



# Digital Affinity in Medical Students Influences Learning Outcome: A Cluster Analytical Design Comparing Vodcast With Traditional Lecture

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**BACKGROUND/OBJECTIVE:** Undergraduate medical education still relies on lectures as the core teaching activity. However, e-learning and new media have begun to augment learning and information gathering over the last few years. The aim of this study was to investigate the effect of 2 teaching formats in surgical education, a classic lecture and a video podcast (vodcast), on knowledge gain, in particular with respect to the participants' characteristics and preferences.

**DESIGN:** A prospective study was conducted over 2 consecutive semesters. A traditional lecture on goitre was given to the first of the 2 semesters and replaced by a matching vodcast made available to the second. An untaught subject (cholelithiasis) served as control. Knowledge gain was calculated as the difference in point scores between entry and mid-module examinations. Furthermore, participants completed a postintervention survey, in which they specifically rated their digital affinity and learning preferences. A cluster analysis was conducted pooling both semesters to evaluate differences between individuals affecting their performance.

**RESULTS:** Both teaching formats resulted in a significant knowledge gain. Two clusters could be identified across

both semesters: Cluster 2 (Digital natives) proved to be significantly different from Cluster 1 (Traditional) with respect to the 4 variables: "technically interested," "use of smartphones," "activity in social networks," and "reading in digital formats." The knowledge gain differences between formats for students in the "Traditional" cluster were statistically insignificant. However, students in the cluster "Digital natives" performed significantly worse when exposed to the lecture format.

**CONCLUSIONS:** Cluster analysis revealed that the students with an obvious affinity to information communication technology were found to be at a significant disadvantage in the lecture. In future, we recommend offering some form of pretest to determine an individual's profile and empower students to plan their learning activities accordingly. (J Surg Ed 76:711–719. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

**KEY WORDS:** Vodcast vs. Lecture, E-learning, Personalized learning environment

**COMPETENCIES:** Professionalism, Practice-Based Learning and Improvement, Systems-Based Practice

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## INTRODUCTION

Medical education is taking more and more advantage of a number of modern information technologies.<sup>1</sup> A large number of medical schools already offer internet-based teaching resources of which the content, format availability, and integration into the curriculum is variable.<sup>2–5</sup>

E-learning and media-sharing technologies have augmented learning and information gathering in particular.

Although lectures and word/text-based resources have remained the standard for many centuries, they do not seem to meet students' current criteria of comfort, attitude, as well as their predilection for information and communication technology (ICT).<sup>6</sup> Although there is no single, universal definition of an affinity to ICT, the umbrella term can be attributed to skills that refer to several aspects related to knowledge, beliefs, and values concerning new technologies. Others define it in a more technically oriented sense as the readiness and ability to use devices, networking components, applications, and systems that allow people to interact in the digital world.<sup>7</sup>

E-learning and media sharing may result in more profound learning, given their ability to provide the information at both a location and time of convenience, at a pace comfortable to students, as well as provide for repeated access to reinforce and revise the material.<sup>8–10</sup> This would explain why web-based tutorials, webinars, wikis, blogs, instant-messaging services, and podcasts, as teaching aids and learning platforms, have gained in popularity so much over the last decade.<sup>11–14</sup>

Podcasting is a simple and user-friendly technology.<sup>15</sup> The term podcast describes the regular publishing of audio excerpts downloaded or streamed from the Internet or a file server to a PC or mobile device. The wide availability of devices capable of streaming film and video over the last decade has seen a rise in the development of video podcasts, more recently frequently termed vodcasts. The addition of visual data to the stream provides an extra dimension to the popularity of the format, turning the listener into a viewer.<sup>16</sup> A number of universities have already digitized and uploaded their entire series of lectures to file servers as streams or downloads.<sup>17</sup> Research suggests that podcasts enhance student engagement, depth of understanding, and overall satisfaction with higher education courses.<sup>18</sup> However, students have also been found to rate podcasts as generally less engaging than a lecture.<sup>19</sup> There are only few studies that have assessed the efficacy of podcasts as a teaching format.<sup>17,20</sup> There is even less evidence as to if and under which circumstances podcasts could replace lectures, and whether podcasts may be implemented to suit specific learning styles<sup>13</sup> or attitudes toward ICT.<sup>21</sup>

To date, students in undergraduate medical education are very much used to relying on lectures as the core of their learning activities. Whereas the popularity of new digital technologies and podcasts is ever increasing, there is still an ongoing and rather heated debate on the effectiveness of the respective methods available.<sup>22</sup> Some students may only see the convenience aspects and possible advantages of podcasts over lectures, such

as flexibility with work schedules, individual time planning, and an ability to pause and/or replay. Others are known to hold heterogeneous opinions on traditional teaching formats when compared to the new formats that fit in with the lifestyles of current generations.<sup>13</sup> From a teacher's perspective, we may not only have to account for the increase in knowledge scores (students' performance), but also the students' expectations and predilections of teaching with such resources.

Here, we conducted a prospective study, in which the learning outcome of a traditional lecture was compared to that of a matching vodcast. Our aim was to explore the effect of both teaching formats on student performance. We were particularly interested in specific differences between individuals, such as digital affinity, as represented by parameters indicating the use of ICT, and learning preference, in order to calculate the respective knowledge gain.

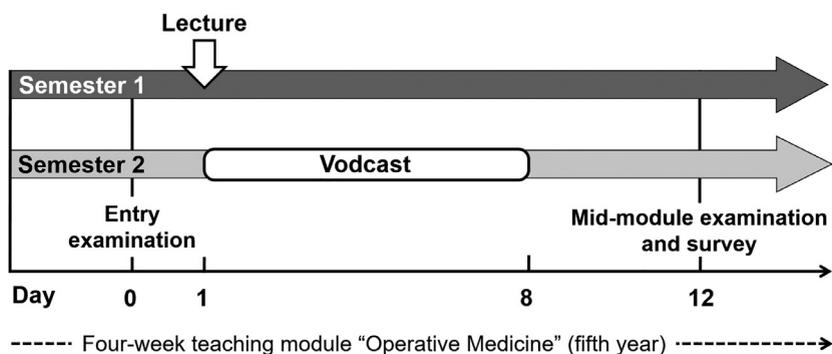
## MATERIALS AND METHODS

### Study Design and Participants

This prospective cohort study was conducted at the University Medical Centre in Goettingen (UMG), Germany, and ran during the 4-week teaching module "Operative Medicine" in the fifth year of the degree course in human medicine. Like most German medical schools, the UMG offers a 6-year curriculum comprising 2 pre-clinical and 3 clinical years, followed by a practical year. The clinical curriculum is modular in structure. During the module "Operative Medicine," knowledge and skills are recapitulated in various surgical specialties through emphasis on clinical decision-making.

At the beginning of the module, the study rationale was explained and students were informed that participation was totally voluntary and nonparticipation would be in no way detrimental to their degree course results. However, the lectures as well as the vodcast were compulsory course elements of the module. All students participating in the study provided written consent to have their data analyzed for study purposes. The structure of the study is outlined in [Figure 1](#).

A traditional lecture on goitre lasting 90 minutes in total was given to the first cohort during the winter term 2014/2015. The lecturer was a qualified consultant surgeon with more than 7 years of plenary teaching experience in general and visceral surgery. The lecture was held in the traditional format of ex-cathedra teaching and divided into 2 sections each lasting 45 minutes and a 15-minute break in between. There were no activating elements as didactic interventions planned during the lecture: however, students were given the opportunity to ask questions.



**FIGURE 1.** Study design within the 4-week teaching module “operative medicine”. The first semester was given a traditional lecture on the subject goitre (lecture condition). In the following (second) semester, the lecture was replaced by a vodcast covering the same contents (podcast condition). Students had access to the goitre vodcast (via the web-based, educational platform StudIP) for a time period of 7 days. The gain in knowledge was calculated from the 2 examinations (entry and mid-term). Students rated their use of ICT and learning preferences in a postintervention survey.

A video of the goitre lecture was recorded in a studio setting (without an audience) using Camtasia Studio 8 (TechSmith). The resulting video included the presentation slides used and the lecturer’s portrait as small video insert. The final vodcast (MP4 format) totaling 49 minutes in length was divided into 8 chapters, the duration of each varying between 2 and 9.5 minutes. The lecture was replaced by the vodcast and made available to the second cohort in the summer term 2015. Students’ access to the vodcast, in particular the number of chapters and the total duration of viewing/streaming, were recorded on a database.

In both semesters, the gain in knowledge was calculated from the scores attained in entrance (baseline knowledge) and mid-module electronic examinations (postintervention), which were scheduled to take place within the institution’s computer facilities. Questions addressing the untaught subject of cholelithiasis served as control in both semesters. The examinations consisted of 10 questions on each subject, 9 single-choice questions, and one 4-option, multiple true-false-type question, all of which were identical in the entry and mid-module examinations. The time limit for answering the questions was set to 1.5 minutes per question.

On completion of the mid-module examination, students were then invited to take part in an online postintervention survey provided through the platform EvaSys (Lueneburg, Germany). Participants were asked to provide their personal data. Furthermore, they were invited to rate their respective learning preferences and digital affinity (as represented by parameters indicating the use of ICT) using a 5-point Likert scale ranging from 1 = strongly agree to 5 = strongly disagree.

### Statistics

IBM SPSS Statistics 23.0 was used to perform statistical analyses. Descriptive analyses were run on the

examination results as item difficulty, item variance, and item discrimination. Cronbach’s alpha served as a measure of internal consistency. Students’ knowledge gain was calculated as the difference in point scores between the entry and mid-module examinations.

An a priori estimation for a small effect size (Cohen’s  $d = 0.3$ ) suggested that a total sample size of 116 was considered sufficient to detect true differences in a  $2 \times 2$  within-between-subjects factorial design (Table 1), given an alpha error probability of 0.05 and a power of 0.95. Of note, Cohen’s “ $f$ ” (equal to 0.15) was used for sample size computation. Since Cohen’s “ $d$ ” is more common, we declared the corresponding “ $d$ ” value.<sup>23</sup>

To evaluate differences between individuals affecting performance (knowledge gain), the analysis was conducted in 2 steps:

- Paired sample  $t$  test: Differences were analyzed in relation to the condition (vodcast vs. lecture vs. control). A paired sample  $t$  test with post hoc Bonferroni correction for multiple comparisons was performed.
- Cluster analysis and factorial ANOVA: Cluster analysis is a statistical approach that can be used to create profiles. Pooling the data from the postintervention survey of both semesters, we ran a cluster analysis using the variables which relate to digital affinity and learning preferences. In the case of homogeneous clustering, a factorial ANOVA was performed in order to incorporate the influence of cluster membership.

**TABLE 1.**  $2 \times 2$  Factorial Design

Subject	Teaching Condition	
Goitre	Lecture (experimental)	Vodcast (experimental)
Cholelithiasis	Not taught (control to the lecture)	Not taught (control to the vodcast)

Students who could not be assigned to 1 of the clusters were excluded from further analysis. In case of a significant difference, effect size according to Cohen was calculated.

We evaluated the quality of extracted clusters, implementing the original silhouette width criterion (SWC) as a validity measure for data partition. The SWC geometrically quantifies cohesion and separation of clusters. It was chosen as a measure of cluster validity, because it has been shown to outperform its variants.<sup>24</sup> Furthermore, it is helpful in detecting redundant variables in the dataset.<sup>25</sup> Since the SWC with the highest value is to be preferred,<sup>26</sup> this criterion is used to determine the optimum number of clusters. One recommendation is that the SWC value should exceed 0.50.<sup>27</sup> Moreover, the ratio of the largest cluster size to the smallest cluster size should not exceed the value of 3.00.

### Ethics Approval

The local institutional review and ethics board judged the project as not representing medical or epidemiological research on human subjects and as such adopted a simplified assessment protocol. The project was approved without any reservation under the proposal number 1/11/14.

## RESULTS

### Response Rate, Characteristics of Participants, and Examinations

One hundred thirty-five and 143 students were enrolled in the module in the winter semester of 2014/2015 and summer semester of 2015, respectively. One hundred two and 78 students, respectively, completed the entry as well as the mid-module examination and were taken into account for the calculation of the knowledge gain. Seventy-six and 64 students presenting complete data from all components of the study (also including the post-intervention survey as well as the attendance of lectures or viewing of the vodcast) were included in the

**TABLE 2.** Demographic Characteristics of Students With Complete Data in Both Conditions

Characteristics	Lecture (n = 76)	Vodcast (n = 64)
Gender female [% (n)]	68.4% (52)	62.5% (40)
Age [mean in years ± SD]	26.8 ± 2.7	26.2 ± 2.8
Semester [mean semester ± SD]	11.0 ± 1.5	10.8 ± 0.8
Mother tongue German [% (n)]	88.2% (67)	90.6% (58)
Parenthood [% (n)]	13.2% (10)	6.3% (4)

final inferential analysis. There were no significant differences with respect to the demographic data on comparison of the study participants in the 2 semesters (lecture and vodcast condition; Table 2).

During the 7-day period over which the vodcast was available, students viewed  $7.2 \pm 1.7$  chapters on average. Interestingly, although of absolutely no consequence to the study, participants spent significantly less time viewing the vodcast when compared to the compulsory lecture (on average 66.23 (median = 58) vs. 90 minutes,  $p < 0.01$ ).

Item characteristics of the examinations were assessed for both semesters. Mean item difficulty was 0.73 and 0.74 respectively, item variance was in both semester 0.15, and item discrimination 0.25 to 0.24. The reliability (Cronbach's alpha) of the entry and mid-module examination was  $\alpha = 0.71$  and  $\alpha = 0.69$ . Therefore, the overall test quality was considered acceptable.<sup>28,29</sup>

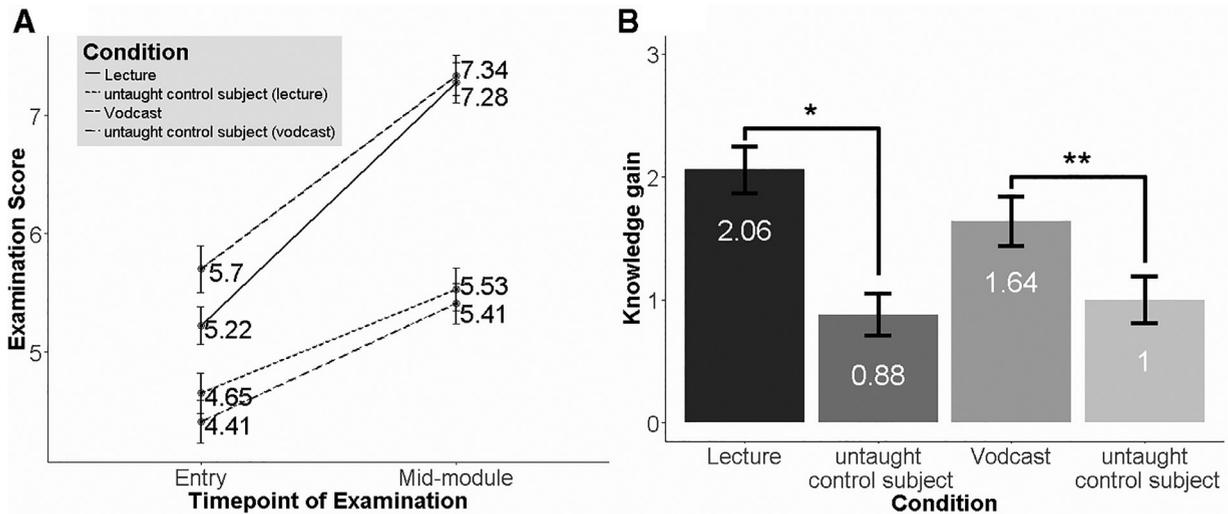
### Student Performance Is Not Dependent on the Teaching Format

Figure 2 displays student performance as raw point examination scores in the entry and mid-module examinations (A) as well as the calculated knowledge gain (B). No significant differences could be determined between the vodcast and lecture on goitre. However, the differences between each experimental condition and its respective untaught control were significant,  $p < 0.001$ .

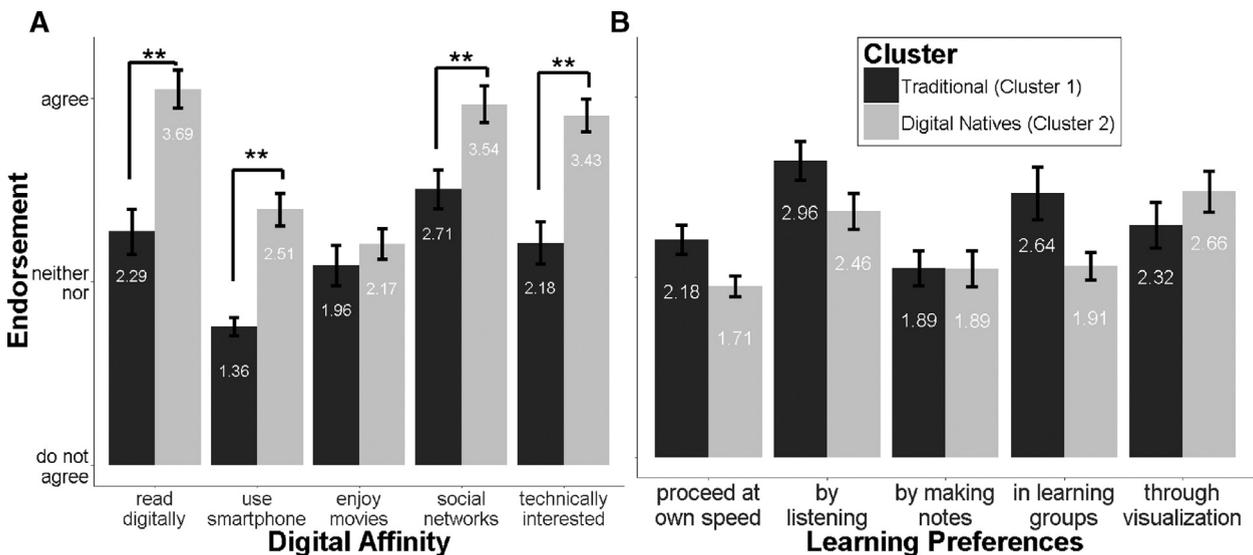
### Identification of Two Different Clusters Relating to Digital Affinity and Learning Preferences

Cluster analysis was conducted across both semesters by pooling the data. A 2-cluster solution yielded the best results with respect to the SWC (0.54) and the ratio of the largest cluster to the smallest cluster of 1.05. The clusters were named "Traditional" (Cluster 1) and "Digital natives" (Cluster 2). The solution consisted of 10 variables, which are listed on the x-axis of Figure 3. The sample size for clustering was reduced by 35 participants who could not be assigned to either 1 of the clusters.

Cluster 2 proved to be significantly different from Cluster 1 with respect to the 4 variables "technically interested," the "use of smartphones," "activity in social networks," and "reading in digital formats" ( $p < 0.001$ ). These variables could best be categorized as "digital affinity," whereas the cluster variables measuring "learning preferences" appeared to be more homogeneously distributed in both clusters. Nevertheless, the latter contributed to the stability of cluster formation.



**FIGURE 2.** Student performance in the experimental conditions lecture and vodcast and the untaught control subject as raw point examination score (and standard deviation) for the entry as well as the mid-module examinations (A). Calculated knowledge gain is significantly higher in the lecture and vodcast condition; \* $p < 0.05$ , \*\* $p < 0.01$  (B).



**FIGURE 3.** Variables included to form the 2 clusters “traditional” and “digital natives” were based on students ratings in the categories “digital affinity” and “learning preferences.” The data are expressed as means and standard error, \*\* $p < 0.01$ .

The demographics of the clusters are given in [Table 3](#). Students forming the lecture and vodcast condition were equally distributed in both clusters. Significant differences were only found for gender, with more female participants assigned to Cluster 2. Parenthood and mother tongue proved to have no influence on cluster membership.

### Knowledge Gain Is a Function of Cluster Membership and Teaching Format Combined

[Figure 4](#) illustrates the association between knowledge gain and cluster membership in each respective teaching

format. When exposed to the lecture format, the knowledge gain in Cluster 2 is significantly lower than in Cluster 1 ( $F(3.1) = 7.41$ ,  $p < 0.005$ ), which is not the case for Cluster 1 when exposed to the vodcast format. According to Cohen’s conventions, there was large effect ( $d = 0.843$ ). In other words, our “Digital natives” (Cluster 2) are at an apparent disadvantage with respect to performance when exposed to the lecture format. This illustrates an interaction effect of the lecture format with the cluster “Digital natives.” In contrast, the traditional cluster (Cluster 1) is at no apparent disadvantage when exposed to the vodcast.

**TABLE 3.** Demographic Characteristics of the Two Clusters

Characteristics	Cluster 1 (n = 66) (Traditional)	Cluster 2 (n = 69) (Digital Natives)
Lecture [No. (%)]	38 (57.6%)	34 (49.3%)
Vodcast [No. (%)]	28 (42.4%)	35 (50.7%)
Gender female [n (%)]	36* (54.5%)	54* (78.3%)
Age [mean age in years ± SD]	26.27 ± 2.37	26.71 ± 3.13
Semester [mean semester ± SD]	10.74 ± 0.93	11.06 ± 1.41
Mother tongue German [No. (%)]	58 (87.9%)	62 (89.9%)
Parenthood [No. (%)]	5 (7.6%)	9 (13.0%)

Note.

\*p < 0.001.

## DISCUSSION

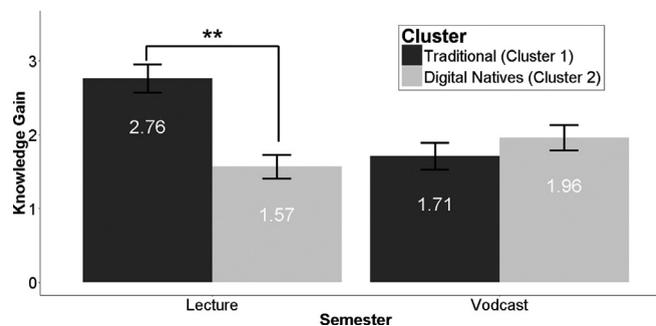
It is without doubt that ICT have the potential to meet current and future needs of medical education.<sup>30,31</sup> Although there is a growing body of research on evaluating the benefits, little attention has been paid so far to any investigation into differences between individual learners.<sup>32</sup> In this study, we demonstrate that e-learning, in this case exemplified by vodcast, can be as effective as a traditional lecture at delivering information on a common surgical topic such as goitre. However, the association of knowledge gain as a function of cluster membership sheds a somewhat different light on the learning effect.

With respect to the technical requirements, vodcasts can be produced with fairly basic equipment and infrastructure these days. Any additional costs may result purely from the labor required to record the video. Many medical faculties implement podcasts/vodcasts as a routine teaching strategy or supplementary learning tool<sup>33–35</sup>). Some universities even systematically record their lectures such as the Faculty of Medicine of the University of Bern in Switzerland<sup>36</sup>).

We conducted the study in 2 subsequent semesters not only to increase sample size but to make it impossible for vodcast participants to poison the results through any unwanted distribution of the vodcast downloads among lecture participants. Taking into account differences between individuals, we were able to demonstrate that students benefit differently from the 2 teaching conditions. We identified 2 clusters of which Cluster 2 could be best described as having an affinity to ICT. Both clusters experienced a similar gain in knowledge when exposed to the vodcast. However, the interaction effect of Cluster 2, the “Digital natives,” with the lecture resulted in significantly lower examination scores. Thus, the students with a greater affinity to ICT were at a disadvantage with the traditional teaching format of a lecture, whereas the vodcast suited both clusters. This finding may perhaps reflect a general trend in society as a whole involving divided attention spans, as well as changes in tolerance and needs, through shifts in the way information is presented and disseminated.<sup>27,37</sup> It would appear from our results that some form of forward compatibility exists in those used to the established teaching formats when exposed to newer information communication formats. In contrast, the digitally literate new generations may appear to lack the reverse compatibility required to come to terms with established, classic formats such as lectures.

As a consequence, and from the teacher’s perspective, more student-oriented e-learning modules need to be implemented to improve learning efficiency.<sup>38</sup> Institutions may even suggest a self-assessment strategy, so that students can determine their own personal profile and subsequently choose the appropriate teaching format or medium, respectively. An adaptive approach could use the corresponding learner characteristics and suggest effective strategies by implementing a corresponding prompt.<sup>39</sup> Knowing one’s learning preferences could further facilitate learning or perhaps at least give students hints as to where they may be at risk on exposure to a specific teaching format.<sup>40–42</sup>

The strength of our study lies in the fact that the same teacher delivered both the lecture and the vodcast. As a



**FIGURE 4.** The association between knowledge gain and cluster membership in each respective teaching format. The data are expressed as means and standard error, \*\*p < 0.001.

result, student performance in the mid-module examinations may be attributed to the identical content rather than to the medium employed. Indeed, the information delivered in both the lecture and the vodcast was highly structured, well-spoken, and clearly summarized. The results of our study illustrate that both conditions provided students with the required material leading to an improvement in performance. The similar knowledge gain in both teaching formats is very much in line with recent randomized (crossover) trials, which also revealed that students demonstrated similar information recall after vodcast and live lectures or print media.<sup>19,43–45</sup>

When vodcast and lecture are compared, accessibility and durations of study have to be considered. Inspection of the log files revealed that the time students allocated to studying with the vodcast would appear to be significantly shorter than with the lecture. Of course, the lecture was effectively longer than the vodcast (with an incorporated break, time for questions, gaps in delivery). It would also be exceptionally difficult to assess exactly how much time any student devoted to learning during a lecture. The same obviously applies to the vodcast. However, since the learning outcome was similar, this may be an indication that the vodcast worked more efficiently.

The success of the vodcast may be further enhanced by offering a more flexible, user-oriented approach, empowering students structurally as well as psychologically.<sup>46</sup> The beneficial educational effects in conventional lecture-based environments are well documented for the healthcare professions; nevertheless, these can be easily outperformed by teaching formats including personal interaction and group discussion.<sup>47</sup> In the case of our vodcast, no activating elements were included from the outset. However, carefully designed “e-tivities” may compensate for learning interactions that usually occur between teachers and students.<sup>48</sup> Aimed at fostering student empowerment in the near future, “e-tivities” may provide different forms of active and participative online learning.<sup>49,50</sup>

The significantly different distribution of female participants in the cluster with a pronounced affinity to ICT may be rationalized as an attempt by females to catch up with their male peers. However, Link and Marz found that it is not gender which actually accounts for differences in ICT use, but rather age, experience, and whether or not the Internet and computers form a part of one’s leisure activities.<sup>51</sup> Nevertheless, there is vast evidence that females feel less confident using ICT.<sup>51,52</sup>

## Limitations

There were several limitations in this study. Although all participating students were at the same stage of their degree course at the time they participated, we cannot

exclude confounders such as differences in socioeconomic and educational background, as well as prior medical training or experience. However, this well reflects the genuine challenge of a heterogeneous population of students with whom educators and examiners are confronted. It is important to restate at this point that we specifically chose our participants to be recruited from 2 separate consecutive semesters. Thus, we avoided any contamination of the vodcast semester by the lecture participants. We had to assume that students would distribute the vodcast illegally among those randomized to participate in the “old-fashioned” lecture group, had we selected participants randomly for each condition in only 1 semester. Of note, when given the choice, students are known to prefer vodcasts as a supplement to traditional lectures, but not as a replacement.<sup>44</sup>

There were 35 students, who could not be clearly assigned to 1 of the clusters. These may comprise a third group, perhaps more versatile in learning. However, future studies may have to explore further characteristics to capture the exact profile.

Over the course of the study, a significant number of students excluded as a result of not participating in all components of the study and/or failing to provide the data requested on the questionnaire highlights the potential for response bias. Our interventions comprised a single and somewhat brief teaching event and knowledge was assessed short- to mid-term following the intervention. A crossover trial with sequential knowledge assessments over a longer period of time may be warranted in further studies.

## CONCLUSION

A greater degree of affinity to ICT was found to have a negative impact on the learning outcome of the lecture. In contrast, the vodcast proved to be as effective as the lecture with respect to knowledge gain and proved to be a reliable content delivery platform to students from both clusters. On the foundation of our study, we would recommend offering some form of pretest to determine an individual’s personal learning profile and empower students to plan their learning activities accordingly.

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## SUPPLEMENTARY INFORMATION

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