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Original Article

Modernized Didactic Techniques and Their Impact on the Teaching of Histology by Means of Virtual Microscopy

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ABSTRACT

Background: Virtual microscopy is heavily reliant on the quality of computer equipment. The purpose of this study was to determine how students perceived computer upgrades in a histology classroom, and whether these upgrades had any effect on their performance in the administered tests.

Methods: This was a pretest-posttest experimental study. Census sampling was applied, and a structured researcher-made questionnaire with 5 items was distributed to 83 students (23 males, 60 females, 20-22 years old). The students took a histology course at the Faculty of Medicine and Dentistry of Palacky University in Olomouc, Czech Republic. The outdated technical equipment used in the first semester was replaced with modern systems in the second semester in 2019. Moreover, students' performances were compared in computer-aided tests. We compared the average test scores (percentage of correct answers) of the same group using the Wilcoxon test before and after the upgrades. To exclude other possible influences (e.g. better understanding of histology in 2nd semester and approaching histology exam), we also compared the test scores of students who had attended histology classes in the preceding year.

Results: In total, 75 completed questionnaires (90.4%) were returned, and the results showed that the majority of students (82.7%) noticed a difference when using the new computer equipment. They pointed to the overall comfort of viewing virtual slides using widescreen full HD monitors (n=64/75, 85.3%), better perception of details (n=59/75, 78.7%) and a lower incidence of technical difficulties (n=46/75, 61.3%). Moreover, an improvement was observed in students´ performance in tests (P=0.0002) following the upgrades.

Conclusion: Investment in the modernization of didactic techniques should be considered as an integral part of any e-learning strategy in morphological fields such as histology.

Keywords: Virtual microscopy, Computer upgrade, E-learning, Teaching histology, Perception, Performance

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Introduction

For many decades, teaching of histology and histopathology was based on the observation of structures in glass slides under the light microscopes. With the rapid digitization of education and introduction of virtual microscopy over the past two decades, instruction in this field has been dramatically transformed in most academic institutions across the globe (1, 2).

This teaching method is based on the observation of digitally scanned histological specimens via computer, and as such it is a suitable replacement for glass specimens. The whole teaching procedure can be based on this approach. Many studies have pointed out the undeniable didactic and practical advantages of teaching histology and histopathology using virtual microscopy (3, 4). Teachers and students can simultaneously observe the same structures. In this sense, inter-individual variability (which is common for glass slides) and changes in quality over time do not play a role in this approach. Furthermore, it is possible to teach larger groups of students. Additionally, one can set up remote access to a database of virtual slides, allowing students to view virtual slides from anywhere and at any time (5-7).

These indisputable advantages of teaching histology using virtual microscopy are reflected in the students´ opinions. They clearly prefer this method, or a combination of virtual microscopy and traditional glass slides, over mere observation of these slides under a light microscope (8, 9). This method of teaching histology appears to be directly dependent on the quality of computer equipment (10). As for morphological sciences, no substantial information is available as yet regarding the effect of the computer upgrades on students´ perceptions and performance in tests.

The first aim of the study was to find out how the computer equipment upgrades in a histology classroom were perceived by students. The second aim was to investigate whether the upgrades could affect the students´ performance in tests.

Methods

Study Design

The present study was a pretest-posttest experimental design with one group being subjected to two subsequent interventions.

Setting and Participants

The study was conducted in summer and winter 2019 at the Dental School of the Faculty of Medicine and Dentistry, Palacky University, Olomouc, Czech Republic. The population included all students attending scheduled histology classes at the School. Those students who were unwilling to continue their participation in the study were excluded.

Intervention

The intervention involved an upgrade of technical equipment in a histology classroom. When first introduced to e-learning platforms in 2011, the classroom was equipped with 30 personal computers and light microscopes. Technical specifications of the computers were as follows: Intel Core 2 Duo EB 400 processor, 4GB DDR3 1333 MHz memory, 250 GB HDD, Windows XP Pro operating system, and 19´ monitors (1280×1024 resolution). During summer 2019, the computers were replaced by new ones with the following specifications: Intel Core i5-8500T processor, 8GB DD4 2666MHz memory, 256 GB SSD, Windows 10 Pro operating system, 22´Full HD monitors (1920×1050 resolution). Therefore in 2019, arrangements were made for students to receive training with old systems in the first semester and new ones in the second semester. Students completed the questionnaires at the end of the winter semester (December 2019), i.e., at the end of the histology course. The participation in this study was on a voluntary basis.

Outcomes

We used a researcher-made structured questionnaire with a total of 5 questions to evaluate students´ opinions on the upgrade of the computer equipment. The questions were scored on a three-point Likert scale (Yes / I don´t know / No). The individual questions are listed in Figure 1. The answers were anonymous.

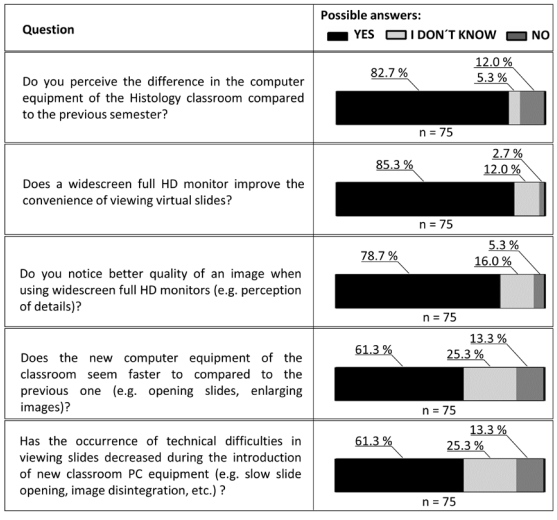

Figure 1: Evaluation of students´ opinions on upgrade of computer equipment. The results are displayed as the frequency of answers to individual questions. The questionnaire was answered by 75 students at the Dental School of Palacky University.

The questionnaire was validated by experts from the faculty, and CVR and CVI were used. The reliability was measured using Cronbach´s alpha coefficient. In this study, CVR scores were found to be 1.0 (3 questions) and 0.5 (2 questions), and the CVI for the entire instrument was 0.80. The Cronbach´s alpha coefficient for the reliability of the questionnaire was reported as 0.83 in this study.

Students´ knowledge was assessed by means of three computer tests during each semester (semesters 1 and 2). Each test included a total of 25 multiple-choice items presented on virtual slides (sample test questions are provided in Figure 2). To exclude influences other than computer upgrades, we also compared the scores with those of the students who had attended histology classes in preceding year (2018; n=68).

Sample Size

The sample size for this study was calculated using Cochran´s correction formula for categorical data: $n = \frac{n_0}{1+\frac{n_0}{population}}$, where $n_0 = \frac{t^2 * pq}{d^2}$, assuming standard deviation P=0.5, and acceptable margin of error of d=0.05 (11), using census sampling method. The minimum sample size was calculated

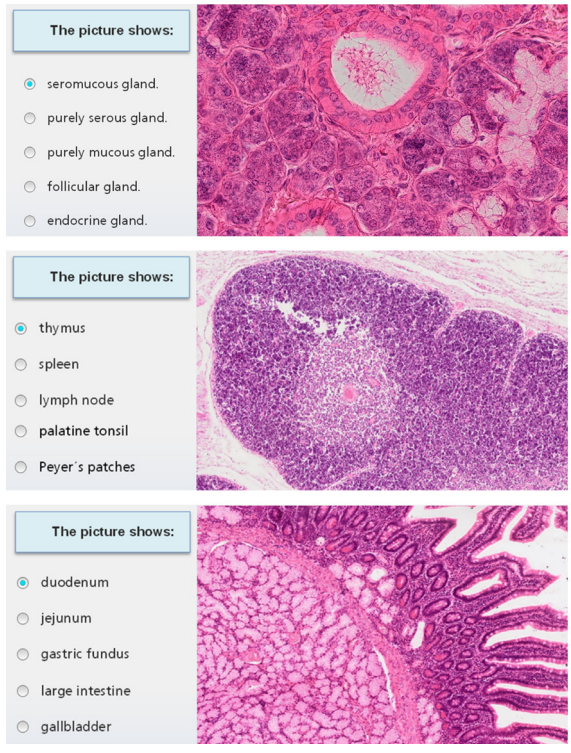

Figure 2: Sample multiple-choice questions.

to be 68. In total, there were 83 students, including 23 males and 60 females, who were in the age range of 20 to 22 years.

Statistical Methods

The data obtained from the survey study were evaluated as scores and percentages of the answers. To evaluate students´ performance in the tests, we compared the average test scores (percentage of correct answers) of each individual student for the first and second semesters (before and after the upgrades). For that purpose, Wilcoxon signed rank test was used at a significance level of $P<0.05$. The same calculation was applied to compare the test scores obtained for students in the year 2018. All calculations were performed by using GraphPad Prism 6.0.

Ethical Considerations

The study was conducted under the supervision of the Faculty of Medicine and Dentistry at Palacky University in Olomouc, Czech Republic. The study objectives were explained to all students. The participation of students in the questionnaire survey was voluntary and the answers were anonymous.

Results

We distributed the questionnaires to all 83 students (23 males, 60 females, 20-22 years of age) attending scheduled histology classes at the Dental School of the Faculty in summer and winter semesters of 2019. A total of 75 evaluable questionnaires were returned. This amounted to a response rate of 90.4%, which was sufficient to obtain representative results.

Students´ Opinions on Computer Upgrades (Survey Study)

The survey revealed that the upgrade of classroom computers for practical teaching of histology was generally very positively received by the students. Answers were obtained from 75 out of 90 (90.4 %) students of the Dental School for evaluation. The results are displayed as the frequency of answers to individual questions (see Figure 1). The vast majority of respondents (n=62/75, 82.7%) noticed a difference in using new computer equipment, and reported an overall greater comfort when viewing virtual slides. Similarly, a noticeable majority (n=59/75, 78.7%) acknowledged that the use of widescreen full HD monitors improves image quality and the visibility of details. Students also reported higher speed when working with new computers (n=46/75, 61.3%), as well as lower frequency of technical difficulties in viewing slides (n=46/75, 61.3%). More details are provided in Figure 1.

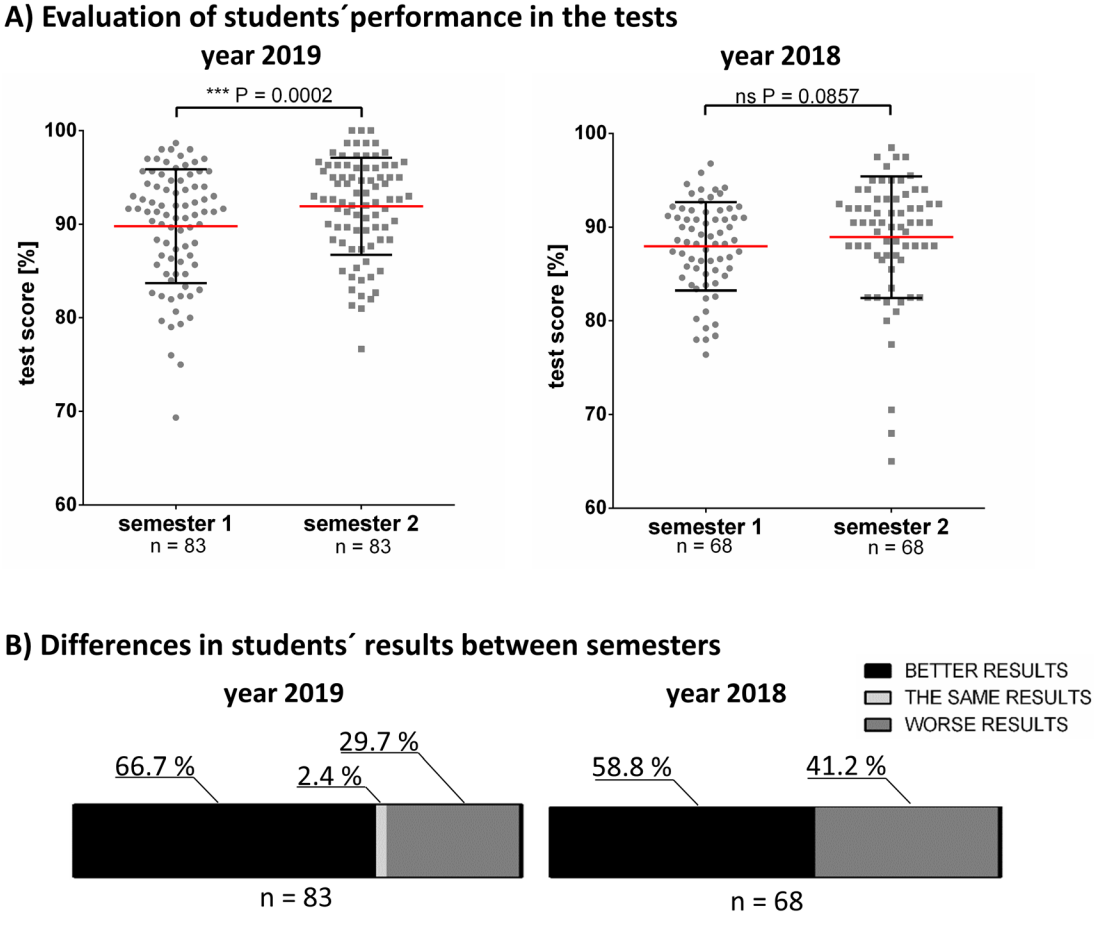

Figure 3: A) Evaluation of students´ performance in the first and second semesters of 2018 and 2019 (in 2019 the computer upgrades for the histology classroom were implemented between the two semesters). One dot represents average test score [%] of one student, red line represents the entire group's mean score, and error bars represent SD. The results were evaluated by Wilcoxon signed rank test at the P<0.05 level of significance. Statistically different results are marked by asterisk. B) Differences in students´ performances between semesters (evaluating the percentage of students with higher, equal and lower average scores in the tests administered between the two semesters of 2018 and 2019.

Evaluation of Students' Performance in Tests

It was observed that the students (n=83) achieved better test results with new computers. In total, 56 out of 83 students (66.7%) achieved higher test score in semester 2 compared to semester 1. On the flip side, 25 students (29.7%) achieved lower test scores in semester 2, and in 2 cases (2.4%) the scores were identical in both semesters. The average test score for the entire group was 89.79±6.08% in the first semester, and 91.92±5.18% in the second semester. The difference in scores between the two semesters was statistically significant with P=0.0002 (Wilcoxon test). The test scores of the students attending histology classes before the computer upgrades (n=68) showed smaller improvement after the upgrades, with 40 students (58.82%) achieving higher scores and 28 (41.17%) achieving lower scores in the second semester compared to the first semester. The average test score for whole group was 87.96±4.71% in the first semester and 88.94±6.48% in the second semester. In this case, there was no significant change in test scores between the two semesters, with P=0.0859 (Wilcoxon signed rank test). Sample test questions and students´ test results are displayed in Figure 2 and Figure 3 respectively.

Discussion

The aims of the present study were to find out how the computer upgrades in a histology classroom were perceived by students and whether these upgrades had any effect on their performance. The results showed that students acknowledged the impact of the upgrades on the quality of instruction in the histology classroom. It was also revealed that the students displayed a better performance in tests after the upgrades.

To the best of our knowledge, no other study has focused on students´ perception of computer upgrades in histology courses, and the possible effects of these upgrades on students' motivation, abilities and learning performance.

The literature shows that, compared to the traditional method of glass slides and light microscopes, students clearly prefer virtual microscopy or a combination of virtual microscopy and glass slides (12, 13). As verified by our results, computer upgrades could make the study of virtual slides much easier for students. Here one needs to take into account the specifics of the histology courses that students take at the beginning of their medical studies. Histology is a morphological subject that centers on students' ability to correctly recognize and identify the particular structures in tissues, i.e., it is crucial to pay attention to details. The results of our questionnaire survey demonstrated that modern computer equipment can improve the image quality and visibility of minor details. Improvement was also observed in terms of the students´ overall comfort when working with virtual slides. These findings are important in view of the fact that virtual microscopy, as compared with light microscopy, enhances students perceptive abilities, which are a motivational factor in the study of histology (14).

Lee et al. recently showed that the students whose instruction involved a combination of virtual and light microscopy achieved significantly better scores in laboratory exams compared to the ones using light microscopy only (15). A meta-analysis published by Wilson et al. also revealed that virtual microscopy had a small yet significant positive effect on learner performance compared to light microscopy (16).

Furthermore, it is known that students improve their results in following semesters, and this corresponds to the fact that in the second semester, students perceive histology as easier compared to the first semester (17). To find out whether the computer upgrades made any contribution to the improved results in the second semester, we compared the inter-semester results of the students using new computers in the second semester with the results from previous year, when only older computers were used in both semesters. The improvement in test results (second semester) was statistically significant only for the

students working with upgraded computers. New computer equipment accompanied by higher image quality and better visibility of specimens can be conducive to a better understanding of histological structures. This will, in turn, contribute to improved student performance in tests, as observed in our study.

The results of the questionnaire survey showed that the upgrade of computer equipment in the histology classroom was acknowledged by students in all the monitored parameters. We also observed statistically significant improvement in students´ performance in the administered tests after installing the new computers. Investment in the modernization of didactic techniques is one of the key ingredients of an e-learning strategy for teaching morphological subjects. The results of this work may be relevant for all morphological disciplines such as anatomy, histology and histopathology, where the perception of details is of paramount importance.

Modernization of computer equipment between the two semesters provided us with a unique opportunity to assess the impact of this development on students´ perception and performance in tests, since it was the only year in which a group of students were exposed to both old and new equipment. A limitation of this study is the fact that this effect cannot be assessed over a longer time period. Therefore, further research may be required to verify our findings.

Ethical Considerations

The study was conducted under the supervision of the Faculty of Medicine and Dentistry, Palacky University in Olomouc, Czech Republic. The participation of students in the questionnaire survey was voluntary and the answers were anonymous.

Authors´ Contributions

Study concept, design, preparation, and critical revision of the manuscript were conducted by all authors who participated in all stages of the research process. All authors read and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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