Online instructional videos as a complimentary method of teaching practical rehabilitation skills for groups and individuals.

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Abstract

Online instructional videos are becoming increasingly common within education. This study adopts a quasi-experimental 2x2 crossover design (control and experimental groups) to evaluate the efficacy of instructional videos to teach practical rehabilitation skills. The students performed practical sessions in class and were formatively assessed by their lecturers. The results demonstrate that the group effect was moderate with an effect size of 0.68 (CI 0.04 to 1.31); the magnitude based inferences indicate the probabilities the video was beneficial/trivial/harmful were 93.9%/5.4%/0.6%. The results of the study demonstrate that the instructional videos had a small to moderate beneficial effect on all assessed criteria.

Keywords: instructional videos; e-learning; psychomotor skills; constructivism.

Introduction

During the last decade the use of instructional videos has gained significant momentum within a range of educational contexts. For example, videos are being used in music instruction (Kruse & Veblen, 2012) as tools for teaching English as a second language (Seilstad, 2012), by DIY hobbyists instead of traditional manuals (Swarts, 2012) and finally videos are being used by students themselves to visualise elements from chemistry manuals (Benedict & Pence, 2012).

Videos can provide on demand demonstrations of how to perform a simple or complex task. They are increasingly being used in educational settings as they have become simple to create and disseminate through e-learning environments (Van Gog, Verveer, & Verveer, 2014). A predominant problem associated with multimedia learning is whether it is possible to promote constructivist learning from passive media (Mayer, 2002). This unique problem is still relevant today as video is fast becoming the primary medium for instructing users about a range of procedures (van der Meij & van der Meij, 2014). Multimedia Learning Theory (MMLT) provides a well-evidenced instructional design approach with substantial effect sizes recorded for the majority of its principles (Mayer, 2014). MMLT encompasses the main pedagogical theories and is used as a foundation for the development of further instructional design principles, that are emerging such as those presented by Meij and Meij (2013). Meij and Meij (2013) state that their guidelines (e.g., provide easy access, use animation with narration, enable interactivity, see Meij and Meij, 2013, for a full list) summarise key notions of accepted thinking rather than advance new theory for instructional video design. Although the instructional videos used in this study were created prior to the publication of Meij and Meij (2013) they are consistent with these guidelines as there are similar principles in earlier sources of guidance (for example Mayer, 2008). Therefore, the application and effectiveness of the specific e-learning resource used in the

current study is the prime focus of this paper. In doing so we aim to advance previous work by Cooper and Higgins (2014) that suggested that instructional videos can be used successfully to help the teaching of practical skills.

Study Background

The study was undertaken in a practical undergraduate rehabilitation module where students are taught the underpinning fundamentals of the rehabilitation process. Rehabilitation is an integral skill for Sports Therapists that should to be taught following an evidence-based approach. Whilst a number of sources provide criteria for the safe and effective rehabilitation of individuals with musculoskeletal injuries, the current study was based on the work of Smith (1998). Rehabilitation is a continuum that can be divided into stages that the patient has to progress through before they can return to sport successfully. Typically these are early, intermediate and late, each can be further sub-divided if necessary when setting physical and psychological goals with the patient. The efficacy of rehabilitation is dependant upon the knowledge (cognitive domain) of the therapist, their ability to communicate and empathise appropriately with the 'patient' (affective domain) and to demonstrate the required exercises with appropriate modifications, regressions or progressions (psychomotor domain) for the patient.

Pedagogical Approach

When assessing an intervention's efficacy it is helpful to consider the theoretical principles that the approach to learning is based upon. The main current learning theories are based on behaviourist, cognitivist and constructivist principles, and each have their own role within the instructional design of e-learning resources. The role of behaviourism within multimedia design has predominantly been associated with lower-level learning tasks, such as

the rapid acquisition of basic concepts and skills. As a result evidence for its usefulness for higher-order learning tasks is lacking (Deubel, 2003). The rationale behind this argument is that behaviourist designs tend to be passive, and do not foster cognitive activity that is generally associated with higher-order learning (Samaras, Giouvanakis, Bousiou, & Tarabanis, 2006). This underlines one of the challenges associated with multimedia learning in educational contexts.

Cognitive theory views learning as the acquisition or reorganisation of cognitive structures to process and store information (Alonso, Lopez, Manrique, & Vines, 2008). The social cognitive model of sequential skill acquisition summarised by Wouters, Tabbers, and Paas (2007) describes how learners initially start with observing a model, but then begin practicing and gradually learn how to self-regulate their own performance. Different cognitive processes such as problem solving and cognitive behaviour modification then accompany this. However, critics of multimedia learning do not link this component directly with the instructional video and see the resource as a form of imitation. This argument has some merit given that videos are generally viewed multiple times prior to performing the skill(s).

Constructivism is less well defined and has varying approaches, which however tend to follow a common philosophy. Learning is understood, knowledge stored and applied most effectively when learners develop their own mental representations from presented information (Mayer, Moreno, Boire, & Vagge, 1999; Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2011). Consistent with current constructivist beliefs, educationalists often emphasise the need for a student-centred learning approach and the transition from teacher-centred to student-centred learning (Kala, Isaramalai, & Pohthong, 2010). Although constructivism is complex and the detail beset with controversy, a constructivist approach in education can be simplified to the idea that learners actively construct their own personal learning experiences rather than passively

receiving them (Kim & Reeves, 2007; Vogel-Walcutt et al., 2011). In the context of multi-media learning, although the media is passive as the viewer only observers rather than interacts, constructivism can be fostered when cognitive activity is present within the learner (Mayer, 2002). Mayer (2002) argues that it is not necessary to include hands-on activities or opportunities for social collaboration when designing multi-media learning environments. In essence, a well-designed multimedia explanation embedded within an appropriately interactive learning environment should provide conditions that will promote learning, consistent with a constructivist approach (Mayer, 2002).

Group vs. Individual Learning

In addition to the general learning theories another dimension considered in this paper is that of group versus individual learning (see Hill, 1982; Laughlin, Hatch, Silver, & Boh, 2006; Lou, Abrami, & d'Apollonia, 2001). Laughlin et al. (2006) showed that cooperative groups of three to six members performed better than independent individuals on a wide range of problems. Similarly, when students worked in pairs there was a positive effect on both group and individual achievement (Laughlin et al., 2006; Lou et al., 2001). Therefore controlling the group size (which was undertaken in this study as far as attendance allowed) may be of critical importance, however none of the identified studies relate to the teaching of practical skills through online videos and are purely focused on problem solving tasks. Therefore this study aims to contribute to this field of enquiry as the use of instructional videos is steadily increasing.

In sum, the aim of this study is to evaluate the effectiveness of online instructional videos as a complementary method of teaching practical rehabilitation skills to students in groups and individually.

Methodology

Participants

The participants were 68 level 5 (2nd year undergraduate) students (mean age 20.6 ± 2.8 years, 53% female). Students were enrolled onto the Rehabilitation and Remedial Therapy module at a University in the North East of England (2012-13).

Study Design

A quasi-experimental design was adopted utilising existing seminar groups as control and experimental conditions for the duration of the study. The experimental condition had access to instructional videos for the first half of the experimental period (9 weeks) whilst the control condition only had access to traditional teaching resources. The groups then swapped conditions for a further 9 weeks, as it would be unethical for students to not have access to a resource that could potentially improve their knowledge, skills and summative assessment scores (i.e., 2x2 repeated measures crossover design).

Condition Allocation

The Rehabilitation and Remedial Therapy module in 2012-13 contained four seminar groups. As two distinct groups were required for the study, two seminar groups were combined to form the control condition (group A initially) and two were combined to form the experimental video condition (group B initially). They will be further identified with a ‘c’ designating membership to the Control group or a ‘v’ for the Video group (i.e. Bv). Creating two groups this way was deemed to be the most feasible option for condition allocation, it also ensured that each seminar group was undertaking only one condition, minimising the potential

for treatment diffusion (the students would typically only prepare with other students from the same seminar group). Whilst this may not be seen as true random allocation (hence quasi-experimental) the seminar groups were allocated alphabetically at the beginning of the academic year. Whilst this cannot guarantee true randomisation, it is a reasonable assumption that this should not directly lead to significant systematic differences between groups, at the beginning of the study.

Academic Setting

For the majority of the Rehabilitation and Remedial Therapy module, the students were requested to perform practical sessions (20 minutes in duration) to demonstrate their understanding of the rehabilitation processes, for peripheral joints, based upon the work by Smith (1998). In the practical sessions the students were using peers as 'patients' and conducted the session as though their peer had a particular injury.

Instructional Videos

The current study used a group of instructional videos (twenty-five short duration videos ranging from 55 to 118 seconds) that were designed in accordance with the principles for instructional design devised by Mayer (2008). Participants in the experimental group had access to the instructional videos through a virtual learning environment (or VLE in this study 'Blackboard'). The participants who had access to the resource could access them freely throughout the duration of their experimental period via any means that were supported by the VLE (computers, tablets and mobile phones).

Procedure

All of the students, regardless of group, were informed prior to the lesson as to which skills they would be required to demonstrate in class that week (e.g., late rehabilitation for the ankle). This enabled them to prepare by accessing either the traditional teaching resources (control group) or the traditional teaching resources plus the online instructional videos (experimental group). Each week the students were asked to devise a series of exercises to form a programme, up to twenty minutes in duration, that would be suitable for the particular stage and joint. Due to the size of the classes the practical sessions were devised and delivered by a small group of students (three to four), and multiple practical sessions were delivered per lesson.

The students were formatively assessed throughout each of their individual practical sessions by their lecturers against an instrument based upon their summative assessment (detailed below). There were six peripheral joints and three distinct rehabilitation stages that students needed to prepare in total throughout the study, which yielded nine measurement opportunities, per condition (referred to as phase 1 and 2 respectively). As three to four groups performed sessions during each lesson, a maximum of 36 aggregate scores (4 groups x 9 weeks) could be obtained for each of the two conditions (control and experimental). Although the scores were gained within groups, they were assigned to each individual (within the group) to provide an individual score for each participant throughout the duration of the study. The students worked in different groups each week ensuring no individual score would be the same. In essence, each participant had the potential for nine separate scores (one score per lesson, per week, over a period of nine weeks) within each condition (experimental or control), yielding an overall total for each condition.

Students were requested not to share elements of the instructional videos with friends outside their seminar group to minimise treatment diffusion. Students did not receive their scores during the duration of the study to prevent resentfulness or demoralisation between groups, particularly from those who initially had access to the instructional videos and then experienced the control condition subsequently. The lecturers responsible for the academic delivery and formative assessment of the module remained consistent throughout the study.

Instruments

The students were formatively assessed (see Appendix 1) on five criteria (Motivation, Safety, Exercise, Timing and Progression) that each used a 10cm analogue scale (from 0 to 10 with no marked increments). The five criteria where directly derived from the end of module summative assessment and mapped to one, or a combination of the cognitive, affective or psychomotor learning domains from descriptors provided by Rovai, Wighting, Baker, and Grooms, (2009). The aim was to maintain the structure of the assessment form the lecturers were familiar with, to enhance the validity of the assessment and the reliability to which it is completed. The formative assessment form was deemed to be reasonably valid as scores correlated moderately and positively ($r = 0.53$) with end of year summative results (Cooper & Higgins, 2014). Totals were summed and averaged to provide an aggregate score for each condition and a score for each specific criterion.

Motivation. This scale is used to identify components of the affective domain and was assessed according to the level of enthusiasm, motivation, professional demeanour and efficacy and clarity of the instructions given by the student to the group throughout the rehabilitation session.

Safety. This scale identifies how safe the programme and how controlled the environment was that the rehabilitation participants were conducting their rehabilitation exercises in. The criterion is a core component of any sports therapist's practice and straddles the cognitive and affective domain.

Exercise. The purpose of this criterion is to determine the appropriateness of the exercises the students have chosen and straddles the cognitive and affective domain.

Timing. This scale was used to quantify how the student was able to manage their time and implement the planned rehabilitation programme logically; this scale straddles the cognitive and psychomotor domain.

Progression. This scale is used to assess the ability of the students to progress the exercises that they have chosen as their patients perform them; as a result this scale straddles the cognitive and psychomotor domains.

Data Analysis

The principal outcome was the difference between the overall mean aggregate scores obtained by each group, during each of the weeks through both conditions (Control vs. Video). Additionally the means of the specific criteria obtained throughout each condition by the student groups will be used to provide a more detailed analysis. The secondary outcome was the difference between the individual students mean aggregate scores and each of the criteria assessed in the study across the two conditions.

For the group-level analyses Cohen's effect size statistics were calculated (Hopkins, 2008) and evaluated using the descriptors and magnitude-based inferences (determined by

referring to a three-level scale: beneficial, trivial and harmful) provided by Batterham & Hopkins, (2006). For the individual-level analyses effect sizes were calculated using the same calculations as above with the addition of Hedges and Olkin's correction for *d* statistic bias that is recommended when there are less than 10 individuals in each condition (Hedges & Olkin, 1985).

Due to the design of the study having to conform to the academic calendar there was no distinct opportunity for a washout period (typically this refers to pharmaceutical studies were the experimental group have a period of time after the experimental condition, for the drug to 'washout' of their bodies before being part of the following condition to prevent erroneous findings) for students to 'forget' the content. As a result the potential for a carryover effect was analysed following Welleck and Blettner's (2012) procedure.

Results

Group-level analyses

Aggregate scores: The mean difference in overall aggregate formative assessment scores between control and experimental conditions was 2.33 (95% confidence interval (CI)0.57 to 4.08) when using group-level data. The magnitude of this effect was moderate (effect size 0.68; CI 0.04 to 1.31) and the probabilities that the true population effect is beneficial/trivial/harmful were 94%/5.4%/0.6%. The difference between student groups is illustrated in Figure 1. During weeks 1 to 9 (phase 1) there is a significant observable difference in the mean aggregate formative scores between the control and video conditions. The trough at week 4 is the only time the score from group Bv, is lower than the score of Ac. Additionally the scores of Bv, are generally more consistent than those of Ac, the latter vary more each week. At week 10 when the

experimental / control groups switched an interesting pattern began to emerge. Group Bc maintained their performance throughout this period as Av, increased their total formative scores. This continues week after week resulting in Av, outscoring Bc in the final week of data collection.

Figure 1 near here

Criterion scores: Table 1 details the mean differences between conditions (with 95% Confidence Intervals) and effect sizes (with magnitude, 95% Confidence Intervals and the beneficial/trivial/harmful probabilities) separately for each of the five criterion scores. The most notable of the five criteria are Timing and Progressions as here the differences between experimental and control groups are moderate in size. Despite this each of the criteria have a probability of being more than 80% beneficial; the most harmful probability was only 3.2%.

Table 1 near here

Crossover from phase 1 to phase 2

Figure 1 shows how the provision of instructional videos was generally associated with higher formative assessment scores, both in phase 1 and 2. It also demonstrates how group Bc experienced a carryover effect in phase 2 due to a minimal/no washout period. This is demonstrated by substantially higher aggregate scores than those that were observed by the control group at the beginning of phase 1. Using the calculations from Welleck and Blettner (2012) the pre-test (to check the assumption of negligible carryover effects) T value is -0.019 ($n=68$, $df=134$, $p < 0.001$) demonstrating that there is a carryover effect and the test for differences yields a T value of -34.76 ($p < 0.001$).

Individual-level analyses

The mean difference in individual aggregate formative assessment scores between control and experimental conditions was 3.92 (95% confidence interval -4.10 to 11.93) when analysed using individual-level data. The magnitude of this effect was small (effect size 0.40; CI -0.40 to 1.21) and the probabilities that the true population effect is beneficial/trivial/harmful were 41%/ 56%/ 3%.

Table 2 details the mean differences between conditions (with 95% Confidence Intervals) and effect sizes (with magnitude, 95% Confidence Intervals and the beneficial/trivial/harmful probabilities) separately for each of the five criterion scores. The mean differences ranged from 0.38 to 0.78, yet despite this the magnitude of each effect size was small (between 0.32 and 0.39). As a result the probabilities of each criterion being Beneficial/Trivial/Harmful were comparable throughout demonstrating that no specific criterion was more important than any other.

Table 2 near here

Discussion

Group-level analyses

The results from the current study clearly demonstrate the benefit of online instructional videos when teaching rehabilitation skills. The aggregate formative scores collected during the first 9 weeks of the study exemplify the difference that the instructional videos made for students working in groups. The overall effect size of 0.68 and a probable beneficial effect of 93.9% with the possibility of harm only 0.6% is very encouraging. In every week (except one) during the

first nine weeks the video group scored higher on the formative assessment than the control group. When the groups swapped conditions a different trend emerged, probably due to a crossover effect. Normally a crossover contamination were the results are not analysed independently are of limited, if any, scientific value (Wellek & Blettner, 2012), and hence such findings need to be treated with caution. In this case however, the crossover effect might indicate the efficacy of the instructional videos, in that it might suggest that the information was retained by those in the experimental group in phase 1 of the study, and then used by them, when they were in the control condition in phase 2.

It is impossible to establish if there was any treatment diffusion between groups, however during the first phase of the study, the differences between mean aggregate scores were generally equal suggesting that the intervention was causing a difference. Treatment diffusion may have been present throughout the second phase of the study, as the students with prior knowledge of the instructional videos would be able to communicate effectively with precise information and/or details about the resources with the other students, potentially gaining reinforcement of prior knowledge. During the second phase of the study group Bc continued to outscore the group Av in most weeks. During this period the Av group steadily began to increase their aggregate formative scores (see Figure 1). This resulted in a more predictable pattern of mean differences between the two groups, as the relative ease or difficulty of each joint manipulation and stage resulted in comparable increases or decreases in both groups.

The study is able to demonstrate how one group when using the instructional videos consistently outperformed their counterpart. This then appears to have enabled them to maintain performance at a comparable level, even when the resource had been withdrawn. This suggests that the approach supported more than the specific skills demonstrated in the videos and involved

more complex learning and broader application of the approach (Kim & Reeves, 2007; Vogel-Walcutt et al., 2011). This is consistent with Mayer's (2002) view that constructive cognitive activity can occur, despite the media being predominantly passive. This study may therefore provide an avenue to explore how higher-order learning can be facilitated by observing instructional videos, an aspect that was previously unsupported (Deubel, 2003).

When the formative assessment criteria were analysed separately, the largest effects were found for Timing and Progressions, criteria that include both the cognitive and psychomotor domains. This finding is not unexpected, since as the students perform an increasing number of rehabilitation sessions, they gain external and internal feedback relating to the Timing of the exercises and knowledge about how patients can be progressed. Overall each of the criteria demonstrates a positive effect when the students were working in groups. The smallest effect size was 0.46 with the lowest beneficial probability being 80.6%.

Additionally, it is also worth noting that the study demonstrates that the 2x2 crossover design is also an ethically sound model, as group B, who were in the control condition initially, were able to match and exceed the scores of group A by the end of the study.

Individuals

In addition to the student group data, each individual obtained an aggregate score based on the performance of the different student groups they participated in throughout the study. Although the scores were obtained within a group setting, it is possible with some assumptions and limitations to track an individual using this method. The mean difference between experimental and control groups was 1.59 greater when analysed using individual-level data as compared to group-level data. However this was not all positive, as the confidence intervals

demonstrate by crossing zero. Greater variation between individuals is not unexpected and the magnitude based inference (Hopkins, 2007) is most revealing regarding this, especially when compared with the student groups. The magnitude based inference from the student groups suggests the intervention was highly beneficial, however for individuals it is predominantly trivial rather than beneficial. It is however worth noting that the potential for harm is only slightly greater than that from the student groups at 3.2%.

The analysis of the formative assessment criteria using individual-level data demonstrates that although the range of mean differences and the distribution is similar to that found when using group-level data, the effect sizes are more comparable and range from 0.32-0.39. Therefore no particular criterion or domain emerges as being most beneficial for an individual compared with the group.

Implications

A limitation of the study is the lack of a washout period, due to the constraints of the academic year. In future a 2x2 crossover design could be used with the mid or inter semester break to allow a washout period. Another potential limitation of the study relates to the participants and their allocation to experimental and control groups. Random allocation was not feasible in this study due as group allocation could not be varied and, as a consequence; we cannot be sure that the groups were balanced at baseline. That said however, our design did allow us to minimise treatment diffusion, and the final phase of the study demonstrated that the groups were able to achieve comparable outcomes.

The current study has identified a larger effect size (d = 0.68) for the use of instructional videos for student groups and individuals alike, than reported previously (d = 0.27 in Cooper and

Higgins, 2014). In addition, the current study has revealed the specific formative assessment criteria where instructional videos improved group and individual performances.

Conclusion

In summary, the instructional videos have consistently proved to be beneficial at best, or trivially helpful at worst, for students when learning and performing rehabilitation skills in both a group and individual context. Whilst there was a greater variation within the individual-level data, the probability that the instructional videos would have a harmful effect for individual students was never greater than 5%. In addition the instructional design and dissemination of the videos from this study suggest that, they may have have supported a student-centred approach. It appears to have encouraged greater self-directed learning, allowing students to retain knowledge, leading to a more consistent performance when the resource was withdrawn. The findings of the study could be applied to other academic areas, where skills can be taught through instructional videos. Further research into this area is therefore warranted due to the growing presence of instructional videos in academic communities, most notably for a practical setting.

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Appendix 1 Formative Feedback Sheet (not to scale)

Rehabilitation and Remedial Therapy

Formative Feedback Sheet

Group names:

Demonstrates enthusiasm, motivational skills and professional demeanour, giving clear and effective instructions to athlete/group

0 10

Safe and controlled environment

0 10

Appropriateness of exercises for the stage of rehabilitation and specific joint concerned

0 10

Effective timing and implementation of program

0 10

Demonstrating appropriate exercise progression

0 10

Seminar time: **Seminar date:**

Lecturer: