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The Effects of Online Organic Chemistry Laboratory Videos on Students' Perceptions and Intrinsic Motivation

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Abstract: The purpose of this exploratory study is to investigate students' use and perceptions of online videos and intrinsic motivation toward the online videos in an organic chemistry laboratory course, which used online videos to assist students' preparation and learning in the lab. Students' responses to an anonymous survey showed that they watched the online videos one or more times based on their available time. Descriptive statistics showed that students had positive perceptions about the effect of online videos in terms of their preparation of labs, understanding the concepts, doing hands-on activities, and other aspects in the lab, which were consistent with their written comments. 44% of students showed positive intrinsic motivation toward the online videos according to items based on self-determination theory. Correlation results showed that the effect subscales were strongly related to each other, and students' intrinsic motivation was significantly and positively related to students' perceived effect of the online videos on their understanding and preparation with medium to large effect sizes. Inferential tests showed that students who had a positive perception of intrinsic motivation scored significantly higher on the understanding subscale with a medium to large effect size. The findings in this study suggest the online organic chemistry laboratory videos have significant potential to improve students learning and it is important to stimulate student intrinsic motivation toward the online videos which will help students benefits more from the effects of the online videos.

Keywords: *Intrinsic motivation; Laboratory education; Organic chemistry laboratory; Online videos*

Introduction

Online Videos

Chemistry laboratory work is considered a vital component of the chemistry curriculum and it plays an important role in student learning (Bruck et al., 2010; Burrows et al., 2017; Elliott et al., 2008; Johnstone & Al-Shuaili, 2001; Reid & Shah, 2007). Pre-laboratory preparation is considered important for laboratory education (Johnstone & Al-Shuaili, 2001). Well prepared students are more likely to understand the laboratory theories and concepts, master laboratory skills, and achieve the greatest feasible benefits from the laboratory classes (Gregory & Di Trapani, 2012). However, appropriate pre-laboratory preparation could be challenging for students.

In order to get students prepared for the chemistry laboratory, some instructors require students to do some of the prelab preparations by completing online activities before attending the lab sessions (Agustian & Seery, 2017). Online prelab videos, which may include a brief introduction to the experiment, a short review of related theory and concepts, demonstrations of equipment and techniques, and reminding of safety issues, have been used in many undergraduate labs (Stieff et al., 2018). Research has shown that online videos have positive effects on student preparations and performance in laboratory courses. For example, pre-lab videos of techniques and synthetic procedures have been developed to move some of the prelab components to outside of the lab classes in general chemistry, organic, and inorganic chemistry laboratory courses (Fung, 2015; Teo et al., 2014). When the pre-laboratory work was made to be closely related to the in-lab work, results suggested that the videos could help students understand the written laboratory procedures which they found difficult to interpret, and students also reported that they felt more comfortable with the fundamental theory by watching videos in advance (Teo et al., 2014). In general chemistry laboratory courses, students performed better in the achievement assessment which assessed their understanding of laboratory procedures with the help of online pre-laboratory videos (Stieff et al., 2018); furthermore, the use of online interactive materials was found positively correlated with students' laboratory final grades who had medium performance backgrounds (Veiga et al., 2019). In organic chemistry laboratory courses, students perceived the online videos helped them prepare for the lab work better, understand the experiments better (Chaytor et al., 2017; Jordan et al., 2016), and perform better on prelab questions (Box et al., 2017; Pölloth et al., 2020) and post-test laboratory quizzes (Nadelson et al., 2015). The online videos also improved students' understanding of experimental methods and allowed them to complete their work more quickly and efficiently (Box et al., 2017; Nadelson et al., 2015). In an analytical chemistry laboratory course, results showed that the prelab videos improved students' preparation and grades (Jolley et al., 2016). Videos which summarized theory, experimental details, and data analysis were provided to students in analytical and physical chemistry to complement advanced practice during the semester, which helped students with preparations of the labs (Schmidt-McCormack et al., 2017).

Motivation

Motivation has been reported as one of the important factors on students' persistence in science, technology, engineering, and mathematics (STEM) and their academic achievement (PCAST, 2012; Taylor et al., 2014). Self-determination theory (SDT) regards motivation as a multidimensional concept that can vary not only in amount but also in type (Deci & Ryan, 2000; Ryan & Deci, 2000). According to the theory, when people do an activity for the inherent satisfaction of the activity itself rather than for some separable consequence, people tend to feel the enjoyment of the activity, and thus their intrinsic motivation will be integrated or enhanced (Guay et al., 2010; Ryan & Deci, 2000). A meta-analysis of 40 years of publications reported positive associations between intrinsic motivation and academic achievement with medium effect size for college-aged samples (Cerasoli et al., 2014; Taylor et al., 2014). Motivation is also important in the laboratory setting as students with higher intrinsic motivation made more use of the online videos (Pölloth et al., 2020), and the students performed significantly better on the lab final exams when they were more motivated to prepare for the lab (Pogacnik & Cigic, 2006). However, there is little work studying student motivation in the chemistry laboratory settings, although it is important to consider the affective domain, including in preparative activities (Galloway & Bretz, 2016; Galloway et al., 2016).

Research Questions

This study contributes to research on the applications of online videos in organic chemistry laboratory settings. Prior to the study, introductory pre-lab lectures were delivered briefly using chalk and board at the beginning of each lab class before students performed the experiments in the research context. During the study period, publicly available YouTube online videos were selected by the instructor and assigned to students as part of their pre-lab assignments to assist in their preparation of the lab hands-on activities and pre-lab quizzes. In particular, the current study would address the following research questions:

1. How often and in what ways do students use assigned on-line videos?
2. What perceptions do students have about the effect of online videos in terms of their preparation of labs, understanding the concepts, doing hands-on activities, and other aspects in the lab?
3. What is the status of student perceptions of intrinsic motivation toward online videos?
4. How is students' perceived intrinsic motivation toward online videos related with student perceptions of effect of the online videos?

Methods

Research Context

The study was conducted in an organic chemistry laboratory course at a public university in the Midwestern United States in 2018 Spring. In total, about 4500 students are enrolled at the university, among whom about 52% are females and about 60% are first-generation students. The organic chemistry laboratory course is a one-semester laboratory course. Usually there is one section in the fall semester and there are three sections in the spring semester during an academic year. Most of the students who are enrolled in this course are pre-health or biological sciences majors and most students take the course to satisfy their major requirements. Students enrolled in this course have either completed or are concurrently taking the second-semester organic chemistry lecture. During each semester, students first learn about organic chemistry techniques including melting point, recrystallization, fractional distillation, acid-base extraction, IR/NMR instrumentation, column chromatography, and refluxing, then students will perform different organic reactions. The course consists of two three-hour lab classes each week. There are no stand-alone lab lectures to help students prepare for the labs. Instead, the instructor usually spends about 15 minutes at the beginning of each lab class to briefly discuss the experiment, and then the students will spend the rest of the lab time doing the experiments.

Survey

A survey containing twenty-four items in total was used to collect information to answer the research questions in the organic chemistry laboratory learning environment. Thirteen items, which were adapted from previous literature (Mellefont & Fei, 2016; Richards-Babb et al., 2014) by considering the course contents and requirements in the organic chemistry laboratory course, were used to get students' perceptions of the effects of online videos. The items had five response scales ranging from "strongly disagree" to "strongly agree". One sample item was "*The online videos increased my understanding of the material of the laboratory class*". Four items were used to get to know how students used the online videos and a sample item is "*When did you use the videos?*" Moreover, one free-response question was used to get more in-depth information about how the online videos have helped students in the laboratory course.

Six items adapted from interest/enjoyment subscale of Intrinsic Motivation Inventory (IMI) (McAuley et al., 1989), an instrument based on SDT, were used to measure students' intrinsic motivation toward the online videos. The interest/enjoyment subscale has been used to represent students' perceptions of intrinsic motivation in chemistry settings (Liu, 2017; Vaino et al., 2012). For example, interest/enjoyment items have been adapted and administered to students in introductory general and organic chemistry courses in Australia to measure student intrinsic motivation toward process-oriented guided-inquiry activities; The psychometric evidence results showed good internal consistency reliability with alpha coefficients ranging from 0.89 to 0.91 and models showed reasonable fit to the data via internal structure validity (Liu, 2017). Adapted interest/enjoyment items have also been administered to high school students in Estonia to explore the effect of context-based learning modules on students' intrinsic motivation for learning chemistry; The validity was collected by a principal axis method in the pilot study and final subscales had internal reliability estimates of 0.61-0.84 for the subscales (Vaino et al., 2012). In the current study, the items were specifically rephrased to include "these videos" and the subscale was coded as intrinsic motivation for the research purpose. One sample item is "*I enjoyed viewing these videos very much.*"

Data Collection

Data collection and secondary data analysis were in accordance with the Institutional Review Board (IRB) applications. The anonymous survey was administered as a paper-and-pencil test during the fifth week of class in three sections of organic chemistry laboratory course in Spring 2018, after all the technique labs were completed. The three lab sections were taught by the same instructor (not the author). The students were introduced to the study purpose before the anonymous surveys were distributed and they were given about 10 minutes during the lab period to complete the survey.

Participants

All 36 students enrolled in the three sections of organic chemistry laboratory course responded to the survey anonymously in Spring 2018. Based on the institutional data, for the students enrolled in the three organic chemistry laboratory sections, 55.9% (19 out of 34) were first-generation students, 38.9% (14 out of 36) were females, and 22.2% (8 out of 36) were under-represented minority students. 33.3% were juniors and 61.1% were seniors. In terms of majors, 61.1% were biological sciences majors and 19.4% were applied health sciences majors.

Data Analysis

The negative stated items were recoded before data analysis with a rating of "1" suggesting a student's perception of the effect of online videos or intrinsic motivation was low. A rating of "5" suggesting a student's perception of the effect of online videos or intrinsic motivation was high. Cronbach's alpha coefficients, descriptive statistics for the items and subscales, correlation studies, and independent *t*-tests were conducted in SPSS 27. The internal consistency of each subscale was assessed using Cronbach's alpha coefficients, where a benchmark of 0.7 or greater is usually suggested (Murphy & Davidshofer, 2005).

Responses to the open-ended questions were coded by the author. First, the written comments were coded in terms of whether the comments showed positive perceptions of the effect of online videos for their study in the laboratory course. Then the written comments were coded in terms of whether the online videos helped students understand concepts and labs, prepare for the labs, perform the hands-on experiments, or other aspects of the laboratory course. Therefore, the themes were consistent with the subscales from quantitative results. The data were coded based on the ideas shown in the responses. That could be one phrase, one sentence, or an entire response. In this way, one student's response may be coded with only one theme or with several themes, depending on how many different ideas were expressed in a student's written response.

Results

Student Usage of Online Videos

Four items were used to investigate the usage of online materials by students. According to students' responses, 86.1% of students watched at least 75% of the videos and the rest of students watched at least half of the videos. Regarding how often students watched the videos, students' written responses showed that 78% of students watched the videos one to two times by using phrases such as "once-twice", "once, but I put it on pause and took notes", "once or twice". 22% of students watched the videos more than two times by using phrases such as "2-3 times".

Regarding when students watched the videos, the results showed that 39% of students watched the videos before reading the lab manual, about half of students (47%) watched the videos after reading the lab manuals, and 14% of students watched the videos both before and after reading the lab manual, as shown in Figure 1. Regarding the specific time when students watched the videos, students could choose from "at weekend", "once during the week", "the night before lab", "right before the lab", or "when I need some clarification on some concepts." Results showed that 36% of students circled more than one option, suggesting that they had watched the videos more than once or they watched videos at different times. 64% of students chose one option, suggesting that they formed the routine of viewing the videos at a specific time or they had watched the videos once, and among these students, about 1/3 students showed that they chose to watch the videos at the night before the lab as shown in Figure 2.

Figure 1

Results regarding when students watched the videos

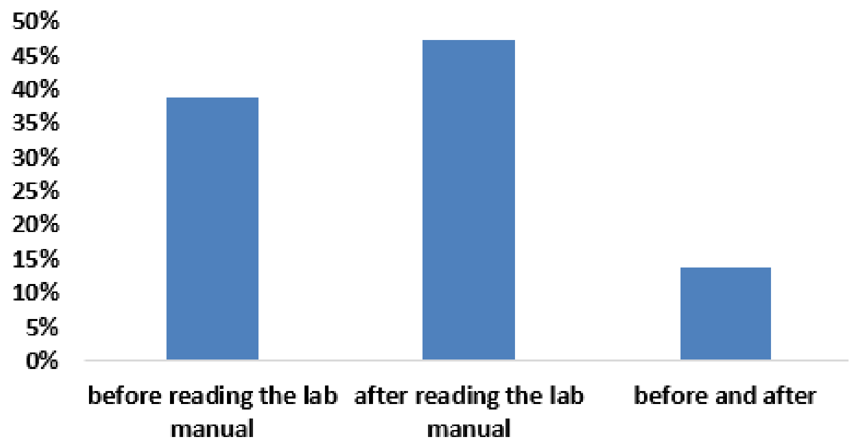
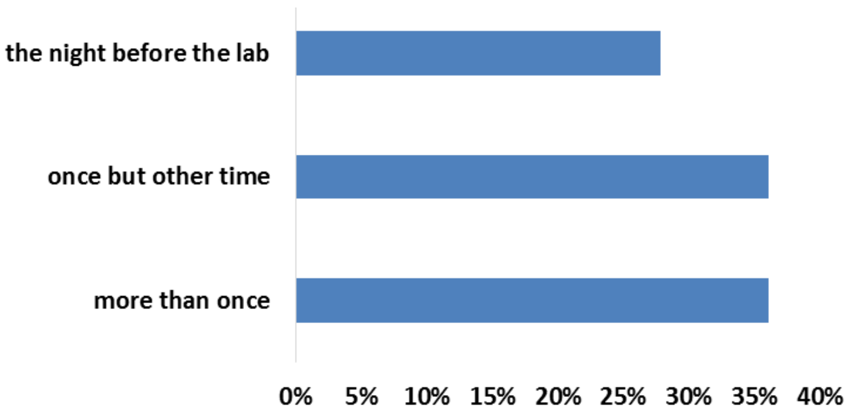


Figure 2

Results regarding frequency based on when students watched the videos.



Note. "Once but other time" means students chose one of the following options: "at weekend", "once during the week", "right before the lab", or "when I need some clarification on some concepts".

Effect of Online Videos

Quantitative Results

A series of survey items were administered to students to collect information regarding how students perceived the online videos were helpful to their chemistry learning in the lab. Both fixed-response questions and open-ended questions were used for this purpose. For the thirteen items ranging from 1 for "strongly disagree" to 5 for "strongly agree", item statistics showed that the means ranged from 3.64 to 4.36, suggesting that students generally agreed that the online videos were helpful to their learning. The skewness and kurtosis for most items were within ±1, suggesting an approximately normal distribution of the items. When examining the internal consistency reliability of the thirteen items, the Cronbach's alpha coefficient was 0.87; however, one negative stated item "*The online videos were not necessary for my* *preparation*" showed a misfit with a corrected item-total correlation of -0.05. As the corrected item-total correlation usually should be greater than 0.3 for a subscale, the negative stated item was deleted for further analysis. After deleting this problematic item, the Cronbach's alpha coefficient for the remaining twelve items increased to 0.90 with corrected item-total correlations ranging from 0.43 to 0.80. The scale was coded as "overall effect" from now on as they measured the general/overall effect of online videos. The Cronbach's alpha coefficient suggested the internal consistency was good for the overall effect scale. The frequency of each response for the twelve items was shown in Table 1.

Table 1

Students' perceptions of the effect of online videos with number of responses for each rating option

Item	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Subscale: Understanding						
1	The online videos increased my understanding of the material of the laboratory class.	16	17	3	0	0
2	The online videos assisted in clarifying confusing topics.	12	15	7	0	0
Subscale: Preparation						
5	The online videos assisted my preparation for the laboratory class.	15	18	3	0	0
6	The online videos helped me to prepare for the in-class quiz.	10	14	6	1	5
8	The online videos allowed me to prepare independently at my own pace.	9	15	10	1	1
10	The online videos helped me with completing the weekly pre-lab assignments.	11	21	1	3	0
Subscale: Hands-on						
9	The online videos allowed more lab time to be available to complete lab tasks.	9	12	9	5	0
11	The online videos helped me feel confident that I can undertake all the tasks in the laboratory class.	5	17	10	4	0
Subscale: Other						
3	The online videos improved my overall learning experience.	12	15	8	1	0
4	The online videos helped me with language differences.	12	8	12	3	1
12	Overall, I am satisfied with the quality of the videos.	9	10	16	1	0
13	The online videos complemented the written material in the laboratory manual.	5	17	10	3	0

When examining the items closely, the twelve items could be grouped into four different subscales based on different aspects of the effect (Table 1). The first subscale measured the effect of online videos on students' understanding of lab, the second subscale measured the effect of online videos on students' preparation of pre-lab assignments, the third subscale showed students' perceptions of how the online videos helped them to perform the hands-on activities in the lab, and the fourth subscale measured the other aspects of the online videos. Therefore, these subscales were coded as understanding, preparation, hands-on, and other, respectively. The Cronbach's alpha coefficient, mean, standard deviation, skewness, and kurtosis for the subscales were shown in Table 2.

Table 2

Cronbach's α coefficients and descriptive statistics of overall effect and the subscales

Subscale	Sample Size	Cronbach's α	M	SD	Sk	Ku
Understanding	36	0.89	4.19	0.73	-0.56	-0.28
Preparation	36	0.67	3.98	0.68	-0.27	-0.23
Hands-on	35	0.61	3.67	0.80	-0.01	-0.66
Other	35	0.77	3.83	0.70	0.17	-0.79
Overall Effect	34	0.90	3.92	0.63	0.18	-0.64

Note. Sk = skewness, Ku = kurtosis

As shown in Table 2, the Cronbach alpha coefficients for the four subscales ranged from 0.61 to 0.89. Understanding subscale had a Cronbach's alpha coefficient of 0.89. The mean for this subscale was 4.19. Preparation subscale had a Cronbach's alpha coefficient of 0.67 and hands-on subscale had a Cronbach's alpha coefficient of 0.61. The lower reliability could be due to the small sample size and the small number of items in the subscales. Preparation, hands-on, and other had means ranging from 3.67 to 3.98, suggesting the students perceived the online videos helped their preparation of the labs, the hands-on work in the lab, and other aspects of the laboratory course. The mean of overall effect was 3.92, suggesting positive perceptions of the effect of online videos on student learning.

Qualitative Results

In order to get more evidence of the effectiveness of online videos on student learning in the lab, an open-ended question was asked for students to provide details on how the online videos have helped them. Among the 34 students who responded to the free-response question, 31 students (91%) expressed that the online videos had positive effects on their learning in the lab while the other students did not respond to the question or expressed that the online videos haven't affected their study. The comments were groups into four themes which supported students' positive perceptions of online videos on their understanding, preparation, hands-on activities, and other aspects of the laboratory course.

Firstly, 32.4% (11) responses showed that students perceived the online videos helped them to understand various aspects of the labs. Some sample quotations follow. According to students' written comments, the online videos helped them to understand the lab better in general, or some specific unknown concepts, or in particular about the procedures, for example, why the lab was done in a particular way. In addition, the students' comments indicated that the online videos helped to clarify their understanding of the materials covered in the lab.

> *"Helped me understand the lab better and is always a good source to review past labs."*
> "*They merely clarify my understanding of the material after I study."*
> *"Helped understand the procedure steps and why each step"*
> *"It allows me to clarify unknown concepts."*
> *"They make me understand the lab better"*

Secondly, 29.4% (10) of the students' written responses provided evidence that the online videos have helped them to prepare for the lab quizzes and to do the hands-on activities in the lab. Six sample quotations were displayed below. The first three quotes reflected that the online videos helped students prepare better for the labs, in particular, the online videos helped them prepare for the pre-lab assignments, such as pre-lab quizzes. The last three quotes suggested that the online videos helped them visualize the procedure/what they needed to do in the lab. This is particularly helpful for students in organic chemistry laboratory because they need to use various glassware, chemicals, and solvents to set up different experiments to learn various techniques in the course.

> *"I used the videos to help me study for the lab quiz."*
> *"Made me plan for class better and had me prepared better for labs."*
> *"They have helped me prepare for lab a little bit, but I study the same amount and still read the textbook."*
> *"Watching the videos help me visualize the procedure in the lab manual"*
> *"I think they are helpful. It's good to see the reading put into practice before doing it on your own."*
> *"It clarifies and gives a visual representation of what I will be doing in the lab that week."*

Thirdly, 29.4% (10) of the responses suggested students perceived the online videos as helpful to them in general or on other aspects of the effect. Some sample responses were shown in the following. The student comments suggested that the online videos were essential to their success in the lab because they may get lost without watching the online videos. Some students also expressed that the online videos were good supplements to the lab manual and were helpful to them.

> *"It helps."*
> *"Yes, I know without them I'll be completely lost."*
> *"They are good supplements to the reading and are very helpful."*

Student Intrinsic Motivation Toward the Videos

Six items were used to measure student perceptions of intrinsic motivation toward the online videos. Regarding the internal reliability of intrinsic motivation, the Cronbach's alpha coefficient was 0.81 and the corrected item-total correlations were between 0.33 and 0.77, suggesting good consistency of scores for data interpretations. Students' ratings of their intrinsic motivation toward the online videos were mixed, 16 students (44%) had negative perceptions (M < 3.00) of intrinsic motivation; however, 15 students (44%) had positive perceptions of intrinsic motivation toward the online videos.

Interrelationship of Intrinsic Motivation and Aspects of Effect Toward Online Videos

Pearson's correlation coefficients were computed between students' perception of the effect of the online videos and intrinsic motivation toward the online videos, as well as between different subscales of overall effect of the online videos. Notable correlations include the statistically significant correlation between intrinsic motivation and overall effect, $r = 0.345$, $p = 0.046$, a medium effect size (Cohen, 1988). As displayed in Table 3, intrinsic motivation was significantly and positively correlated with understanding and preparation subscales, with $r = 0.504$, $p = 0.002$, a large effect size, and $r = 0.348$, $p = 0.037$, a medium effect size, respectively. Understanding subscale was also found significantly and positively correlated with the other three subscales of overall effect, and *r* ranged from 0.614 to 0.638, $p < 0.001$, large effect sizes. The magnitudes of the correlations as shown in Table 3 were small, 0.225 and 0.188, and nonsignificant for hands-on and other subscales with intrinsic motivation.

Table 3

Intercorrelations between the effect subscales and intrinsic motivation

	1	2	3	4	5
1. Intrinsic Motivation	1				
2. Understanding	0.504**	1			
3. Preparation	0.348*	0.618**	1		
4. Hands-on	0.225	0.614**	0.685**	1	
5. Other	0.188	0.638**	0.562**	0.753**	1

Note. * Correlation is significant at 0.05 level (two-tailed), ** Correlation is significant at 0.01 level (two-tailed).

To test whether students' perceptions of intrinsic motivation toward online videos affect their perceptions of the effect of the online videos, independent samples *t*-tests were conducted. The students were grouped based on whether they had positive (M > 3.00) or negative (M < 3.00) intrinsic motivation perceptions. Significant difference was found between the two groups for understanding subscale, $t(29) = -2.856$, $p = .008$, Hedge's $g = 0.69$, a medium to large effect size. Students who had a positive perception of intrinsic motivation scored significantly higher on understanding subscale. For preparation, hands-on, and other subscales and overall effect scale, there was no evidence for a significant difference; however, students who had a positive intrinsic motivation perception had more positive perceptions of the effect of the online videos and the effect sizes ranged from medium to large (Table 4).

Table 4

Students' perceived effect of the online videos by intrinsic motivation for independent samples t-test

	Intrinsic Motivation	*n*	M	SD	Hedges' *g*
Understanding	Negative	16	3.84	0.81	0.69
	Positive	15	4.53	0.48	
Preparation	Negative	16	3.75	0.61	0.68
	Positive	15	4.08	0.72	
Hands-on	Negative	16	3.53	0.87	0.85
	Positive	14	3.68	0.77	
Other	Negative	15	3.77	0.60	0.71
	Positive	15	3.85	0.82	
Overall Effect	Negative	15	3.74	0.62	0.62
	Positive	14	4.02	0.61	

Note. Hedges' *g* is reported because of the small sample size ($n < 20$).

Discussion

The results suggested that most students made use of the assigned online videos, the online videos were convenient for students to get access to according to their schedule and their specific needs, and students could watch the videos multiple times or pause the video to take notes when needed (Bergmann & Sams, 2012), which were in accordance with previous literature reports that online videos assisted students with their preparation for the labs independently and at their own pace (Mellefont & Fei, 2016).

The mean of overall effect was 3.92, suggesting students had a positive perception of the effect of the videos in general. The means for the subscales were all greater than 3 (neutral), suggesting students had positive perceptions that the online videos had helped their preparation, understanding, and performing of the experiments in the lab. The qualitative findings reflected students' positive perceptions of the effect of the online videos in the organic chemistry laboratory course, suggesting that students' free responses were consistent with the quantitative results. In particular, students' comments suggested that they perceived the online videos were helpful for them to understand the lab, to prepare for the lab quizzes, and to perform the hands-on activities during the lab classes. Such results were also consistent with previous findings in the organic chemistry laboratory classes (Box et al., 2017; Chaytor et al., 2017; Fung, 2015; Jordan et al., 2016; Nadelson et al., 2015; Pölloth et al., 2020; Teo et al., 2014). The instructor who taught the organic chemistry laboratory course reported that students performed better in the lab after online videos were provided and assigned to them in 2018 Spring compared with the previous semester (2017 Fall) when online videos were not provided to students. On average, 47.2% students earned A in the laboratory course in 2018 Spring with an average GPA of 3.56 compared with 23.1% of A and an average GPA of 3.26 in 2017 Fall. Furthermore, after students were required to watch the online videos to prepare for the labs, students could do the experiments faster and were able to finish the labs on time, while students usually had a lot of questions regarding the procedure and some students were unable to complete the experiments on time during the scheduled lab time in 2017 Fall.

Although the videos were about organic techniques, such as the usage of analytical instruments and set up of experiments, and so on, the statistics of intrinsic motivation suggested that about half of the students had enjoyed the videos or paid close attention to the videos. Intrinsic motivation is important in the laboratory course because students with higher intrinsic motivation made more usage of online videos for their learning in the lab (Pölloth et al., 2020). Triangulation of results from student motivation and perceptions of the effects of online videos on student preparation in the lab provided more insights into our analysis that online videos worked in the organic chemistry laboratory course.

Pearson's correlation coefficients suggested that students' intrinsic motivation toward the online videos are closely related to the students' perceived effect of the online videos. First, based on the large effect sizes of the correlation coefficients between effect subscales and between understanding subscale and intrinsic motivation, it suggested that when students had more positive intrinsic motivation perceptions of online videos, they were more likely to perceive the online videos could help their study in the organic chemistry courses, for example better understanding of the chemistry concepts, more prepared for the in-class quizzes and hands-on activities, and other aspects of the laboratory courses. The in-dependent *t*-test results provided evidence that students who had a positive perception of intrinsic motivation scored significantly higher on understanding subscale, which suggested that when students found the online videos interesting, they were more likely to pay attention to the videos and therefore benefit from the online videos. Moreover, students who had a positive intrinsic motivation perception scored higher on the other three effect subscales and overall effect scale than students who had a negative intrinsic motivation perception with medium to large effect sizes. The results suggest that we could try to have online videos that not only deliver the chemistry concepts but also can promote student intrinsic motivation so as to have greater impacts on student learning.

Conclusion

The purpose of the present study is to explore the students' perceptions of online videos and intrinsic motivation in an organic chemistry laboratory course where online videos were assigned to students as part of the pre-lab assignments. First, results showed that the online videos provided flexibility for students to watch and learn. For example, students could watch the online videos multiple times at their own time and they could also pause or watch the video multiple times for better understandings, depending on their specific needs. Second, results suggested that students perceived the online videos as helpful. In particular, the online videos could help students' understanding of the lab materials, concepts, and procedures, as well as preparing for the labs. In addition, the online videos helped them perform the hands-on activities in the lab. Students' written comments provided more details for the effect of the online videos, and the findings were consistent with the quantitative results. Lastly, scores from the theory-based intrinsic motivation subscale suggested about half of the students had positive perceptions of intrinsic motivation, suggesting that the online videos held some students' attention when they were watching online videos. Intrinsic motivation was also found positively correlated with effect subscales and students who had a positive perception of intrinsic motivation had a significantly higher perception of understanding subscale. This encourages us science educators to prepare and provide online videos that can stimulate student intrinsic motivation, which can potentially have a more positive effect on student learning. In summary, online videos in the organic chemistry laboratory classes were effective to students' preparation, understanding and performance of the labs, and student intrinsic motivation, which were expected to contribute to student achievement in the laboratory learning environment.

Limitations

There were several limitations in this study. For example, data was collected in one semester in a small institution which resulted in small sample size although the response rate was high. Based on IRB guidelines in the research context, we were unable to compare student perceptions by sections and by subscales. The internal validity evidence of the subscales was not collected because the sample size was too small. Moreover, students responded to the survey anonymously; therefore, it was impossible to identify the students, which limited our analysis to compare results by gender, race/ ethnicity, or first-generation status. Even though the survey was anonymous, it may still cause some self-report issues/biases. In the future, more data could be collected including student identifications, so that more psychometric evidence could be collected at the research setting, as well as to explore how the online videos could help the females, first-generation students, and other students who are underrepresented at STEM.

Implications

Our findings have several implications in laboratory education. First, the results provided more evidence that online videos were useful in laboratory courses. It was convenient for students to watch the online videos based on their time available, and the online videos helped students to prepare for the lab better, understand the lab deeper, and perform the lab better and more quickly. Therefore, lab instructors could select and assign publicly available online videos and resources to students to facilitate their lab preparation and learning. However, it is better that the online videos are aligned with other course materials, such as the lab manuals, learning objectives, and resources available in the setting, which could reduce possible confusions of students. Given resources available, the lab instructors could also make their own videos to match the experiments in their curriculum. Second, by carefully selecting or developing online videos to assist students' preparation and understanding of the labs, the students could have the freedom to watch the online videos at different times and for one or more times, and there could be more meaningful learning in the lab when students do some of pre-lab activities before lab classes and when students are better prepared for lab classes. Based on self-determination theory, when students' basic needs of autonomy, competence, and relatedness are met, we could promote higher student intrinsic motivation (Abeysekera & Dawson, 2015; Deci & Ryan, 2000; Ryan & Deci, 2000). When students are intrinsically motivated, they are more likely to perceive the effect of the online videos and succeed and persist in STEM.

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