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DESIGN, IMPLEMENTATION AND DELIVERY OF CUSTOMIZED DIGITAL RESOURCES IN LARGE MULTI-SECTION ANATOMY & PHYSIOLOGY LABORATORY TO IMPROVE OUTCOMES ON LABORATORY ASSESSMENTS

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Design, Implementation and Delivery of Customized Digital Resources in Large Multi-section Anatomy & Physiology Laboratory to Improve Outcomes on Laboratory Assessments

Abstract

Assessment in our 2 semester Anatomy & Physiology lab consists of lab exams testing working knowledge of human anatomy. Covering over 1000 items per lab exam, 8 exams total, we developed custom resources to prepare our students. Our focused resources include visual model reviews and quizzes to incentivize early consistent study, narrated model videos for auditory reinforcement, customized image banks and full practice exams. All resources are available online to students via Blackboard and represent exactly what they would expect on lab exams. This can be a model for other courses.

Introduction

Anatomy & Physiology is a required course for undergraduates pursuing degrees in, and entry into the Health Sciences such as Nursing, Physical Therapy, Nutrition and Occupational Therapy. Hunter College's Anatomy & Physiology course has minimally specialized pre-requisites: 1 semester of general chemistry with lab (itself requiring basic math proficiency). Upon entry to the course, especially for those students having no formal biology studies at the undergraduate level, a great challenge is found in the volume of material in lab, and also the conceptual difficulty encountered in lecture. In our 2-semester Anatomy & Physiology lab we cover over 1000 items per lab exam and give 4 lab exams per semester, 8 in total. Lab is worth about 50% of their grade in the course, plus extra credit for incentivizing quiz preparation, with

lecture being 50%. The exam format is pure recall, no multiple choice or matching, using actual lab materials, models, equipment, and specimens used during lab. This assessment format is time-proven and necessitated by the volume of material and its importance to their further studies. Meaningful retention and use of the material learned is the measure of success of any course in this area. Adequate performance on these exams requires much study time at lab, and even more beyond, with regular reinforcement to elicit stronger memory formation. It is like learning a visual language and thus requires a great deal of practice. However, the question of just how to study for lab, and how much, when one is away from lab presents some pitfalls: use of lab manuals and figures to learn anatomy, image searches and other references, all some degree or another differing from the exact materials on which they will be assessed. Many students misplace their efforts in one of several ways: studying less than ideal material, studying at the wrong time(s), for the wrong duration, or without follow up to reinforce the importance of the work put in earlier. Any deficiency in study skills would become apparent during lab exams. Thus we undertook making a set of resources to focus students' attention and provide access to the lab materials in the truest way possible, and to prepare them much more directly for their exams. The resources we developed consist of model & slide image banks, model review PowerPoints, quiz questions, narrated model videos, and full demonstration lab exams which have been setup as normal, then photographed. All of these resources are placed on the course Blackboard site in our case, and made available to all students with guidance on how to use the resources and what purpose each has. This approach has proven to be powerful and we are in the process of observing the extent of increased engagement and improved performance in lab. These developments can provide a model to other courses with similar needs, and an assessment

and outcomes focused methodology to course design and delivery, and usage of digital resources to these ends.

Materials & Methods

Narrated Model Videos

Anatomical models used in lab were used to make narrated multi-angle videos showing close-ups of all structures along with mentions of their names and functions. A red or black pointer (a pre-painted chop-stick) was used to point to specific small structures on the models. We covered all structures used in the model keys and thus all anatomical structures that could be on exams. Included in the scripts written by Frank Martinez were functions of the structures, and mention of physiological pathways, and typically the structures were covered in a sequence resembling these pathways.

We proceeded to film over 50 such videos, one or more per model used in lab, ranging from 2 minutes to over 14 minutes in length each. Multi-angle video was shot at 720p and 1080p, using a Panasonic HDX-200 p2 camcorder and a Canon EOS dSLR and synced in Apple Final Cut Pro. Narration audio was scripted and captured simultaneously with the video using a Neumann TLM-193 microphone and captured at 48khz / 24bit. Footage was edited in Apple Final Cut Pro by Todd Miller. Music for play during titles and outro was recorded using Apple Logic Pro at 48khz / 24bit and imported into Final Cut for the titles and credits. Music credit is to Todd Miller. Final video files were exported to .mp4 format and then transcoded using Adobe Media Encoder to final mp4 format for uploading to a Kaltura streaming server with the help of Mr. Joseph Pelaez at Hunter College.

The videos are accessed online through our blackboard site via a playlist item inserted as a short java script that creates the playlist and contents from the Kaltura server such that videos

are arranged by topic into playlists, and each can be selected, started, stopped, and the playhead may be positioned at will, and audio can be muted, or adjusted in volume.

Creation of some model videos was supported in 2010 by a Faculty Innovations in Teaching with Technology (Miller, Martinez, & Pereira, FITT 2010 Projects: Human anatomy digital video modules, 2010) Presidential grant at Hunter College.

Model Image Banks

From the narrated model videos, directly in the non-linear editor Apple Final Cut Pro, suitable frames showing every structure within each video file were exported as tiff files. These tiff files were batch converted to jpeg using Adobe Photoshop. Some models were photographed separately as still images using a Canon EOS dSLR camera. All final jpeg image files were then placed onto slides of a PowerPoint file at 4 per slide. This PowerPoint was then converted to adobe PDF file for delivery via our course Blackboard site. This layout allows online viewing, and also printing where the letter-size page can be cut to approximately 4 index-card sized images which can be notated on the back if desired.

Quiz Questions

Our typical lab exam has several stations that are questions on definitions or concepts from Marieb & Smith's Anatomy & Physiology laboratory manual (Marieb, 2016), termed 'thought questions'. These exam questions were turned into quiz questions and given as a quiz the week prior to lab exams. The questions were also made available to students following compilation into an excel file with the questions arranged by topic. These excel files were converted into adobe PDF files and uploaded to our course Blackboard site. Students can use this file to make sure they are covering everything in the lab manual that will be on a lab exam as 'thought questions'. Frank Martinez wrote the vast majority of the Quiz Questions, and some were written prior by Mr. Agustin Pita of Hunter College.

Model review PowerPoints

Images from the Image Bank PowerPoints were selected and copied into new PowerPoints to make a model review PowerPoints. These differed from the image bank in several key ways: the image(s) are provided with leader lines (created in PowerPoint) pointing towards anatomical structures but with empty title boxes. There could be several such blanked leader lines on each slide. For example, 3 structures in the images may be pointed to, and the pointers connect to blank boxes. On the next slide, these boxes would have the names of the structures filled in that were pointed to on the previous slide. So a student would look at each slide, and determine the structures asked, and then check their work on the next slide. These files were created for every model and made into adobe PDF files and uploaded onto the course blackboard site. These PDF files could also be used by the students to print or make files that every slide either shows the answers, or does not by changing the print ranges. The former can also be used as a model key.

Creation of model review PowerPoints was supported in 2015 and 2017 by 2 separate Faculty Innovations in Teaching with Technology (FITT) Presidential grants at Hunter College (Miller & Martinez, FITT 2015 Projects: Using digital interactive lab activities to improve student outcomes in Anatomy & Physiology lab, 2015), (Miller & Martinez, FITT 2017 - Using Digital Interactive Lab Activities to Improve Student Outcomes in Anatomy & Physiology Lab - BIOL 120, 2017).

Model review quizzes

The model review PowerPoints were used to make 5-question quizzes in two differently colored versions, pink & blue (similar to A and B versioning of exams) to be used for adjacent students to prevent easy copying of answers. A set of pink & blue quizzes was given to each lab section instructor (thus each lab section had a unique quiz). These quiz PowerPoint files were

projected to the class, with adjacent students doing the alternating colors as mentioned, and were asked different structures. The questions were printed on their answer sheets, where they would write the structure or function of the item asked on the corresponding projection. These quizzes were given the week prior to the lab exam, to incentivize early study, and were the same models used on the lab exams.

Creation of model review PowerPoints was supported in 2015 and 2017 by 2 separate Faculty Innovations in Teaching with Technology (FITT) Presidential grant at Hunter College. (Miller & Martinez, FITT 2015 Projects: Using digital interactive lab activities to improve student outcomes in Anatomy & Physiology lab, 2015), (Miller & Martinez, FITT 2017 - Using Digital Interactive Lab Activities to Improve Student Outcomes in Anatomy & Physiology Lab - BIOL 120, 2017).

Demonstration (Practice) lab exams

From the lab exam versions that are being used in a given semester / year, questions were selected in a semi-random manner and made into a new exam file. The resulting exam was setup and photographed and made into a PowerPoint file and then exported as an adobe PDF file and uploaded to the course Blackboard site. Students are instructed that this practice lab exam would have some stations (typically 3 out of 25) that would be the same as their lab exam for their section. The practice exam (just like a regular lab exam) would have 25 stations, each in 2 parts (A. and B.), and in 2 colors, pink and blue. Thus the Blue version would have stations 1-25, A. and B. parts, and the same for the Pink version. Thus the practice exam is 2 exams, totaling 100 questions. Students were also instructed to do one color (select pink or blue) soon after the lab the week prior to their lab exam. Using the answer key at the end of the PDF file, they can score themselves, and do corrective study if required. Then 2 to 3 days prior to their lab exam they can do the other color for further practice.

Survey of students' use of lab resources and study habits

Two surveys were conducted to specifically ask about lab resource usage and study habits. In the first survey, students in one laboratory section (n=21) were asked how many hours per week, hours per day, and days per week they studied for laboratory in Biology 120 (Anatomy & Physiology 1) in Fall 2016. In the second survey, a comprehensive survey of lab resource usage consisting of 25 questions (Miller, APPENDIX 1: BIOL 122 Lab Study Resources Survey April 2018, 2018) was administered to the Biology 122 (Anatomy & Physiology 2) course during Spring 2018. 93 responses were collected and analyzed, in terms of assessment, at the mid-point of the semester where 2 out of 4 sets of lab quizzes and lab exams had been completed.

Results & Discussion

Study time and Distribution

Early and consistent study was evidenced by survey of students in the course. During the Fall 2016 Biology 1 survey of one section (n=21), students that were on track to get A or B in the lab were spending 10-20 hours per week, outside of attended lab and lecture time. This amount of study required spread over many weeks, keeping up with the pace and flow of information (Figure 1).

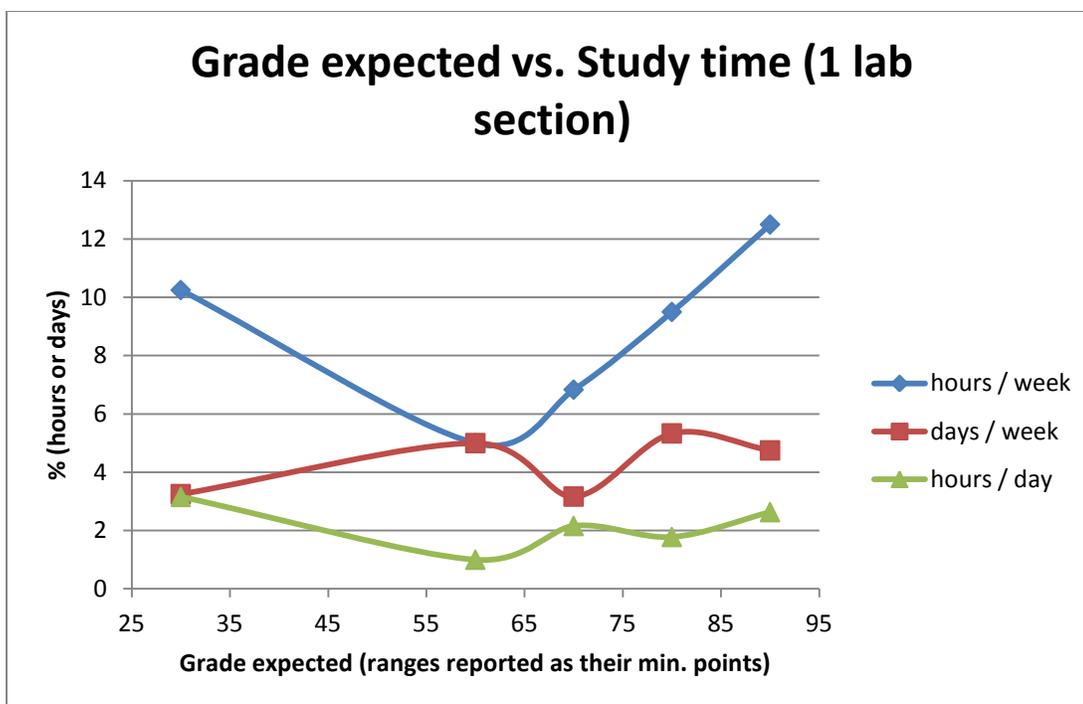


Figure 1: Grade expected in Anatomy & Physiology 1 lab vs. study times of students in a sample section (n=21). Grade range vs. study in hours / week, days / week & hours / day studied. Grade ranges were reported as 50-60% etc. but shown here as the minimum of each range e.g. 30-40 shown as 30, 60-70 shown as 60, etc.

Students were surveyed on their self-reported lab grade average in percent vs. hours per week and days per week. Students at the low end of their self-reported grade range (30 – 60%) were struggling, but also spending large amounts of time without much increase in exam performance. They also reported they did not use the model videos and model review PowerPoints to the same extent as higher scorers, and tended to use more text-based sources in their study. Students from 60 – 90% showed a nearly linear increase in overall study time from 5 hours / week average of the students in the 60-70 range, up to over 12 hours / week average of students in the 90-100% range. Number of days per week studied is notably on the high side for students >80% (~5 days / week). Hours per day was variable between 2-3 hours per study day across students sampled, however, there was a trend of increasing duration of study sessions from students scoring in the 60-70% range up to students scoring in the 90-100% range.

From this small set of $n=21$ (where the course size that semester was approximately 616 students), there is a clear indication that performance on lab exams requires a large amount of time, and focused study time. Using videos and images of the actual models used on lab exams was paramount to increasing success rate and lab exam performance. Having recall-based exams (no multiple choice or matching), requiring students to write the name or function of a structure labeled on a model, requires a level of fluency with that model that can only be attained by repeated study and practice, as in learning a language. Here the students are learning the language of anatomy with its many terms and structures and this is a very fitting analogy, and also fits our current recommendations to students on how to prepare for the exams. The numbers of hours of study was found to be lower across several groups organized by grade strata in the Spring Anatomy & Physiology 2 course surveyed below. In the Anatomy & Physiology 1 course it should be noted that 2 of the most intensive lab exams occur, each requiring as much study as is possible over a several week period. The topics covered are bone, skeletal system and bone markings & joints & articulations on lab exam 2, and muscle, names of muscles and their actions, origins & insertions and muscle activity on lab exam 3. The volume of material on these 2 exams is at least 10-15% greater than other exam units throughout the year of Anatomy & Physiology 1 and 2. Students are also encountering the course for the first time, and these types of resources for the first time, and are relatively unfamiliar with them and how they will affect their performance on assessments.

Study time and its quality and degree of focus was absolutely critical to students' success in our course, and investigated further during the Spring of 2018. The resources utilized, and their respective proportion of overall study time appears to have an ideal baseline usage scenario which high-scoring students have discovered. Starting with the amount of time students at

different grade strata are dedicating to laboratory study outside of the lab to prepare for quizzes and exams. Students studied for lab during the week in several individual sessions on separate days. The distribution and total time of study both had different manifestations in the grade strata (Figure 2). For the students scoring 90-100% on overall lab scores, the group averaged 8.35 hours per week, distributed between 3 and 4 days per week. Students scoring between 80-90% studied 6.94 hours per week on average, over 3.9 days. The Student scoring in the 60-70% range studied 3 hours per week over 2 days. The student scoring in the 40-50% range studied 3 hours per week in 1 day per week. The results are in-line with the recommendation to spend at least 2 hours of study time per hour of classroom time. As such, our laboratory is clearing counting as ‘classroom time’, and not simply an extra recitation to understand and orient for the physiology lecture for example. While the study time overall is lower than the small survey set from Fall 2016 shown above, this is likely due to 2 very demanding lab exams during that semester (lab exams 2 and 3).

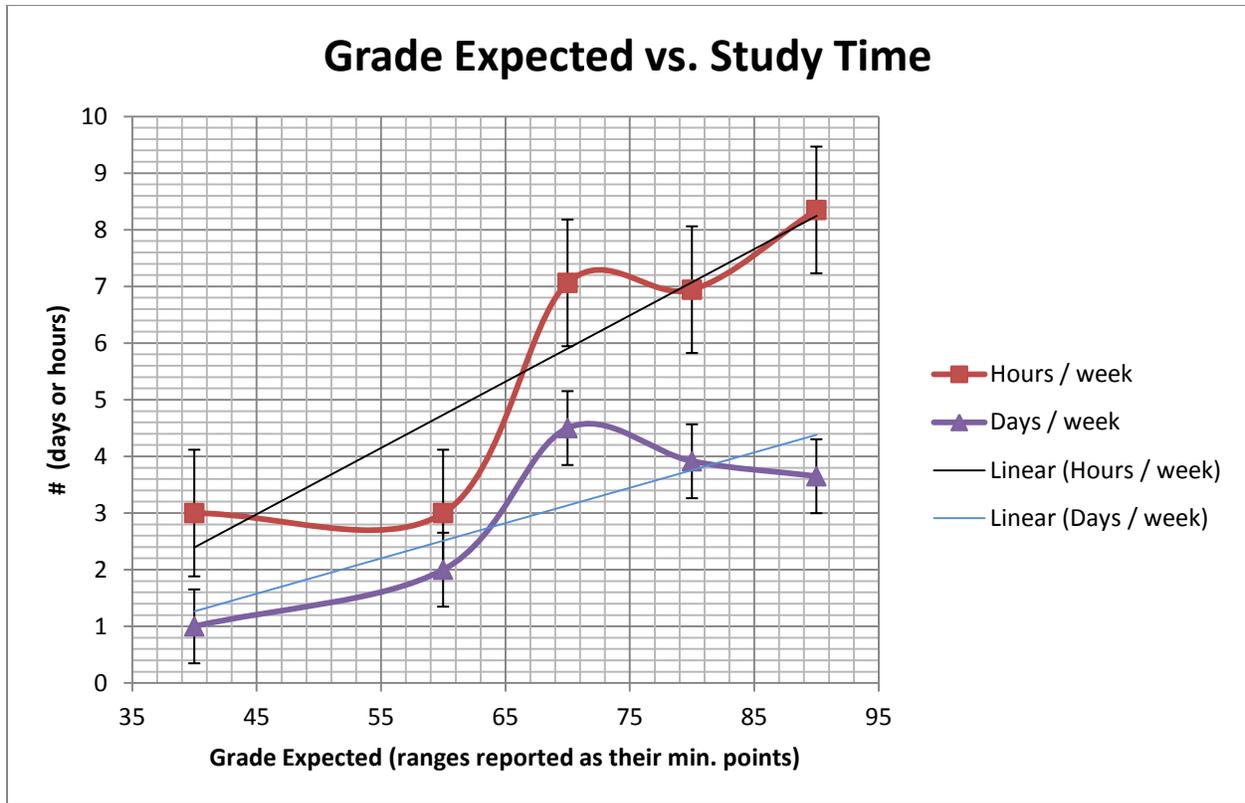


Figure 2: Grade expected in Anatomy & Physiology 2 lab versus study time and distribution of students surveyed. The average # of hours per week, and days per week studied was calculated per grade range. Each grade range was surveyed as 40-50%, 50-60% etc. but reported here as the minimum of each range e.g. 40-50 shown as 40. n=93. Standard error & linear trend lines included. N=93.

Despite the demands on attention and time, from the students surveyed the vast majority of students will successfully pass the laboratory. In our course laboratory counts 50% of the course grade plus extra credit, and represents the anatomical knowledge. The physiological basis and conceptual areas can give a greater cognitive challenge than laboratory work, but we can see the expected performance in laboratory from the survey data (Figure 3). This is quite reassuring to have data with these success rates mid-semester after 2 out of 4 lab exams and quiz sets: one-half of the lab has been completed at the time of the survey collection. Note that these students have already successfully passed lecture and lab of Anatomy & Physiology 1 during the Fall semester.

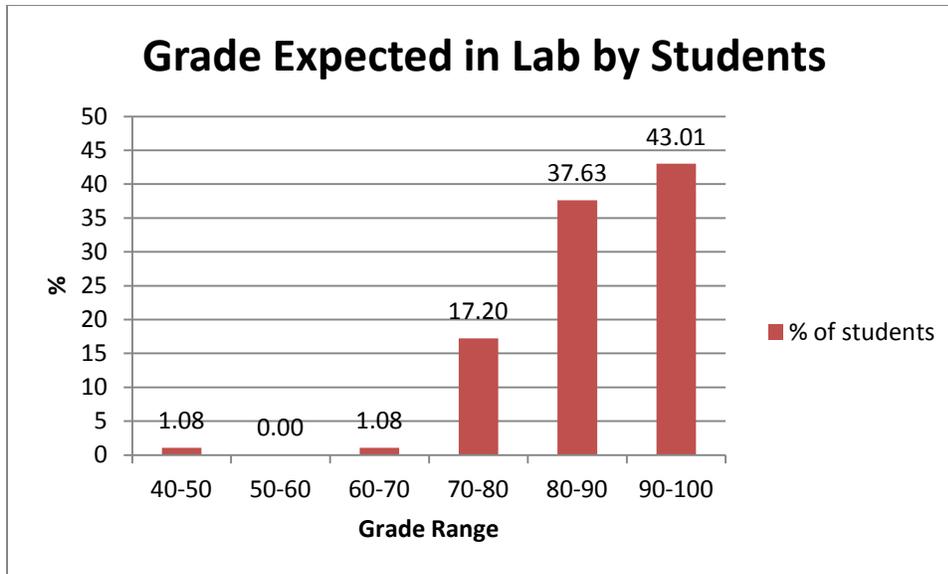


Figure 3: Grade Expected in Anatomy & Physiology 2 Lab by students. Grade range vs. percent of students surveyed. Percent of students surveyed reporting their expected grade range. n=93

Lab Resource Utilization

The resources were not utilized to the same extent or in the same ways by all students. Furthermore, there are some consistent differences between students in different grade strata. Looking first at overall resource utilization, the students successfully focused more of their time and attention on the resources that would be assessed upon directly due to their design compared to the assessments themselves: the quiz questions and model review PowerPoints were utilized most directly and the degree of translation from the resource to the assessment is closer to a 1:1 alignment. Other modalities such as videos were not favored when such resources were made available. The model review PowerPoints were used during lab, and off-site, and were needed to prepare for model quizzes, and model stations on the lab exams and they were the most utilized resource by 45.16% of students (Figure 4). The quiz questions prepared students for the lab manual / handout quizzes, and general questions on the exam not pertaining to models or figures. It is refreshing that we see an overall lower utilization of the quiz questions, as they are only

roughly 20% of a given lab exam. Thus our movement in development to have resources more directly tailored to the lab exams is being picked up by the students, and communicated to them by their individual lab instructors. The model videos, while utilized by roughly 40% of students this semester, were not their most utilized either. This modality has its uses, but it isn't the most urgently required and directly related to the assessments, and is more passive by design in terms of student interaction with the resource. The model image banks & projected slides are mainly unlabeled practice resources and this would explain their lower usage when compared to the model review PowerPoints.

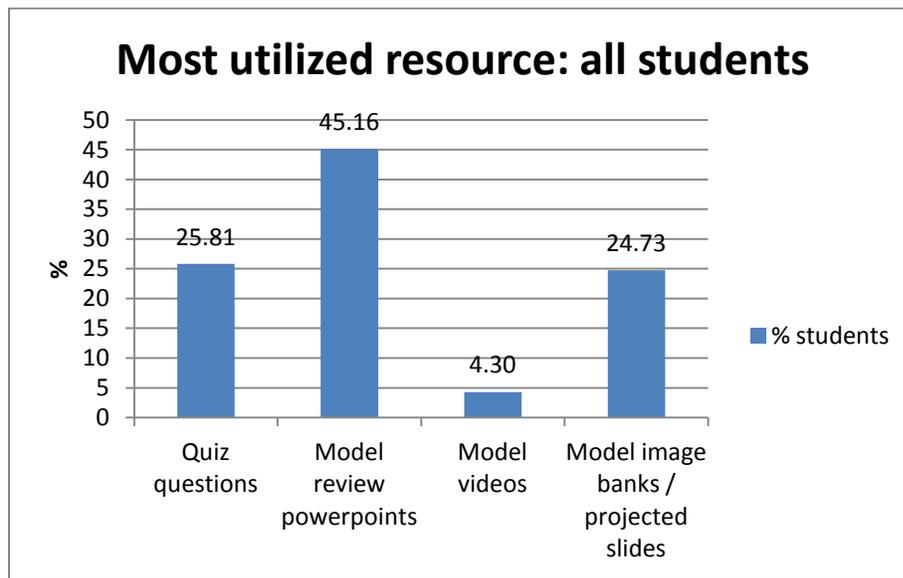


Figure 4: Percentage of students surveyed in Anatomy & Physiology 2 lab vs. their highest utilized lab resource. N=93

Parsing the resource utilization by grade strata reveals differences in usage depending on the grade range of the student. For instance, for students scoring in the highest group there is a marked increase in usage of the model review PowerPoints, at 60% saying it was their most utilized lab resource (Figure 5). Students in the next stratum from 80-90% favored the model review PowerPoints in only 37.14% of cases, and as a group were using the quiz questions to a slightly higher extent than the highest scorers, and more than double the instances than in the

highest scorers, they were using the unlabeled model image banks (Figure 6). This trend continues looking at the 70-80% grade stratum where 37.5% were mainly using the unlabeled image banks. Interestingly and telling, they had the highest focus on quiz questions at 31.25% for the group, the lowest usage of the model review PowerPoints at 25% (compare that to 60% in the highest scorers), and also the highest usage of the model videos, which may actually count as a distraction for students not ultimately putting in enough study time, and active measures to prepare most directly for the assessments (Figure 7).

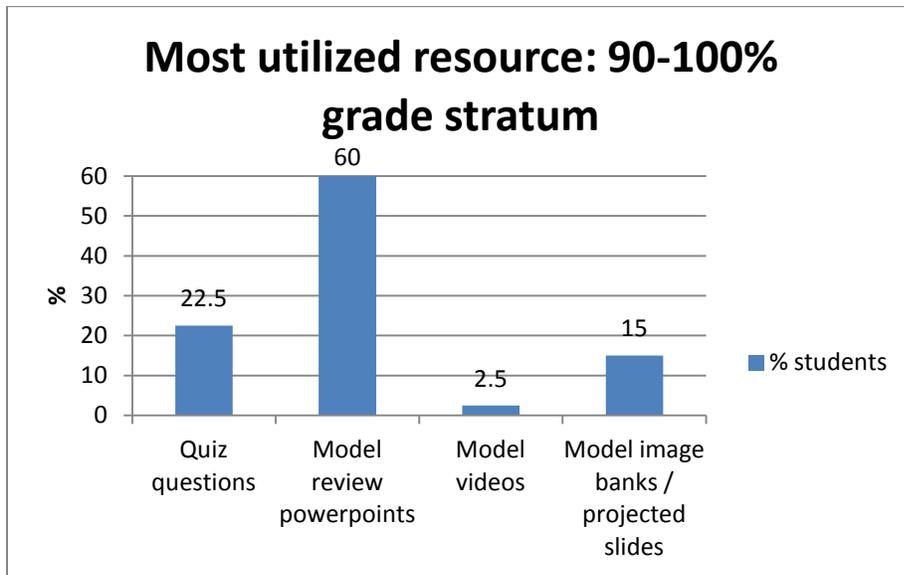


Figure 5: Percentage of students in the 90-100% stratum vs. their highest utilized lab resource. N=40

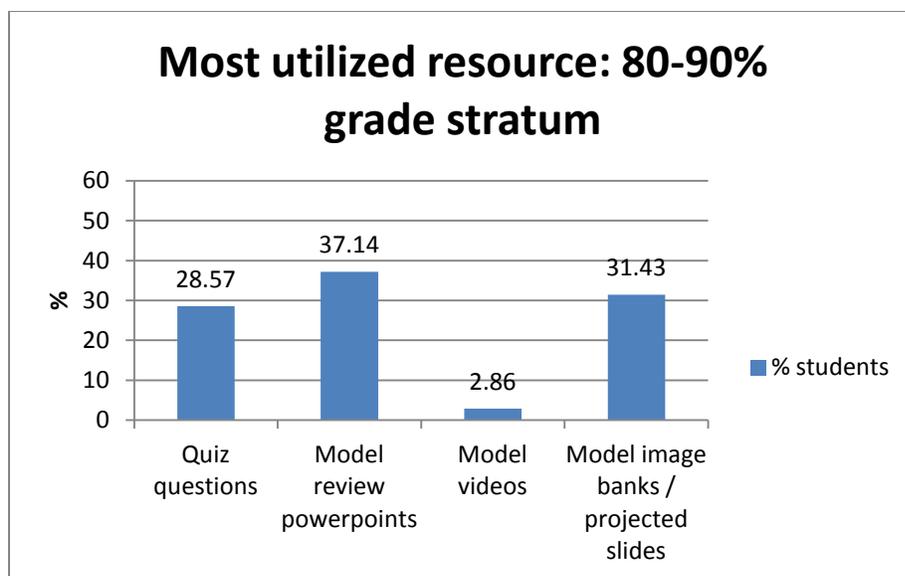


Figure 6: Percentage of students in the 80-90% stratum vs. their highest utilized lab resource. N=35

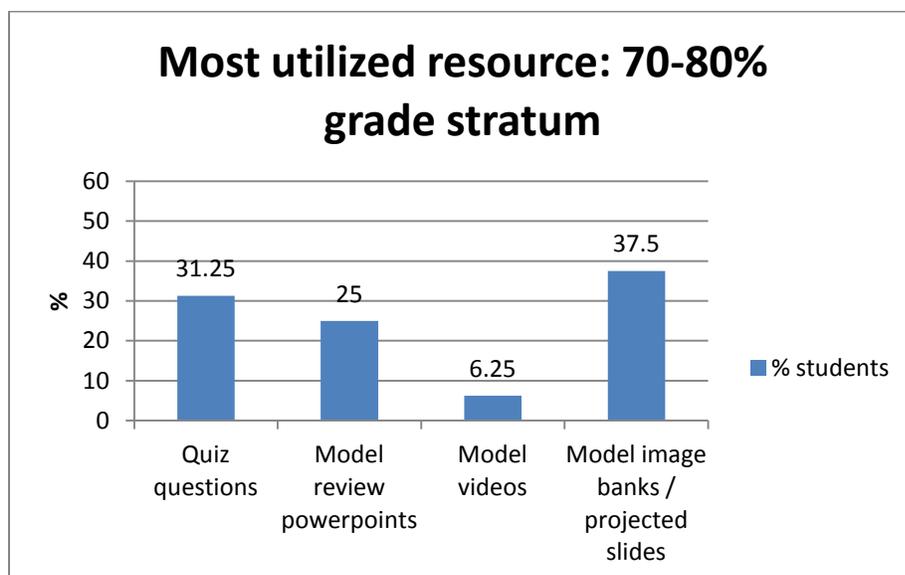


Figure 7: Percentage of students in 70-80% stratum vs. their highest utilized lab resource. N=16

These notions are carried further by the survey itself where students reported the most important resources they used in preparing for the lab exams. Overall the model review PowerPoints and quiz questions were deemed most important by students (Figure 8). Analyzing the various grade strata for their input on the most important tools for lab exam preparation

shows that the highest scorers saw the model review PowerPoints as most important @45% (Figure 9), also note the low numbers citing the model videos as most important. In the next stratum from 80-90% we see a drop in favoring the model review PowerPoints of about 13%, down to 31.43% (Figure 10). But there is still a healthy favor on the quiz questions and a slight increase in favor of the unlabeled image banks. There is an increase in the model videos being reported as essential, up to 8.57% which is about the same as the course total average.

Interestingly, this trend continues in the 70-80% stratum and the model videos are up to 18.75% reporting as most important resource (Figure 11). This could point to misallocation of study time and attention by this group, and guidance by individual lab instructors should be applied according to these results to help students reach higher lab exam scores by putting in the right kind of time into the best resources for the task required.

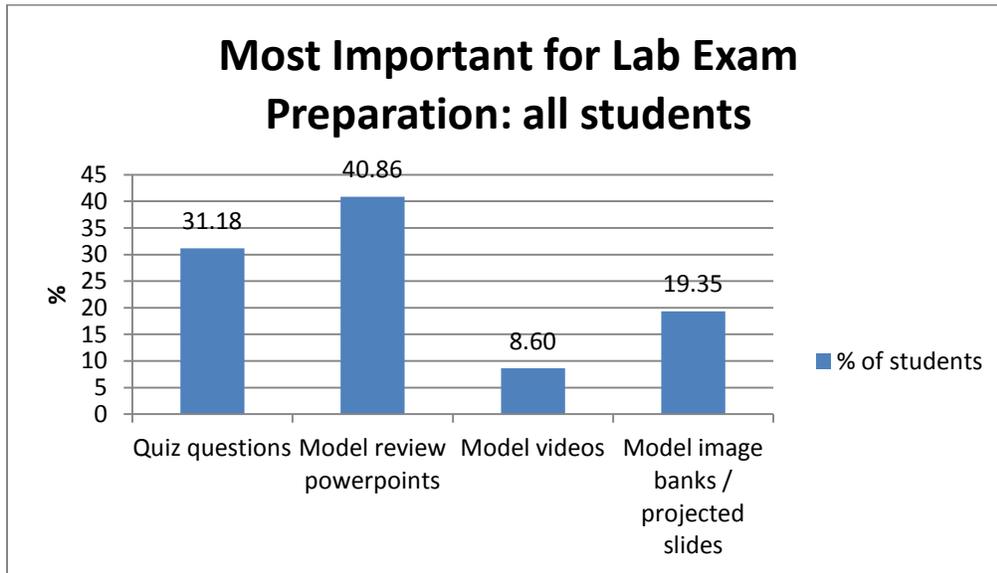


Figure 8: Most important resource for lab exam preparation. Students were asked which resource was the most important in preparing them for the exams themselves. N=93

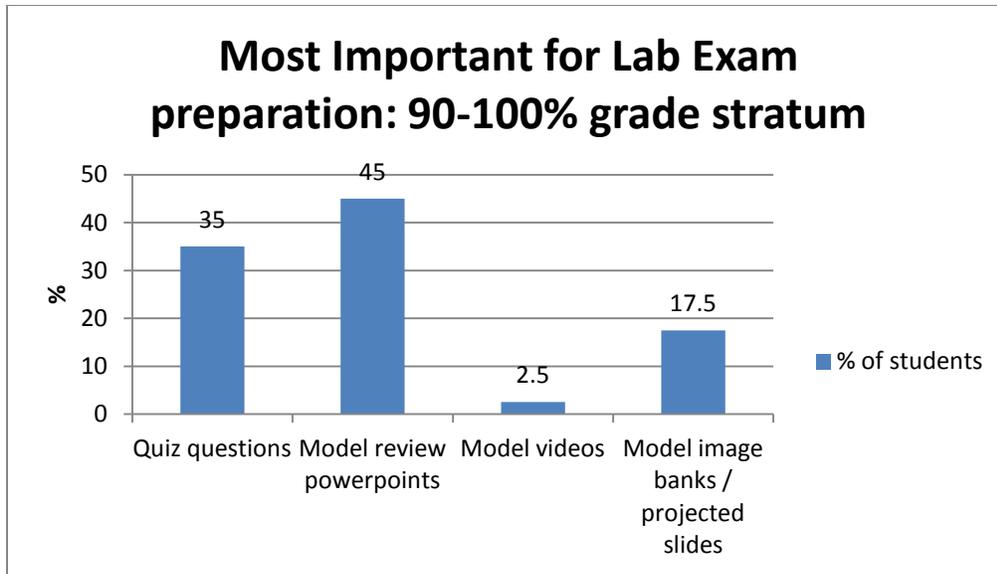


Figure 9: Most important resource for lab exam preparation as reported by students in the 90-100% stratum. N=40

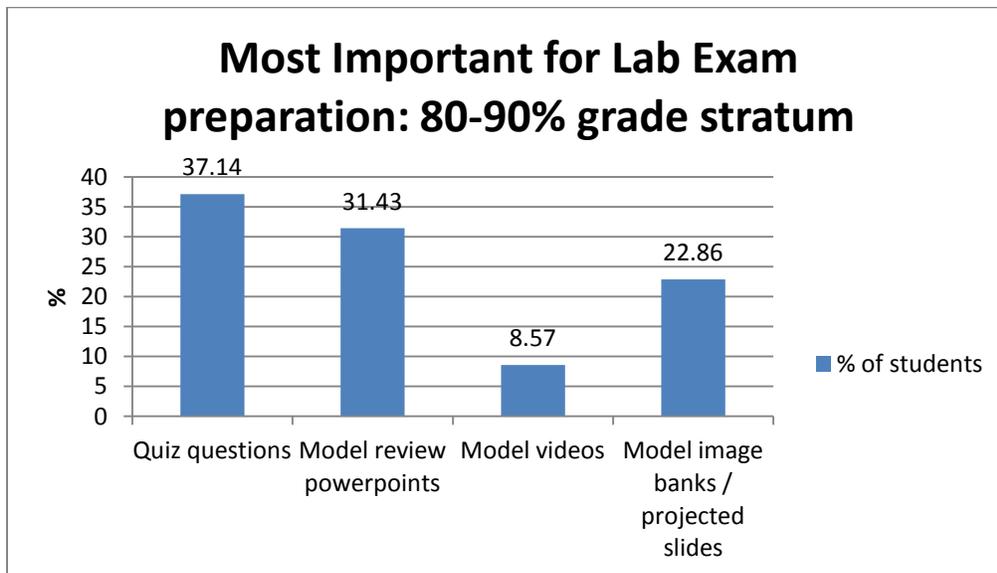


Figure 10: Most important resource for lab exam preparation as reported by students in the 80-90% stratum. N=35

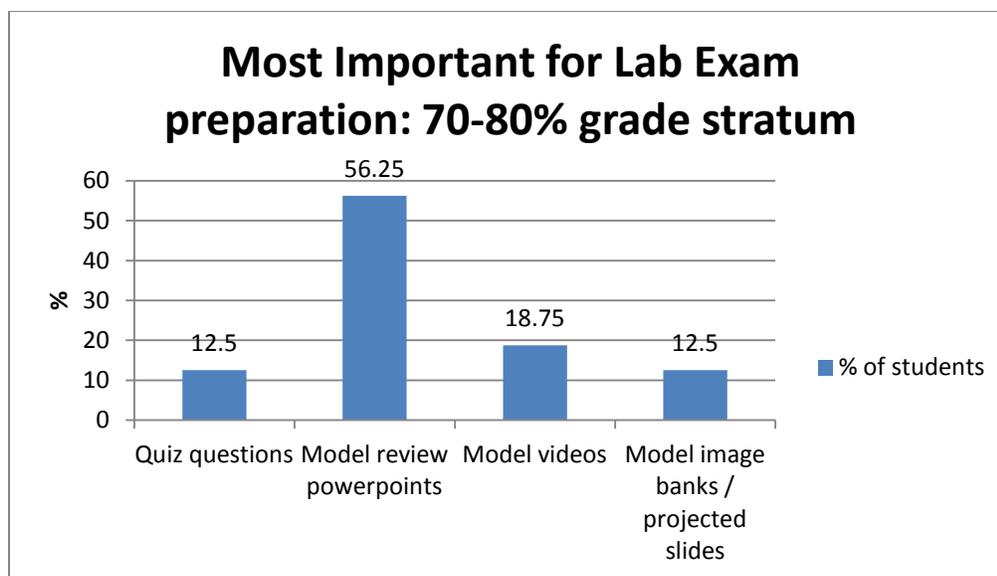


Figure 11: Most important resource for lab exam preparation as reported by students in the 70-80% stratum. N=16

The lab resources were reported as very helpful outside of lab, as in the lab students have the ability to interact directly and utilize more senses in processing the models and specimens, including tactile, visual, in some cases olfactory, and having discussions with other students and working in groups. Some students won't undertake group study outside of lab, and thus it becomes another benefit of being at the lab. 87% of students said the resources were more helpful when they weren't in lab, in a nod to the importance of the lab setting for learning this material (Figure 12). This is a great testament to their power and our delivery method of having always-available online access to the resources. However, this did not stop students from using them in lab as well (Figure 13). Quiz questions were reviewed prior to the lab manual & handout quizzes, model review PowerPoints were reviewed intensively during labs, and to a greater extent at labs where the visual model quizzes would be administered. Students were witnessed using these as their only model keys. Visually going thru the model and learning and reviewing a couple or a few structures at a time with a visual guide. The alternative would be simple text-based numbered model keys. Some students are still using these (provided on blackboard), but a

growing number are using the model review PowerPoints since they will be tested on those, and the resource itself is more similar to the modality of the assessment (images of the model on the visual quiz, the actual model / specimen on the lab exam). A real question is whether to make the text-based document model keys unavailable so all students use the model review PowerPoints as model keys. However, this means devices, battery usage, internet access all have to be relied upon, versus printing a model key out and having it on hand, and able to write notes onto it as well. There are benefits to both approaches. The model videos were used during lab by over 20% of students and they are an especially good way to go through a model the first time, as they consist of a multi-angle virtual tour of the model, with all structures and functions narrated and spoken aloud, which adds the auditory modality to the initial learning. Unlabeled model image banks were used to a surprising extent of 60.22%. This is likely due to their being a great study tool in and outside of lab in that they are arranged in color photos of 4 per page and can be cut to index card size and notated on the back. They can be studied off-line, and outside of lab, and in the subway, café etc. However, it was noted earlier there are some reliance on this resource to a higher degree in the grade strata below 90%, so caution should be advised and further investigation in terms of instruction to make the most prudent recommendations on their usage.

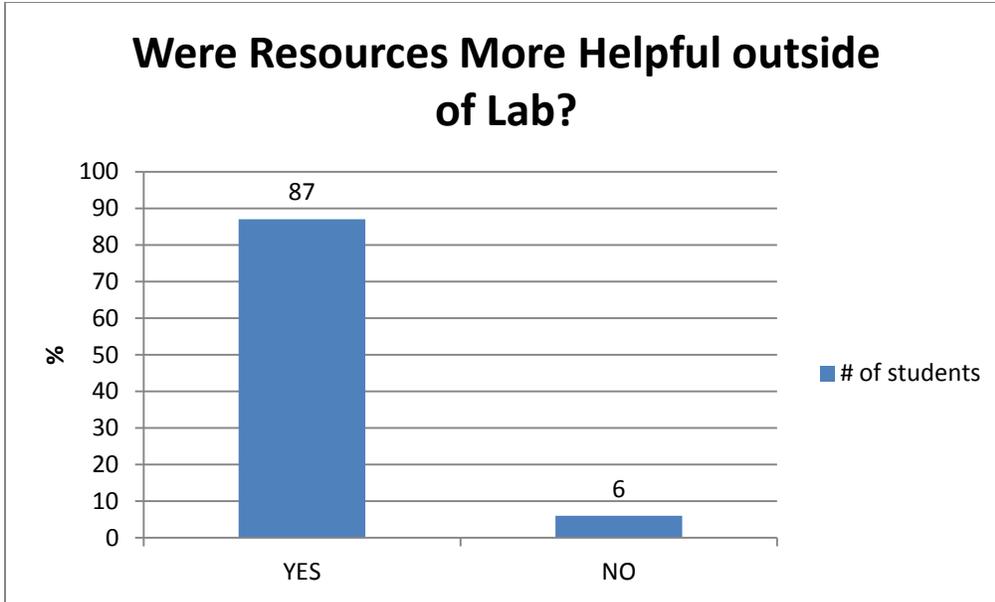


Figure 12: Students reported the digital lab resources were more helpful outside of the lab. N=93

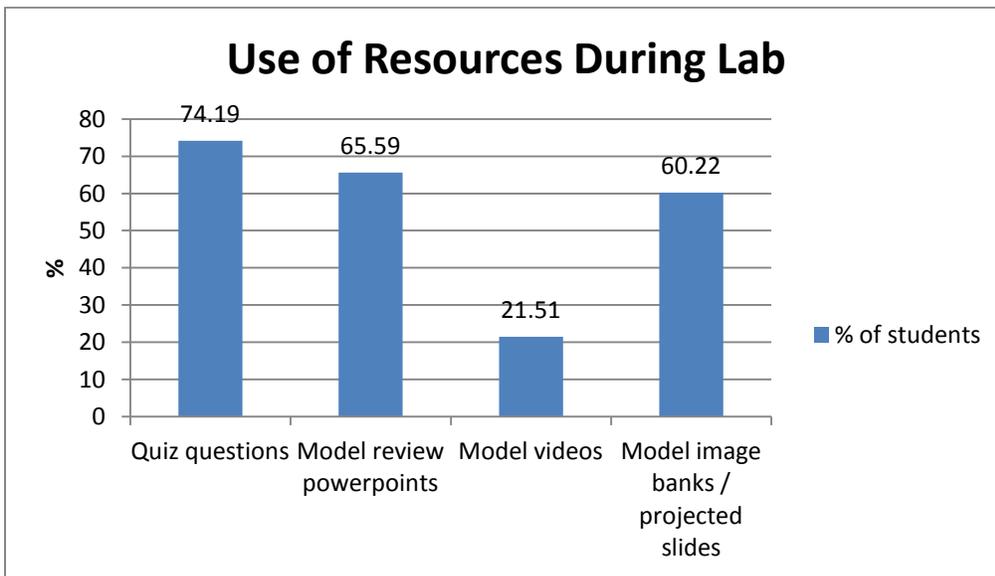


Figure 13: Use of various digital lab resources during lab class time. N=93 students and 299 total reports of types of resources used during lab for that group.

Model Review PowerPoints, Visual Quizzes

The Model Review PowerPoints available on Blackboard at all times, and were designed to prepare students for Visual quizzes given the week prior to the relevant lab exam. Thus the visual quizzes were meant to help prepare students for lab exams and be assessed earlier and to

move their study earlier to increase preparation for the lab exams and to improve scores on these high-stakes assessments. Looking at the usage data from the survey (Table 1) we see that 90.32% of students used all the model review PowerPoints. It is worth noting that there are many model review PowerPoints provided in Anatomy & Physiology 2: as of this time there are 10 on lab exam 1, 8 on lab exam 2, 15 on lab exam 3, 16 on lab exam 4. To study all of these PowerPoints is quite a task, as is studying the models they cover. However the incentive is being provided in terms of preparation for lab exams.

ITEM / Question	% of students
Used all model review PowerPoints	90.32
Model review PowerPoints helped prepare for quizzes	94.57
Visual quizzes improved lab exam scores	75.00

Table 1: Percent of students surveyed usage of model review PowerPoints and reporting their effect on quiz preparation and the quiz preparation ultimately on lab exam scores. N=93

The reported effect of the model review PowerPoints on the visual model quizzes was extremely positive with 94.57% of students saying they helped to prepare for those assessments. The high correlation is explained by the content itself: the model review PowerPoint slides themselves are used directly in the visual quizzes. Thus students are practicing on exactly what they need to in preparation for the visual model quizzes when using these model review PowerPoints. The translation to the practical lab exams the following week was reported slightly lower with 75% of students saying the visual quizzes improved their lab exam scores. It should be noted this question is asking about total lab exam score improvement and there are other types of stations on the lab exam (lab manual questions, equipment, specimens, samples), so there is less correlation of the model review PowerPoints & the associated visual model quizzes to the overall content of the entire lab exam.

An unexpected result of the model review PowerPoints became apparent to us in lab quite quickly and was mentioned briefly earlier. Students had the PowerPoints open on their devices while studying the models, and not having their normal model keys open at all (the model keys are word / excel files printed or given as pdf files that list the identification number and name of the structures). Some students seemed to prefer these model view PowerPoints as visual model keys, and were using them to go thru the models. This was actually predicted by the students that had 1-2 years earlier using the model videos to guide their own self-study of models in lab. But using a smartphone, ipad, or chromebook to load a pdf file and look at a model side-by-side is exceedingly easy and doesn't take much network bandwidth or battery consumption of their mobile devices.

The model quizzes were a great success and helped to direct lab study time to the models which would be the bulk of each lab exam. Thus having an assessment incentivizing preparation for that quiz helped students prepare for the lab exam to a far greater extent than only assessing the lab manual concepts in advance. When we had only quizzes on the lab manual, prior to the creation of the visual model quizzes, and we found that students were preparing for that quiz during lab time to the detriment of study of the models, and materials in the lab. The model quizzes made it easier for lab instructors to refocus the students on the lab materials.

Quiz Questions on the lab manual & handouts

The quiz questions were posted on blackboard without answers with the understanding students must discover the answers in the lab manual & additional lab handouts. The quiz questions were assessed on during the week prior to a lab exam at the same lab the visual model quiz was being administered. Thus students took 2 quizzes on that day, each of 5 questions (5 minutes duration each). 86.02% of students reporting using the quiz questions in advance, with 89.25% saying their use helped them to prepare for the quizzes (Table 2). This is slightly lower

than we saw with the model review PowerPoints earlier. We also see the same reported effect on lab exam scores, at 75.27%. Thus far we would say these two resources are seen as roughly equivalent in terms of improving scores on lab exams. Slightly higher weight was reported by students when rating the overall effect of both of these quizzes on the upcoming lab exams at 79.57%.

ITEM / Question	% of students
Used quiz questions (lab manual)	86.02
Quiz questions helped prepare for lab manual quizzes	89.25
Lab Manual quizzes improved lab exam scores	75.27
<i>Overall both quizzes improved lab exam scores</i>	<i>79.57</i>

Table 2: Percent of students surveyed usage of the quiz questions resource, and reporting their effect on quiz preparation and the quizzes effect subsequent on lab exam scores. N=93

Model Videos

The Model Videos were incredibly well-received and intensely utilized by our students. We had a large amount of viewership hours, in the thousands of hours in total, in the first semester of launch, in 2011. It is important to note at that time this was the first of the resources to be created and was thus relied upon intensely by the students. One group of students stood out within the data: students who viewed each video 5-10 times or more. This signals another mode of learning and studying is being employed by these students. Our original intention and design of the model videos was to make the anatomy clear to students without any ambiguity and to be guided through it by an experienced instructor who knows the common mistakes (Frank Martinez did the narrations in the videos and has taught our labs for over 18 years). However, having online access and a familiar YouTube-like delivery format allowed our students to find these new ways to use them. In the instance already mentioned, students were watching the videos several times, over the span of several days, repeating many times to see how much more they would remember. We have been told of reports students would mute the audio and try to

name structures and functions along with the video. This could speed up memory recall time. With the video player in pause, the playhead could be put anywhere in the video to ask themselves random questions to quiz themselves. The tool was already powerful and engaging but dedicated students were using them in these innovative ways. We saw usage statistics overall steadily increasing until and throughout the lab exam week. Another aspect of the videos is the passive absorption of knowledge, combined with audio input and hearing the terms spoken. Along with other active study methods this can be effective in helping memory formation due to stimulus by other sensory modalities. In the lab we have touch and sight, now students can have sight and auditory cues to help further memory formation. In addition, being another study tool and being a different type of activity can give a refreshing break of monotony that might build up practicing the same way for hours and days, thus potentially allowing students to engage more time in their study than they might have otherwise.

Students were also using these videos in lab and looking at the real model side-by-side as the video was playing. So they were also using them in an active manner for guided self-study. We are still seeing students using these in lab, but the frequency has decreased in favor of other resources, particularly the model review PowerPoints (Figure 13).

In the Spring 2018 semester we saw 45.16% of students using the model videos and 31.87% reporting they improved their lab exam scores (Table 3). However due to an imperfection in the survey question design, students not using the model videos could say that they didn't improve their lab exam score, and the lower the usage rate the greater this effect. Nevertheless the numbers are lower, suggesting the use of this resource is either limited or doesn't have as large of an impact on lab exam scores overall. However of the students using the model videos, they reported they used them multiple times (Figure 14).

ITEM / Question	% of students
Used model videos	45.16
Model videos improved lab exam scores	31.87

Table 3: Percent of students surveyed usage of model videos and their effect on subsequent lab exam scores. N=93

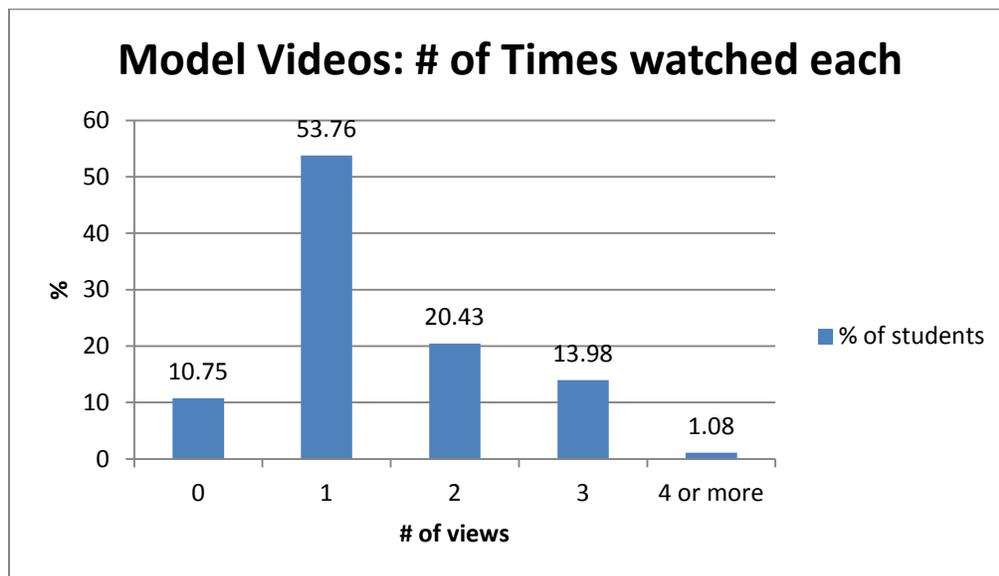


Figure 14: Number of views of each model video vs. percentage of students. Students had the option to not answer, students not answering are reported here as 0. N=93.

Thus while 53.76% of students watched the videos no more than once, a total of 35.49% watched two or more times.

Demonstration Lab Exams

The demonstration, or practice, lab exams are photographed full lab exams in PowerPoint / pdf format on blackboard. Students were informed by their lab instructors and by other reminders that the content of these ‘demo’ exams consisted of several stations that would be the same on their lab exam version. We prepare many lab exam versions in parallel and once they are finalized questions are pulled from them and put into a separate exam file used to make this demo exam. Thus knowing the demo lab exam would get you 3 or 4 stations out of 25 being known beforehand, *if* the student did the exam (both pink & blue versions), and checked their answers (See materials & methods). Thus we saw a very high rate of demo exam usage of

92.31% (Table 4), and a similar percentage of students reporting they helped their lab exam scores to the resources already discussed, at 76.09%.

ITEM / Question	% of students
Did demonstration lab exams	92.31
Demonstration lab exams improved lab exam scores	76.09

Table 4: Percentage of students doing self-administered demonstration (practice) lab exams. Reported effect of these demo lab exams on their lab exam scores. N=93.

Image Banks & Projected Slides

Our model image banks were initially, similarly to the model videos – the most utilized and prized resource for our students. Updated following the HD model video creation, and based on them, they were detailed and clear and covered everything relevant to students from multiple angles in a usable and portable and flexible format (see materials & methods). Their usage scenarios were online on a laptop, PC, smartphone, and offline via printing or downloading as pdf for offline viewing on a device. Upon employing the model review PowerPoints, many of the images became redundant, but further, structure were unlabelled in the image banks and we were concerned with their utility in comparison to the model review PowerPoints and we were also concerned they would create a distractive resource and time competition with other more relevant resources. However, students reported a usage rate of 81.72%, with 76.09% of students saying their lab exam scores were improved as a result (Table 5), which is in-line with the effect on lab exams as the resources discussed earlier.

ITEM / Question	% of students
Used image banks & projected slides	81.72
Image banks & projected slides improved lab exam scores	76.09

Table 5: Percentage of students using the image banks & projected slides resources. Reported effect of image banks & projected slides on lab exam scores. N=93.

Study time and distribution revisited

The usage of lab resources has been a boon for students to improve their study focus, and to provide ample avenues for the study attention, yet in a focused manner. Our final questions on the survey were meant to find out the effect of the lab resources, taken together, on their total study time spent, and if the additional quiz assessments made students distribute their study time over a greater period, including starting earlier in their preparations. We see both of these to be true (Table 6). An exceptionally high 92.92% of students increased their study time in order to study the resources. This makes sense since the resources are highly tailored to the exams and assessments. It also implies that the quality of study is perceived to be high as the amount of time input is increasing, partially due to need, and likely partially also due to the volume and amount of detail in the resources themselves, which are a mirror of the materials covered directly in lab. A large majority of students reported that the quizzes on the lab manual and models made them prepare earlier for lab exams, which is a truism in the sense that studying these items directly prepares students for those lab exams based on their design, but the most important point is that the students are studying earlier than they would have otherwise, since they need to prepare for a set of 2 quizzes, which is a week earlier than the lab exam, and it will also provide early feedback, or an early warning in some cases, on a student's readiness for the upcoming high-stakes lab exam.

ITEM / Question	% of students
Lab resources increased study time	98.92
Quizzes made me prepare earlier for lab exams	86.96

Table 6: Percentage of students increasing study time due to usage of lab resources, and effect of additional assessments on lab exam preparation. N=93.

Conclusion

We have seen increases in actual lab exam grades due to several of these resources, and this is an area that is being actively explored and quantified currently. From our observations and

surveys carried out currently, we are seeing a net effect of the suite of resources and assessment on the student population in the course.

The quiz questions being studied in advance, the anatomical structures in the models being made more accessible out of lab, using review PowerPoints and the models being studied and prepared for earlier advance due to early quizzes prior to lab exams, and the demo lab exam having some questions that they have also seen in advance are all meant to have the effect of preparing them for the high-stakes lab exams making the bulk of their lab grade. None of these resources on their own will guarantee a higher score on the corresponding lab exam, but the achievement of one's potential is proportional to the time invested in the preparation for the exam in these areas. This would seem to go without saying, but investing time on resources that are more directly related to the exam content is, we think, essential in a course with this much memorized material for each lab exam. The study is focused, and on relevant information. Throughout this process our main concern is to maintain high educational standards and a curriculum of rigor for our future health-sciences professionals going into nursing, physical therapy, nutrition, and other areas where this knowledge is required for practice and success. There is nothing in our lab or on the models or materials or in the lab manual & handouts that isn't tested on, or to be deemed superfluous or unimportant. Thus the decision tree for study by our students is made more clear as to a) what to study, and b) the effects of that study, and how much time to invest. This is the main guidance that led us to developing these resources in particular, and deploying them and assessing on them as we have.

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APPENDIX 1: BIOL 122 Lab Study Resources Survey April 2018

Please answer the following questions, results will be kept anonymous.

Estimated time: 2 minutes

1. What grade range will you earn in A&P lab (assume you are dropping your lowest score)
 - 0-40
 - 40-50
 - 50-60
 - 60-70
 - 70-80
 - 80-90
 - 90-100
2. How many hours per week do you study on average for A&P lab (only). Don't count lab time, but you CAN count open lab time
 - 2-4
 - 4-6
 - 6-8
 - 8-10
 - 10-12
 - Over 12
3. How many days per week do you study for A&P lab (only). Any day you spent over 15 minutes can count as a day studied
 - 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
4. Which resource did you use the MOST in studying for LAB?
 - Model videos
 - Model review powerpoints
 - Model image banks / projected slides
 - Quiz questions
5. Which resource(s) did you also use DURING LAB?
 - Model videos
 - Model review powerpoints
 - Model image banks / projected slides
 - Quiz questions
 - Other: _____

6. If "Other" entered for previous question, please enter below:
7. Which resource do you think helped you the MOST in preparing for lab exams?
- Model videos
 - Model review powerpoints
 - Model image banks / projected slides
 - Quiz questions
8. The model review powerpoints, videos, and image banks were more helpful for me outside of lab
- yes
 - no
9. Did you utilize all of the model review powerpoints?
- Yes
 - No
10. Did using these powerpoints help to prepare you for the visual lab quizzes on the models?
- Yes
 - No
11. What effect do you feel preparing for visual lab quizzes had on your lab exam scores?
- Lab exam scores were about the same
 - Lab exam scores were improved
 - Lab exam scores were not improved
12. Did you utilize the quiz questions (on the lab manual)
- Yes
 - No
13. Did using the quiz questions help to prepare you for the quizzes on the lab manual?
- Yes
 - No
14. What effect do you feel preparing for lab manual quizzes had on your lab exam scores?
- Lab exam scores were about the same
 - Lab exam scores were improved
 - Lab exam scores were not improved
15. Did you utilize the model review videos?
- Yes
 - No
16. What effect do you feel using the model videos had on your lab exam scores?
- Lab exam scores were about the same
 - Lab exam scores were improved
 - Lab exam scores were not improved

17. How many times did you watch the videos each?

- 1
- 2
- 3
- 4 or more

18. Did you do the practice / demo lab exams?

- Yes
- No

19. What effect do you feel doing the demo / practice lab exams had on your lab exam scores?

- Lab exam scores were about the same
- Lab exam scores were improved
- Lab exam scores were not improved

20. Did you use the lab image banks / model images / projected slides?

- Yes
- No

21. Did the lab image banks / model images / projected slides improve your lab exam scores?

- Yes
- No

22. Overall, what impact do you feel that preparing for the lab quizzes (lab manual & model quizzes) had on your lab exam scores?

- Lab exam scores stayed about the same
- Lab exam scores went up
- Lab exam scores went down

23. In your experience, did these resources (model review powerpoints, model videos, model image banks, demo lab exams) increase your amount of study in this course?

- Yes
- No

24. Did having quizzes on the lab manual and models a week before each lab exam make you study earlier than you would have otherwise?

- Yes
- No

25. Please enter any comments about the lab study resources or their use in your study for lab below (*optional*)

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