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ORIGINAL RESEARCH ARTICLE

University learners' utilisation of online videos in a general chemistry course

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The effectiveness of course videos needs to be analysed, and in doing so, it is important to consider the utilisation behaviours and opinions of learners. In this regard, this study was primarily conducted to analyse Kyrgyz learners' utilisation of videos in a general chemistry course provided at the university level. This study was conducted during the 2019–2020 spring term at a state university in the Kyrgyz Republic and was structured using a mixed-method approach. The total number of participants was 105 Kyrgyz learners studying at the undergraduate level. Quantitative data were collected through an online survey, which consisted of demographic questions and items related to the utilisation of chemistry videos. Qualitative data were obtained through in-depth interviews with 13 learners. It was demonstrated through the data that learners used chemistry videos for 1–2 h per week. Also, the learners' utilisation did not change with regard to their success from watching the videos. Learners' utilisation of the chemistry videos was based on five factors: intrinsic motivation, self-concept of ability, self-perception of conscientiousness, video use and expectations of an online video library. This study also provided results regarding Kyrgyz learners' problems and suggestions related to their utilisation of the videos.

Keywords: online video; chemistry; utilisation factors; instructional video; ICT tools

Introduction

Science education is structured to include the three major disciplines of physics, chemistry and biology. The concepts in chemistry courses are abstract; thus, it becomes difficult to build relationships between these concepts and the real world (Chen and Liu 2020). Learners often experience difficulties in comprehending the abstract concepts covered in chemistry (Suchyadi, Safitri, and Sunardi 2020), and as a result, laboratory instruction is recommended to build scientific knowledge through use of concrete materials (Setiawati *et al*. 2021).

The use of videos in the context of educational instruction is becoming more prominent. One aspect of this is that instructors in higher education utilise videos in a variety of ways. For example, they use demonstration videos during class, share online lectures,

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provide course-related recordings and share supplementary instructional videos for self-study purposes (Santos Espino, Afonso Suárez, and González-Henríquez 2020). Video laboratories are also provided due to increasing technological opportunities. For example, in video laboratories, experiments are recorded and then presented through various software (Schmidt-McCormack *et al*. 2017). Since there are a limited number of laboratories and lack of relevant laboratory equipment within developing countries, video laboratories continue to gain importance (Scagnoli, Choo, and Tian 2019).

One developing country, the Kyrgyz Republic, recently initiated the use of videos in university education. Due to the emergence of the COVID-19 pandemic, courses and laboratories began to be implemented online. Therefore, chemistry lectures and laboratories formerly provided in a face-to-face setting at state universities in the Kyrgyz Republic were now provided through online videos.

It is becoming essential to investigate learners' use and experiences related to their interaction with instructional videos. In addition, it is important to provide answers regarding the effectiveness of course videos (Laaser and Toloza 2017). However, there is limited number of studies that investigate learners' acceptance and motivation related to online video lectures (Scagnoli, Choo, and Tian 2019). Although prior studies in other countries have been used to analyse learners' video use experiences, there have not been these types of studies carried out within the Kyrgyz Republic. Thus, the aim of the current study was to analyse factors affecting Kyrgyz learners' utilisation of general chemistry videos. Furthermore, another study intent was to explore Kyrgyz learners' problems as well as to provide suggestions regarding the utilisation of chemistry videos.

Literature review

In recent years, videos have been widely used as an effective medium for delivering educational content (Beheshti *et al*. 2018). In this sense, videos 'increase the level of engagement of students compared to traditional text course material, increase the level of retention and reduce teacher intervention' (Benkada and Moccozet 2017, p. 344).

The effect of watching videos has been analysed in various studies. In this respect, the effect of video use on learners' academic success has often been investigated. Thus, it has been shown in a majority of these studies that learners increase their success after utilising instructional videos. For instance, Yükselir and Kömür (2017) reveal that learners increase their speaking abilities and grades after watching videos provided within the context of an English course.

The success of a particular technology is highly dependent on its actual use by the target users. To date, several studies investigating the determinants of information technology use have been performed as a way of increasing its expected level of use. Thus, researchers have applied different theoretical models to reveal the intentions and behaviour of users towards information technology. The most commonly used models are the Technology Acceptance Model (TAM) (Davis 1989), Diffusion of Innovation Model (DoI) (Rogers 1995) and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al*. 2003).

Some past studies have been used to investigate learners' acceptance and motivation regarding online video lectures. For instance, Costa, Alvelos and Teixeira (2018) investigated learners' acceptance of an Educational Video Platform and determine that learners indicate a positive attitude towards three variables: Perceived Ease of Use, Perceived Usefulness and Attitude towards Using. In a similar study, Nagy (2018) investigated factors of learners' video use and their related satisfaction in a

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business mathematics course and finds that perceived usefulness, attitude and internet self-efficacy have a significant effect on learners' video use.

In the context of chemistry education, Pölloth, Schwarzer and Zipse (2019) proposed a framework to analyse learners' utilisation of chemistry videos. This framework consists of various factors, including intrinsic motivation, self-concept of ability, self-perception of conscientiousness and use of video tutorials. The intrinsic motivation factor is defined as 'a motivation type in which the learning requirement and the sense of achievement develop in typical environments' (Fırat, Kılınç, and Yüzer 2017, p. 64). The factor related to the self-concept of ability in experimental chemistry considers items related to learners' self-confidence in performing experiments. Therefore, learners' thoughts and concerns regarding their skills in doing experiments were considered. Next, the factor related to students' self-perception of conscientiousness covers items related to learners' conscientiousness in studying their dutifulness towards their studies and the completion of tasks in a precise and planned manner. The factor related to the use of video tutorials in daily life considers learners' video use for learning about a specific topic, looking for information regarding a daily problem and using explanation videos from various video platforms. Importantly, expectations towards an online video library can vary. Thus, another factor was used to analyse learners' thoughts regarding the appropriateness of online videos, their ideas towards comprehensiveness of explanations of lab techniques and learners' confidence in performing experiments after watching videos.

In the context of this current study, a survey proposed by Pölloth, Schwarzer and Zipse (2019) was found to be relevant for investigating Kyrgyz learners' utilisation of online chemistry videos. Their survey had previously been used to investigate the utilisation of videos in chemistry courses but had yet to be applied to Kyrgyz learners. In this respect, this study was the initial study of its type to provide findings with regards to Kyrgyz learners' utilisation of chemistry videos.

Methodology

Research questions

The purpose of this study was to investigate Kyrgyz learners' utilisation of online videos in a general chemistry course provided at the university level. The primary research questions were as follows:

(1) Does the utilisation of videos in the chemistry course influence learners' chemistry grades?
(2) Which factors influence Kyrgyz learners' utilisation of videos in the chemistry course?
(3) Is there any difference in each video utilisation factor with respect to Kyrgyz learners' demographic characteristics?
(4) What problems do Kyrgyz learners have in watching the chemistry course videos?
(5) What are the suggestions of Kyrgyz learners for improving the chemistry course videos?

Research design and participants

This study was performed during the 2019–2020 spring academic term and followed a mixed-method approach.

Table 1. Analysis of demographic data of participants.

Category	Sub-categories	Frequency (f)	Percentage
Gender	Male	15	14.3
	Female	90	85.7
Age	17–19	34	32.5
	20–22	65	61.9
	23–25	6	5.7
Faculty	Engineering	44	41.9
	Science	13	12.4
	Pharmacy	48	45.7
	Total	105	100

The total number of participants was 105 Kyrgyz learners studying at the undergraduate level. Demographic profiles of the participant learners are provided in Table 1.

Setting

This study was conducted in the context of an undergraduate level general chemistry course at a state university in the Kyrgyz Republic. The course was provided to learners studying in three different academic majors, including engineering, science and pharmacy.

The course covered weekly 2-h theoretical sessions and 2-h laboratory sessions. In the theoretical session, learners were taught topics related to general chemistry. Whilst in the laboratory session, learners were taught about experiments from corresponding topics.

Due to the emergence of the COVID-19 pandemic during the 2019–2020 spring academic term, a majority of the general chemistry course content was provided through video lectures, and laboratory experiments shared through online videos. These video lectures and experiments were developed by experts from chemistry education. Since there was a lack of available content in the Kyrgyz language, these videos were provided in either English or Russian language. In addition, during each week, learners watched both the course and laboratory videos.

Data collection and analysis

The research data were collected from participant learners through a survey, which consisted of two major sections. In the first section, five demographic questions were directed to participants. Whilst in the second section, questions related to the utilisation of the chemistry videos were directed to learners. The second section covered video utilisation items based on Pölloth, Schwarzer and Zipse (2019). These items were rated on a 5-point Likert scale ranging from 1 – strongly disagree to 5 – strongly agree.

The survey used in this study was developed online and then shared with learners registered for the chemistry course during the 2019–2020 spring academic term. The survey was distributed and then completed on a voluntary basis. Next, interviews were carried out with 13 learners who volunteered to provide more in-depth information. The quantitative study data were analysed using the SPSS software package for both descriptive and inferential analyses. Whilst the qualitative data from the 13 volunteer participant interviews were collected and transcribed for analysis.

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Table 2. ANOVA results related to the difference with regards to learners' chemistry success.

Learners' chemistry success	Sum of squares	Df	Mean square	*F*	Sig.
Between groups	1908.164	5	381.633	1.098	0.365
Within groups	39955.836	115	347.442		
Total	41864.000	120			

Results

Research question-1: Does the utilisation of videos in the chemistry course influence learners' chemistry grades?

The analysis of variance (ANOVA) was used to investigate the difference of chemistry video utilisation with regards to the learners' final exam chemistry course grades. The corresponding results are provided in Table 2.

Thus, it was demonstrated in the results that learners' utilisation of the chemistry videos did not change with regards to their success in the chemistry course. This implied that both successful and unsuccessful learners preferred to watch the chemistry videos.

Research Question-2: Which factors influence Kyrgyz learners' utilisation of videos in the chemistry course?

To begin, Kaiser-Meyer-Olkin measure and the Bartlett's Test were performed to measure sampling adequacy. The related results are provided in Table 3. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was calculated as equal to 0.742. Moreover, the null hypothesis for the Bartlett's Test of Sphericity was rejected since the p-value was calculated as 0.000. According to Bentler (1990), a p value of <0.05 for the Bartlett's test of sphericity and >0.05 for KMO are considered as appropriate for factor analysis. In addition, the KMO value was found to be greater than 0.7 and with a limit of 0.5 (Sukor and Fisal 2020). Hence, data reduction was identified as being possible for this dataset.

Next, the principal component factor analysis was performed, and the rotated component matrix result suggested five differing factors. The factor loadings for all variables were greater than 0.406 and are provided in Table 4.

Five factors were determined through the factor analysis, including g intrinsic motivation, self-concept of ability, self-perception of conscientiousness, video use in daily life and expectations of an online video library. Only two items from the survey (i.e. #18. I think a video tutorial for the chemistry lab course is redundant, and #19. I think I will not invest time watching the online-video tutorial videos.) were not found in any factor. Thus, the five factors explained for 59.5% of the variance.

Research Question-3: Is there any difference in each video utilisation factor with respect to Kyrgyz learners' demographic characteristics?

The differences between male and female learners were analysed with respect to the five factors defined in the second research question. The corresponding results are provided in Table 5. It was demonstrated through the results that male and female

Table 3. Results of Kaiser-Meyer-Olkin and the Bartlett's Test.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.742
Bartlett's Test of Sphericity	Approx. chi-square	932.581
	Df	231
	Sig.	0.000

Table 4. Factors related to chemistry video use.

	Factor loadings for factors				
	1	2	3	4	5
Factor 1: Intrinsic motivation					
1. Lab courses are a reasonable part of studies in chemistry.	0.687				
2. If I didn't have to I'd rather not participate in the chemistry lab course.	0.441				
3. I am looking forward to the chemistry lab course.	0.753				
4. I expect that my interest in experimental work will be strengthened by this lab course in chemistry.	0.802				
5. I think that I will learn a lot by attending the basic lab course in chemistry.	0.687				
Factor 2: Self-concept of ability					
6. I am more skilled in experimental work than most of my fellow students.					0.628
7. Whilst experimenting I often feel overstrained.					0.406
8. I think that the experiments in the basic lab course will not pose a major problem for me.					0.579
9. I am very skilled in experimental work.					0.803
Factor 3: Self-perception of conscientiousness					
10. I think that I am more conscientiousness in studying than the average of my fellow students.		0.657			
11. I am very dutiful in my studies.		0.748			
12. I always complete tasks for university very precisely.		0.720			
13. I always fulfil my duties in a planned manner.		0.855			
Factor 4: Video use in daily life					
14. I frequently use video tutorials (i.e. for recipes, computer problems, beauty tips, etc.)				0.741	
15. If I look for information about a daily problem on the internet, I watch a video rather than reading a text.				0.775	
16. I use explanation videos on YouTube or similar platforms if I have problems understanding some content in my studies.				0.801	
Factor 5: Expectations of an online video library					
17. I think an online-video tutorial for the chemistry lab course is a good idea.			0.721		
20. From an online-video tutorial for the basic lab course, I expect that lab techniques are explained comprehensibly.			0.721		
21. From an online-video tutorial for the basic lab course, I expect that I'll feel more confident in working experimentally after watching the videos.			0.645		

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Table 5. Gender differences with respect to factors related to chemistry video use.

Factors	Chemistry video use	Sum of squares	Df	Mean square	*F*	Sig.
Factor 1	Between groups	0.367	1	0.367	1.142	0.288
	Within groups	33.076	103	0.321		
	Total	33.442	104			
Factor 2	Between groups	2.833	1	2.833	5.588	0.020
	Within groups	52.228	103	0.507		
	Total	55.062	104			
Factor 3	Between groups	0.914	1	0.914	1.450	0.231
	Within groups	64.958	103	0.631		
	Total	65.873	104			
Factor 4	Between groups	1.460	1	1.460	1.605	0.208
	Within groups	93.740	103	0.910		
	Total	95.200	104			
Factor 5	Between groups	3.734	1	3.734	4.774	0.031
	Within groups	80.556	103	0.782		
	Total	84.289	104			

learners differed significantly with regards to two specific factors: Factor 2 – Self-concept of ability and Factor 5 – Expectations of an online video library. Thus, according to Factor 2, male learners demonstrated more self-concept of ability compared to female learners. Whilst according to Factor 5, female learners indicated more expectations towards online videos.

The differences amongst faculties were also analysed with respect to the five factors defined in the second research question. The corresponding results are provided in Table 6.

It was demonstrated in these results that there were differences amongst the faculties with regard to two specific factors: Factor 2 – Self-concept of ability and Factor 5 – Expectations of an online video library.

Research Question-4: What problems do Kyrgyz learners have in watching the chemistry course videos?

Kyrgyz learners' problems related to chemistry course videos are depicted in Figure 1. Amongst the participant learners, some were living in rural areas, and as a result, they indicated experiencing technology-related problems, such as systematics problems with their internet connection, loss of internet connection, low quality of internet bandwidth, systematic loss of electricity, etc. Due to these problems, some learners were not able to watch videos and had difficulty in following the chemistry course video lectures. They consequently experienced problems in successfully completing the course. Learners also complained about the limited interaction within the course. Whilst watching videos regarding course content and experiments, they listened to instructors and watched the videos. However, they could not actively participate during the laboratory experiments. Also, learners complained about the reports they were asked to submit after watching the video laboratory experiments. They were not able to understand the purpose of these reports and thought it did not make sense to write these reports as part of their learning.

Table 6. Faculty differences with respect to factors related to chemistry video use.

Factors	Chemistry video use	Sum of squares	Df	Mean square	*F*	Sig.
Factor 1	Between groups	0.966	2	0.483	1.517	0.224
	Within groups	32.476	102	0.318		
	Total	33.442	104			
Factor 2	Between groups	4.681	2	2.341	4.739	0.011
	Within groups	50.381	102	0.494		
	Total	55.062	104			
Factor 3	Between groups	0.351	2	0.175	0.273	0.762
	Within groups	65.522	102	0.642		
	Total	65.873	104			
Factor 4	Between groups	0.226	2	0.113	0.121	0.886
	Within groups	94.974	102	0.931		
	Total	95.200	104			
Factor 5	Between groups	5.543	2	2.771	3.590	0.031
	Within groups	78.746	102	0.772		
	Total	84.289	104			

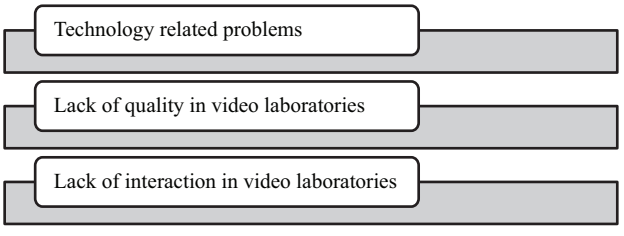

Figure 1. Learners' problems related to videos.

Learners were queried about the quality of the video laboratories. One learner indicated that,

> Even if it is a video laboratory with experiments, the language of this laboratory is very important. I cannot understand some words in English, even if the instructor explained I had to watch the video after the lecture again and again. The most important problem was to write a report about the reactions of this video laboratory experiment.

That is, learners were not satisfied with the language used in the chemistry videos. Instead, they expected the videos to be in their local language. On the other hand, learners mentioned that modern technology gave them an opportunity to watch the video repeatedly as well as rewind and play back any specific point in the video until they understood the experiment.

Another issue mentioned by learners was that online courses, especially online video laboratories, were not as beneficial as face-to-face courses. For example, in traditional settings, learners play an active role when performing experiments, whereas in video courses, learners cannot physically interact with the instruments, cannot use their five senses and cannot do the experiments themselves. For instance, one learner stated,

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> During face-to-face learning and laboratory experiments, we were working in a group of 3–4 and sometimes had to spend more than 8 hours to complete some experiments. We had to do it over and over until we reached the best result. But in video experiments, they do it in seconds, and we cannot touch, see or smell how it is really done.

They also mentioned a big gap between theory and practice. Due to the COVID-19 pandemic, they did not have an opportunity to conduct interesting and useful experiments for their future career.

Research Question-5: What are the suggestions of Kyrgyz learners for improving the chemistry course videos?

Kyrgyz learners' suggestions regarding the improvement of chemistry course videos are provided in Figure 2.

Learners living in rural areas needed internet connection problems to be resolved to properly access course videos. They indicated that without improvements, they would continue to experience problems in accessing online course materials, and their academic achievement would be negatively affected. In addition, learners complained about the lack of videos in the Kyrgyz language and highlighted that all the chemistry laboratory videos were in English or Russian. Thus, the learners suggested developing chemistry course videos in the Kyrgyz language to help increase their comprehension. Learners also mentioned that compared to other public universities in the Kyrgyz Republic, they were satisfied with their chemistry course. However, they would be more satisfied if the chemistry lectures were provided in the Kyrgyz language.

Furthermore, most learners mentioned the effectiveness of the video experiments. For example, they highlighted not having an opportunity to complete experiments themselves and were not sure about getting the same results within an in-person course. On the other hand, through video lectures, learners observed that experiments were easy and ideal, which was not the case under traditional conditions. Nevertheless, the learners proposed conducting experiments in a face-to-face setting. Learners also wanted a self-assessment quiz after watching each lecture and before starting the video laboratory experiments. In this way, they could measure what they had learned through the lecture and be prepared for the experiment.

Some learners did state a lack of effectiveness of video laboratories compared to traditional in-person laboratories. Also, the learners suggested that Kyrgyz instructors prepare the video laboratory experiments in the Kyrgyz language. Furthermore, learners expected to have preliminary video lectures and explanations prior to the laboratory experiments, which could provide them deeper understanding. They also

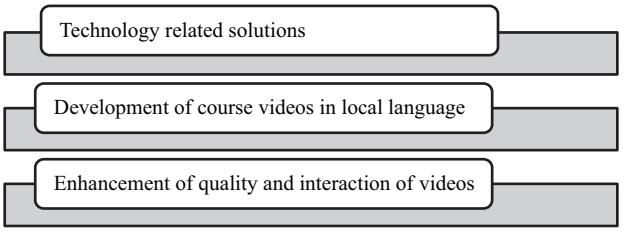

Figure 2. Learners' suggestions for improving course videos.

wanted to increase the number of video lectures, which were understandable, detailed and accessible. In addition, some learners complained about the video lecture quality and suggested instructors should review the videos prior to sharing them. That is, learners expected high-quality videos in terms of both technical and content aspects.

Discussion and conclusion

In the context of various courses, videos are intended to be used as effective instructional tools. Thus, a need emerged for the investigation of learners' utilisation of instructional videos as well as problems related to video use. The information obtained from such analysis allows for the improvement of these videos, so that learners' overall utilisation and satisfaction increases. In this regard, this study was primarily performed to examine Kyrgyz learners' utilisation of chemistry videos. Furthermore, the study intent was to examine learners' problems as well as their suggestions related to these videos. In total, 105 Kyrgyz learners studying at the university-level participated in this study.

It was found in the initial study results that a majority of Kyrgyz learners were utilising chemistry videos for 1–2 h per week, whereas higher durations of instructional video use were found in the existing literature. For instance, in Metruk (2018), it was found that university learners watch foreign language videos for 1–2 h per day. Thus, the duration in the current study was lower than expected due to learners in rural areas having limited internet access, and as a result, lack of access to the course videos. The lack of consistent internet access amongst the Kyrgyz learners was brought to the attention of Kyrgyz officials and the telecom industry, who stated they would address the internet access problems within their country (Adanır et al. 2020). Thus, improving learners' internet access should increase the amount of time they utilise instructional videos. Lack of internet access is an important issue, which should be considered in other developing countries. That is, internet infrastructure should be robust due to video streaming requiring greater bandwidth and a high-speed internet connection. Otherwise, learners with limited internet access will continue to experience problems accessing and downloading course videos. As a result, learners' motivation towards these courses may not reach expected levels, and their achievement may decrease. An important purpose of online education should be to provide equal opportunities for learners. In this regard, providing adequate internet infrastructure for everyone can lead to improved access of course materials.

According to the second result of this study, there was no change in Kyrgyz learners' utilisation of chemistry videos with respect to their chemistry course success. On the other hand, various related results were found in the current literature. For instance, Altinpulluk *et al*. (2020) explored increases in learners achievement following the utilisation of instructional course videos, whereas Ketsman, Daher and Colon Santana (2018) found no difference in learner achievement with respect to learners' video use. In this study, it was determined that learners were generally not satisfied with regards to the language and quality aspects of the course videos. In addition, some learners faced internet problems and preferred to generally not watch the course videos. Thus, improvements are necessary for improved use of chemistry videos amongst learners. For example, as learners stated, it was important to develop videos in the Kyrgyz language due to their lack of knowledge of English or Russian. In another suggestion, to improve learners' understanding, subtitles in the local language could be integrated

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into the course videos. Also, it is essential to provide detailed explanations regarding both the course content and experimental procedures. Otherwise, learners may experience problems in understanding the topics and experiments covered within the instruction. Harrison (2020) investigated which type of instructional videos are most preferred by learners and finds that learners believe instructional videos should have high-quality production, be short in duration and include interactivity. Similarly, in the current study, Kyrgyz learners expected course videos to include high-quality features. As a result, when these issues are addressed, learners can fully benefit from instructional video use and ultimately improve their learning achievement. In addition, further study can be conducted regarding how to improve and analyse instructional videos for improving students' success.

In the third result of the study, it was found that learners utilised the chemistry videos based on five factors: intrinsic motivation, self-concept of ability, self-perception of conscientiousness, video use in daily life and expectations of an online video library. Intrinsic motivation is described as a type of motivation existing within learners (Vanslambrouck *et al*. 2018). In this respect, it was revealed that learners' utilisation of course videos increased when they viewed lab courses as an important part of their chemistry studies, wanted to participate in the course, looked forward to participate in the course and understood the benefits of course attendance. It was also revealed that being skilled in the experiments and being a dutiful student increased learners' utilisation of the chemistry videos. Similarly, Beheshti *et al*. (2018) revealed that video use as an educational tool increases learners' motivation and interest in any discipline. In addition, videos were found to be effective tools since they facilitate the transmission of information and allow learners to comprehend abstract concepts.

Daily video use was found to be another important factor related to learners' utilisation of the chemistry videos. For instance, individuals can use video tutorials for recipes, computer problems and beauty tips. Moreover, individuals can apply videos to obtain information regarding daily problems and/or understanding general course content. It is implied in a finding related to this study that if learners benefit from videos in their daily lives, they are more likely to watch course videos. This was an expected result and similar to results observed in Pölloth, Schwarzer and Zipse (2019), who found that learners using video tutorials in their daily life are more likely to watch course-related videos. Thus, learners' behaviour regarding video use in daily life can be a topic of further analysis. As a result, the analysis of behaviours related to instructional video use can allow instructors to produce course videos, which are appealing to learners.

Learners' expectations regarding videos are most often based on problems related to the videos. One problem indicated by the learners was a lack of video interactivity. This result was also found in Bonafini *et al*. (2017), who revealed that learners watching interactive videos have higher levels of achievement and satisfaction compared to those watching non-interactive videos. Thus, interactivity in instructional videos can be satisfied in different ways. For example, Sauli, Cattaneo and van der Meij (2018) proposed six features for interactive videos: dynamism (in-motion aspect of video images), control features (ability to play in non-linear structure), hyperlinks (providing access to additional materials), individual video annotation (adding notes in videos whilst watching), collaborative video annotation and quiz functionality.

It appears that the Kyrgyz instructors were not fully prepared to provide online teaching during the COVID-19 pandemic. However, they were able to provide online lectures and ready-made video laboratory experiments from the internet. Regardless,

most learners complained about the effectiveness of online video laboratory experiments due to them not being able to use their five senses and/or perform the experiments themselves. On the other hand, innovative technologies such as virtual learning can be a possible solution for this situation in the future. The aim of virtual reality-based instruction is to represent a realistic simulated environment where learners can perform instructional tasks (Yildirim 2017). For example, in the context of a chemistry course, a virtual reality multisensory classroom was developed to allow learners to 'touch atoms and bonds, view them in 3D space and bring them together to form molecules' (Edwards *et al*. 2019, p. 364). Unfortunately, this kind of technology can be difficult for developing countries to acquire due to problems related to infrastructure, technology and economics. Another complaint from learners was the requirement to submit reports following each video experiment. However, a solution may be for instructors to provide discussion forums, which allow learners to ask questions and share their experiences regarding the experiments. Similarly, Bonafini *et al*. (2017) proposed that when instructional videos are developed along with discussion forums, learners' overall engagement and achievement will increase.

Suggestions and implications

An important limitation of this study was the limited sample size. The number of learners who submitted questionnaire responses was low. To better understand factors affecting learners' utilisation of online instructional videos, a larger sample size could be beneficial. In applying this study, it was also revealed that there was a need for improvement of the videos to fully satisfy learners. In this respect, learner expectations regarding instructional videos can be identified prior to the term beginning. As previously stated, it is important to provide effective videos in terms of quality, interactivity and language. At the same time, learners can become stakeholders in the video production process through their ideas and suggestions. Importantly, this study shed light on the effectiveness of video use for general chemistry courses during the COVID-19 pandemic. If the proposed suggestions are utilised by future instructors, then the effectiveness of students' learning success can increase.

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