Original Article

Teaching Pathology to Medical Students — Impact of Transition from Glass Slides to Digital Images

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Abstract

Background : Teaching Pathology with the traditional glass slides has problems like fading of the slides, storage and breakage. Digitalisation of slides has many advantages. The images can be retrieved and studied anytime; they are effective in more objective assessment, as the field of study can be made uniform; the slides can be uploaded into the e-learning portal, and the slides (images) are permanent. This study was done to compare the effectiveness of teaching Pathology using glass slides against digital images.

Material and Methods : The study was started after IEC clearance. The slides of the selected topics were digitalised. The students were divided into three groups and were taught using glass slides/ images/ both slides and images, with cross over, followed by a test. Feedback was obtained on the satisfaction levels of the students and Faculty.

Results : Analysis of the learning process (performance in the class test), following these classes, varied from slight improvement to marked improvement. The test marks obtained were not statistically significant. The results were not conclusive as the topics were few, and other variables which need to be considered are the students' academic abilities and the difficulty level of the topics. Results of the feedback obtained on a 5-point Likert Scale showed a significant difference (p=0.002) among those who preferred digital to glass slides.

Conclusions : The feedback obtained from the students showed a significant difference among those who preferred digital to glass slides.

Key words : Pathology, Teaching, Digital Images.

Pathology provides a scientific foundation for clinical practice[1,2]. The learning of Pathology is the first introduction to the understanding of human disease processes[1]. Pathology is a subject that is based in part on histopathologic examination of tissues which is important to understanding basic mechanisms of disease[1]. It is the medical discipline connecting morphological changes to clinical aspects. Therefore, the knowledge and study of pathology is essential for the understanding of clinical subjects[2].

The microscope has been the most widely used instrument in pathology education and is still the mainstay in the classroom[1]. In pathology education, there are shortcomings in the use of traditional microscopy. The major ones include the need for producing multiple glass slides from limited tissues for individual viewing by a large number of students; replenishment of slides for faded stains; broken or lost slides; and laboratory-bound access to learning[3].

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Editor's Comment :

- Use of Digital Pathology using slide scanners is not within the ambit of medical institutions in countries like India. Hence, use of static digital images capturing relevant fields is a suitable alternative for training Undergraduate students.
- This could also be used for training fresh Pathology Residents.
- It could also be implemented in other subject curricula as well as for preparing for the Postgraduate entrance exams.

Digital technology is ubiquitous and is an essential part of human existence today whether in a social, educational or professional arena[3]. The teaching of pathology is undergoing a digital revolution enabled by digital/virtual microscopy that has demonstrated a decrease in the use of traditional microscopes in medical education, both as a result of current developments in the curriculum as well as some disadvantages of the technique itself[1].

This study was done to compare the effectiveness of teaching Pathology using traditional glass slides against digital images and to record the perceptions among the Faculty & students.

Material and Methods

For this study, three major topics (each divided into

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two subtopics) which are taught in the practical classes were selected. The glass slides were studied and specific areas were selected. The microscopic images were converted into digital images using a microscope with attached camera. Multiple images were taken in scanner, low power and high power views, including all the relevant fields.

The 2nd year MBBS students who were studying Pathology, were divided into three groups: In the first group, the students were taught Practical Pathology using conventional microscopes using glass slides only. The second group was taught entirely using digital images. A few glass slides were kept focused for comparison. The third group, teaching was taught using glass slides along with digital images.

A cross over was done between the three groups using the same three topics. The teacher for a particular topic was the same for all the three groups to avoid bias and variation in the teaching. To assess the learning process, a test was conducted after these sessions and the performance was recorded.

Feedback on the perceptions (satisfaction survey) was obtained from the students and the Faculty involved in teaching using a 5 point Likert scale. The level of satisfaction/agreement was recorded as 1-Strongly disagree; 2-Disagree; 3-Neither agree nor disagree; 4-Agree; 5-Strongly agree. The results were analysed using the Chi-square test.

The feedback statements for the learning experience from the students included – Question (Q)1.I feel that digital slides were better than glass slides for learning; Q2.I feel that I was more interested in this type of practical class; Q3.I felt that I was more motivated to study after these practical classes; Q4.I felt that I learnt more with digital than glass slides; Q5.I feel that the clarity of images is better with digital slides: Q6. I would prefer similar practical classes in future and Q7. I prefer digital slides for the exam.

The Faculty experience feedback criteria included – Q1. I feel that digital slides were better than glass slides for teaching & learning; Q2. I felt that the students more engaged in the class; Q3.I felt that the students were more motivated to learn, Q4. I feel that the clarity of images is better with digital slides and Q5.I prefer to use digital slides for the exam.

The study was started after obtaining clearance from the Institutional Ethical Committee (IEC Protocol No 2019/140). As the students form a vulnerable group and may experience perceived coercion from their teachers to take part in the study, informed consent was taken from the students so that they know they have a voluntary choice to take part or refuse to take part in the study.

Results

The learning process as recorded by the performance in the class tests is given in Table 1.The values depict the number of students who identified the slides correctly against the total number of students who answered the test.

The perceptions were recorded from the feedback forms. All the Faculty (100%) agreed or strongly agreed that digital slides were better than glass slides. The feedback from the students is given in Table 2. There was a statistically significant difference among the students who preferred digital slides to glass slides (p=0.002).

Discussion

With the rapid acceleration in the use of computers in medical education, teaching pathology has taken a big turn in this century. Technology has been

Table 2 — *Results of the feedback from students obtained on a 5-point Likert Scale*

Question	Strongly agree/ Agree	Disagree/ Strongly disagree
1	75 (60%)	18 (15%)
2	80 (64%)	21 (17%)
3	68 (54%)	22 (18%)
4	73 (58%)	22 (18%)
5	101 (80%)	5 (4%)
6	80 (64%)	10 (8%)
7	96 (76%)	10 (8%)

Table 1 — *Analysis of performance in the test*

Classes		Teaching Methodology			Remarks of the performance
		Glass slides	Digital Images	Both slides & Images	
TOPIC 1	Subtopic 1	3/36 (8%)	25/43 (58%)	14/46 (30%)	Marked improvement
	Subtopic 2	29/36 (81%)	30/43 (70%)	31/46 (67%)	Slight improvement
TOPIC 2	Subtopic 1	33/46 (72%)	36/36 (100%)	30/43 (70%)	No change
	Subtopic 2	30/46 (65%)	35/36 (97%)	6/43 (14%)	Uncertain
TOPIC 3	Subtopic 1	20/43 (47%)	36/46 (78%)	36/36 (100%)	Improvement
	Subtopic 2	34/43 (79%)	39/46 (85%)	35/36 (97%)	No change

developed to photograph slides and store the images, which can be retrieved and studied anytime.

Technology for production of virtual slides was developed in 1985; however, it was not until the late 1990s that technology could be used to apply virtual microscopy to medical education[4,5]. Virtual Microscopy is being used in some parts of the USA, Europe and also in a few Middle East and Far East countries.

On completion of scanning, the pictures which are captured in millions of pixels, are blended together with the help of software to finally produce a composite picture which is an exact replica of the tissue section. The image thus created is automatically stored in the computer. The image is called digital slide or whole slide image or virtual image or e-slide and has the characteristics of the original section[6].

The digital slide can be viewed on the screen of the PC or laptop in any magnification just like a glass slide is viewed under the microscope and any area of the slide can be viewed.

Image can be annotated to point out salient features which are very useful for Undergraduate teaching[6].

The need for digital microscopy has arisen because of the several problems with traditional microscopy. These include, the need for producing multiple glass slides from limited tissues for individual viewing by a large number of students; replicating the same finding in all the sections; replenishment of slides for faded stains; broken or lost slides; difficulty in storage and laboratory-bound learning[3,6,7].

There are many avenues for implementation of Digital microscopy. Various studies have been done in teaching Undergraduate medical students, histology for first year students and histopathology for second year students. The current integrated and problem-based curricula make this innovative method of teaching a boon[4]. It has also been used for teaching dental students[9]. Postgraduate students in Pathology and Dermatopathology can also be trained by using virtual slides[2]. They can serve as slide repositories to be shared among Institutions[4]. Training and discussion of autopsy cases can be done and the slides of the cases can be stored permanently[2]. Digital pathology can also be utilised in proficiency testing in other fields of anatomic pathology and in cytopathology[1].

Virtual microscopy is being introduced into the Continuing Medical Educational (CME) and self-assessment programmes in many medical educational organisations. Virtual microscopy is very attractive to medical educators because it emulates the pan and zoom features of traditional microscopy, with the added advantages of the efficiency, accessibility and versatility of computer-assisted education[4].

The benefits of using digital slides are many. Digital images can be standardized, with the potential for image enhancement, so that all students will study the exact same tissue section· reproducing 100 or more slides showing just the same alteration is actually impossible. One perfect example can be converted to digital images[1,2,4]. With classes having a large number of students these days, sharing of the microscope and slide set is required[6].

In pathology postgraduate education, collections of rare cases can be made. Also slides of Immunohistochemistry, Immunofluorescence and Fluorescent in-situ Hybridisation (FISH) can be permanently stored. These stains are not long-lasting and are very expensive when it comes to making multiple sets. Fluorescent microscopes are also expensive[2].

Conventional microscope glass slides cannot be easily annotated with any precision, and rely on crude techniques like pen-marking/"dotting". Teaching is done by utilising an eyepiece with a pointer for highlighting a certain area in the field. Multiple annotations (arrows, circles, texts, etc.) can be placed exactly where needed in the digital images[1,2].

The time used for setting up the educational sessions and actual teaching process are much less compared to traditional microscopy[1].

The use of the microscopes is often limited to the working hours of the Departement. This requires the students to be physically present during these hours (lab-bound learning). With digital pathology study can occur wherever and whenever the student wishes to and encourages self-directed learning[1,4].

Storage and maintenance of microscopes and glass slides sets are cumbersome and require significant expenses. Digital images can be easily stored in in the computer which makes the retrieval easy[1].

This technology enabled the students to learn pathology in a more interactive and stimulating manner[1] as the slides can be integrated in the form of case-based studies. Curriculum reforms in medical education worldwide has focused on an emphasis on independent learning, and on the development of interpersonal skills and problem solving abilities[10].

Blake, *et al* (USA) describe how the histology course

for first-year medical students changed successfully from using glass slides and microscopes to using virtual slides and virtual microscopes. This study published in 2003 is thought to be the first report of a successful complete transition from the use of glass slides and microscopes to the combined use of static labeled images and virtual slides and virtual microscopes for the teaching of medical histology in North America[5].

Fonyad, *et al* (Hungary) have summarised the experiences gathered with the installation of a fully digitised histology lab for under graduate education. Student satisfaction questionnaire and a Tutor satisfaction questionnaire confirms the satisfaction and the acceptance of digital slides[2].

Lakhtakia, *et al* (UAE) studied the feasibility of achieving early integration of clinical reasoning with undergraduate pathology teaching on a virtual microscopy platform and to determine its student-centricity through student feedback. Most of the students agreed that the there was development of a strong clinical foundation. Integration and clinico-pathological correlation were found to be the strengths of this educational effort. High student attendance and improved assessment scores on critical thinking were observed. Easy access was a significant student-centric advantage. They found that using pathological basis of disease as a fulcrum, and critical clinical thinking/reasoning as an anchor, a digitally-enabled generation of medical students embraced this educational tool[3].

Pospisilova, *et al* (Italy) created a teaching environment in a computer-equipped and networked classroom dedicated to histology practical sessions. The e-learning format of histology practical based on virtual slides was found to be an efficient method of teaching histology. Students evaluated positively their use of virtual slides. Teachers benefitted from a uniform quality of slides and also from a straight forward and easy communication method with the students[8].

Syzmas, *et al* (Lithuania) development and evaluation of the user-friendly web based virtual microscopy for teaching dental students basic and oral pathology. Most of the students regarded using virtual slides at their convenience as highly desirable. Faculty considered the use of the virtual microscope for the study of basic as well as oral pathology as a significant improvement over the light microscope[9].

Ordi, *et al* (Spain) determined the impact in student scores when moving from conventional microscopy to virtual microscopy. They also assessed the students' impressions and changes in study habits regarding the impact of this tool. They found that Virtual microscopy can effectively replace the traditional methods of learning pathology, providing both mobility and convenience to medical students[10].

Sagol, *et al* (Turkey) evaluated the use of virtual microscopy in practical pathology sessions and its effects on the students of undergraduate education. The evaluation of the ratings showed that the students were easily adapted to the use of virtual microscopy. They found it user-friendly and thought that the opportunity of viewing slides at home was advantageous. Collaboration between students and interactive discussions was also found to be better improved with this technique[7].

Foad (Saudi Arabia) evaluated the acceptance of the virtual microscopy and its learning outcomes compared with the conventional light microscopy. The students' performances in our study in the virtual microscopy group was better than those of the conventional light microscopy group. The potential advantages of virtual microscopy include active student engagement in sessions, better coverage of learning objectives, and the practicability of self-directed learning[11].

Vainer, *et al* (Denmark) describe how virtual microscopy system for teaching pathology and histology was implemented, from an administrative, an economic, and a teaching perspective. Digital microscopy was received positively by both teachers and students, and a decision was made to convert all courses involving microscopy to the virtual microscopy format, phasing out conventional microscopy[12].

Elmore, *et al* (USA) studied the use of virtual microscopy in training pathology residents. The positive attitudes of pathology trainees toward future use of digital whole slide imaging highlight the importance of exposure to this technology in training programmes[13].

Cho, *et al* (USA) studied the use of digital pathology which has become an integral part of pathology education in recent years, during the COVID-19 pandemic, for its potential utility as a teaching tool. Majority of the trainees showed an improvement in their scores, which demonstrates the utility of Whole slid image-based self-assessment learning as a source of improving diagnostic skills of pathology trainees in a short period of time[14].

Inspite of the many advantages, there are certain challenges and concerns regarding the use of digital images for teaching-learnng. Students may not know

how to use a traditional microscope if virtual microscopy is used extensively[4]. Virtual microscopy replacing the traditional optical ones may result in a pathology resident using a light microscope for the first time, on the first day of their residency[2]. This issue can be addressed by providing glass slides for light microscopy alongside the digital images and encouraging to use the same.

Teacher-student interaction is also a concern. It could be possible that virtual microscopy would decrease the dynamic interaction between teachers and students[1]. However this has not been found in any of the studies[1].

In low resource areas such as in our setting, there are certain technical challenges. Access to the Internet on academic networks is often slow and expensive. Aside from the cost, other technical aspects such as unreliable supply of electrical power and adverse weather conditions which could disrupt telecommunications[1,5].

Limitations : Limitation in this study, were that the performance in the test were not conclusive as the topics were few. Also the students' academic ability varies and the performance is also dependent on the difficulty level of the topics.

The Way Forward is to make available a set of a standardised digital slide collection in the Department, adding related images and case studies. This could also be used for training fresh pathology residents. It could be implementation in other subject curricula. The slides would also be useful when preparing for the postgraduate entrance exams.

At present, the very high cost of the slide scanners is the main reason for slow adoption of digital pathology by medical institutions in countries like India. An alternate therefore would be to capture relevant fields under different magnifications and store them as static digital images (photomicrographs)[5]. Relevant annotations and case studies can be combined. The digital slides can be supplemented with the availability of a small set of glass slides. This method is not as effective as Virtual microscopy,[4] considering the cost of a digital scanner, it is much more cost-effective. Also for examinations, only static digital images can be used[9,12].

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