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ORIGINAL AND APPLIED RESEARCH

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Short instructional videos for the TikTok generation

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ABSTRACT

This quasi-experimental study examines the effect of short instruction videos on students' business statistics learning. Two hundred and thirty-one Dutch students attended 6-week online seminars on *Business Statistics*. One hundred and nineteen students were in an experimental group, and 112 in a control group. Students in the experimental group watched short instructional videos and studied online quizzes at their own pace. In the control group, students followed teachers' instructions throughout the seminars. It was found students watching short videos significantly outperformed those following teachers' virtual instruction. Short videos were especially useful for those who were good at math. The research sheds light on the design of hybrid learning, particularly for business statistics education at the university level.

HIGHLIGHTS

- A quasi-experimental research to examine the effects of short instructional videos on students' statistics learning performance *vs.* the virtual lectures with teachers.
- Evidence of the benefits of short videos in statistics education for students who are good at math.
- Practical experiences sharing for designers of instructional videos.
- Recommendations for creating short instructional videos in higher education.

KEYWORDS

business statistics; hybrid education; video instruction

Introduction

Shifting to online-only education during the Covid-19 pandemic has challenged teachers to redefine their didactic methods and explore an effective way to engage students in distance learning. Meanwhile, it is witnessed that videos have replaced texts as university students were obsessed to watch TikTok online, a social medial app to share short videos. Instructional videos provide an important method for teachers to build a learning environment that features high-quality instruction (Kunter & Voss, 2013). A plethora of empirical studies has highlighted the advantages of online instructional videos, such as students' increased learning motivation and effectiveness (Marchionini, 2003), attention to the learning content (Clifton & Mann, 2011), and better preparation for exams (Kay, 2012).

However, prior studies yielded inconsistent results regarding what kind of instructional videos can help students learn effectively (Henderson & Schroeder, 2021). Furthermore, we contend that the effects of instructional videos may differ according to subject and learner. Additionally, we have noticed that the application of instructional videos is rarely examined in statistics courses in higher education, despite the fact that statistics and statistical literacy are particularly essential in rapidly changing and increasingly competitive business environments, as stressed by Garfield and Ben-Zvi (2007). The current research was driven by online-only education during the Covid-19 pandemic, comparing the effect of short instructional videos and real-time virtual classes with teachers on students' statistics learning. The main research question is stated as: Will short instructional videos help students learn business statistics better than teacher-centred virtual seminars? In the study conducted by Haughton and Kelly (2014), they found that the hybrid courses of introductory business statistics are sustainable and attractive to university students. However, further understanding of employing short instructional videos in an online-only learning environment is required.

The remainder of the this study is organized as follows. To begin, we present a brief overview of

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previous research related to instructional videos and statistical learning. Based on the previous research findings, we developed our research hypotheses. Next, we detail the methodology and research findings. To conclude, we highlight our contributions to the application of instructional videos in educational practice.

Literature review

Data accessibility has increased dramatically over the last decade, making statistics more important (Carver et al., 2016). With the high demand for statisticians in today's global job market, statistics training programs in higher vocational education have grown significantly in size in the past two decades (Manyika et al., 2011). However, business schools are lagging behind in responding to this demand, and teachers often underestimate the need for innovation in their teaching methods (Horton & Hardin, 2015). According to Moore (1997), statistics instruction and curriculum should be reformed to emphasize the synergy between content, pedagogy, and technology. Nevertheless, he cautioned statisticians to remember that we teach "our subject, not the tool," (pp. 135) and that we must select the appropriate technology for student learning, rather than using the software that statisticians use, which may not be pedagogically sound (Chance, Ben-Zvi, Garfield, & Medina, 2007).

In teaching introductory statistics, there is a pressing need for innovative didactical approaches (Cobb, 2007). In a study that analyzed the impact of the reform movement, Garfield (2001) found that many statistics teachers are trying to align their courses with technological innovation. Alternative learning environments using instructional videos, such as flipped classrooms and hybrid courses are gaining popularity (Carver et al., 2016). According to Fiorella and Mayer (2018), instructional videos refer to multimedia product that presents visual and verbal materials to convey knowledge and can be viewed online. Thanks to YouTube, Khan Academy, and various MOOC platforms, a wide range of online courses on statistics learning are available, shedding light on traditional classroom-based statistics education at universities. The unexpected Covid-19 pandemic forced education practitioners to consider how they can utilize instructional videos to keep students' sustained motivation and boost their learning achievement in an online-only learning environment.

Craig and Friehs (2013) compared two types of online instructional videos for biology students: one used animation and one used text and static images. They found that students who watched the animated videos outperformed their counterparts. Apart from the positive research findings, some researchers have noted that online video lectures may not help students better than live lectures. In experimental research on university students' macroeconomics learning, Figlio, Rush, and Yin (2013) found a very trivial effect of online instructional videos. Chen and Wu (2015) stated that inappropriate video types may result in poor learning performance. They examined the effects of three instructional video types: lecture capture, picture-in-picture, and voice-over presentation method. Their research revealed that the former two types outperformed the latter one, and the voice-over presentation requires the highest sustained attention and cognitive load.

Despite the inconsistent evidence for the benefits of online instructional videos over in-person instruction (Driscoll, Jicha, Hunt, Tichavsky, & Thompson, 2012), there are compelling reasons to continue using them under the prerequisite that they are well-designed. To begin with, instructional videos are beneficial for students who are following lectures that deliver information to a large group, such as mass lectures (Förster, Maur, Weiser, & Winkel, 2022) where there is limited room to detect and rectify individual students' misconceptions. Second, instructional videos can be viewed multiple times (Carmichael, Reid, & Karpicke, 2018), and this is particularly useful for weak students and those who tend to put off studying until the exams (Gilboy, Heinerichs, & Pazzaglia, 2015; Schmidt, Wagener, Guus, Keemink, & van der Molen, 2015). Finally, from a practical perspective, more universities are encouraging instructors to use instructional videos to either replace or supplement classroom-based lectures because of their long-term affordability and the growing availability of video producing and editing technologies (Merkt, Weigand, Heier, & Schwan, 2011; Seo et al., 2021).

From past evidence-based research, we have identified several instructional design principles that may be useful in guiding the design of online instructional videos (Henderson & Schroeder, 2021). For example, some research focused on the communication of videos, such as employing dynamic text to highlight the conversation with learners (Ginns, Martin, & Marsh, 2013), or presenting the instructor's face throughout the video (Guo, Kim, & Rubin, 2014). Some research looked into the video structure, such as inserting pop-up quizzes within the video (Lee & Lai, 2017), or connecting videos with a forum to foster more online discussion (Street et al., 2015). Researchers examined the length (Guo et al., 2014), the combination of

visual and verbal aids (e.g., Mok, 2014), and the feedback strategies (Guo & Reinecke, 2014) of instructional videos. Previous research indicated that different types of instructional videos can result in varying results for learners. Considering the aforementioned principles, the present research focuses on short instructional videos with animation, which are shorter than 4 min.

Hypotheses development

Short instructional videos vs. real-time virtual class

Seaton, Bergner, Chuang, Mitros, and Pritchard (2014) found that students currently spend the majority of their study time watching videos. Lancellotti, Thomas, and Kohli (2016) conducted quasi experimental research with 479 students in their marketing classes. They prepared 75 video modules which lasted 4 to 6 minutes. After comparing students who watched the short instructional videos with those from the previous semesters, they found a significant improvement in students' marketing exam grades, and they further pointed out that the short videos allowed students to focus on those difficult concepts and review them repeatedly. In a study of MOOC video engagement, Guo et al. (2014) studied 6.9 million video-watching sessions from four MOOC courses and noted that video length is the most significant indicator of students' engagement. To augment the effect of in-person lectures in electrical engineering, Martin (2016) investigated tutorial videos of short to medium duration (2–15 min). He concluded that short and well-edited videos enjoyed the highest frequency of access, viewed by students with both high and low lecture attendance. Some researchers indicated that short videos of <6 min are much more engaging than long videos. In the review study on online instructional videos at Kaltura, an open-access digital library of videos for higher education, Hibbert (2014) advised breaking up longer lectures into several 4-min segments.

Finally, in the research by Varao-Sousa and Kingstone (2015), two lecture formats were studied, live and prerecorded videos. Students were asked to report their learning experiences after following both types of lectures. The findings revealed that the presence of a lecturer is crucial for students' learning engagement, knowledge acquisition, and retention, and this presence cannot be fully replaced by instructional videos. Regarding online instructional videos' effect on memory performance, they claimed that students tend to retain less content knowledge because live lectures are more interesting and motivating for students to follow. During the Covid-19 pandemic, most higher education institutions have been required to deliver online instruction. It is debatable whether lecturers should be required to present live online courses or use instructional videos to replace the lecturers. On the one hand, the teaching duties are compulsory for lecturers. On the other hand, the previous research has provided ambiguous findings. Therefore, we formulate our first hypothesis as follows:

H1: Regarding the learning performance of Business Statistics, students who follow the short instructional videos will perform differently compared to those who follow real-time virtual classes.

Mathematical and language skills

There are two types of statistics courses in modern higher education. One treats statistics as a curriculum major, and the other one is connected with other disciplines, such as business, biology, engineering, or medical science. The latter relies more heavily on real data analysis and interpretation. Early in 1994, Jon Kettenring (CATS, 1994, pp. 5–9) pinpointed the industrial demand for nimble problem-solvers as using real-world data.

Taking Business Statistics as an example, the general learning objective is that students should be able to recognize problems in business practices and use collected data to resolve the problems through an investigative process. Afterward, students should be able to interpret and contextualize the results. Nonetheless, some content is considered complicated (Legaki et al., 2020) and makes it difficult for students to stay motivated to learn (Craighead, 2004). To successfully achieve the learning objective, students' mathematical skills and language proficiency are crucial.

Firstly, it requires students' mathematical skills and numerical understanding of the data. Cobb (2007) coined the tedious calculation process in statistics as "a tyranny of the computable" (p. 10) which is still essential even when computers are believed to share many calculation tasks. It remains challenging, however, to teach students to understand statistics through mathematics, partly because some undergraduates' understanding of mathematics is not sufficient enough to join a statistics course (Gould, 2010). It has been found that there is a negative relationship between math experience and statistics anxiety (Forte, 1995). Since the instructional videos can be repeatedly reviewed, they may benefit those who are weak in math more than those who are good at it. Winch and Cahn (2015) looked into the relationship between students' learning performance in quantitative courses

and the use of supplemental videos. In their study, the video tutorials received a high participation rate and were found effective in terms of students' learning.

H2: There is a positive interaction effect of students' math performance and the use of short instructional videos on business statistics examination performance.

In addition to processing and calculating data, Business Statistics emphasizes data analysis as well (Cobb, 1992). It requires students to have certain language proficiency to comprehend complex business problems and interpret the findings (Kros & Rowe, 2016). According to Gould (2010), a challenge for modern statistics education is to go beyond the rote procedure of using formulas and emphasize the understanding of problem context because data are more than just numbers. They are "numbers with a context" (Cobb & Moore, 1997, pp. 801). From action research in English writing classes, Ginting, Syafitri, Nehe, Manullang, and Tarigan (2019) discovered that instructional videos with animated storylines boosted students' learning motivation and kept them concentrated on English writing. For students who are not good at English, short instructional videos may help them understand the business problem effectively. Thus, our third hypothesis is stated as below.

H3: There is a positive interaction effect of students' English performance and the use of short instructional videos on business statistics examination performance.

Methodology

Participants and procedure

A quasi-experimental study was conducted in a business statistics course at the Dutch University of Applied Sciences. The first-year students of the bachelor's program had learned fundamental mathematics and they needed to complete the six-week long Business Statistics course which was offered in the second semester.

Due to Covid-19, the school and other Dutch universities had to provide all lectures online. 231 students from ten classes attended all 6 weeks of online lectures on *Business Descriptive Statistics*. Classes were randomly assigned to an experimental group (five classes, $N = 119$) and a control group (five classes, $N = 112$). The average age of the students was 19 years. Students were informed that the instructional methods may differ among classes.

In the Covid-era adaptation of the course, all students were required to first participate in a weekly, 1-h online mass lecture to learn basic concepts and theories of business statistics. After the mass lecture, students joined the virtual seminar to practice what they had learned. The mass lecture took 1 h while the weekly virtual seminar lasted up to 2 h, with an average of 1.5 h over 6 weeks. The virtual seminar was guided by statistics teachers for each class.

There were two versions of the virtual seminars. The students in the experimental group seminars were asked to watch four or five short videos, each lasting an average of 2 min. Based on the learning goals of each weekly seminar, some seminars contained four videos while some contained five. Following each video, an online quiz consisting of eight to twelve questions was offered. Students could watch the videos at their own pace. They had the option of skipping or reviewing certain parts of the videos. In the last 15 min of the virtual seminar, the statistics teacher showed up to collect questions from students and explain the answers.

In the control group, the traditional classroom-based instruction was shifted online. The statistics teacher guided students throughout the virtual seminar. First, they went through the concepts of the mass lecture together, then the teacher taught students how to solve the quiz questions one by one. The questions were the same as the ones given to the experimental group. The process for the control and experimental groups is depicted in Figure 1.

This study enlisted the help of five statistics teachers. Three of them taught classes from both experimental and control groups. One instructed a class from the experimental group, while the other taught two classes from the control group. The instructional procedure was clearly explained to both parties, and the teaching content was kept the same. All students took a 1.5-h online exam on business statistics in the 8th week. The exam consisted of nine open-ended questions that required students to demonstrate the problem-solving process.

Instrument

The statistics teachers of this subject used Vyond, an internet program for creating animated videos, to create a total of 24 short instructional videos. Each video matched a topic covered in the mass lectures. The content was identical to what statistics teachers demonstrated in their weekly virtual seminars in the control group. Each video was about 2 min long. To attract students' attention in the online-only learning environment, the videos included quite a few vivid

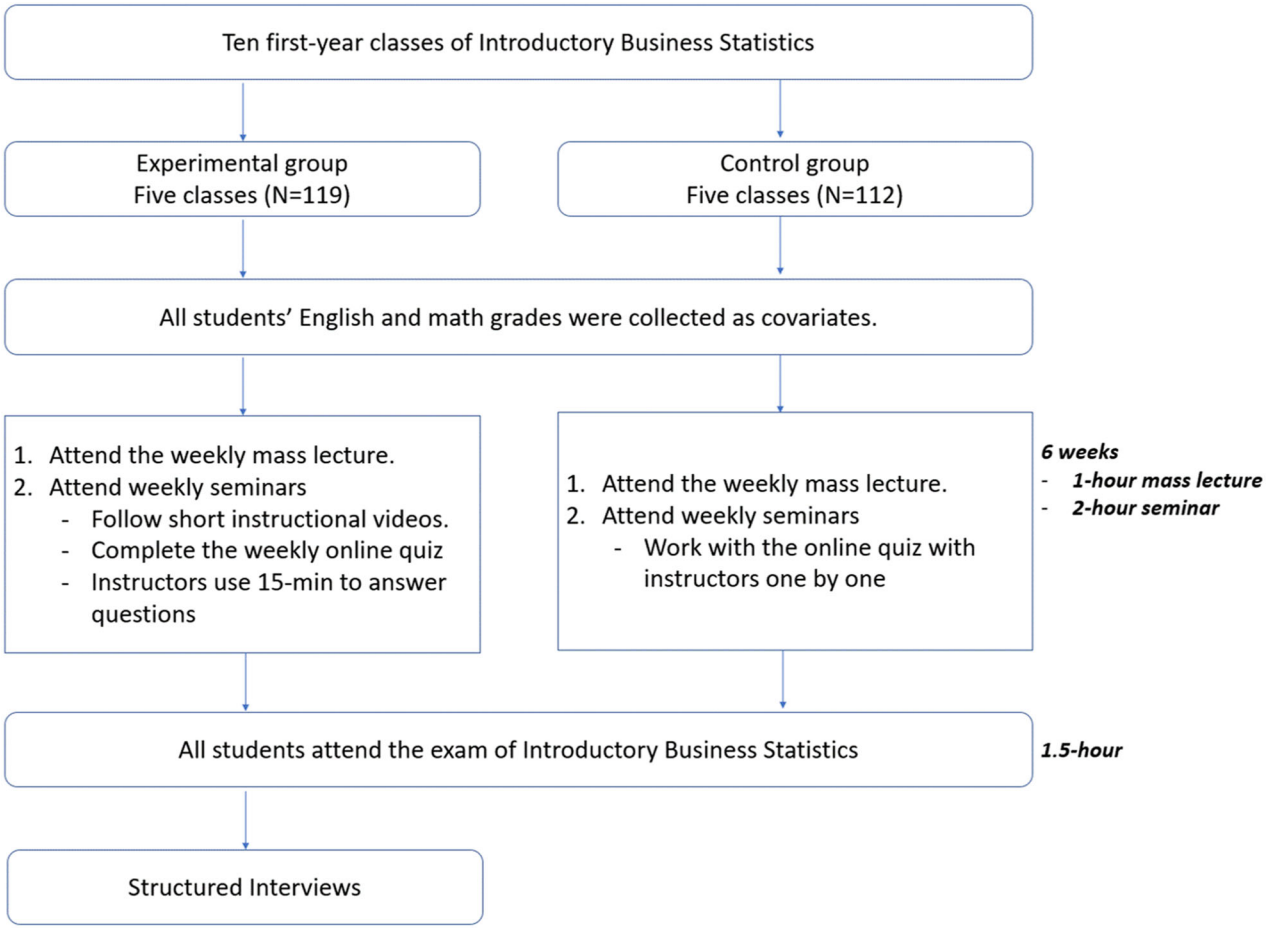

Figure 1. Working procedure of control and experimental groups.

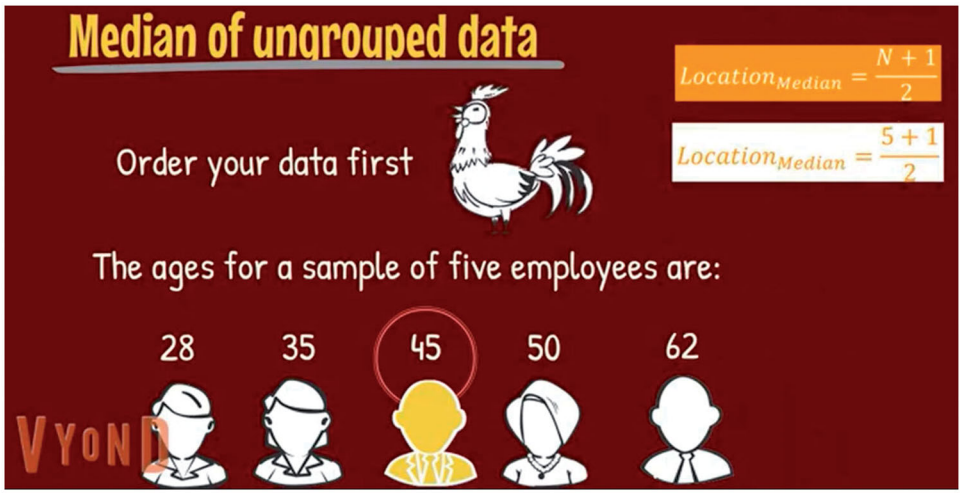

Figure 2. The interface of one short instructional video.

animated images. In each weekly seminars, students were asked to watch four or five short videos that were related to the topic of the mass lecture. All classes in the experimental group have watched the same amount of videos. Figure 2 shows an interface of one example.

Data collection procedure

The course was offered in the second semester for the first year bachelor students who have just had some foundation knowledge of business operations. Their math and business English grades were retrieved from the previous semester. All teachers have more than 10

years experiences of teaching statistics, and the course materials were developed by these teachers together. During the 6-week data collection procedure, we had regular communication with the statistics teachers from both experimental and control groups in order to check whether the class attendance and students' learning engagement were comparable. The teachers also exchanged their experiences of using short videos and instructing students in virtual seminars. Such kind of communication largely minimized the variation of teaching quality between experimental and control groups.

Measures

To measure whether students in the experimental group performed differently as students in the control group, we collected students' grades on the exam in the 8th week. The general linear model was used while students' exam grades were taken as the dependent variable. Moreover, we also retrieved students' math and English exam grades from the previous semester. They were used as the covariates to measure the interaction effect between groups and the math and English skills.

Structured interviews

After the exam, we invited volunteer students from the experimental group to take part in online structured interviews. Twenty-five students accepted the invitation to participate in our interviews, with 17 females and eight males. Among them, eight were German students, and 13 were Dutch students. The other four students came from Bulgaria, Italy, and the United Arab Emirates. The interview consisted of eight questions centered on the aspects of the short instructional videos they valued the most. Twenty-one students mentioned that they have followed almost all weekly mass lectures. All of them followed the weekly practice lectures and watched the short instructional videos. Their contributions help us better understand how short instructional videos might be used in educational settings.

Findings

Descriptive analysis

The grades of students' math and English exams were used to determine whether the control and experimental groups were assigned at random. Both exams were held in the first semester, around three months before the statistics course. The math exam measured students' basic calculation abilities, and the English exam assessed their reading comprehension. Table 1 presents the results of the descriptive analysis.

Table 1. Means and standard deviations (in parentheses) for the measures.

	Control group		Experimental group		Mean difference
	N	Exam performance	*N*	Exam performance	
Math	96	5.79 (1.97)	103	6.20 (1.97)	−0.42
English	103	6.39 (1.03)*	113	5.89 (0.91)*	0.50*
Business Statistics	112	5.58 (2.16)*	119	6.16 (2.14)*	−0.58*

*indicates significant difference at 95% confidence level.

Looking at the math scores, it seems no significant difference between the students in the control and intervention groups, $t(197) = -1.491$, $p = 0.14$. This indicates that students came to these two research groups with similar math abilities. However, the analysis of English skills showed that students in the control group had a significantly better command of English than those in the experimental group, $t(214) = 3.76$, $p < 0.05$.

In the second semester, the Business Statistics course was offered to the first-year bachelor's students. After 6-week intensive teaching for both control and experimental groups, 231 students attended an online exam in the 8th week. To ensure the validity of the online exam, we installed an online invigilation system. A total of twelve professional invigilators were invited to watch the exam process remotely. Exam questions were also selected at random from pools of four or five similar questions of the same difficulty levels. As a result, the likelihood of potential students defrauding was greatly reduced. The exam grades for both control and experimental groups are shown in Table 1.

Effect of short instructional videos

According to the first hypothesis, in the final statistics exam, students in the experimental group may perform differently from students in the control group. The independent sample *t*-test indicated that students from the experimental group achieved significantly higher grades than those from the control group, $t_{(229)} = -2.05$, $p = 0.042$, Cohen's $d = 2.15$. Our hypothesis is confirmed that short instructional videos have a significantly positive effect on business statistics learning.

Our structured interviews with 25 students showed that the short instructional videos were especially helpful for them to understand the basic statistical

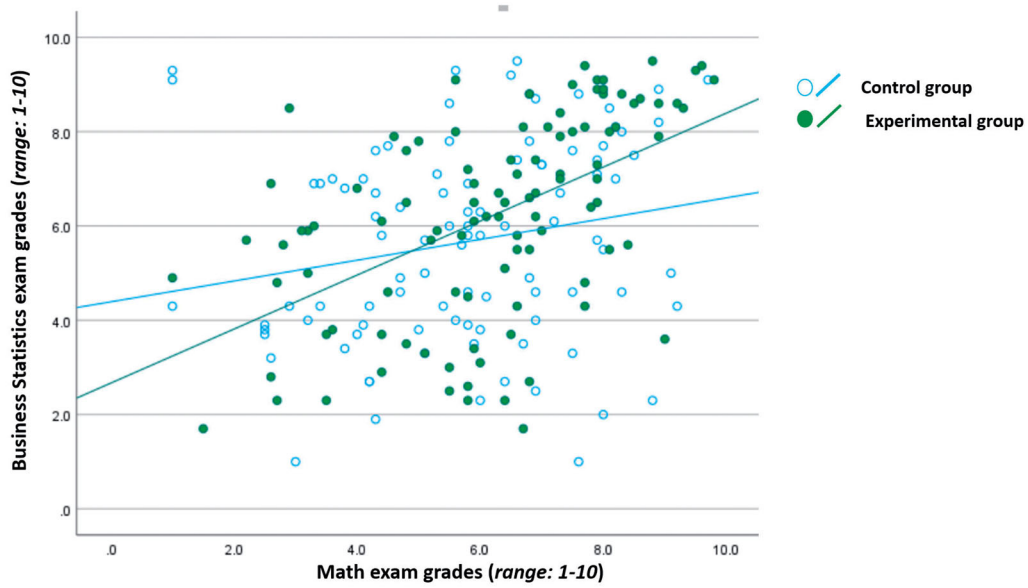

Figure 3. Interaction effect of math exam grades and groups.

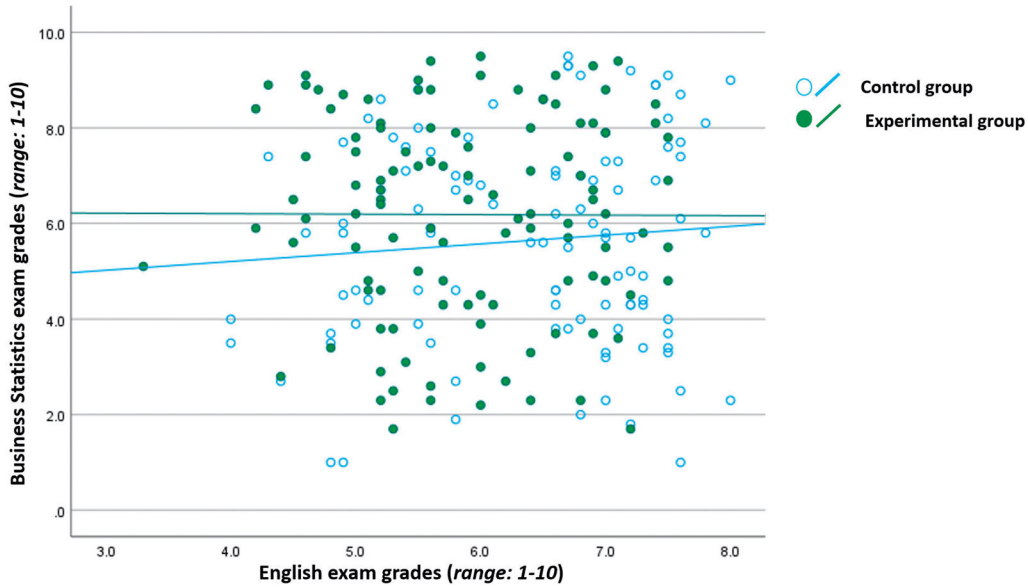

Figure 4. Interaction effect of English exam grades and groups.

concepts and the calculation process. The most prominent benefit of short videos is that they are easy to follow. They indicated that to understand the abstract statistical concepts thoroughly or memorize the calculation steps, they replayed the videos frequently. In the weekly mass lectures, although the concepts, theories, and calculation process were clearly explained and demonstrated, these were ephemeral, and the average length of the mass lecture recordings was around 70 min. Students found it too long to review the entire length.

Joe who scored above 8.0 in the business statistics exam, added, "the instructional videos helped me a lot, and they were more helpful than the mass lectures." Sanne who got 6.2 in the statistics exam, praised the effort put in by all these short videos. She mentioned that she was not confident at the beginning of the course because she was frustrated in most numeric subjects, but the short videos helped her understand the concepts very well and she was able to conduct data analysis independently. Five interviewees further expressed enthusiasm for short instructional videos like this in other subjects like financial accounting and economics, etc.

Looking into students' attendance at the online mass lectures, we noticed there was no statistically significant difference between the control and experimental groups, $\chi^2_{(df=6,\ N=219)} = 0.76$, $p = 0.99$. Receiving

short instructional videos didn't seem to stop participants from attending the weekly mass lectures.

We further checked the frequency of replaying the online recordings of mass lectures and found that the students in the control group watched the mass lectures significantly more than those in the experimental group, $t_{(229)} = 2.39$, $p = 0.018$. On average, students in the control group reviewed the mass lectures 4.15 times while students in the experimental group have watched it 2.50 times before the exam. It is not difficult to understand because students in the control group didn't have access to the short instructional videos. They had to go over the recordings of mass lectures again to prepare for the exam. However, we discovered that the highest frequency of replaying mass lecture recordings happened in Week 5 and Week 6, which may be too late for students to catch up on the learning content.

Short instructional videos and math skills

Because the short videos are easy to watch numerous times, it was hypothesized that students who are weak in math may benefit more from them than those good at math. The General Linear Model was used to test if there was an interaction effect between students' math performance and their groups. Students' math exam grades were used as the covariate, and a statistically significant interaction effect was found, $F(1, 199) = 6.08$, $p = 0.015$, $\eta^2 = 0.03$, as shown in Figure 3. H2 was supported at the 95% confidence level. We categorized students' math grades into three categories, those who scored below 5.5 (insufficient grades at Dutch system), those who scored sufficiently but below 8, and those who score above 8.0. For each category, we compared their statistics exam grades between experimental and control groups. For those who were weak in math, there was no significant difference, $t_{(65)} = 0.009$, $p = 0.99$. For those who scored between 5.5 and 8, there was no significant difference either, $t_{(95)} = 0.752$, $p = 0.45$. But for those who were good at math, we noticed that those in the experimental group scored significantly higher than those in the control group, $t_{(33)} = 2.32$, $p = 0.03$. It seems that short instructional videos may provide better support to students who are good at mathematics.

Short instructional videos and English skills

We also assumed that students with limited English skills would benefit more from the short instructional videos. However, in this quasi-experimental research, we noticed that students in the control group outscored students in the experimental group at the outset. In the follow-up analysis, the interaction effect between English and the group was not significant, $F(1, 216) = 0.40$, $p = 0.53$, $\eta^2 = 0.002$, as seen in Figure 4. Therefore, H3 which states a positive interaction effect of students' English grades and the use of short instructional videos, was not supported.

Discussion and conclusion

The current study was conducted during the Covid-19 pandemic when all Dutch universities were forced to go online. Teachers have tried a variety of instructional strategies to improve student's learning performance in an online-only educational context. Short videos, such as those on TikTok, are attracting young people born after 1996, referred to as Generation Z, all around the world (Khlaif & Salha, 2021). As a result, in the last 2 years, more emphasis has been placed on exploring the instructional values of short videos in higher education.

Focusing on whether short instructional videos can help students learn statistics better than virtual classes with teachers, we designed the current quasi-experimental research. After 6 weeks of mass lectures and weekly seminars, it was found that students who watched short instructional videos significantly outperformed those who attended the virtual seminars with teachers. Based on our interviews with participants, we found that short instructional videos of 2 min or less can effectively keep students focused on the learning content. Students are also motivated to work on the quiz questions to test their knowledge immediately after watching the short videos. This setting has also engaged them more actively with the video content, which is instrumental to their knowledge acquisition (Seo et al., 2021). This conclusion corroborates the findings of earlier research that students' engagement with instructional videos is the key to their academic achievement (e.g., Soffer & Cohen, 2019).

Furthermore, we found that the short instructional videos are particularly beneficial for those who are good at math. They are able to achieve higher grades in the statistics exam than those follow the traditional class instruction. However, there is no interaction effect between short videos and students' English level. One plausible explanation is that the level of English required in first-year students' statistics courses is not very high. All of the descriptions of the problem context or interpretations of the results are written in plain English. Future research should look into

whether short instructional videos can help students who are weak in English learn high-level statistics.

Moreover, due to the limitation of the school's online education system, we could not retrieve students' visiting records of the short instructional videos. It is difficult for us to know the frequency of replaying these videos and map the relationship between learning engagement while video watching and learning achievement. To gain more insights into how the videos influence students' knowledge acquisition, we suggest future research focus on the students' cognitive engagement while watching the instructional videos.

Another suggestion for future research is to compare the knowledge retention of students who watch short instructional videos with students who follow teachers' virtual instructions. In our study, the exam took place right after the regular classes. We have only assessed the students' short-term comprehension of statistics knowledge. Short videos might have helped students more than virtual guidance from teachers because the videos help keep students interested or focused on learning content for a short period. One of the future research topics could be the effects of short instructional videos on long-term knowledge acquisition.

By a way of closure to this study, we would like to share some of our experiences with the designers of short instructional videos.

1. *Designing attractive short instructional videos needs coordinated effort.* For this study, we created twenty-four short videos for a 6-week course. Although each video is only 2 min long on average, it took a team of five statistics teachers and one ICT staff member over 40 h to create them. We used multiple pilot tests to improve the quality of the content and visual depiction. Because the videos can be repeatedly used, it is cost-effective to invest in this process in the long run.
2. *Self-testing allows students to manage their own learning and internalize the knowledge.* Hung and Zhang (2012) stated that students achieved higher grades because they are actively engaged in the digital learning system, such as a higher frequency of assessment for course materials. Students reported that the quiz questions encouraged them to watch the short videos intently. Some of them reviewed the videos many times to answer the question.
3. *Teachers' guidance is still necessary for the group who watch short instructional videos.* In the experimental group, although quiz questions all correspond to the short video content, students still had various questions requiring help from teachers. In sum, short instructional videos can replace partly, but not completely, the teacher's instructions.

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