test was conducted to compare the teachers' attitudes in the first and second study phases. The results indicated that in 2020, teachers were significantly less likely to state that additional Bagrut electives should be offered (via DL) as a means of increasing Bagrut success rates (M = 3.51 decreased to M = 2.67, df = 136, t = 3.74 $p < 0.0002$). Yet, they were more likely to agree that the school management helped teachers to implement DL (M = 2.97 increased to M = 3.5, df = 133, t = −2.189, *p*-value < 0.03). No other significant differences were found between the results before and during the pandemic.

We observed (Table 2) that most teachers' and students' opinions were similar. Teachers underestimated students' desire to pursue additional learning electives. There was moderate to low support for this initiative across all levels, and the main barrier to opening new tracks was a lack of qualified teachers (q1_1–q1_7).

Among school principals, three main trends were evident regarding the opening of additional tracks:

1. Small student numbers: Principals highlighted that the small number of school students poses a challenge. If many tracks are opened, insufficient students will populate them.
2. Limited teaching positions: Principals expressed concern that opening local or regional tracks may further reduce teacher employment percentages, creating challenges in teacher employment and the overall teaching composition in the school.
3. Student dropout from a matriculation program during remote learning may hinder their ability to complete their matriculation certificate.
4. Geographical isolation and accessibility: The principals identified geographical isolation, distance from science centers, and lack of accessibility as significant barriers.

4. Discussion

Despite the proven benefits of DL (Fraillon et al., 2020a; Lachner et al., 2021) and the potential to improve scientific literacy in the periphery by using ICT (Ortagus, 2017), the data collected in 2018–2019 regarding Q1 and Q2 indicate that school principals and teachers discouraged their students from participating in DL programs. Their arguments were primarily organizational, e.g., that small schools could not support regional (science) learning electives while supporting the schools' programs. However, it seems that the main barrier to using DL in 2019 was internal. Students and teachers expressed a lack of enthusiasm about using DL technology, and did not perceive it as applicable. At the same time, they expressed confidence that they could easily develop skills for using ICT if needed, i.e., technology was not a barrier to DL. This perception can explain the minimal investment in training of local teachers in conducting DL before the pandemic; a similar phenomenon has been described in other parts of the world (Fraillon et al., 2020a; Francom et al., 2021; Rundel & Salemink, 2021).

The TPACK model indicates the many technological and pedagogical skills that teachers need to use ICT effectively (Koehler & Mishra, 2009; Willermark, 2018). Teacher training in ICT tools enhances the efficiency and enjoyment of DL among students (Levy et al., 2016; Ravid, 2004). Teachers' perceptions that they do not need ICT training create a barrier to change, as noted by Bauer and Kenton (2005) and Turgut and Aslan (2021), who emphasized the importance of experiencing technology-based education in changing teachers'

perceptions of it. This chicken-and-egg effect could partly explain the low use of DL in the southern Israeli periphery, despite the government's considerable investment in technological infrastructure. As the model suggests, three components are required to achieve educational success in the periphery: content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK), which create pedagogical content knowledge (PCK) and technology content knowledge (TCK).

Regarding Q3, COVID-19 forced teachers and students to accept DL through existing infrastructure not necessarily intended for this purpose (Hebebci et al., 2020), exposing teachers' lack of skills and knowledge for conducting DL (Carrillo & Flores, 2020). Teachers used DL technology, but maintained traditional teaching methods (Schleicher, 2020). The teachers' lack of experience often rendered DL frustrating and tedious (Spiteri & Chang Rundgren, 2020; Yates et al., 2021). This disappointing experience could explain the decrease in students' perceptions of DL's usefulness in our 2020 data collection round, and the decrease in their self-estimation regarding their ability to learn from afar easily. This could also explain the significant decrease in the students' desire to choose DL regional Bagrut classes. Therefore, we conclude that the challenge of assimilating DL in the periphery may have increased in 2020.

However, COVID-19 may also have created an opportunity to improve the use of DL (Zhao & Watterston, 2021). In Israel, the urgent need for DL following lockdowns focused on improving technological infrastructure and developing basic ICT knowledge among teachers. All our interviewees admitted that the pandemic emphasized their need for suitable technology, skills, and support—a finding in line with the TAM (Davis, 1989), whereby the optimal use of ICT will only be implemented if it is straightforward and yields concrete outcomes. This change in perception may be temporary following the state of emergency. Therefore, the education system should seize this opportunity as soon as possible.

Experienced technological teams could support the effective integration of DL and ICT into the education system and increase the teachers' skills (OECD, 2018). For peripheral schools, using distance communication tools may facilitate the establishment of regional support teams to overcome the distances between isolated schools.

In addition to the barriers, our study revealed some unique opportunities for DL in the periphery. School principals in the Bedouin sector mentioned that positive cooperation with parents during lockdown significantly motivated students to participate in DL lessons. Small peripheral schools can be a convenient platform for nurturing such cooperation. Further research could examine the impact of parental support on developing independent learning skills (Koehler et al., 2011) and self-regulation capabilities during DL (Zhou et al., 2020). The geographical periphery also creates opportunities through proximity to nature, facilitating hybrid programs, including DL and fieldwork. Such blended programs could expand science educational possibilities during routine and emergencies (Demkanin & Sands, 2023; Geer & Sweeney, 2012; Shamir-Inbal & Blau, 2021). Future studies should examine this direction.

5. Conclusions

Despite the unique circumstances of the case study, we suggest the following generalizations based on our findings. Comparing the perceptions of students, teachers, and principals during routine and after forced experience in DL helped us to recognize barriers and challenges in bringing the sciences to the periphery through DL. Objections to DL among teachers and principals may stem from a lack of technological and pedagogical training and inadequate organization. This emphasizes the critical knowledge that educators need for effective technology integration in teaching (Carrillo & Flores, 2020; Demkanin &

Sands, 2023). A key conclusion is that government investments in communication technology for schools in the periphery must be paired with appropriate training in DL, specifically addressing teachers' perceptual barriers pre- and in-service.

6. Research Limitations and Future Studies

One limitation of this study was the inability to distribute translated surveys to Bedouin schools during the COVID-19 lockdowns. As a result, Bedouin schools are underrepresented in this research. Future studies focusing on Bedouin schools, which are generally larger and face unique challenges in offering varied matriculation tracks, would offer a broader view on DL in social and geographic peripheries. Additional interesting follow-up studies may explore the relationship between parental support of students' independent learning and the effectiveness of DL during emergency times, and investigate how COVID-19 lockdowns affected teacher's acquisition of skills derived from the TPACK model.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee of Ben Gurion University of the Negev (October 2018). The research was approved by the Chief scientist and IRB committee of the Ministry of Education in Israel (Ref. 10590).

Informed Consent Statement: Informed consent was obtained from all individual participants included in the study.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questionnaires

Appendix A.1. Questionnaire for School Principals and Education Department Heads

Name of the Council (School): _____

5. Background Information (Education Department Manager):

- How many high schools are there in the city/council?
- How many students are there in grades 10–12?
- In which grade do specialization studies begin?
- How many teachers are there in science and technology subjects?
- What matriculation subjects are available in the locality/council?
- By schools? By the number of students?
- What are the success rates in the various specializations?

6. What educational advantages does the school/locality/council enjoy due to its location?
7. What educational advantages does the school/council enjoy due to the small number of students?
8. What are the strengths of the school/locality/council in terms of education?

9. Are there educational centers in the locality (e.g., science center, museum, Maṭha (Open University) branch)? What is their impact?
10. What is the educational vision of the council?
    6.a What factors influence/influenced the determination of the educational vision?
    6.b Which matriculation subjects would you like to open but cannot?
11. What are the considerations for opening additional matriculation subjects?
12. What enabled you to open unique specializations (e.g., unique teacher, proximity and access to the desert, collaborations)?
13. What are the barriers to opening matriculation subjects?
14. (Circle the appropriate factors and provide an explanation)

- Minimum number of students required to open a specialization?
- Lack of a teacher to lead the specialization?
- Low chances of success in the specialization?
- Lack of infrastructure (labs, computers) for the specialization?
- Other reasons?

15. Are there barriers to teachers' professional development?

- Lack of available training?
- Distance and travel time to training centers?
- Other reasons?

16. Is there use of computers for local educational purposes at the school? In what way?
17. What needs to happen for a digitalized specialization to be opened?

- Is there use of communication tools for learning? In what way?

18. What type of support is required for teachers and students to use digital learning spaces? (Circle the appropriate answer and provide an explanation)

- Technical support
- Professional mentoring
- Training
- Other?

19. How do you view the possibility of opening regional digital matriculation classes?

Appendix A.2. Student Questionnaire—Expanding the Range of Study Programs in the South Through Distance Learning

Introduction

Hello,

You are invited to participate in a study examining the expansion of study program offerings in the south through distance learning.

"Distance learning" refers to the ability to study while the teacher and the student are in different locations (e.g., the student is at home, and the teacher is at school). The lesson time during which the teacher teaches is not necessarily the time when the student learns (e.g., the student may study in the evening from home using a computer). Please respond generally to your familiarity with distance learning systems.

If you agree to participate in the study, you will be asked to complete a questionnaire on the following topic: "Using Distance Learning as a Means to Expand the Range of Study Tracks in the South". Completing the questionnaire takes only a few minutes. Please read the questions carefully and answer them honestly. Your answers are anonymous and will be used solely for research purposes. The questionnaire is written in the masculine form for convenience only, and is intended for all genders.

Your personal information is completely confidential, and there will be no way to link your identity to the answers you provide. The data will be stored securely and will only be accessible to the research team. If for any reason you wish to withdraw from the study, you may do so at any time by closing the window, which will prevent the data from being saved.

First Question: Is the lack of variety in study tracks perceived as a problem (by teachers/students)?

Attitudes toward study tracks at your school:

(Questions: q1_1; q1_2; q2)

Please indicate to what extent the following statements reflect your attitude toward study tracks at your school:

20. I would like more study tracks to be opened—(q1_1)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

21. Students should be encouraged to enroll in regional scientific matriculation tracks (not held at the school)—(q1_2)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

22. Indicate your agreement with the following statement: "If I had the option, I would choose a regional online matriculation class instead of an additional track at my school" (q2)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

Second Question: Is there sufficient internet infrastructure, and are there adequate conditions for distance learning?

(Questions: q3_1; q3_2; q3_3):

Please indicate your level of agreement with the following statements regarding internet infrastructure and conditions for distance learning at your school:

23. A student interested in participating in distance learning receives full support from the school and administration, including a computer and internet connection (q3_1)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

24. A student interested in participating in distance learning receives full support from the school and administration, including late transportation to their locality (q3_2)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

25. A student interested in participating in distance learning receives full technical support from the school and administration (q3_3)

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

Third Question: Do teachers/students see distance learning as a viable solution?
The UTAUT model suggests four predictors of adoption and use:

- Performance Expectancy
- Effort Expectancy
- Social Influence
- Facilitating Conditions

The following statements relate to using distance learning as a means of expanding scientific matriculation tracks in the south. Indicate your agreement with each statement on a scale of 1 to 5, where 1 = strongly disagree and 5 = strongly agree.

Performance Expectancy of the Distance Learning System
(Questions: q4_1–q4_3)

26. I find the distance learning system useful for me—q4_1)
27. Using the distance learning system will improve my chances of obtaining a quality matriculation certificate—(q4_2)
28. I believe that using the distance learning system will allow me to learn at a faster pace—(q4_3)
29. I estimate that I will easily reach a good level of proficiency in using distance learning—(q4_4)
    Rate this on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.
30. I estimate that I will find the distance learning system easy to use—(q4_5)
    Rate this on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.
31. I estimate that I will easily learn how to use the distance learning system—(q4_6)
    Rate this on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.
32. My friends think I should use the distance learning system—(q4_7)
    Rate this on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.
33. Generally, the school management supports the use of distance learning—(q4_8)
    Rate this on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.

Question: The usability of technology

This connects to the second question: Is there internet infrastructure and are there sufficient conditions for distance learning? (q5_1–q6_5)

34. I own a smartphone (a smart mobile phone that allows internet browsing)—q5_1

- Yes

- No

35. I have a computer at home with an internet connection—q5_2

- Yes
- No

36. At the school where I study, there are computers with internet access that I can use for learning—q5_3

- Yes
- No

Please rate how frequently you engage in each of the following activities:

37. **Browsing the internet**—q6_1

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

38. **Using apps (applications) on a mobile phone**—q6_2

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

39. **Searching for information using search engines (e.g., Google)**—q6_3

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

40. **Using social networks (e.g., Facebook/Instagram)**—q6_4

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

41. **Chatting through messaging apps (e.g., WhatsApp)**—q6_5

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

Details regarding the students' study trends

Questions q7_1–q9_3.

42. **Please specify the study tracks you are currently enrolled in**:—q7_1, q7_2, q7_3

- _____
- _____
- _____

43. **Please specify the study tracks you wish to enroll in**:—q8_1, q8_2, q8_3

- _____
- _____
- _____

44. **Please specify the study tracks you would like to enroll in, but which are not available at your school**:—q9_1, q9_2, q9_3

- _____
- _____
- _____

Details regarding the quality of distance learning:

- **25a.1** Compared to classroom learning, I learn better in synchronous distance learning:
  1. Strongly disagree 2 3 4 5. Neutral Strongly agree
  99 Don't know/unsure
- **25a.2** Compared to classroom learning, I learn more easily in synchronous distance learning:
  1. Strongly disagree 2 3 4 5. Neutral Strongly agree
  99 Don't know/unsure
- **25a.3** Compared to classroom learning, I understand the material better in synchronous distance learning:
  1. Strongly disagree 2 3 4 5. Neutral Strongly agree
  99 Don't know/unsure

Details regarding the mode of learning

- **25b. During the COVID-19 period, learning took place in the following ways:**
- Learning the entire week according to the regular class schedule.
- Learning through synchronous lessons (a situation where students and teachers are present at the same time, e.g., via Zoom).
- Learning through asynchronous lessons (a situation where learning activities between teachers and students do not occur simultaneously, e.g., via email).
- Learning in a flipped classroom (students study new material independently before the lesson, often via video, and then practice or complete tasks with the teacher during class time).

Demographic Questionnaire
(Questions: q10–q13)
To conclude, please provide some general background information about yourself:

- Mother tongue:—q10
- Hebrew
- Arabic
- Russian
- English
- Other: _____

45. Sector:—q11

- Secular Jewish
- Religious Jewish

- Christian Arab
- Muslim Arab
- Bedouin Arab
- Druze
- Other: _____

46. I am currently in grade:—(q12_1)

- Residential area:—q13
- Central Arava Regional Council
- Ar'arat an-Naqab Regional Council
- Tamar Regional Council
- Yeruham
- Arad
- Ramat Negev Regional Council
- Mitzpe Ramon
- Hevel Eilot Regional Council (Southern Arava)
- Segev Shalom
- Hura
- Neve Midbar Regional Council
- Other: _____

Thank you for your cooperation!

Appendix A.3. Questionnaire for Teachers: Expanding the Range of Study Programs in the South Through Distance Learning

Introduction

Dear Teacher,

You are invited to participate in a study examining the expansion of study programs in the south through distance learning.

"Distance learning" refers to the possibility of studying when the teacher and the student are in different locations (e.g., the student is at home, and the teacher is at school). The timing of the lesson taught by the teacher does not necessarily align with the time the student studies (e.g., the student studies in the evening from home via a computer). Please refer to the general use of distance learning systems you know.

If you agree to participate, you will be asked to complete a questionnaire: "*Using Distance Learning as a Means to Expand the Range of Study Programs in the South*". Completing the questionnaire will take only a few minutes. Please read the questions carefully and answer them honestly. Your responses are anonymous and will be used solely for research purposes.

The questionnaire is written in masculine form for convenience only. All references in the masculine form are intended for both males and females.

Your details are entirely confidential, and there will be no way to link your identity to the answers you provide. The data will be stored on a secure site and accessible only to the research team. If you wish to withdraw from the study, you may do so anytime by closing the window. Closing the window will prevent data storage.

Thank you for your participation!

(Related to: The usability of technology)

- **34a. How often do you engage in the following activity:**

  Using virtual conferencing during the COVID-19 period—q16

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely
- **34b. I have the necessary infrastructure at home for remote teaching during the COVID-19 period**—q17
- Yes
- No
- **34c. Most of my students have the necessary infrastructure at home for remote learning during the COVID-19 period**—q18
- Yes
- No

(Related to: Is the lack of variety in study programs perceived as an issue by teachers/students?)

Attitudes towards study programs in the school where you teach

- **34d. The lack of computers and internet access in students' homes is a barrier to opening new study programs for matriculation subjects through distance learning during the COVID-19 period**—q19
- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

(Related to: The social impact of using the distance learning system)

- **34e. The school administration supported the transition to distance learning during the COVID-19 period**—q20
  Rate this on a scale of 1 to 5, where
  1 = Strongly disagree, 5 = Strongly agree, 11 = Don't know/unsure.
- **34f. The transition to distance learning was easy and simple during the COVID-19 period**—q21
  Rate this on a scale of 1 to 5, where
  1 = Strongly disagree, 5 = Strongly agree, 11 = Don't know/unsure.
- **34g. Distance learning is as effective as face-to-face learning during the COVID-19 period**—q22
  Rate this on a scale of 1 to 5, where
  1 = Strongly disagree, 5 = Strongly agree, 11 = Don't know/unsure.
- **34h. I feel the need to specialize in teaching remotely during the COVID-19 period**—q23
  Rate this on a scale of 1 to 5, where
  1 = Strongly disagree, 5 = Strongly agree, 11 = Don't know/unsure.

First Question: Is the lack of variety in study programs perceived as an issue by teachers/students?

Attitudes towards study programs in the school where you teach

Questions: q1_1–q1_7.

Please indicate to what extent each of the following statements reflects your opinion regarding study programs in the school where you teach:

47. **Study programs should be closed to increase the success rate in matriculation exams**—q1_1

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

48. **Additional study programs should be opened to increase the success rate in matriculation exams**—q1_2

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

49. **My students would like more study programs to be opened**—q1_3

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

50. **Students should be encouraged to enroll in regional scientific programs, meaning programs not offered in their school**—q1_4

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

51. **Non-scientific programs (e.g., communication studies) should be closed to open additional scientific programs**—q1_5

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

52. **The lack of teachers for matriculation subjects is the main barrier to opening unique study programs**—q1_6

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

53. **In my opinion, if my students had the choice, they would choose an online regional matriculation class over an additional program at their school**—q1_7

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

Second Question: Is there sufficient internet infrastructure and conditions for remote learning?

Questions: q2_1–q2_7

Please indicate to what extent you agree with the following statements regarding your perspective on internet infrastructure and conditions for remote learning at the school where you teach:

54. **The lack of computers and internet connectivity at the school is a barrier to opening study programs for matriculation subjects through distance learning**—q2_1

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

55. **The lack of teacher training in ICT and computer skills is a barrier to opening study programs for matriculation subjects through distance learning**—q2_2

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

56. **The lack of a technical support professionals in computing at the school is a barrier to opening study programs for matriculation subjects through distance learning**—q2_3

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

57. **The lack of a digital learning space (including a computer with internet access and a quiet, comfortable learning area) is a barrier to opening study programs for matriculation subjects through distance learning**—q2_4

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

58. **A student interested in participating in distance learning receives full support from the school and administration through a computer and internet access**—q2_5

- Not at all
- To a small extent
- To a moderate extent
- To a great extent

- To a very great extent

59. **A student interested in participating in distance learning receives full support from the school and administration through late transportation to their home community**—q2_6

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

60. **A student interested in participating in distance learning receives full support from the school and administration through technical support**—q2_7

- Not at all
- To a small extent
- To a moderate extent
- To a great extent
- To a very great extent

Third Question: Do teachers/students see remote learning as a viable solution?
The **UTAUT model** suggests four constructs as predictors for adoption and use:

- **Performance Expectancy**
- Effort Expectancy
- Social Influence
- Facilitating Conditions

Below are various questions about using remote learning to expand the availability of scientific matriculation programs in the south.

Please indicate your level of agreement with each statement on a scale of 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.

Performance Expectations in the Remote Learning System
Questions: q3_1–q3_3.

Performance Expectations in the Remote Learning System

61. **I find the remote learning system useful for me**. (q3_1)
Rate on a scale of 1 to 5, where
1 = Strongly disagree, 5 = Strongly agree, 11 = Don't know/unsure.
62. **Using the remote learning system could increase my workload.** (q3_2)
Rate on a scale of 1 to 5.
63. **I believe that using the remote learning system will enable me to teach more efficiently.** (q3_3)
Rate on a scale of 1 to 5.

Effort Expectancy in Using the Remote Learning System

64. **I estimate that I will easily achieve a good level of proficiency in using remote learning.** (q3_4)
Rate on a scale of 1 to 5.
65. **I estimate that I will find the remote learning system easy to use.** (q3_5)
Rate on a scale of 1 to 5.

Social Influence of Using the Remote Learning System

66. **My students believe I should use the remote learning system.** (q3_6)
Rate on a scale of 1 to 5.
67. **My teaching colleagues believe I should use the remote learning system.** (q3_7)
Rate on a scale of 1 to 5.
68. **The school administration assists teachers in using the remote learning system.** (q3_8)
Rate on a scale of 1 to 5.
69. **Overall, the school administration supports the use of remote learning.** (q3_9)
Rate on a scale of 1 to 5.

Facilitating Conditions: Intentions to Use the Remote Learning System

70. **I intend to use the remote learning system for teaching purposes**. (q4_1)
Choose one:

- Very low usage
- Low usage
- Moderate usage
- High usage
- Very high usage

71. **I intend to use the remote learning system in the evenings to support my students**. (q4_2)
Choose one.

- Very low usage
- Low usage
- Moderate usage
- High usage
- Very high usage

72. **I plan to use the remote learning system in the coming months**. (q4_3)
Choose one.

- Very low usage
- Low usage
- Moderate usage
- High usage
- Very high usage

Technology Usability and Infrastructure

73. **I own a smartphone (smartphone capable of internet browsing)**. (q5_1)

- Yes
- No

74. **I have a computer at home with an internet connection**. (q5_2)

- Yes
- No

75. **At the school where I teach, there are computers with internet access that I can use for teaching**. (q5_3)

- Yes
- No

Frequency of Technological Activities

76. **Browsing the internet.** (q6_1)

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

77. **Using applications (apps) on a mobile phone.** (q6_2)
Choose one.

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

78. **Searching for information using search engines (e.g., Google).** (q6_3)
Choose one.

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

79. **Using social networks (e.g., Facebook).** (q6_4)
Choose one.

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

80. **Chatting via messaging apps (e.g., WhatsApp).** (q6_5)
Choose one.

- Several times a day
- At least once a day
- Several times a week
- Several times a month
- Rarely

This comprehensive questionnaire covers the various aspects of remote learning, including usability, social influence, and the required infrastructure. Let me know if further customization is needed!

Demographic Questionnaire

Questions: q15–q7_

To conclude, please provide some general background information about yourself:

81. **Native Language:** (q7)

- Hebrew
- Arabic
- Russian
- English
- Other _____ (q7_tv5)

82. **Sector:** (q8)

- Secular Jewish
- Religious Jewish
- Christian Arab
- Muslim Arab
- Bedouin Arab
- Druze
- Other _____ (q8_tv7)

83. **Education Level:** (q9)

- Up to 12 years of schooling
- High school diploma
- Professional certification
- Bachelor's degree
- Master's degree
- Doctoral degree

84. **Years of Teaching Experience:** (q10_1)

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85. **Teaching Subject(s):** (q11_1)

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86. **I teach in the following grades:** (q12_1)

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87. **Number of years of experience in professional development programs for teachers:** (q13)

- No experience
- Up to 4 years of experience
- 5–10 years of experience
- 11–15 years of experience
- Over 15 years of experience

88. **Number of teacher training courses you have completed since starting at your current school:** (q14)

- I have never completed any training courses
- I have completed 1–5 courses
- I have completed 6–10 courses
- I have completed more than 10 courses

89. **Place of Residence:** (q15)

- Central Arava Regional Council
- Ar'ara BaNegev Regional Council
- Tamar Regional Council
- Yeruham
- Arad
- Ramat Negev Regional Council
- Mitzpe Ramon
- Southern Arava/Eilot Regional Council
- Segev Shalom
- Hura
- Neve Midbar Regional Council
- Other _____ (q15_tv12)

Thank you for your cooperation!

Appendix B. Analysis of the Survey Items

The survey results are presented across six panels, each representing a distinct group of items. Within each panel, individual items are displayed as gray facets, with their identifiers shown in the headers. The full text for each item can be seen in Table 2. Each facet displays response data through a series of bars: orange for teachers and purple for students, with solid colors representing the 2019 cohort and lighter colors indicating the 2020 cycle. Mean responses are shown with error bars extending ± 1 standard error from the mean. Statistical comparisons between groups are indicated above the bars, examining both within-group temporal differences (between 2019 and 2020) and between-group differences (teachers versus students) at each time point. Significance levels are denoted using a conventional system: **** for $p < 0.0001$, *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$, and "ns" for non-significant results. To illustrate this visualization approach, consider item q1_3 ("My students would like more electives to be offered"), shown in the top-right facet of image 1. This item demonstrates the highest mean response among students in the 2019 cycle and the lowest among teachers in the 2020 cycle. Statistical analysis reveals significant differences between student responses across cycles ($p < 0.01$) and between teacher responses across cycles ($p < 0.05$). In contrast, comparisons between teachers and students within each cycle showed no significant differences.

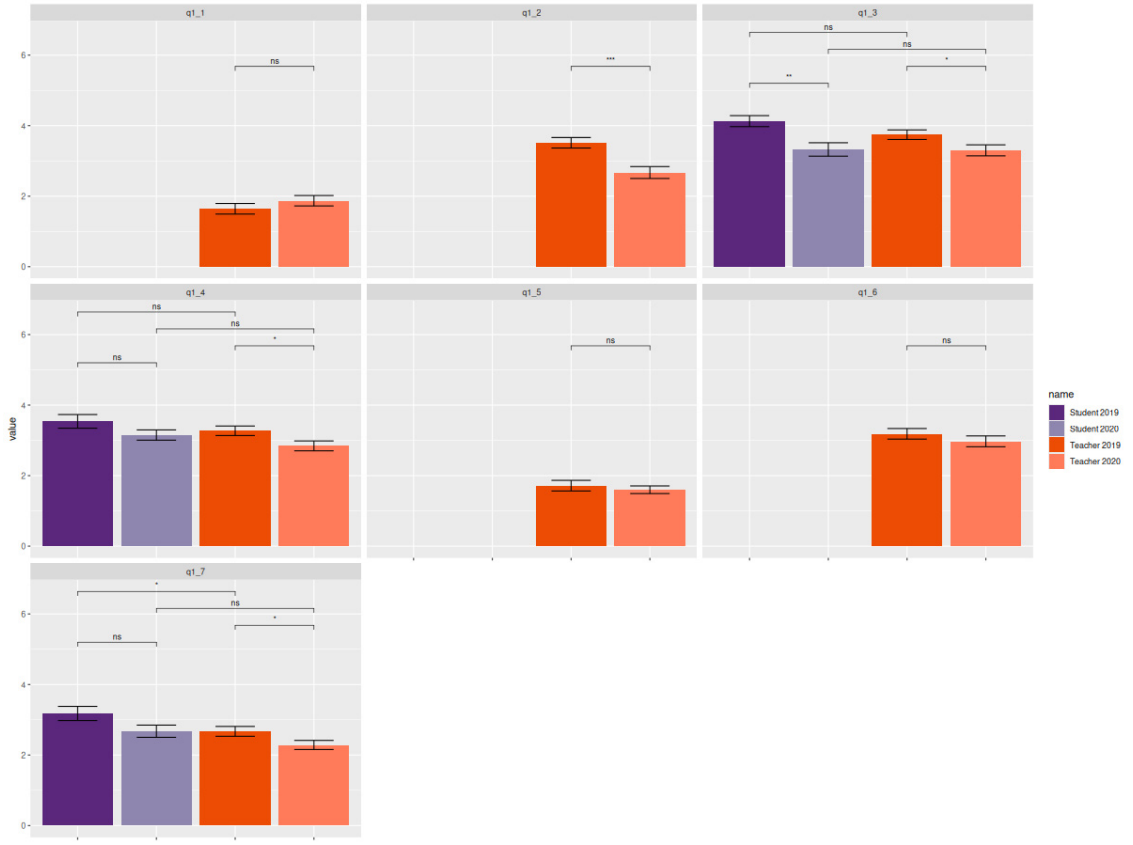

Figure A1. Attitudes toward Bagrut and elective courses.

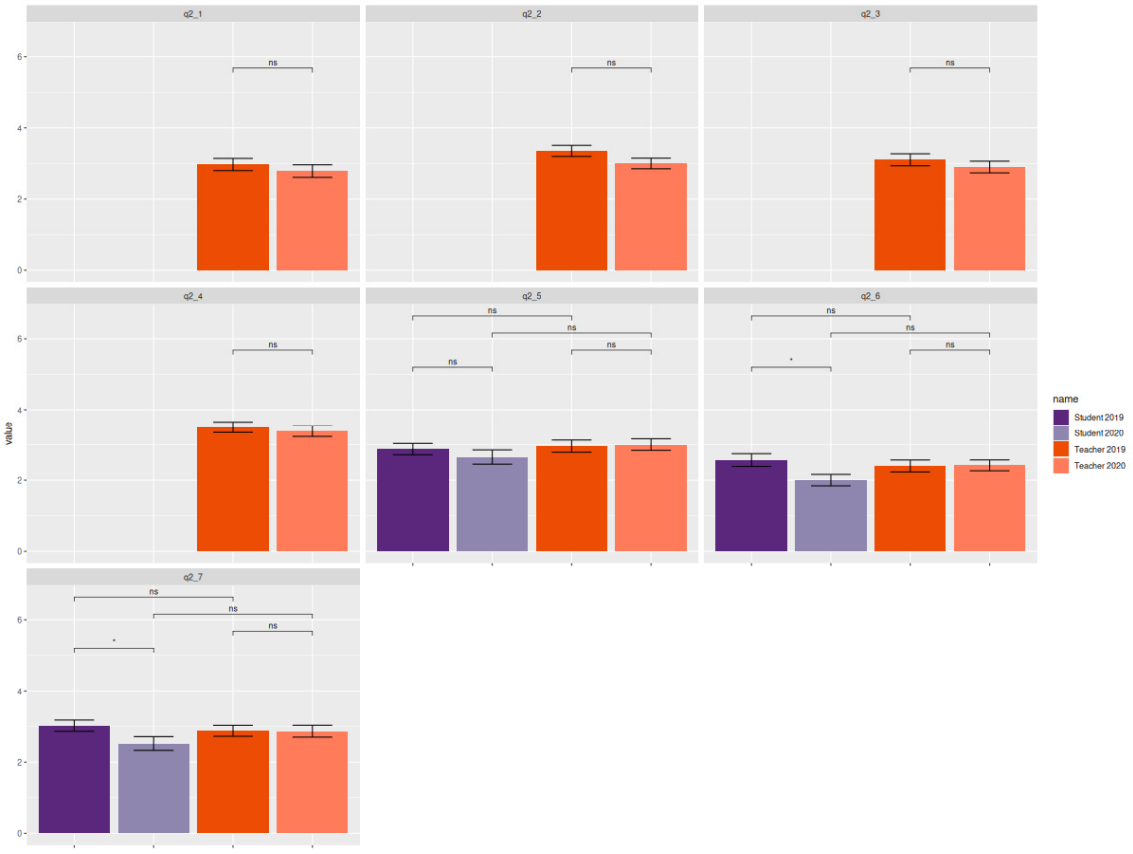

Figure A2. Barriers to ICT Adoption.

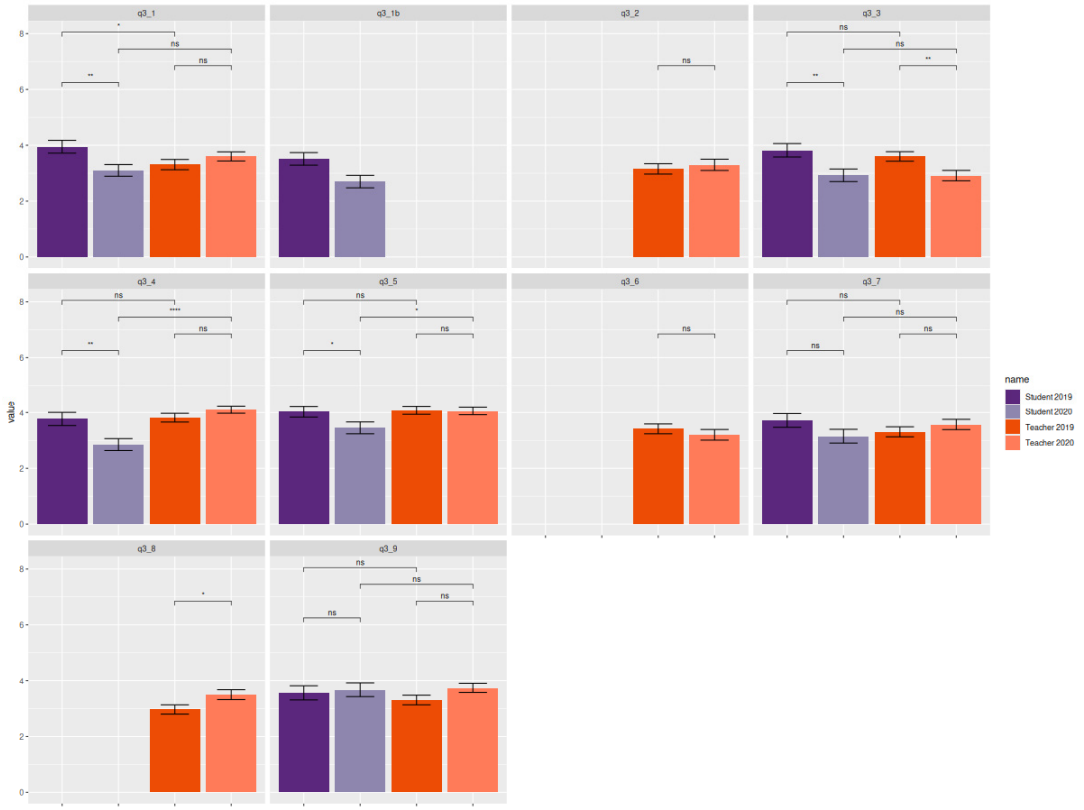

Figure A3. Perceived usefulness.

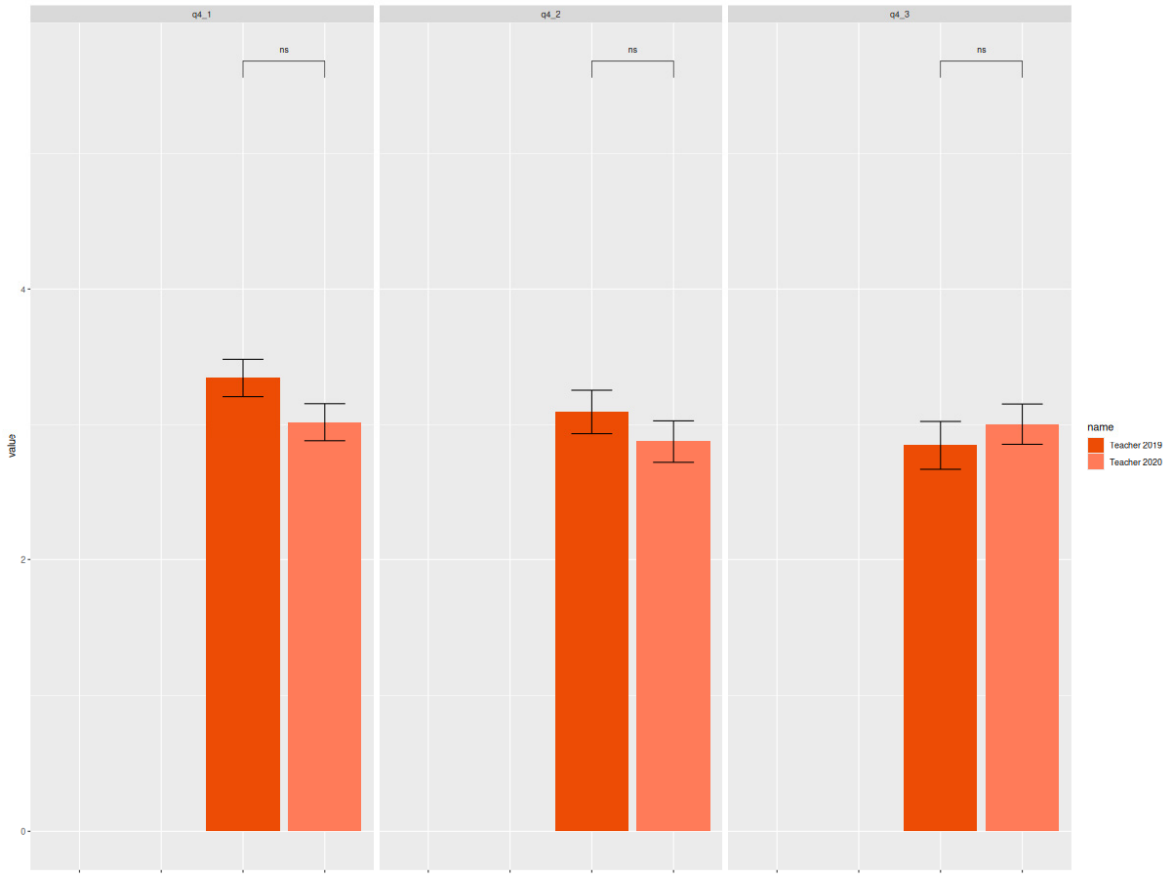

Figure A4. Behavioral intention to use ICT.

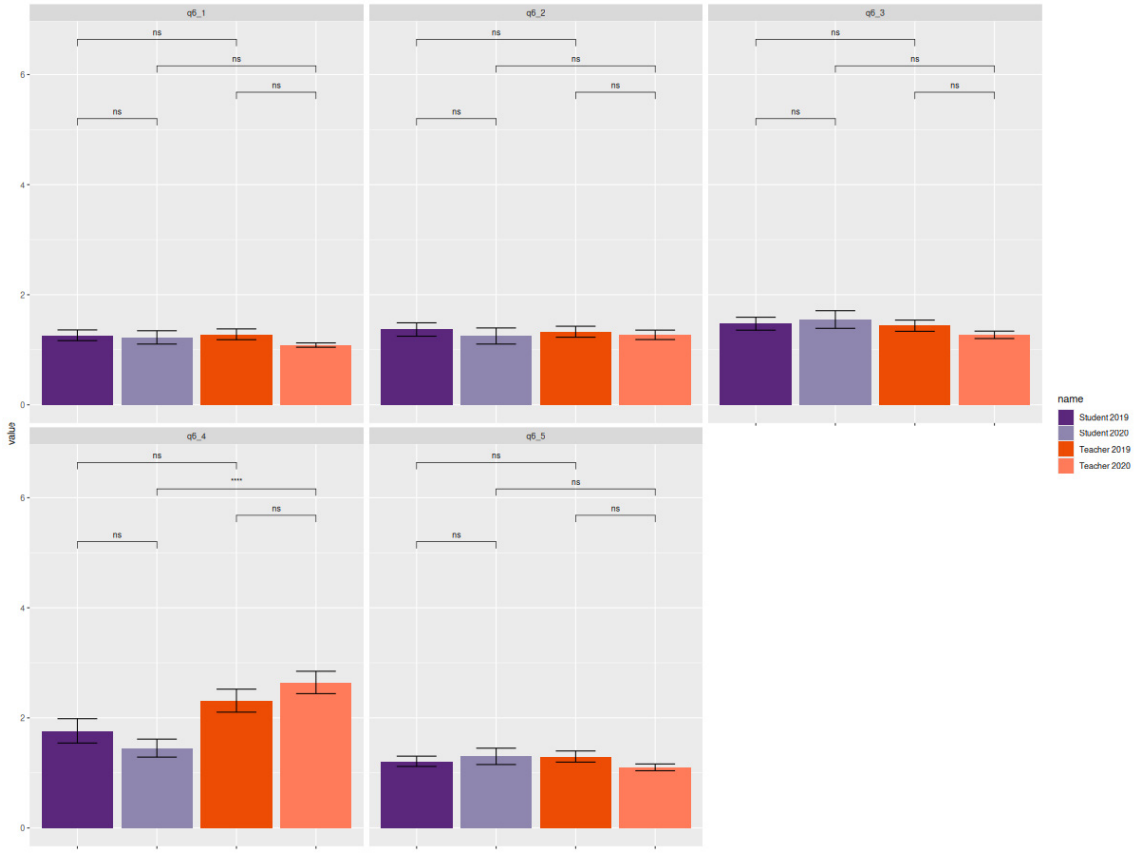

Figure A5. ICT literacy and usage.

References

Ambrose, S. A., & Lovett, M. C. (2014). Prior knowledge is more than content: Skills and beliefs also impact learning. In V. A. Benassi, C. E. Overson, & C. H. Hakala (Eds.), *Applying science of learning in education. Infusing psychological science into the curriculum* (Division 2). American Psychological Association. Available online: http://teachpsych.org/ebooks/asle2014/ (accessed on 5 January 2025).

Avidov-Ungar, O., & Eshet-Alkalai, Y. (2011). [Chais] Teachers in a world of change: Teachers' knowledge and attitudes towards the implementation of innovative technologies in schools. *Interdisciplinary Journal of E-Learning and Learning Objects*, *7*(1), 291–303. Available online: https://www.learntechlib.org/p/44745/ (accessed on 5 January 2025).

Ayalon, H., Grodsky, E., Gamoran, A., & Yogev, A. (2008). Diversification and inequality in higher education: A comparison of Israel and the United States. *Sociology of Education*, *81*(3), 211–241. [CrossRef]

Bauer, J., & Kenton, J. (2005). Toward technology integration in the schools: Why it isn't happening. *Journal of Technology and Teacher Education*, *13*(4), 519–546. Available online: https://www.learntechlib.org/primary/p/4728/ (accessed on 5 January 2025).

Blass, N. (2020). *Achievements and gaps in the Israeli education system: A state of the art*. Taub Center for Social Policy Research in Israel. (In Hebrew)

Blau, I., & Shamir-Inbal, T. (2017). Digital competences and long-term ICT integration in school culture: The perspective of elementary school leaders. *Education and Information Technologies*, *22*(3), 769–787. [CrossRef]

Bryant, S. J. (2021). An examination of high-impact strategies that increase success in marginalized student groups. *Community College Enterprise*, *27*(2), 58–73.

Carrillo, C., & Flores, M. A. (2020). COVID-19 and teacher education: A literature review of online teaching and learning practices. *European Journal of Teacher Education*, *43*(4), 466–487. [CrossRef]

Central Bureau of Statistics. (2019). *The face of society in Israel-gaps between the center and the periphery report no. 11*; Central Bureau of Statistics. [CrossRef]

Chesters, J., & Cuervo, H. (2021). (In) equality of opportunity: Educational attainments of young people from rural, regional and urban Australia. *The Australian Educational Researcher*, *49*(1), 43–61. [CrossRef]

Clark, T. (2008). Online learning: Pure potential. *Educational Leadership*, *65*(8), 11–15. Available online: http://www1.ascd.org/publications/educational-leadership/may08/vol65/num08/Online-Learning@-Pure-Potential.aspx (accessed on 5 January 2025).

Davidson, R., & Poor, N. (2019). Location, location, location: How digital platforms reinforce the importance of spatial proximity. *Information, Communication & Society*, *22*(10), 1464–1478. [CrossRef]

Davis, B., & Sumara, D. (2002). Constructivist discourses and the field of education. *Educational Theory*, *52*(4), 409–428. [CrossRef]

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–339. [CrossRef]

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982–1003. [CrossRef]

Demkanin, P., & Sands, D. (2023). The development of experimental skills, the role of digital technologies and multimedia in physics teacher education. In J. B. Marks, & P. Galea (Eds.), *Physics teacher education: More about what matters* (pp. 65–76). Springer Nature Switzerland. [CrossRef]

Donham, C., Barron, H. A., Alkhouri, J. S., Changaran Kumarath, M., Alejandro, W., Menke, E., & Kranzfelder, P. (2022). I will teach you here or there, I will try to teach you anywhere perceived supports and barriers for emergency remote teaching during the COVID-19 pandemic. *International Journal of STEM Education*, *9*(1), 19. [CrossRef]

Driscoll, D. L., Appiah-Yeboah, A., Salib, P., & Rupert, D. J. (2007). Merging qualitative and quantitative data in mixed methods research: How to and why not. *Ecological and Environmental Anthropology*, *3*(1), 18–28. Available online: https://digitalcommons.unl.edu/icwdmeea/18 (accessed on 5 January 2025).

Eidelman, R., Livne, S., & Shwartz, Y. (2014). First survey of using ICT in chemistry education in Israel: Results and applications. *Al-Chimia*, *24*, 29–34. Available online: http://stwww.weizmann.ac.il/chemcenter/img/news/1680.pdf (accessed on 5 January 2025). (In Hebrew).

Eidelman, R. R., & Shwartz, Y. (2021). Promoting self-regulated learning by designing a chemistry online blended learning environment. In *Long-term research and development in science education* (pp. 44–70). Brill.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. [CrossRef]

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. [CrossRef]

Feerrar, J. (2019). Development of a framework for digital literacy. *Reference Services Review*, *47*(2), 91–105. [CrossRef]

Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning*, *4*(5–6), 304–317. [CrossRef]

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2020a). *Preparing for life in a digital world. IEA international computer and information literacy study 2018 international report*. Springer International Publishing.

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2020b). Teaching with and about information and communications technologies. In *Preparing for life in a digital world* (pp. 175–214). Springer. [CrossRef]

Francom, G. M., Lee, S. J., & Pinkney, H. (2021). Technologies, challenges and needs of K-12 teachers in the transition to distance learning during the COVID-19 pandemic. *TechTrends*, *65*(4), 589–601. [CrossRef]

Ganayem, A., Rafaeli, S., & Azaiza, F. (2009). Digital divide: Internet usage in the Arab sector in Israel. *Megamot*, *36*, 164–196.

Geer, R., & Sweeney, T. (2012). Students' voices about learning with technology. *Journal of Social Science*, *8*(2), 294–303. [CrossRef]

George, F., & Ogunniyi, M. (2016). Teachers' perceptions on the use of ICT in a CAL environment to enhance the conception of science concepts. *Universal Journal of Educational Research*, *4*(1), 151–156. [CrossRef]

Gökdaş, İ., & Kayri, M. (2005). E-Learning-The problems and solution recommends terms of Turkey situation. *Van Yuzuncu Yil University Journal of Education*, *2*(2), 1–20.

Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., St. Claire, L., & Harris, R. (2009). TPACK development in science teaching: Measuring the TPACK confidence of in service science teachers. *TechTrends*, *53*, 70–79. [CrossRef]

Haisraeli, A. (2021). Ethnicity or class? Mizrahi students from the periphery describe their path to higher education. *Israel Affairs*, *27*(6), 1143–1159. [CrossRef]

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.

Hebebci, M. T., Bertiz, Y., & Alan, S. (2020). Investigation of views of students and teachers on distance education practices during the coronavirus (COVID-19) pandemic. *International Journal of Technology in Education and Science*, *4*(4), 267–282. [CrossRef]

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, *55*(3), 223–252. [CrossRef]

Himmetoglu, B., Aydug, D., & Bayrak, C. (2020). Education 4.0: Defining the teacher, the student, and the school manager aspects of the revolution. *Turkish Online Journal of Distance Education*, *21*(Special Issue-IODL), 12–28. [CrossRef]

Hsu, P. S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends*, *60*(1), 30–40. [CrossRef]

Hwang, K. (2008). International collaboration in multilayered center-periphery in the globalization of science and technology. *Science, Technology, & Human Values*, *33*(1), 101–133. [CrossRef]

Kent, C., Rechavi, A., & Rafaeli, S. (2019). Networked learning analytics: A theoretically informed methodology for analytics of collaborative learning. In *Learning in a networked society: Spontaneous and designed technology enhanced learning communities* (pp. 145–175). Springer. [CrossRef]

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70. Available online: https://www.learntechlib.org/primary/p/29544/ (accessed on 5 January 2025). [CrossRef]

Koehler, M. J., Mishra, P., Bouck, E. C., DeSchryver, M., Kereluik, K., Shin, T. S., & Wolf, L. G. (2011). Deep-play: Developing TPACK for 21st century teachers. *International Journal of Learning Technology*, *6*(2), 146–163. [CrossRef]

Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., Küchler, U., Paravicini, W., Randler, C., & Thomas, P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers & Education*, *174*, 104304. [CrossRef]

Lassoued, Z., Alhendawi, M., & Bashitialshaaer, R. (2020). An exploratory study of the obstacles for achieving quality in distance learning during the COVID-19 pandemic. *Education Sciences*, *10*(9), 232. [CrossRef]

Le, B., Lawrie, G. A., & Wang, J. T. (2022). Student Self-perception on digital literacy in STEM blended learning environments. *Journal of Science Education and Technology*, *31*(3), 303–321. [CrossRef] [PubMed]

Levin, B., & Fullan, M. (2008). Learning about system renewal. *Educational Management Administration & Leadership*, *36*(2), 289–303. [CrossRef]

Levy, E. C., Rafaeli, S., & Ariel, Y. (2016). The effect of online interruptions on the quality of cognitive performance. *Telematics and Informatics*, *33*(4), 1014–1021. [CrossRef]

Lin, T. C., Tsai, C. C., Chai, C. S., & Lee, M. H. (2013). Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK). *Journal of Science Education and Technology*, *22*(3), 325–336. [CrossRef]

Luterbach, K. J., & Brown, C. (2011). Education for the 21st century. *International Journal of Applied Educational Studies*, *11*(1), 14–32.

Macintyre, R., & Macdonald, J. (2011). Remote from what? Perspectives of distance learning students in remote rural areas of Scotland. *International Review of Research in Open and Distributed Learning*, *12*(4), 1–16. Available online: https://id.erudit.org/iderudit/1067604ar (accessed on 5 January 2025). [CrossRef]

Mathieson, K., Peacock, E., & Chin, W. W. (2001). Extending the technology acceptance model: The influence of perceived user resources. *DATA BASE for Advances in Information Systems*, *32*, 86–112. [CrossRef]

Miller, P., Votruba-Drzal, E., & Coley, R. L. (2019). Poverty and academic achievement across the urban to rural landscape: Associations with community resources and stressors. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, *5*(2), 106–122. [CrossRef] [PubMed]

Mishra, P. (2019). Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education*, *35*(2), 76–78. [CrossRef]

Ness, D., & Lin, C. L. (2015). *International education: An encyclopedia of contemporary issues and systems*. Routledge. [CrossRef]

Nilsen, T., Grillitsch, M., & Hauge, A. (2023). Varieties of periphery and local agency in regional development. *Regional Studies*, *57*(4), 749–762. [CrossRef]

Njenga, J. K. (2018). Digital literacy: The quest of an inclusive definition. *Reading & Writing-Journal of the Reading Association of South Africa*, *9*(1), 1–7. Available online: https://hdl.handle.net/10520/EJC-117300db4f (accessed on 5 January 2025).

Novotná, S., & Demkanin, P. (2024). Physics teachers and use of sensors by pupils themselves, preliminary ideas of typology of physics teachers. *Journal of Physics: Conference Series*, *2750*(1), 012042. [CrossRef]

OECD. (2018). *New OECD PISA report reveals challenge of online learning for many students and schools*. Available online: https://www.oecd.org/education/new-oecd-pisa-report-reveals-challenge-of-online-learning-for-many-students-and-schools.htm (accessed on 15 November 2020).

Ortagus, J. C. (2017). From the periphery to prominence: An examination of the changing profile of online students in American higher education. *The Internet and Higher Education*, *32*, 47–57. [CrossRef]

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science 32*, 1–8. [CrossRef]

Pangrazio, L., Godhe, A. L., & Ledesma, A. G. L. (2020). What is digital literacy? A comparative review of publications across three language contexts. *E-learning and Digital Media*, *17*(6), 442–459. [CrossRef]

Rao, K., Eady, M., & Edelen-Smith, P. (2011). Creating virtual classrooms for rural and remote communities. *Phi Delta Kappan*, *92*(6), 22–27. [CrossRef]

Ravid, G. (2004). *Information sharing with CMC in small groups: Communication groups and tasks* [Unpublished doctoral dissertation, University of Haifa]. [CrossRef]

Rundel, C., & Salemink, K. (2021). Bridging digital inequalities in rural schools in Germany: A geographical lottery? *Education Sciences*, *11*(4), 181. [CrossRef]

Sasson, I. (2019). Building a sustainable university–community partnership: Case study in science education. *Studies in Higher Education*, *44*(12), 2318–2332. [CrossRef]

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, *128*, 13–35. [CrossRef]

Schleicher, A. (2020). *Education disrupted–education rebuilt: Some insights from PISA on the availability and use of digital tools for learning*. Available online: https://oecdedutoday.com/coronavirus-education-digital-tools-for-learning (accessed on 5 January 2025).

Serhan, D. (2020). Transitioning from face-to-face to remote learning: Students' attitudes and perceptions of using Zoom during COVID-19 pandemic. *International Journal of Technology in Education and Science*, *4*(4), 335–342. [CrossRef]

Shamir-Inbal, T., & Blau, I. (2021). Facilitating emergency remote K-12 teaching in computing-enhanced virtual learning environments during COVID-19 pandemic-blessing or curse? *Journal of Educational Computing Research*, *59*(7), 1243–1271. [CrossRef]

Spiteri, M., & Chang Rundgren, S. N. (2020). Literature review on the factors affecting primary teachers' use of digital technology. *Technology, Knowledge and Learning*, *25*, 115–128. [CrossRef]

Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., & Cooper, S. (2006). Teaching courses online: A review of the research. *Review of Educational Research*, *76*(1), 93–135. [CrossRef]

Thurlings, M., Evers, A. T., & Vermeulen, M. (2014). Toward a model of explaining teachers' innovative behavior—A literature review. *Review of Educational Research*, *85*(3), 430–471. [CrossRef]

Tsai, C. W. (2011). Achieving effective learning effects in the blended course: A combined approach of online self-regulated learning and collaborative learning with initiation. *Cyberpsychology, Behavior, and Social Networking*, *14*(9), 505–510. [CrossRef] [PubMed]

Turgut, Y. E., & Aslan, A. (2021). Factors affecting ICT integration in TURKISH education: A systematic review. *Education and Information Technologies*, *26*(4), 4069–4092. [CrossRef]

Walan, S. (2020). Embracing digital technology in science classrooms—Secondary school teachers' enacted teaching and reflections on practice. *Journal of Science Education and Technology*, *29*(3), 431–441. [CrossRef]

Wang, H. H., Hong, Z. R., She, H. C., Smith, T. J., Fielding, J., & Lin, H. S. (2022). The role of structured inquiry, open inquiry, and epistemological beliefs in developing secondary students' scientific and mathematical literacies. *International Journal of STEM Education*, *9*(1), 14. [CrossRef]

Weininger, A. (2014). *Netunim al limudei madaim baperipheriya (Data on science studies in the periphery)*; Knesset Research and Information Center. Available online: https://fs.knesset.gov.il/globaldocs/MMM/dd536b58-e9f7-e411-80c8-00155d010977/2_dd536b58-e9f7-e411-80c8-00155d010977_11_9869.pdf (accessed on 5 January 2025). (In Hebrew)

Willermark, S. (2018). Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016. *Journal of Educational Computing Research*, *56*(3), 315–343. [CrossRef]

Yates, A., Starkey, L., Egerton, B., & Flueggen, F. (2021). High school students' experience of online learning during COVID-19: The influence of technology and pedagogy. *Technology, Pedagogy and Education*, *30*(1), 59–73. [CrossRef]

Yogev, A. (Ed.). (2008). *The spread of higher education in Israel*. Tel Aviv University. (In Hebrew)

Zhao, Y., & Watterston, J. (2021). The changes we need: Education post COVID-19. *Journal of Educational Change*, *22*(1), 3–12. [CrossRef] [PubMed]

Zhou, L., Wu, S., Zhou, M., & Li, F. (2020). 'School's Out, But Class' On', the largest online education in the world today: Taking China's practical exploration during the COVID-19 epidemic prevention and control as an example. *Best Evidence in Chinese Education*, *4*, 501–519. [CrossRef]

Ziguras, C. (2001). Educational technology in transnational higher education in South East Asia: The cultural politics of flexible learning. *Journal of Educational Technology & Society*, *4*(4), 8–18.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183. [CrossRef]