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Teachers' perceptions of using virtual reality technology in classrooms: A large-scale survey

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Abstract

High-immersion virtual reality (VR) technology is often associated with gaming. Yet, it is increasingly popular in educational contexts due to its potential to engage and motivate learners. Prior to VR technology integration in the classroom, the acceptance or resistance toward VR needs to be explored. This paper reports the results obtained from a large-scale (N=20,876) survey on teachers' attitudes toward the use of VR for education. The survey explored the relationships between the teachers' VR integration level and their instructional approaches, as well as the frequency of VR use. Furthermore, the survey yielded answers on the relationship between the availability of information technology (IT) personnel and the frequency of VR use. Overall, teachers had moderately positive perceptions of the use of VR in education. There was no strong correlation between instructional approaches and the level of VR integration, but lower levels of VR integration were associated with more traditional teaching approaches. The results revealed a positive correlation between the level of VR integration and the frequency of VR use. However, the VR frequency use had a weak correlation with the availability of IT personnel.

Keywords Virtual reality (VR) · Technology integration · Teacher perceptions · Teaching approaches · Technology support

Abbreviations

VR	virtual reality.
IT	information technology.

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1 Introduction

The growing implementation of high-immersion virtual reality (VR) for education and the theories that support its use increasingly indicate the need for more insight into VR-based learning. This immersive technology is becoming more popular and successful in classrooms. Thanks to immersive and interactive settings, students are engaged and motivated to learn in VR (Kaplan-Rakowski & Wojdynski, 2018; Makransky & Lilleholt, 2018). Scholars report captivating and maintaining learner engagement along with beneficial pedagogical outcomes as key rationales for using VR in classrooms. This technology encourages student-centered, active learning, simultaneously boosting memorization (Krokos et al., 2019), providing enjoyable learning experiences (Chen et al., 2017; Kaplan-Rakowski & Wojdynski 2018), and reducing anxiety (Gruber & Kaplan-Rakowski, 2020, 2022; Kaplan-Rakowski et al., 2022). Based on the above accolades, it is not surprising that VR has been named "the learning aid of the 21st century" (Rogers, 2019).

On the other hand, some VR-based research also provided mixed or even negative evidence of VR for learning outcomes. High immersion and the sense of presence come at the expense of being less able to focus on the learning aspect of instruction. Evidence of VR having a negative impact on learning has been shown in a variety of subjects, including STEM (Makransky et al., 2019), history (Parong & Mayer, 2021), and language learning (Hartfill et al., 2020). Parong & Mayer (2021) inform that in the majority (7 out of 11) studies, students using desktop-based learning environments had higher learning gains compared to students who used high-immersion VR. As an example of such a study, Papin & Kaplan-Rakowski (2022) found that students learning vocabulary with a VR headset had significantly lower scores compared to the subjects who used less immersive, desktop version of VR. Overall, the case for VR being more effective for learning, and for whom, is not yet compelling.

Despite the growing popularity and acceptance of VR, some reservations exist regarding its full acceptance in curricula. Some obstacles include VR equipment cost, reports of cybersickness, and overheating when used for extended time (Mazloumi Gavgani et al., 2017). Yet, another barrier to the VR implementation in curricula is lack of teacher training. This issue is often linked with inadequate time to learn how to use the equipment, but also the necessity to adjust the traditional curriculum to fit the use of the new medium (Alfalah, 2018).

Traditionally, teachers' perceptions of instructional technologies determine how effectively these technologies are incorporated into instruction (Albirini, 2006). This claim goes along with the Diffusion of Innovations theory which contends that people's attitudes toward technology are essential for its diffusion (Rogers, 2010). Likewise, Alfalah (2018) elucidates the necessary factors impacting the likelihood of technology integration. These factors include: (1) perceptions of students and teaching staff, (2) institutional support, (3) integration barriers, (4) rationale for integration, (5) prior technology experience. All this implies that the attitudes of end users are essential to explore during the early phase of VR technology integration. This study was driven by this urgent necessity in the context of education in the Federal Republic of Russia.

To provide contextual clarity for VR for education, we overview works addressing: (1) VR and its theoretical framework; (2), VR technology in education, (3) perceptions of VR for education, and (4) the educational context in Russia. Once we present our methodology and share our findings, we follow with discussion. The future research section poses several questions that may benefit researchers in designing VR-based research. Practical implications of VR technology are presented along with challenges that still may impair the full integration of VR in the classroom.

2 Background

This section will provide a synopsis of VR technology and its theoretical framework. An overview of VR research in education will follow. We will then discuss VR technology perceptions, integration, frequency of use, instructional approaches, and IT personnel availability and present the current educational context of the Federal Republic of Russia.

2.1 VR definitions and classifications

Various definitions and classifications of VR exist, depending on the stage of its evolution. For example, Steuer (1992) defined VR as "a real or simulated environment in which a perceiver experiences telepresence" (p. 7). In 2021, after several decades of waves in the popularity of VR technology, we follow the definition by Kaplan-Rakowski & Gruber (2019), stating that high-immersion VR is "a computer-generated 360° virtual space that can be perceived as being spatially realistic, due to the high immersion afforded by a head-mounted device" (p. 552). Generally, VR technology can be classified into low-immersion VR, which is experienced on a flat 2D monitor, and high-immersion VR where users wear a VR head-mounted headset to experience VR (see Fig. 1). The main distinguishing factor between the two types of VR is the level of immersion and the sense of presence. Wearing a VR headset requires users to disconnect from the real world, thus enhancing the immersion into the virtual environment (Kaplan-Rakowski & Gruber, 2021). Furthermore, the sensory input afforded by a VR headset enhances the immersion and the sense of presence.

Discussions on the use of high-immersion VR often evoke around the concepts of immersion and the sense of presence. Immersion can be defined as "the involvement of a user in a virtual environment during which his or her awareness of time and the real world often becomes disconnected, thus providing a sense of 'being' in the task environment instead" (Radianti et al., 2020, p. 2). Virtual reality increases

Fig. 1 Experiencing High-immersion Virtual Reality

the sense of presence, which is a feeling of being "there", in the VR environment, simultaneously recognizing that you are not "there" but in the real world (Gruber & Kaplan-Rakowski, 2020). Simply said, VR has the power of "tricking" users into the feeling that they are inside VR experiences, allowing them to fully engage with the VR content. Given that high immersion and the sense of presence are factors contributing to high engagement, from the pedagogical point of view, VR should serve as a potentially attractive platform to compliment classroom instruction, which is often associated with relatively little engagement.

2.2 Educational potential of VR

The exploration of VR for learning has been gaining attention in various education and training fields, including teacher training (Eutsler & Long, 2021; Ferdig & Kosko, 2020), STEM education (Pellas et al., 2020), language learning (Gruber & Kaplan-Rakowski, 2020, 2022; Kaplan-Rakowski & Gruber, 2021; Papin & Kaplan-Rakowski, 2020; 2022; Thrasher, 2022), and medical training (Ros et al., 2021). The growing interest in VR has also resulted in multiple literature reviews on the use of VR for learning (e.g., Dhimolea et al., 2022; Parmaxi, 2020; Radianti et al., 2020).

High-immersion VR has shown potential to be conducive to learning in several contexts. Shin (2017) summarizes the list of affordances in five aspects: presence, immersion, usability, empathy, and embodiment. Drawing on existing literature (Alfalah, 2018; Radianti et al., 2020), we enlist five major characteristics of VR for learning:

1. VR offers experiential learning using visually-rich simulations;
2. VR caters for pedagogically-sound, student-centered learning where students engage in settings and scenarios independently or in socially-rich contexts;
3. VR allows to experience scenarios that may be too dangerous, costly, difficult, or impossible to experience in real life (e.g., manipulating a solar system);
4. Users experience the sense of presence and immersion;
5. Abstract concepts are easier to visualize in VR.

According to the Market Analysis Report (2021), the current 2021 market size value of VR is 21.83 billion dollars, but the forecasted VR industry growth indicates for the VR market to triple by 2028, to the estimated 69.60 billion dollars. Given that VR devices are becoming increasingly advanced and affordable, we may expect the growth of VR-based learning (Kaplan-Rakowski & Meseberg, 2019), but we argue that VR implementation in classrooms should not be accidental. Instead, it should be grounded in learning needs and on integrated curriculum.

The accelerated shift to online learning triggered by the COVID-19 pandemic (An et al., 2021; Ferdig et al., 2020; 2021; Hartshorne et al., 2020), which eventually resulted in Zoom-fatigue, prompted educators to use more engaging educational settings to break the monotony of synchronous Zoom instruction. The implementation of VR instruction seems like a viable way to continue with learning in a more engaging way. This notion may prompt scholars to use VR as an alternative or an addition to traditional or online instruction.

2.3 VR technology perceptions, integration, frequency of use, instructional approaches, and IT personnel availability

Ertmer et al., (1999) classified two types of barriers to technology integration: external and internal. External barriers encompass lack of teachers' proper resources (e.g., software and hardware), lack of IT support, and limited technology training. Internal barriers derive from teachers' attitudes and their unwillingness to learn, adapt, and integrate technology. Bullock (2004) identified the availability of IT support among the enabling factors that affect teachers' willingness to use technology on a regular basis. Many teachers see the need of regular equipment maintenance by technical staff as an important condition for the successful use of computers in class (Wozney et al., 2006).

The integration of technology in education highly depends on teachers' attitude and support (Ismail et al., 2010). Likewise, teachers' perceptions play a role in the way technology can be adopted and diffused (Sugar et al., 2004). Teachers' instructional approaches can be defined as the use of educational methods to facilitate the acquisitions of knowledge, skills, and attitudes (Hauer & Quill, 2011, p. 506), which are considerably influenced by their own learning experiences, disciplines, and previous teaching practices (Singh & Hardaker, 2014). Prior research suggests that teachers' preferred teaching approaches and strategies impact technology integration in the classroom (Ertmer & Glazewski, 2015). More specifically, Wozney et al., (2006) found that teachers using student-centered teaching approaches were likely to report a more frequent use of technology in their teaching and place themselves at higher stages of technology integration.

Technology integration creates new prerequisites for the teaching profession that the individual teacher needs to relate to and cope with (Roumbanis Viberg et al., 2019). A high percentage of teachers do not know how to integrate educational technology into their classes, which can become an obstacle in the meaningful modification of the curriculum (Hu & Garimella, 2014). On the contrary, numerous studies demonstrate that as teachers gain experience with technology, they start to integrate it into educational practices more frequently and with more flexibility (Ertmer et al., 1999; Wozney et al., 2006).

Even though various technology perception studies exist, their findings may not be applicable in the context of VR. Although Ertmer et al., (2012) indicates that the increased access to technology resources that can be observed since early 2000s could reduce, and sometimes even eliminate the external barriers, these barriers are likely to linger with newer technologies, such as VR. This is because newer technologies may lead to new needs for teachers' preparation, their training, and their comfort with using the constantly-evolving VR equipment. These barriers can cause differences between teachers' perceptions and their regular classroom technology practice. Burch and Mohammed, (2019) show that as newer technology becomes available, there will always be new and modified ways of learning and teaching, which in itself creates a new kind of digital gap in the educational system because of the complexity of continuously having to stay up-to-date with technology.

As of 2021, to our knowledge, only one survey (Alfalah, 2018) explored teachers' perceptions toward adopting VR in education. Alfalah (2018) conducted a case study on instructors' perceptions toward adopting VR for teaching information technology (IT) in a Middle Eastern university. Information technology instructors completed a questionnaire evaluating their perceptions toward VR, along with the importance and the applicability of VR as a learning tool. More precisely, the study explored teachers' awareness of VR technology and their willingness to integrate VR in IT. The study investigated which aspects of VR are conducive to its integration, and which ones impede the integration progress. The teachers in the study were willing to integrate VR but it is worthwhile noting that they were IT teachers, with a specific interest in technology. Consequently, such a sample is typically inclined to integrate innovative technology (e.g., Georgina & Olson, 2008). In other words, the sample is skewed because, by default, IT professionals have a better awareness of emerging technology, such as VR, so their views do not represent a typical population of teachers. Besides the atypical sample, Alfalah's study was limited by its sample size ($N=30$).

We build on Alfalah's study in three ways. First, by drawing data from much a larger sample of 20,876 teachers. Second, we re-direct the focus to Russia, which considerably differs from Jordan in its size and culture. Third, we expand the survey elicitation to all educational fields, including STEM, foreign languages, and physical education.

2.4 Educational context in Russia

The Russian Federation has educational institutions in both public and private sectors. The Russian geographic setting has several characteristics that make it ideal for VR integration in education, but there are also several characteristics that may limit the generalizability to other settings. Russia is highly urbanized, yet geographically dispersed. The large distances between many cities make remote learning technologies particularly attractive. Technology levels are high in many urban areas, yet pockets of underdeveloped localities also exist. Russia has a "very high" human development index (United Nations Development Program, 2020), but government funding can be erratic due to dependence on volatile energy export revenue and changing geopolitical conditions. In the context of the integration of innovative technologies and budget spending on technologies such as VR, Russia stands roughly in the middle as compared with other countries in the world.

Similar to the rest of the world, the outbreak of the COVID-19 pandemic in 2019 triggered higher focus on teaching with technology in Russia. Its educational scene has been going through digital transformation. Mikheev et al., (2021) identified several positive and negative trends in the process of the digital transformation in Russia. Positive trends include: (1) introducing innovative teaching approaches, (2) education cost reduction, and (3) increasing access to open educational resources (OER). Among negative trends Mikheev et al. enlist (1) limited budget for incorporation of digital transformation strategies, (2) teachers' low level of confidence in using new technologies; (3) staff resistance to changes and innovation.

2.5 Rationale and research questions

Existing research emphasizes the importance of understanding teachers' attitudes toward and perceptions of the use of technology in the classroom. Even though VR technology is becoming increasingly popular, available, and more affordable, there is a dearth of research on teachers' perceptions regarding VR integration in education. The following research questions drive this study:

1. What are teachers' perceptions of the use of VR technology in the classroom?
2. What is the relationship between teachers' VR integration level and their instructional approaches?
3. What is the relationship between teachers' VR integration level and the frequency of VR use?
4. What is the relationship between the availability of IT personnel and the frequency of VR use?

3 Methods

3.1 Study context

This online survey-based study was conducted in the Russian Federation to examine Russian educators' perceptions of and experience with VR. This study was initiated by the VR/AR Center of Far Eastern Federal University National Technology Initiative (FEFU NTI) in Vladivostok, Russia. To recruit the participants, emails from the database of teachers compiled by the Ministry of Russia were used. Potential survey participants received email invitations in early August 2020. The survey was open for completion until late September 2020 in all regions of the Russian Federation.

3.2 Participants

A total of 20,876 Russian educators participated in the study. Given that the entire population of Russian teachers is approximately 319,000 (https://www.statista.com/statistics/1130807/number-of-teachers-by-subject-in-russia/), our sample represents 7% of the population, making our sample exceptionally representative. Our margin of error calculation, with the confidence set at 95%, yields a value 0.66%. In social research, an acceptable margin of error is 5% (Taherdoost, 2017). We therefore largely surpassed the acceptable value.

The largest number of responses came from Sakha Republic (Yakutia), followed by Orengburg Oblast, Kursk Oblast, Orlovsk Oblast, Vologodsk Oblast and Kemerovo Oblast, with over a thousand responses from each region. The majority (88%) of the participants were female.

The subjects taught by the participants included computer science, chemistry, physics, biology, technology, mathematics, Russian (as the first language), foreign languages, social science, and literature. Most participants had a long teaching service record of over 20 years. Over 80% of the participants were experienced teachers with over five years of teaching record. Young teachers were the minority. Out of the total sample, 69% of female teachers and 31% of male teachers had at least basic experience using VR/AR technology. Table 1 displays demographic information about the participants.

3.3 Survey instrument

The survey (see Appendix A) was adapted from the pre-existing, validated survey developed by Wozney et al., (2006). The original survey focused on teachers' perceptions and practices regarding the implementation of computer technologies. We shortened the original survey from five to three sections because the scope of our study was narrowed down to VR technology. To respect respondents' time and to increase the likelihood of completion of the survey, we included only relevant items. We then adapted the items to better suit the context of our study. Multiple experts, which included VR specialists and experienced teachers, reviewed the items to ensure the survey content validity. Consequently, our survey consisted of the following three sections:

- Section 1: Demographic information, teaching approaches, VR equipment availability, IT support availability, and frequency of VR use.
- Section 2: Perceptions of VR and use of VR technology in the classroom.
- Section 3: VR integration level.

Section 1 consisted of nine questions, focusing on eliciting the demographic information, such as gender, type of institution, location, teaching experience, subjects taught, average class size, teaching approaches, VR equipment availability, availability of IT personnel, and frequency of VR technology use. In this section, the types of questions were multiple choice, open ended, and fill-in-the-blank.

Section 2 consisted of 16 Likert-scale questions to measure teachers' perceptions of the use of VR technology in the classroom. A six-point scale was used for the Likert-scale questions: 1 – Strongly Disagree, 2 – Disagree, 3 – Slightly Disagree, 4 – Slightly Agree, 5 – Agree, and 6 – Strongly Agree. Out of the 33 original items in Wozney et al., (2006), we selected and adapted 16 most relevant items.

Section 3 focused on the VR integration level using the six stages of technology integration in the teaching and learning process: (1) awareness, (2) learning, (3) understanding, (4) familiarity, (5) adaptation, and (6) creative adaptation. We used the items from Wozney et al., (2006) but substituted the term "computers" with the term "VR".

Table 1 Demographic Information about the Participants

		Gender	
	N	Female	Male
Total	20,876	18,270	2,606
%		88	12

3.4 Data analysis

Quantitative data were analyzed using descriptive statistics, including means, standard deviations, and frequencies. Research questions 2 and 3 were answered based on Spearman correlation analysis, which we extended by running $\chi 2$ tests. We present our results in the sections below.

4 Results

Research Question 1. What are teachers' perceptions of the use of VR technology in the classroom?

Sixteen Likert-scale items measured teachers' perceptions with regard to VR technology in the classroom. Respondents used a 6-point scale to indicate the extent to which they agreed or disagreed with the statements. To check reliability of our adapted instrument, we calculated Spearman-Brown stepped-up reliability coeffi-

Table 2 Russian Educators' Perceptions of the Use of VR in the Classroom

Statement: Using VR in the classroom…	*M*	*SD*
1. Improves student academic record.	3.98	0.95
2. *Does not make classroom management more difficult.*	3.62	1.08
3. Promotes the development of communication skills (e.g., writing skills, presentation skills).	4.10	0.98
4. *Is not too costly in terms of resources, time and effort.*	3.98	1.02
5. Is successful only if there's adequate teacher training in the use of VR technology in classroom.	4.61	0.99
6. Is successful only if equipment is regularly maintained by IT personnel.	4.57	1.00
7. Is an effective tool for students of all abilities.	4.32	0.90
8. Effective if teachers participate in selection and implementation of VR technology.	4.38	0.87
9. Allows to accommodate individual attributes of students.	4.21	0.89
10. Motivates students to get more involved in learning activities.	4.31	0.94
11. *Requires software training that is not too time consuming.*	4.18	0.95
12. Promotes the development of student interpersonal skills.	4.01	0.94
13. Effective only if extensive technical resources are available.	4.40	0.94
14. *Requires no extra time to plan learning activities.*	4.38	0.95
15. Improves student learning of critical concepts and ideas.	4.20	0.89
16. *Is reasonable thanks to the existence of subject-specific software.*	4.09	1.03

Note: Items in italics were reverse-coded cient, otherwise known as Standardized Cronbach's alpha (α). Its value was 1.00, indicating a very high level of internal consistency of our scale (DeVellis & Thorpe, 2021).

Means (*M*) and standard deviations (*SD*) of each 16 items are enlisted in Table 2. Five items (2, 4, 11, 14, 16) in our operationalized instrument were negatively-oriented (see Appendix A). To facilitate interpretations, Table 2 includes only positively-oriented perception statements. Overall, educators positively agreed with all the 16 statements. Only three items (1, 2, and 4) resulted in a mean rating less than four (4). The questions with the lowest rates of agreement, of 65.44% respondents answering "slightly agree", "agree", or "strongly agree", was that VR "*makes classroom management more difficult*" ($M=3.62$, $SD=1.08$). Also, a relatively small percentage (78.14%; $M=3.98$, $SD=1.02$) agreed to item 4 expressing that VR "*requires extra resources, time and effort.*", and only 79.73% of respondents agreed that using VR in classroom improves student academic record ($M=3.98$; $SD=0.95$).

The highest agreement items, with over 90% of respondents, corresponded to items 5, 7, 8, and 13. Item 5 was the highest with 93.61% of respondents agreeing that VR integration in classroom is successful only if adequate teacher training takes place ($M=4.61$, $SD=0.99$). A total of 90.34% respondents agreed that VR is an effective tool for students of all abilities ($M=4.32$, $SD=0.90$). Another high rate of 92.56% of respondents agreed that VR is an effective tool if teachers can participate in selection and implementation of VR technology ($M=4.38$, $SD=0.87$). For item 13, a total of 90.85% agreed that using VR in classroom is effective only if extensive technical resources are available ($M=4.40$; $SD=0.94$).

The remaining items (3, 9, 10, 11, 12, 14, 15, 16) are items whose response rate ranged between 82.28% and 89.49%. This group of items represent responses of educators who did not have very strong feelings toward or against using VR in classroom. For example, 82.38% of educators agreed that using VR in classroom promotes the development of student interpersonal skills ($M=4.01$; $SD=0.94$).

Research question #2: What is the relationship between teachers' VR integration level and their instructional approaches?

To determine the relationship between teachers' level of VR integration and their instructional approaches, the study examined two factors: the teachers' subjective evaluation of their progress in VR integration and their preferred instructional approaches. For the teachers' level of VR integration, the participants were asked to choose one of the following six categories that best describes their progress in VR use in the classroom:

(1) Awareness: I am aware that the technology exists but have not used it – perhaps I'm even avoiding it. I am anxious about the prospect of using VR.

(2) Learning: I am currently trying to learn the basics of VR. I am sometimes frustrated using the technology and I lack confidence when using it.

(3) Understanding: I am beginning to understand the process of using VR and can think of specific tasks in which it might be useful.

(4) Familiarity: I am gaining a sense of self-confidence in using VR for specific tasks. I am starting to feel comfortable using the technology.

(5) Adaptation: I think about VR as an instructional tool to help me and I am no longer concerned about it as technology.

(6) Creative application: I can apply what I know about VR in the classroom. I am able to use it as an instructional aid and have integrated VR into the curriculum.

From the descriptive statistics point of view, as Fig. 2 shows, most participants (71.7%) were at the first three stages of awareness (26.6%), learning (21.7%), and understanding (23.4%). About 10% of the participants indicated that they started to feel comfortable using VR in the classroom. About 17.6% of the participants were at the adaption and creative application stages.

To measure the participants' instructional approaches, the following five categories were used:

(1) Teacher-centered,

(2) More teacher-centered than student-centered (teacher in the center of a class, leading lectures and discussions),

(3) Balance between teacher-centered and student-centered approaches,

(4) More student-centered than teacher-centered,

(5) Mainly student-centered (cooperative learning, discovery learning).

As Fig. 3 shows, 61% of the participants reported that they keep the balance between teacher-centered and student-centered approaches. Sixteen % of the partici-

Fig. 2 Subjective Teacher Evaluation of Their Progress in VR Technology Integration

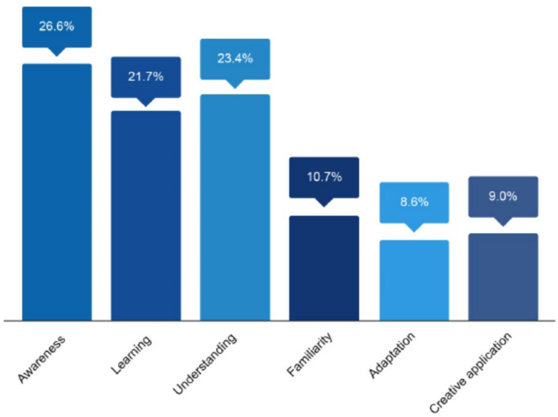
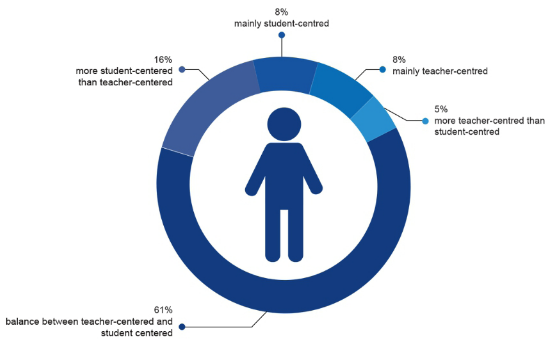


Fig. 3 Participants' Instructional Approaches



pants indicated that they were more student-centered than teacher centered. Eight % reported that they were mainly student-centered, and another 8% reported that they were mainly teachercentered. Finally, 5% of the participants indicated that they were more teacher-centered than student-centered.

We ran Spearman's rank-order correlation to assess the relationship between instructional approaches and the level of VR integration. There was a statistically significant, weak positive correlation between instructional approaches and the level of VR integration, $r_s(20{,}874) = 0.111, < 0.0005$.

We performed χ^2 tests of independence to examine if the proportion of respondents was different from the expected, relative to a uniform distribution across instructional approaches and levels of VR technology integration. We expected that there would be a positive association between instructional approaches and technology integration level. More specifically, we expected that student-centered teachers would be at higher stages of VR integration than teacher-centered teachers.

However, we found this to be the case only for low levels of technology integration (i.e., awareness and learning) and traditional instructional approaches (i.e., teacher-centered and more teacher-centered than student-centered). That is, lower levels of technology integration were associated with more traditional approaches. For teachers with student-centered approaches, there was no association between technology integration and a more student-centered approach.

As seen in Fig. 4, there was also an excess mass of observations (62%) within the central portion of the distribution (see large circles). A little less than half of the participants (45%) indicated that they had balanced instructional approaches and experience with low level of VR integration (awareness, learning, and understanding).

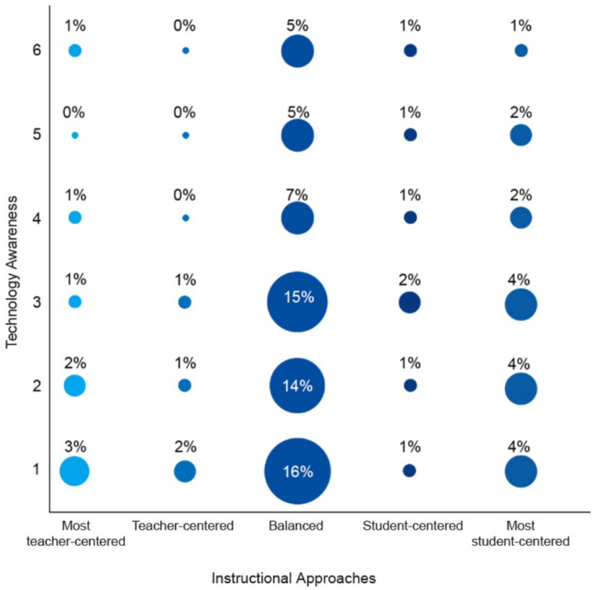


Fig. 4 Relationship between Participants' VR Integration and Instructional Approaches

Last, it is interesting to find that the mainly student-centered teaching approaches with a low level of VR integration are 12% which is higher than that of teacher-centered 6%. Researchers typically link teacher-centered practices with less frequent and less integrated classroom technology use (Ertmer et al., 2015). However, even if teachers adopt student-centered constructivist approaches, meaningful technology integration is not guaranteed (Hermans et al., 2008; Murthy et al., 2017), as many other variables can affect teachers' abilities to translate their perceptions into practice.

Research question #3: What is the relationship between the VR integration level and the frequency of VR use?

The relationship between the frequency of VR use and VR technology integration level was examined based on the responses of those teachers who use VR rarely, when necessary, often, or always. The survey results show that almost equal numbers of teachers use the technology when necessary (35%) or almost never use it (37%). Further, 15% of teachers rarely use the VR technology. Only 7% and 3% of teachers reported using VR often and always.

We found a statistically significant, positive correlation between the frequency of VR use and the teachers' level of VR integration, $r_s(20,874)=0.546$, $p<.001$. That means that the teachers who are familiar with the VR technology attempt to use it more often.

Research question #4: What is the relationship between the availability of IT personnel and the frequency of VR use?

The calculations based on Spearman's rank-order correlation to assess the relationship between IT personnel availability and the frequency of VR use yielded a statistically significant results which revealed a weak positive correlation, $r_s(20,874)=0.344$, $p<.001$.

As Fig. 5 displays, most of the participants reported that IT specialists were available always (25%) or upon request (48%). However, 27% reported that IT personnel are absent in their schools.

The survey findings indicate that almost 45% of respondents are aware that their schools have the equipment but know nothing about its model or manufacturer.

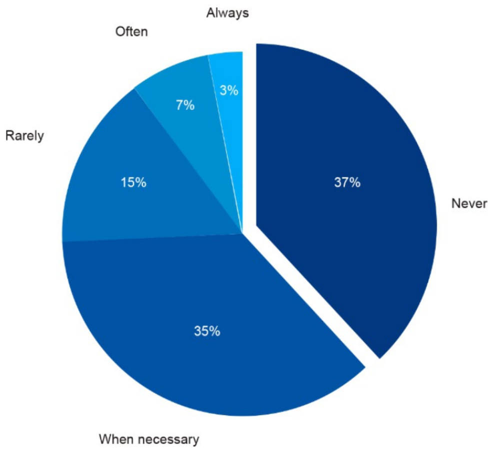


Fig. 5 Frequency of VR Technology use in Learning and Teaching Process

Indeed, most of the surveyed believe that a thorough and time-consuming preparation and ongoing communication with IT specialists are required to successfully use VR in classroom. Nevertheless, it is surprising that, according to our data, the frequency of VR use by teachers has weak correlation with availability of IT personnel (see Fig. 6).

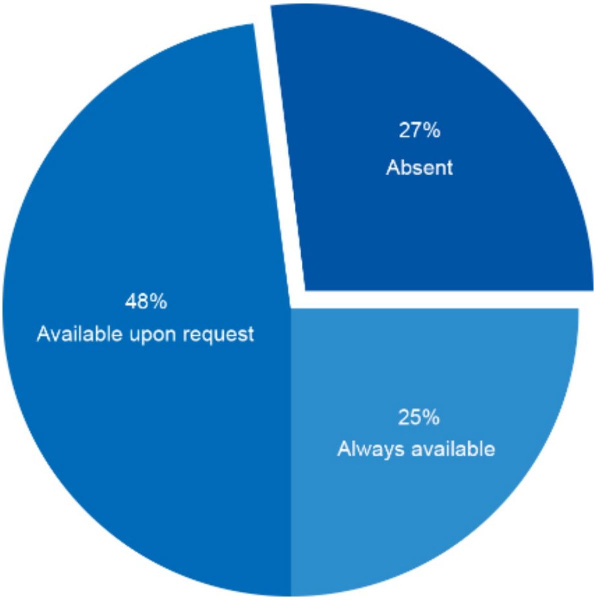


Fig. 6 Availability of IT Personnel in Educational Institutions

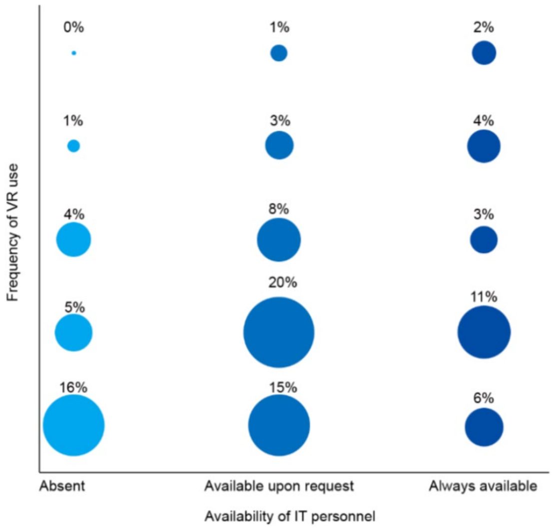


Fig. 7 Relationship between IT personnel Availability and Frequency of VR use

Thanks to the large size of the data set, we were able to investigate some additional correlations, including the correlations between (1) educators' perceptions and VR technology integration, (2) educators' perceptions and the frequency of VR use, (3) instructional approaches and the frequency of VR use and, (4) IT personnel availability and the level of VR integration. We calculated Spearman's rank order correlations for all of the pairs. The values for the corresponding correlations are (1) $r_s(20{,}874) = 0{,}177$, $p < .001$, (2) $r_s(20{,}874) = 0{,}104$, $p < .001$, (3) $r_s(20{,}874) = 0{,}077$, $p < .001$, (4) $r_s(20{,}874) = 0{,}241$, $p < .001$ respectively. The dependency for educators' perceptions was calculated as the correlation between the mean score in the questionnaire (taking into account reverse-coded questions) for every educator and the level of technology integration/frequency of VR use for every educator.

These results were statistically significant but with weak positive correlations. A possible explanation for the weakness of the correlation is that the data set was mixed, and perhaps further analyses of specific parts of the data set can be a goal for future research. For example, analyzing only the data from educators that have at least partial access to the VR technology can lead to stronger correlations, since those teachers who do not have access to the technology can be somewhat biased towards VR due to the lack of experience and opportunities.

5 Discussion

The large sample of this study is representative of the Russian educator population, and the results provide a better understanding of the current state of the VR integration and teacher readiness in Russian schools. In addition, the results provide useful insights into how to better prepare Russian teachers for effective VR integration into teaching and learning.

In general, Russian educators had moderately positive perceptions of VR use in teaching and learning. For example, the participants believed that VR is "effective for students of all abilities" ($M = 4.32$, $SD = 0.90$), it "improves student learning of critical concepts and ideas" ($M = 4.20$, $SD = 0.89$), and it "motivates students to get more involved in learning activates" ($M = 4.31$, $SD = 0.94$). This finding is in line with previous studies (Huang et al., 2019; Kaplan-Rakowski & Wojdynski, 2018).

On the other hand, the participants moderately agreed that VR "requires extra time to plan learning activities" and "requires training in the use of software" ($M = 4.18$, $SD = 0.95$). It is worth noting that most of the participants (71.7%) were at the first three levels in terms of VR technology integration (awareness, learning, and understanding). It appears that Russia, like many other countries, is at its early stages of VR technology integration to education.

In terms of instructional approaches, it was interesting that most participants preferred to keep balance between student-centered and teacher-centered approaches in their teaching. We assumed that learner-centered teachers would use VR more than teacher-centered teachers. However, our analysis showed no strong correlation between the teaching approaches and the level of VR integration in the learning and teaching process. One possible explanation of the results is that instructional approaches did not influence the level of VR integration because most participants were at the early stage of the VR integration. In fact, 37% of the participants never used VR in the classroom. It might be too early to examine the relationship between teaching approaches and the level of VR integration when most teachers are not very confident with the use of the VR technology in their teaching.

The results revealed a positive correlation between the frequency of VR use and the level of VR integration. In other words, teachers who are familiar with the VR technology attempt to use it more often. As mentioned earlier, most of the participants were at the early stages of VR technology integration. Less than 30% of the participants felt comfortable with the VR technology and could use it as an instructional tool in the classroom (familiarity, adaptation, and creative application). This finding suggests that just knowing what VR is, does not necessarily lead to actual use and integration in the classroom.

To effectively use VR in the classroom, teachers should become familiar with the technology and understand how to integrate it into the curriculum. Once they are confident with the VR technology, they will use it more creatively and frequently. It appears that most Russian teachers need professional development opportunities that can help them develop technological, pedagogical, and content knowledge (TPACK) beyond the basic technical knowledge about VR. As the TPACK framework suggests, technology integration requires much more than technical skills (An & Reigeluth, 2011; Koehler & Mishra, 2008; Mishra & Koehler, 2006). Recognizing the importance of the links among technology, pedagogy, and content, the VR professional development programs should provide teachers with VR integration opportunities in authentic contexts.

Generally, the technology support, or IT support, is considered to be a necessary component for successful technology integration. Studies report that lack of technology support is one of the major barriers to technology integration (Ertmer & Ottenbreit-Leftwich, 2013; Kilinc et al., 2018; Nikolopoulou & Gialamas, 2015). Russian teachers in this study also indicated that VR implementation could be more successful if there were IT personnel available along with adequate teacher training. Nevertheless, it is surprising that the frequency of VR use had a weak, positive correlation with availability of IT personnel. This finding indicates that some teachers may integrate VR into the classroom independently without IT support. In fact, about a quarter of the participants (27%) reported the absence of IT personnel in their schools. More IT support could increase the use of VR in Russia.

Overall, Russian educators are at the early stage of VR integration, regardless of their instructional approaches but they have fairly positive perceptions of the use of VR in education even though they have limited experience with the technology. The results of this study suggest that there are various barriers to integrating VR into the classroom in Russia. Ertmer (1999) classified technology integration barriers in two major categories: first- and second-order barriers. First-order barriers refer to obstacles that are external to teachers, while second-order barriers are intrinsic to teachers. Russian teachers appear to face both first-order barriers (e.g., lack of IT support) and second-order barriers (e.g., lack of knowledge and skills). It is necessary to address both types of barriers rather than addressing them separately because they are inextricably linked together (Ertmer, 1999; Hew & Brush, 2007).

6 Limitations, future research, and conclusions

The goal of the study was to obtain data from a vast set of respondents (20,876) to study Russian teachers' perceptions of VR integration in education. The data were based on self-reported questionnaires. Self-reporting can potentially threaten reliability and validity of the measurement. Because solely correlational analyses were implemented in this study, no causal inference can be drawn from the results. Follow-up studies should include analyses drawn from narrowed samples of respondents; for instance, from teachers of specific subjects (mathematics, physics, chemistry, biology, language learning, arts, etc.). The usefulness of VR may differ across disciplines and the perspectives of teachers in particular subject areas may yield interesting results. In fact, given that language instruction is particularly attractive in VR, based on the current study, Kaplan-Rakowski et al. (2023a) explored how a subsample of language teachers perceived using VR in the classroom. Further analyses could consider responses of teachers with various experience levels and ages, to depict how particular sub-samples view VR for education.

Another goal was to obtain large-scale, general data, without detailed analyses of the respondents' responses. Future studies should include teachers' interviews and observations, to triangulate their responses on the survey. Some survey-based studies coupled with focus-group interviews studying teachers' VR perceptions are already taking place (e.g., Kaplan-Rakowski et al., 2023b). Another useful study could focus on teachers' experiences with teaching in VR and use their responses to formulate pedagogically-sound guidelines of how the integration of VR should take place, including details on professional development and teacher training with regard to VR use in the classroom. It would be useful for IT developers to work in collaboration with teachers and curriculum developers. This is because currently many VR experiences are detached from school curricula, and they disallow for learning to be seamless. Before VR technology is fully integrated into the school curricula, it is important to examine how teachers actually use VR in the classroom and how the practice is aligned with their teaching philosophy or perceptions. Such endeavors could be done through either mixed or qualitative paradigms.

7 Appendix A

Questionnaire on Attitudes on the Use of VR for Education.

This questionnaire consists of three sections. In multiple-choice questions, choose only one option that best describes your situation. The responses to open-ended questions must be included in the respective answer fields.

7.1 Section 1

***General information about respondents and available resources*.**

Gender: Female ______ Male ______.

What educational institution do you represent? __________________.

What region are you located in? __________________.
Work experience __________________.
Specify the number of years you have taught __________________.
Subject(s) taught __________________.
Average number of students in your class.
- Less than 10.
- 10–15.
- 16–20.
- 21–25.
- 26–30.
Choose your preferred teaching approach:

- Mainly teacher-centered (e.g., teacher in the center of the classroom, leads discussions, lectures).
- More teacher-centered than student-centered.
- Balance between teacher-centered and student-centered approaches.
- More student-centered than teacher-centered.
- Mainly student-centered (e.g., cooperative learning, discovery learning).

List the available virtual reality equipment in your school (including labs and classes where applicable). Specify equipment model __________________.
Availability of IT personnel in your educational institution (for maintenance and operation of equipment).

- Absent.
- Available upon request
- Always available

Specify how often you use VR technology in your lessons

- Never
- Rarely
- When necessary
- Often
- Always

7.2 Section 2

Professional opinion of the use of VR technology in classroom.
Using the scale, indicate the extent to which you disagree or agree with the following statements with using VR in classroom:

Extent of Agreement					
1.Strongly disagree	2. Disagree	3.Slightly disagree	4.Slightly agree	5. Agree	6. Strongly agree

#	Using VR in classroom …	Extent of Agreement					
		1	**2**	**3**	**4**	**5**	**6**
1	Improves student academic record.	□	□	□	□	□	□
2	Makes classroom management more difficult.	□	□	□	□	□	□
3	Promotes the development of communication skills (e.g. writing skills, presentation skills).	□	□	□	□	□	□
4	Requires extra resources, time and effort.	□	□	□	□	□	□
5	Is successful only if there's adequate teacher training in the use of VR technology in classroom.	□	□	□	□	□	□
6	Is successful only if equipment is regularly maintained by IT personnel.	□	□	□	□	□	□
7	Is an effective tool for students of all abilities.	□	□	□	□	□	□
8	Effective if teachers participate in selection and implementation of VR technology.	□	□	□	□	□	□
9	Allows to accommodate individual attributes of students.	□	□	□	□	□	□
10	Motivates students to get more involved in learning activities.	□	□	□	□	□	□
11	Requires software training, which takes too much time.	□	□	□	□	□	□
12	Promotes the development of student interpersonal skills.	□	□	□	□	□	□
13	Effective only if extensive technical resources are available	□	□	□	□	□	□
14	Requires extra time to plan learning activities.	□	□	□	□	□	□
15	Improves student learning of critical concepts and ideas.	□	□	□	□	□	□
16	Is unreasonable due to the lack of subject-specific software.	□	□	□	□	□	□

7.3 Section 3

Integration

Read the description of the six stages of VR technology integration in the teaching and learning process. Choose a stage that best describes your progress

- Awareness: I am aware that the technology exists but have not used it – perhaps I'm even avoiding it. I am anxious about the prospect of using virtual reality.
- Learning: I am currently trying to learn the basics. I am sometimes frustrated using the technology and I lack confidence when using it.
- Understanding: I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.
- Familiarity: I am gaining a sense of self-confidence in using VR for specific tasks. I am starting to feel comfortable using the equipment.
- Adaptation: I think about virtual reality as an instructional tool to help me and I am no longer concerned about it as technology. I can use many different software.
- Creative application: I can apply what I know about technology in the classroom. I am able to use it as an instructional aid and have integrated VR into the curriculum.

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Declarations

Conflict of interest statement None.

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