Interactive Atlas of Histology
A Tool for Self-Directed Learning, Practice, and Self-Assessment

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Purpose: An interactive atlas of histology was developed for online use by chiropractic students to enable them to practice and self-assess their ability to identify various histological structures. This article discusses the steps in the development, implementation, and usefulness of an interactive atlas of histology for students who take histology examinations. **Methods:** The atlas was developed by digitizing images imported through a video-microscope using actual microscope slides. Leica EWS 2100 and PowerPoint software were used to construct the atlas. The usefulness of the atlas was assessed through a comparison of histology exam scores between four classes before and four classes after the use of the atlas. Analysis of admissions data, including overall grade point average (GPA), science and nonscience GPA, and a number of course units, was done initially to avoid any identifiable differences in the academic competency between the two being compared. A survey of the students was also done to assess atlas usefulness and students' satisfaction with the atlas. **Results:** Analysis of histology exam scores showed that the average scores in the lab exam were significantly higher for the classes that used the atlas. Survey results showed a high level of student satisfaction with the atlas. **Conclusion:** The development and use of an online interactive atlas of histology for chiropractic students helped to improve lab exams scores. In addition, students were satisfied with the features and usefulness of this atlas. (The Journal of Chiropractic Education 21(1): 12–18, 2007)

Key Indexing Terms: atlases (publication type); chiropractic; education; histology; technology

INTRODUCTION

Anatomy is one of the core subjects for first-year chiropractic, medical, and dental students in most health science education centers in the United States. Basic concepts and principles of several anatomy disciplines, such as histology, have always been challenging and demanded extra interest and time for teaching and learning. Traditionally, photomicrographic images of structures presented using 35-mm slides through microscopes are the mainstay of histology courses at most institutions.[1] Later, video-microscopic techniques were developed to see these images.[1–4] These approaches apparently have certain shortcomings such as: 1) students spend a long time to learn the component structures in an image, because identification of a specific structure in a tissue consumes more time when it is surrounded by many other structures with which they are not familiar[1]; 2) self-testing prior to an exam is often difficult for students in a traditional microscope laboratory[5]; and 3) students cannot assume a more active inquiry mode and interact and share among themselves in a traditional microscope laboratory.[5] One of the options to address the above-mentioned issues is to introduce computer-assisted instruction.[6] Integration of text, images, and animations using computer technology can enhance the learning experience of students. It also allows the students to learn the content at their own convenient pace, time, and place.[7] In addition, such a tool serves the educational goal of developing the self-directed learner, who pursues knowledge on his or her own initiative.

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However, resistance and skepticism regarding use of computer technology as well as other factors, which include costs, time, and efforts to develop this technology, have been barriers in developing computer-assisted programs of instruction in the field of histology for a long time.[6]

Ever since the invasion of computers in every field, the use of technology in the classroom has been a subject of great interest to health care educators. It also obligated educators of histology to develop tools that enabled students to take part in their own education. As a result, various multimedia interactive histology programs[8–10] and atlases have been developed, which include *Histological*,[5] *Pathpics*,[11] *ATLAS-plus*,[12] *Histology: A Photographic Atlas by S. Downing*,[13] and *Histoquest.*[14] Most of these programs are evaluated for their utility as an improvised educational tool and research results have shown that the students who used these interactive atlases did better in their exams compared to those who did not use these tools.[15,16]

A review of information on these Web-based atlases revealed that they are customized to the respective curriculum of the school that developed the atlas. In chiropractic there is an in-depth emphasis on nervous, muscular, and skeletal structures. Other body systems are studied at a lesser depth and detail than what medical histology atlases cover. In addition, securing unlimited user licenses is cost prohibitive. The nonavailability of such an atlas for our program, customized to our course curriculum, prompted the development of an interactive atlas of histology in order to: 1) provide an in-depth emphasis on nervous, muscular, and skeletal structures; 2) enable chiropractic students to practice and develop their skills on identification of various histological structures; and 3) allow chiropractic students to self-assess their ability to identify various histological structures. The atlas is made available to students through a course Web site and on a compact disc (CD) format for any interested parties. The specific aim of this article is primarily to share information regarding the development, use, and potential benefits of an interactive atlas of histology in chiropractic.

METHODS

Development of the Atlas

The atlas development process involved the use of an authoring station to digitize images imported through a video-microscope using actual microscope slides. The authoring station configuration was done along the same methods mentioned in one of the author's earlier publications[17] on the same topic.

The digitized images are color enhanced and edited using the Leica EWS 2100 (Leica Microsystems, Wetzlar, Germany) capturing software and its editing utility programs. The images are captured in low, medium, and high powers and saved in a jpg format. The images are then saved in a filing system, which allowed the author to name and sequence the images for easy retrieval. This database of images is used to import images to Microsoft Power Point (Microsoft Inc, Redmond, WA, USA) software to create the atlas. Power Point is used to further enhance and edit the digitized images and create an interactive show of images and text, which require the user to respond by pressing the space bar or the left mouse button. The files within this atlas are titled using a systemic approach and are arranged to follow the sequence in the related course syllabus.

The atlas was adopted for installation on the authors' intranet, during the Fall of 1999 for access by students while on campus or from home. The images used in the atlas were also used to set up lab exams.

Method of Use of Atlas

In this atlas, the user is prompted to select from a menu of topics, which include basic body tissues and various body systems on the home page of the atlas, by clicking the appropriate button displayed on the screen (Fig. 1). For example, if the student chooses bone tissue from the menu, this action opens a file of different types of bone images available for viewing by the student. The first bone image appears and the student can take as much time as needed to identify the image. Next, a press of the space bar or clicking the left mouse button reveals the identity of the image (eg, type of bone). Subsequent clicking will bring about a pointer to a structure in the bone image for detailed identification. Then, a subsequent click will reveal the identity of the structure (Fig. 2) within that type of bone as a side label (eg, Haversian canal). This cycle goes on until all the structures pertaining to the image are identified, then a new image appears and a new cycle begins. Unlike most histology atlases, which project the image with all the structures labeled for identification, this stepwise exercise of identification

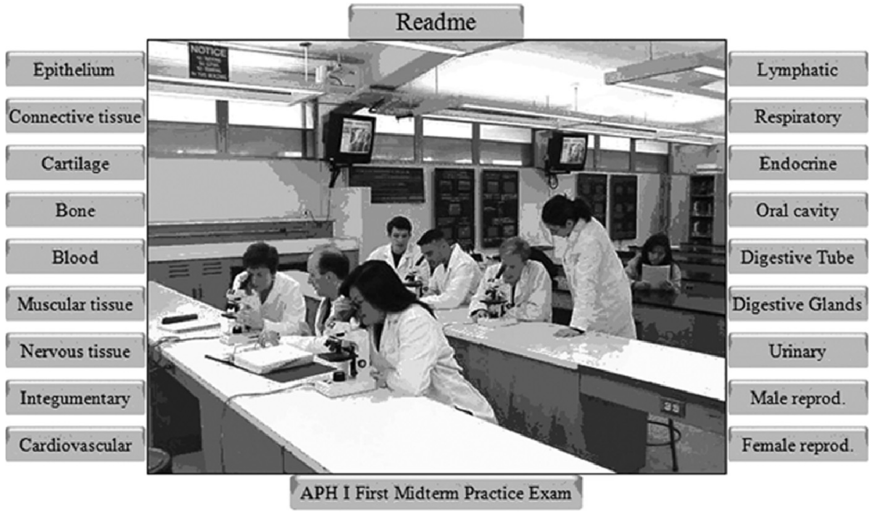

Figure 1. User interface page of the interactive atlas of histology.

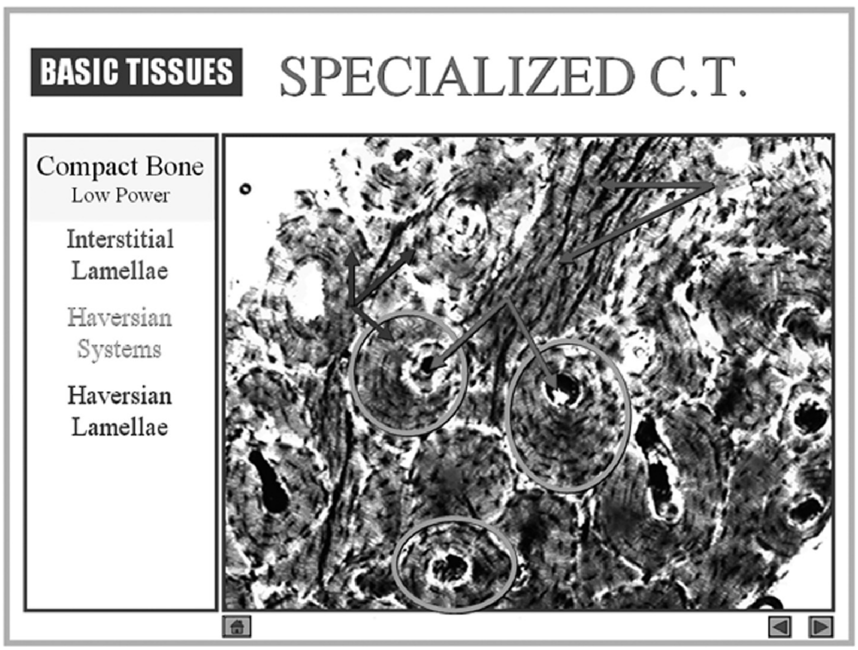

Figure 2. A bone slide from the interactive atlas of histology.

of the histological structures in each slide enables the students to self-assess their ability to accurately identify these structures.

Methods of Assessment of Atlas

Several methods were used to assess the benefits and usefulness of the atlas. The first method of assessment was done by comparing the means of the scores obtained in histology exams between the classes that were not exposed to the atlas (group 1) and classes that were exposed to and used the atlas (group 2). Four classes from group 1($n = 461$) and four classes from group 2 ($n = 332$) were included in this study.

Before comparing the scores, the authors looked at some confounding factors that might influence the scores obtained by the students, including change of course teacher, change in course content, change of exam format, change in classroom technology, and any difference in grade point average (GPA) at point of admissions. The course teacher, course content, and exam format remained constant. The only difference was in the technology used to deliver lab information. Video technology, using the video-microscope, was used to deliver information to group 1 classes, whereas group 2 classes received the same information through the computer, using the atlas images digitized from video microscope slides. In both group 1 and group 2, the information (video or computer) was delivered through a wall-mounted monitor system. This basically projects the same microscopic image either in video or computer formats. A variable that could influence the scores and needed to be assessed was the GPA at the point of admissions. Therefore, to avoid any differences in the academic competencies between the two groups, their average academic units, average class GPA, average science GPA, and average nonscience GPA were compared (Table 1).

The data reported here utilized exam data from all available group 1 and group 2 student scores from Fall 1997 to Spring 2001. Scores from each group were used in the comparison of lab test scores for both midterm and final exams for each class. For both groups, a typical "lab test" included identification of 20 slide images and a description of their functional or clinical correlation. So, two questions per image were given. The first question asked the student to identify a structure, pointed at in the image, and the second question asked the student about the function or clinical application pertaining to the identified structure. Thus, identification was a key factor in determining the final scores. The total possible for lab exams in both groups was 40 points. The data were analyzed by calculating and comparing the means utilizing an independent sample *t* test using SPSS version 14.0 (SPSS Inc, Chicago, IL) to find out the levels of significance.

The second method of assessment of atlas usefulness was done through a survey of students who used the atlas. The items of the survey were developed by the principal author for this study with input from faculty coteaching the course. Reliability of the instrument was not determined. The survey was administered to 100 students, who were exposed to the atlas. The students were informed about their right to participate without retribution. The survey was anonymous and conducted by student representatives who distributed the survey, gathered the forms, and put them in a sealed envelope. Eighty-six students responded to the survey. The survey questionnaire (Fig. 3) included nine questions on atlas overall usefulness, five questions on ease of use and accessibility, and six questions seeking their individual opinions on the various features of the atlas (eg, quality of images). The participants were asked to use a scale from 1 to 5 to express their agreement with survey statements regarding overall atlas usefulness and atlas ease of use and accessibility. On this scale, 5 and 4 indicate level of agreement, 3 is neutral, 2 and 1 indicate level of disagreement. Regarding atlas features, a satisfaction rating scale of 1–10 was used where 1 indicated lowest level of satisfaction and 10 indicated highest level of satisfaction (Fig. 3).

RESULTS

Academic competencies between the two groups did not indicate a significant difference in the number of academic units ($p = .155$), science GPA ($p = .077$), nonscience GPA ($p = .733$), and overall GPA ($p = .492$) (Table 1). An exploratory inferential investigation of performance outcomes between groups was also conducted to determine whether the changes in descriptive data were statistically significant. There were more students in group 1. Thus, an independent sample *t* test was preferred to identify individual variances in the groups. This showed that there was a significant difference ($p < .0001$)

Table 1. Academic Competencies at Admission Comparing Group 1 (Not Exposed to Atlas) and Group 2 (Exposed to Atlas)

Cohort parameter	Group 1 $n = 461$ (SD)	Group 2 $n = 332$ (SD)	*p* value[a]
Academic units	132.89 (34.81)	135.30 (31.07)	.155
Science GPA	2.78 (0.43)	2.84 (0.48)	.077
Nonscience GPA	3.12 (0.46)	3.13 (0.44)	.733
Overall GPA	2.93 (0.34)	2.94 (0.38)	.492

[a] Independent *t* test was used to calculate the *p* values.

I. Atlas overall usefulness:

Indicate your level of agreement with the following statements using the scale below:
Strongly agree (5) Agree (4) Neither agree nor disagree (3)
Disagree (2) Strongly disagree (1)
The interactive atlas allowed me to:

1. Control my study time for the histology lab material (self-paced)
2. Carry out my study of histology lab material independently (self-direc:d learning)
3. Better understand the histological characteristics of various tissues an organs of the body
4. Actively drill myself on identifying histological structure: s
5. Prepare myself for histology lab sessions
6. Evaluate my skills on identifying histological structures
7. Prepare myself for histology practical exams
8. Enforce lecture material
9. Enhance my learning about human histology

II. Ease of use and accessibility:

Determine your agreement with following statements using the same scale above:

10. The interactive atlas was easy to use
11. The interactive atlas was easily accessible from the college
12. The interactive atlas was easily accessible from home
13. There were enough computers available in the LRC for accessing the atlas
14. I used this atlas frequently

III. Atlas features:

Please rank your feelings regarding the following features of the Interactive Atlas. Students marked a scale of 1-10, where 1=very poor, and 10=outstanding

15. The interactive concept of the atlas
16. The quality of the images
17. The screen display format
18. The color coding
19. Adequacy of labeling
20. Picture and labels animation

Figure 3. Survey questionnaire.

between the two groups in lab midterm and final exams (Table 2).

The results of the survey showed that 88% of the respondents were satisfied with the usefulness of the atlas as a learning tool, 11% did not give any opinion and remained neutral, whereas 1% did not think that the atlas was useful to them. Regarding the accessibility and ease of use of the atlas, 63% of the respondents gave "satisfied" as their reply, whereas 14% remained neutral and 23% were not satisfied (Table 3). The respondents' rating on six features of the atlas had a median score of 7 (range 5–10) for each of the items.

Table 2. Comparison of Mean Lab Scores for Group 1 (Not Exposed to Atlas) and Group 2 (Exposed to Atlas)

Exam group (*N*)	Mean (SD)	*p* value[a]
Lab midterm		
Not exposed (449)	30.9 (5.7)	.0001
Exposed (313)	33.5 (4.3)	
Lab final		
Not exposed (445)[b]	26.8 (6.0)	.0001
Exposed (313)	30.5 (5.3)	

[a] Independent *t* test was used to calculate the *p* values.
[b] Four students in the Not Exposed group either dropped from the class or were officially withdrawn from the course based on their performance.

Table 3. Satisfaction With Atlas Usefulness and Accessibility/Ease of Use ($n = 86$)

Parameter	Agreed	Neutral	Disagreed	Total
Atlas usefulness	88%	11%	1%	100%
Accessibility/ease of use	63%	14%	23%	100%

Note: The respondents' rating on the six features of the atlas had a median score of 7 (range 5–10) for each of the items on a satisfaction ratings scale of 1–10.

DISCUSSION

The significant difference ($p < .0001$) between the two groups in the lab scores could be attributed to the students' repeated practice and self-assessment enabled by the atlas interactive mode. The literature indicates that computer-assisted instruction in histology improves students' ability to identify histological structures more readily.[5,6,16]

Results of the survey indicated a strong agreement of the students with the nine statements regarding the atlas usefulness (Table 3). The survey results also indicated agreement of students to statements concerning its ease of use. However, there was a disagreement regarding accessibility from home. The issue of accessibility from home could be attributed more to the download time for students using dial-up modems, as mentioned by some students as part of their own comments in the survey. Informal interaction with some students revealed that those who subscribe to DSL/cable connections did not have problems in downloading/accessing atlas images from home. Similar disagreement was also expressed by the survey respondents regarding the availability of sufficient numbers of computers in the learning resource center (LRC) for accessing the atlas. Since the survey was administered, the capacity of the computer lab in the LRC doubled from 25 to 53 computers and more students accessed the atlas from home through the Internet. The median score indicated an overall student satisfaction with atlas features.

The availability of instructional material developed in video and computer formats in the LRC and over the campus network provides a great opportunity for student self-directed and self-paced learning. In addition to posting the atlas on the institution's Web site, the atlas software is available on CDs for individual use. The accessibility of the atlas database of images enables histology instructors to include the atlas images in their lecture and lab presentations and assists in the development of computer-generated histology tests.

However, this atlas, like its counterparts in other health education institutions, is limited to histology curricula similar to our chiropractic curriculum. The atlas is limited to helping students in structure identification and does not assist in learning more about theoretical information pertaining to the identified structure. It also does not address the issue of organs with similar histological appearances, "histology look-alikes," which should elevate the students' identification skills.

As mentioned above, the survey instrument developed to obtain feedback from the students was not tested for its reliability and was administered to students of a single term and not to the entire group who used the atlas. Plans for future improvement of the atlas include the development of a new multimedia version of the atlas with voice pronunciation of names of structures as they are pointed at, as well as a segment addressing look-alike structures. The development of integrated software crossing various disciplines (eg, anatomy/histology/physiology/pathology) is also being contemplated.

CONCLUSION

While the use of this atlas is limited to histology curricula at a similar level of chiropractic education, the development and use of this interactive atlas of histology has shown that the practice mode of the atlas helped students to test themselves on their ability to identify various histological structures within each image and improved their lab scores. In addition, students were satisfied that it was a useful tool for identifying histological structures. Further, the atlas was also a useful tool for faculty in preparing lecture and laboratory presentations and for the development of laboratory practical exams.

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