The Benefits of Multimodal Interactive Case Studies

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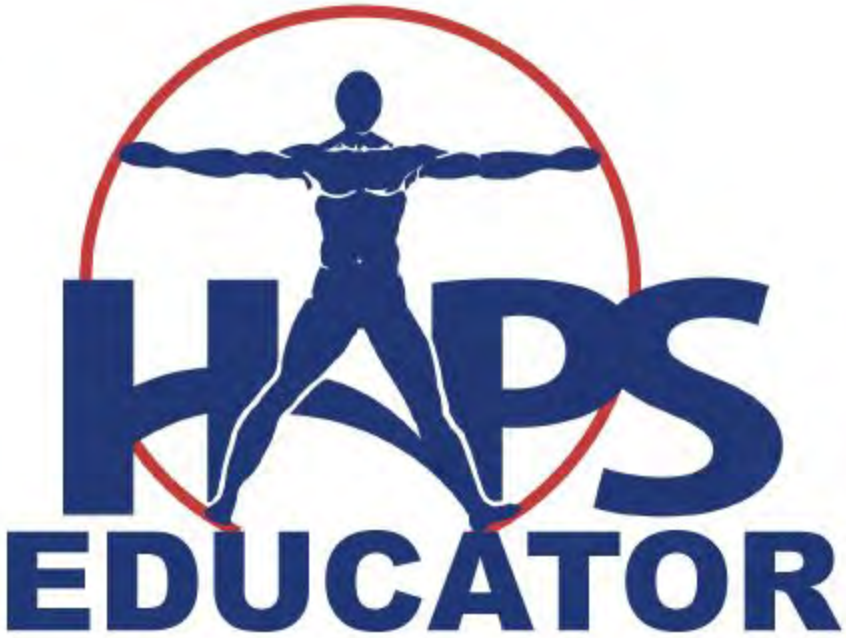

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The Benefits of Multimodal Interactive Case Studies

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Abstract
It is hypothesized that creating case studies that are visually and kinesthetically interactive will encourage experiential and active learning, as well as enhance student engagement and a sense of enjoyment in learning. The case studies in this study were designed to incorporate reading, visual imagery, as well as auditory and hands-on activities for the students. Specifically, each question created has an experiential and/or active component as well as immediate electronic auto-feedback. It was expected that students would find the incorporated images, video clips, interactive websites, as well as hands-on plastic models appealing as well as helpful in their learning. Additionally, it was anticipated that the case studies would assist with remembering key aspects of pathophysiology for the final exam. The four case study topics focus on peptic ulcers, cardiovascular diseases, diabetes, and bone fractures coupled with osteoporosis and sciatica. In addition, each case study begins with reflective questions that are designed to add a metacognitive component to each lesson. Surveys were given after each case study to gauge student satisfaction. In addition, final exam questions responses were analyzed for signs of improvement. https://doi.org/10.21692/haps.2021.011

Key words: pathophysiology, case studies, interactive, images, video clips, kinesthetic, tactile, visual, digital, multimodal, feedback

Introduction
Many studies have shown that using interactive learning strategies can help with increasing students' enjoyment, cognitive processing, and retention of new knowledge (Abykanova et al. 2016, AAAS 2015, Callary et al. 2018, Hyun et al. 2017). Increasingly popular in lesson plans, the AAAS reported that active learning emphases have been increasing in lecture courses since 2012 (AAAS, 2015). This shift has led to positive outcomes being reported. Hyun et al. (2017) studied the implementation of active learning in sixteen courses and found that active learning was associated with higher student satisfaction when introduced in both traditional classrooms, as well as active learning classrooms. Callary et al (2018) reported that incorporating various active components into their lesson plans (e.g. writing, discussion, visual gallery stations, reflection, scavenger hunts, and community engagement) built confidence and fostered curiousity, as well as inner motivation.

Furthermore, research has also found that student-centered activities, involving problem solving, collaboration, student accountability, and teacher management strategies were very effective when acquiring higher order skills (Brush and Saye 2000). In a review of the literature, Abykanova et al. (2016) found that interactive technology activities led to greater mastery of material and more productive communication between students in the classroom, as well as between students and their instructor. They did note that extensive lesson planning and organization on behalf of the instructor is required for optimal success.

As a note of caution, however, Cossom et al. (1991) found that case-based instruction does not appeal to all learners and that some students' needs are not met. Therefore, additional strategies or resources may be required. Furthermore, in reviewing the literature, Ertmer et al. (1995) stated that assuming case-based instruction increases problem solving and critical thinking abilities in all students is likely not accurate. They investigated whether individual self-regulation (motivation and reflection) abilities may play a factor in the varying beneficial impacts of case-based learning within a veterinarian program. They found this was the case and that student success also depended on the students' goal orientations for the course, their strategies (process or product) for completing assignments, their openness to challenges, and other factors affecting personal life and confidence, as well as the format of the case study (Ertmer et al. 1995). Interestingly, this study found that problem-based learning increased student confidence and motivation particularly with students who had scored lower for self-regulation.

Furthermore, Fukuzawa et al. (2017) found that problem-based learning increased student confidence and motivation particularly with students who had less subject matter experience. It is also worth keeping in mind that metacognitive pieces coupled with active learning have been demonstrated to further increase student success. Mutambuki et al. (2020) found that implementing a 50-minute metacognition lesson

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in their active learning lessons led to increases in exam scores compared to the use of active learning on its own. Specifically, in their metacognition lesson, they showed students how to plan studying, monitor self-learning, and evaluate one's own understanding and performance.

As mentioned, many different active learning tools have been used in higher education, including interactive learning objects such as: interactive patient-based case studies (IPCS), review games, simulated interactive patients (SIP), flashcards, and unit quizzes (Reilly 2011). Specifically, within a 1st year medical school anatomy course, Reilly (2011) found that having interactive learning objects significantly improved learner written examination scores, and the SIP learning technique was the most helpful. Reilly (2011) also found that students rated the simulated interactive patients (SIP) and interactive patient-based case studies (IPCS) more favourably than the other activities (e.g. review games).

The use of electronics, such as online case studies has also been shown to allow the students a chance to improve critical thinking skills and be more involved with the course content (Richman 2015). Further, case studies have been found to help students develop problem-solving skills, encouraged reflection and decision making, and allowed the analysis of problematic situations from different levels and points of view (Kunts & Hessler, 1998 as cited in Richman 2015). Case-study-based instructional methods can be more engaging to students compared to traditional instruction, and were preferred by students in a management course (Abeysekera 2015). In addition, Hebert and O'Donnell (2020) found that developing targeted case studies improved student performance on related exam questions. This suggests that assisting students with extra practice questions and study materials that focus on learning outcomes can be appealing as well as beneficial.

Furthermore, Smee and Cooke (2018) found that case studies are an excellent way of ensuring students acquire higher order skills and understanding of course material. Rather than utilizing rote memory, students developed a better and more thorough understanding of physiological systems and acquired greater understanding and insight into real-world applications (Smee and Cooke 2018). Brush and Saye (2000) demonstrated that learning activities such as case studies added to the relevancy of course material and provided students with opportunities to collaborate and solve real-world problems.

It is important to note that Brush and Saye (2000) provided tips on designing active learning activities, and specifically recommended employing a high degree of structure to avoid student disorientation and frustration. Furthermore, they stated that it is important to be cognizant of the following assumptions that are made regarding learning activities and these assumptions should be taken into account by the instructor before designing such activities. First, it is often assumed that the student is willing and able to take on more responsibility for their learning compared to traditional learning activities. In addition, it is often assumed that students are able to self-manage and self-evaluate as well as to set goals. Also, if activities take the form of group-activities, it is often assumed that students have the skills required for successful collaborative learning. Therefore, to ensure success, it is recommended that instructors provide well-defined questions and rubrics, timely feedback, metacognitive pieces, and assistance with setting roles and accountability for both individual and group-work (Brush and Saye 2000).

With this previous research in mind, the case studies created in this study were designed to incorporate many of these ideas: prior knowledge, structure, clarity, immediate feedback, individual accountability, logical flow, metacognition, and active learning. Specifically, this study evaluated the effectiveness of incorporating various stimuli (visual, auditory, tactile, and electronic) into pathophysiology case studies for 2nd year Nursing students and 3rd year Human Kinetics students. The goal was to design case studies that were less text-heavy and potentially more student-centric by creating multi-modal study resources that incorporate various components (e.g. pictures, video clips, animations, manipulatives, and interactive electronic components).

Interestingly, the metacognitive activities we used at the beginning of term revealed that the majority of both the 2nd year nursing students and the 3rd year human kinetics students participating in this study stated that their preferred learning resources were interactive (e.g. hands-on, either tactile or electronic), followed closely by reading/writing, auditory (listening and speaking), and visual (including pictures, video clips, and animations). This is slightly different in comparison to the 3rd year nursing students at a Jordan University who reported read/write as their dominant learning preference, followed by kinesthetic (Alkhasawneh et al. 2008). Though, Alkhasawneh et al. (2008) made clear that most 3rd year nursing students in their class did report having multimodal learning preferences overall which is similar to our findings. Additionally, we noted that most students in our classes preferred to come to class and learn through images, listening, and activities rather than reading the textbook on their own. To that end, the goal in our course was to provide course material in many different formats making it accessible to all of our students, with interactive case studies being a contributing component.

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Methods

Multimodal case study assignments were created for two different pathophysiology courses, reflecting each class's unique learning outcomes. The 113 students enrolled in 2nd year Nursing Pathophysiology and the 201 students enrolled in 3rd year Human Kinetics Pathophysiology were asked to complete graded case study assignments as well as voluntary, optional, ungraded, pre- and post-case study surveys. All case studies were given to the students after they had classes in each topic. Equipped with this prior knowledge, students could engage with the case studies to improve and master their understanding of the concepts. It was hoped that students would use the case studies as they started studying for their exams. The students were able to complete each case study as many times as they wished and their highest score for each was the one that counted towards their final grade.

All case studies were assigned as homework and were completed individually, though students were welcome to work in groups if they chose. The case study format used was Appraisal Case Studies format as depicted in O'Malley et al. (2019) in which the student must use problem solving skills and critical thinking to determine what is happening with the patient, what the diagnostic test results mean, and review each disease's pathophysiology, risk factors, signs and symptoms, possible complications and typical outcomes.

This project was approved by UBC's research board of ethics. This educational research project was explained in detail to all of the students in advance and students were given consent forms to read over and sign if they were willing to have their data used for this study. Participation was voluntary and students were able to change their minds and withdraw from the study at any time.

As part of the study, case study data was linked to scores on related final exam questions to observe any influence on long-term memory and performance. It should be mentioned that final exam questions were purposely quite different from those in the case studies. However, it was anticipated that case studies would bolster knowledge of these topics in general, leading to a better understanding of the topics as a whole, and higher final exam scores. The case study survey data was blinded to the course instructor. Personal identifiers were removed from the data by a 3rd party prior to data analysis to maintain anonymity and confidentiality. Statistical analysis in each data set involved using paired t-tests as well as Pearson correlational analysis.

Results and Discussion

A. Osteoporosis and Fracture Case Study

In this case study, 2nd year nursing students were introduced to a story in which two neighbors of differing ages (89 and 40 years old) came to have bone fractures. As students worked through the case study, they were taken through the different risk factors, the pathogenesis, diagnostic tests, treatments, possible complications, as well as the healing that occurred in both cases. The interactive components of this case study consisted of: 3 x-ray images, 1 DXA image, 4 plastic models representing the progressive stages of vertebral osteoporosis and disc degeneration, 1 image of sciatica, and 1 figure illustrating the 4 stages of bone fracture healing.

Prior to going through the case study, in order to gauge prior knowledge and add a reflective piece, students completed a short survey in which they rated their level of understanding of the risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical treatments of both bone fractures and osteoporosis. Pre-case study survey results are depicted in Figure 1 and show that on average, prior to starting the case study, most students felt they had room for improving their mastery of course content in each area. Specifically, only 7-21% (4-12) of students selected "Excellent" in response to these questions. Furthermore, most (22-32 or 39-57%) respondents rated their level of understanding of each aspect of bone fractures and osteoporosis as "Good". It is not surprising that "Poor" was selected less often (1-10 or 2-18% of students) in answer to these questions, as students completed the case study after attending classes on both topics (bone fractures and osteoporosis). Likewise, only 0-1 students selected "I Haven't Learned Yet".

In considering possible future enhancements to the course, It was noted that prior to the case study, students were least confident in their understanding of diagnostic tools for bone fractures and osteoporosis, with 9-10 students selecting "Poor" in answer to those two questions respectively. On the other hand, students were most confident in their ability to identify risk factors for bone fractures and osteoporosis as well as typical outcomes for bone fractures.

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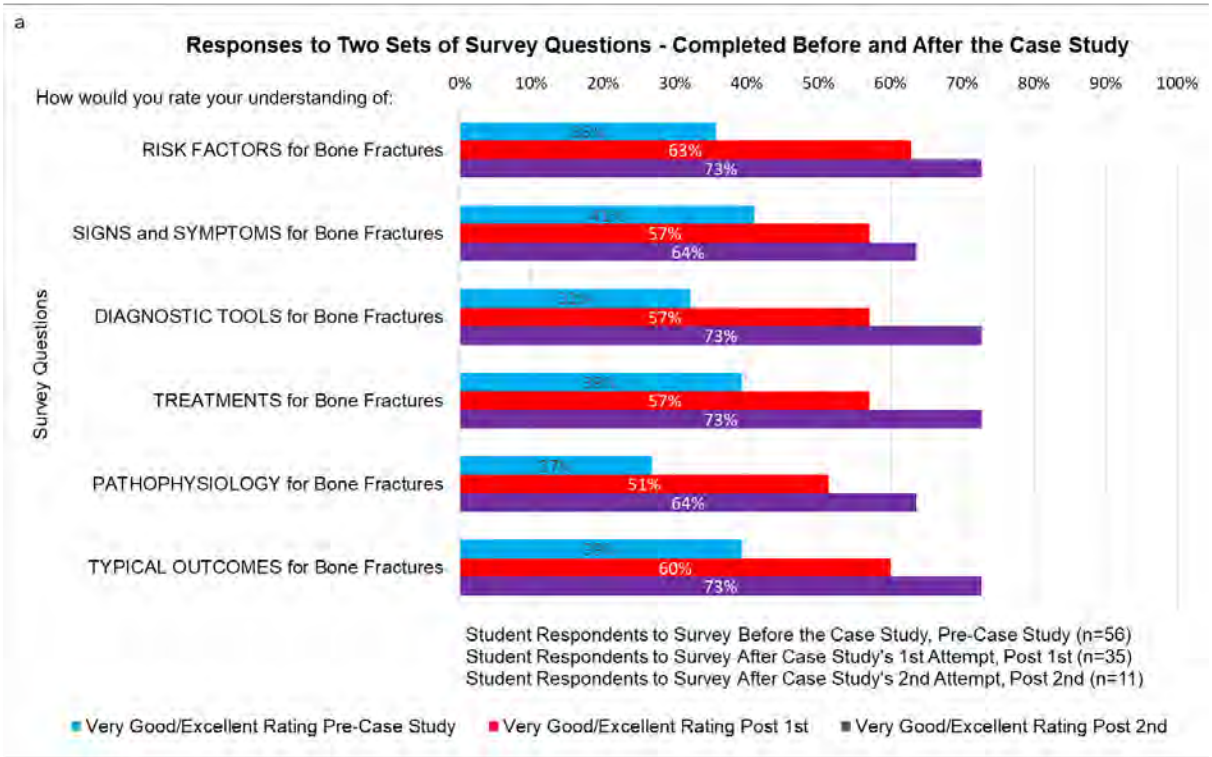

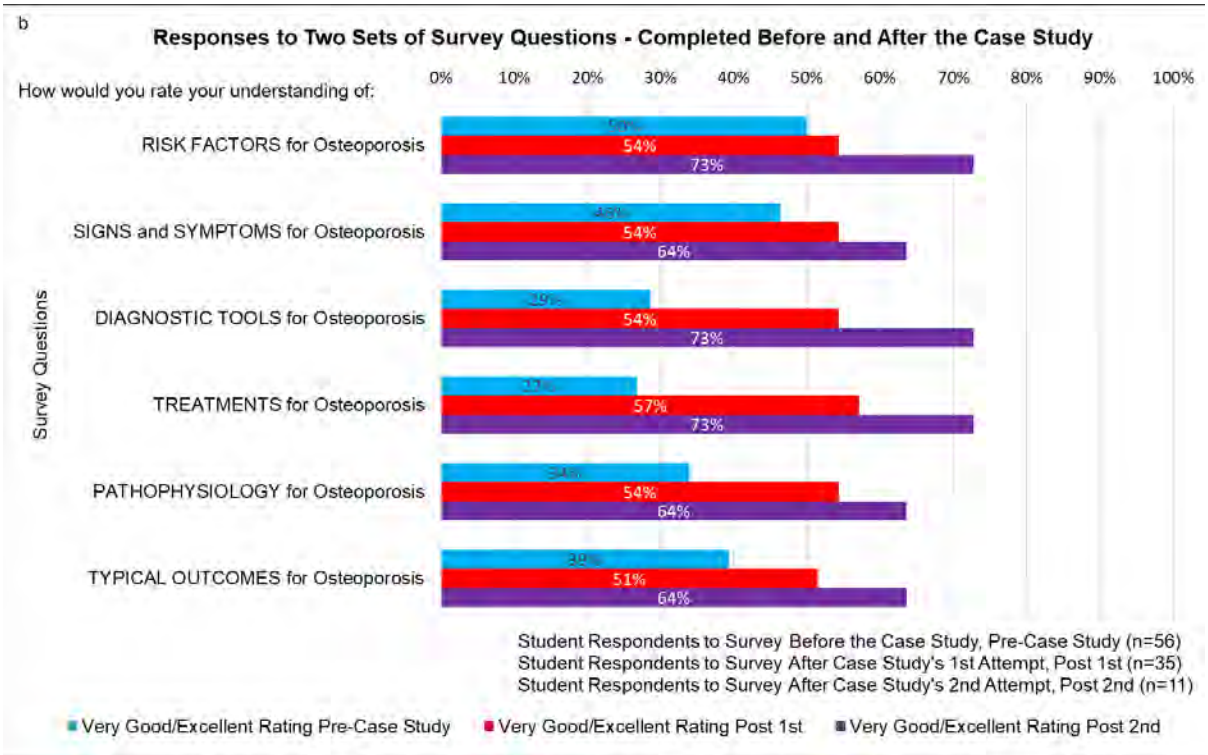

Figure 1. *Student Reflective Knowledge Survey - Completed Before and After the Fracture and Osteoporosis Case Study. Students rated their understanding of aspects of a) Bone Fractures and b) Osteoporosis. Possible choices to each statement were: Excellent, Very Good, Good, Poor, and I Haven't Learned Yet.*

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The survey results after their first and second attempts of the case study are also shown in Figure 1. The majority of respondents felt that they improved in the mastery of each topic after each attempt at completing the case study. After the first attempt, between 37-43% (13-15) of respondents selected "Excellent" and only 0-2 (0-6%) respondents selected "Poor" when rating their understanding of various aspects of bone fractures and osteoporosis.

The average case study score of the 54 respondents on Attempt 1 was 21.92/30 (73%) and the average score of the 35 respondents on Attempt 2 was 29.40/30 (98%). For the 35 students that completed the 2nd attempt, there was an average improvement of 6.8 points (23%). For these 35 students, the difference between the Attempt 1 and Attempt 2 scores was found to be statistically significant (with alpha=0.05). Specifically, results of paired t-tests between Attempt 1 and 2 case study scores found the t-statistic value to be -20.086 and the t-critical value to be 2.032 (and therefore the null hypothesis was rejected).

None of the students indicated a decrease in their understanding of the material on subsequent case study attempts. All students chose either a higher rating or the same rating as on their previous attempt.

11 Students completed the case study a 3rd time and of the 8 students that completed the survey at the beginning of their 3rd case study attempt, an even higher proportion of students (55-64%) selected "Excellent" in response to these questions, and the remaining students selecting "Very Good" most often, followed by "Good". None of the students selected "Poor", or "I Haven't Learned Yet". Results are shown in Figure 1 (labelled "Post 2nd" attempt) and increasing student confidence trends with each topic are depicted after every case study attempt.

Once the students had completed the Osteoporosis and Fracture Case Study they were invited to complete a second set of optional survey questions which was designed to assess their perceived level of understanding of the risk factors, pathogenesis, treatments, diagnostic tools, healing stages, and possible complications of both osteoporosis and bone fractures. This set of survey results is shown in Figure 2. The majority (85%) of students agreed that this case study helped them understand the different options for treating hip fractures. 97% of students agreed that this case study helped them understand the 4 healing stages of bone fractures, 94% agreed that it helped them understand what happens to the bone during osteoporosis, and 79-85% of students agreed that it helped in understanding osteoporosis risk factors such as hormone imbalance, kidney disease, and diabetes. 91% of students agreed that this case study helped them understand how osteoporosis is diagnosed and 76-88% of students agreed that it helped them understand how osteoporosis can lead to vertebral compression, bone spurs, sciatica, and even hip fractures and death.

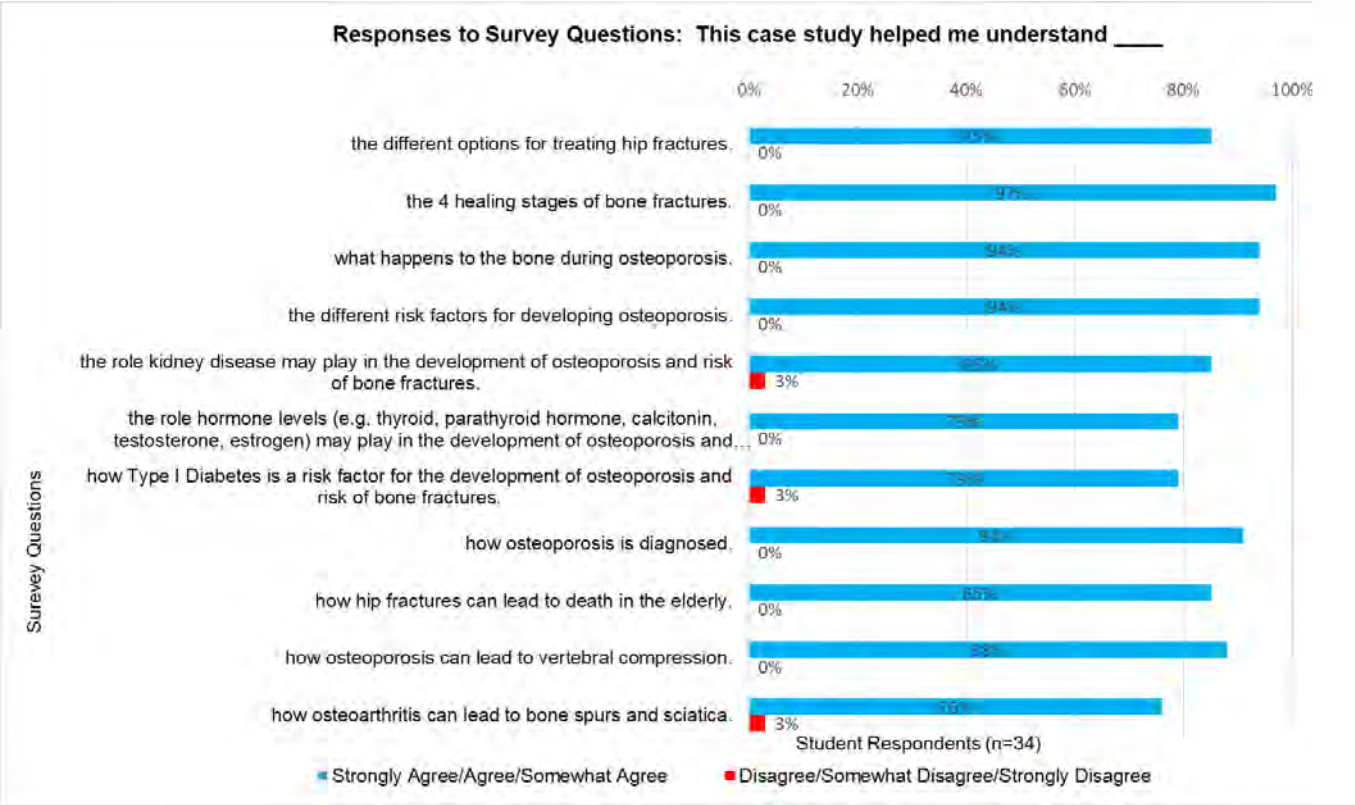

Figure 2. *Student Satisfaction Survey - Completed After the Osteoporosis and Fracture Case Study. 2nd year nursing students rated the case study's abilities to promote learning of different aspects of these topics. Possible ratings of each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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In addition to the questions asked in Figure 2, students were able to fill in an optional comment box as well (Appendix, Table 1). Positive comments included sentiments that the case study was: engaging, fun, useful, interactive, enjoyable, helpful, relevant to the real world, and well done. Suggestions included giving immediate feedback after each question. While we agree that this is a very good idea, it is not possible with our current Learning Management System (LMS). Our current LMS (Canvas) gives feedback immediately after the student has finished and submitted all of the questions. That being said, not having immediate feedback on each question might encourage students to look things up on their own and take the case study again which may foster more long-term memory of the material. As mentioned previously, students were given unlimited attempts at the case study to encourage its use as a learning and studying tool.

There was a suggestion that the content did not align with the course which is unfounded. Another suggestion was to make the images smaller which is possible and something that will be looked into doing in the future. The goal was to have the images large enough for everyone to see clearly no matter what device they use. Three students wanted the case study to be shorter. The case study was 27 questions and worth 30 points. It was open book and there wasn't a time limit, so students could leave the case study running on their computer and take breaks while they were completing it. Indeed, 9 students had very long run times for Attempt 1 (3hr 8min to 1131hr 22min). With these times removed from calculations, students took an average of 32min 13sec on their first attempt. It was anticipated that students would take less time on subsequent attempts, which proved true, with students taking an average of 9min 15sec on their second attempt.

As mentioned, once the students had completed the Osteoporosis and Fracture Case Study they were invited to complete a second set of optional survey questions. Included in this survey were questions designed to assess the various components of the case study to see which were found to be helpful. The results of the case study component survey question are shown in Figure 3. The majority (76-97%) of students agreed that the visual (x-ray images and figures), as well as the interactive and hands-on components (electronic osteoporosis risk tolerance test and plastic models) were helpful in their learning. 85% of students agreed that this case study would help them remember specific details of bone fractures, osteoporosis and disc degeneration. 94% of students agreed that case studies like this should be used in the future.

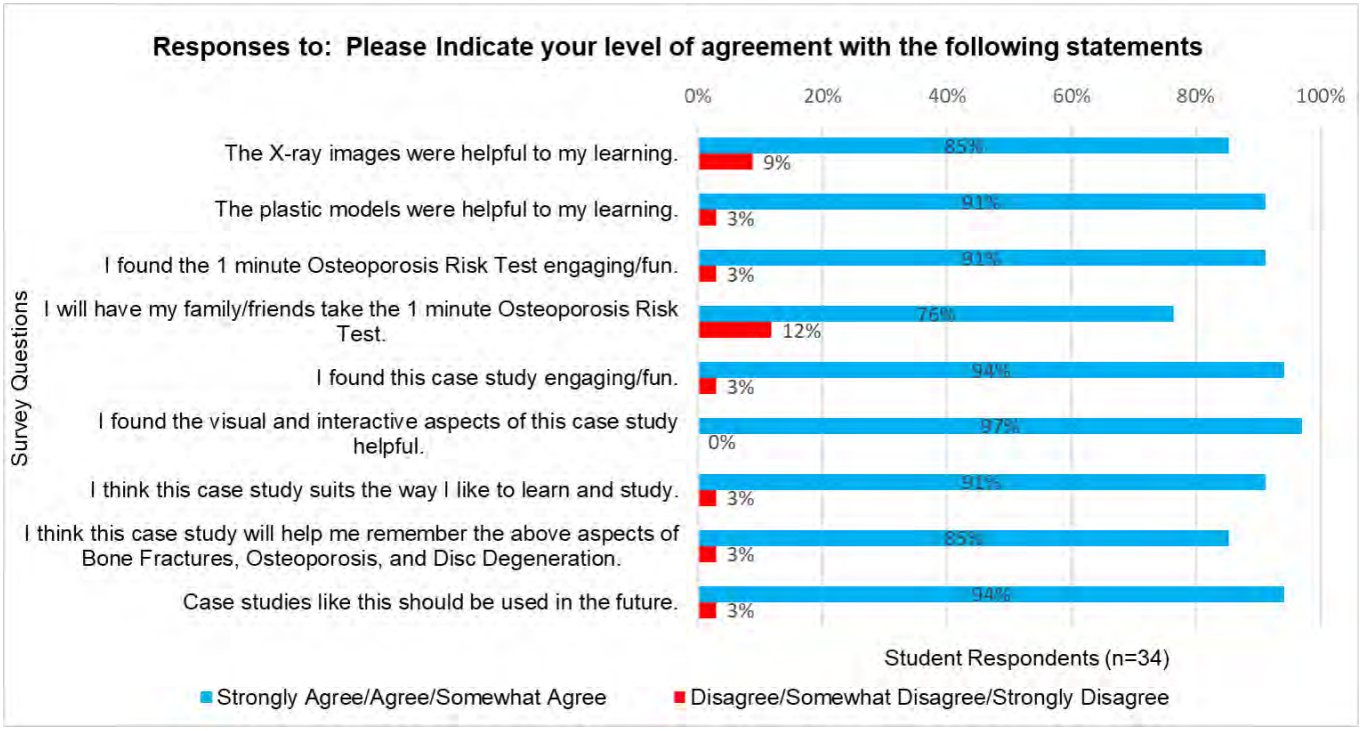

Figure 3. *Student Survey Completed on Osteoporosis and Fracture Case Study Components. 2nd year nursing students rated the usefulness of the various multimodal aspects of this case study. Possible ratings of each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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B. Heart Disease Case Study

In this case study, 2nd year nursing students were introduced to a story in which a client visits the doctor after experiencing blurry vision, headaches, and heart palpitations when climbing the stairs to his apartment. Over the course of 24 questions, students were taken through the risk factors, signs and symptoms, and diagnostic tests associated with both peripheral artery disease and coronary artery disease. Possible complications and pathogenesis of angina pectoris, myocardial infarction, hypertension, congestive heart failure, nephrosclerosis, ischemic and hemorrhagic stroke, retinopathy, metabolic syndrome and non-alcoholic fatty liver were also explored.

The interactive components of this case study consisted of: 17 images and 8 plastic models (which depicted atherosclerosis, angina pectoris, myocardial infarction, congestive heart failure, nephrosclerosis, retinopathy, non-fatty liver disease, ischemic and hemorrhagic strokes). The images included a CT angiogram and a Doppler ultrasound image of peripheral artery disease in the leg.

LMS reporting indicated that students took an average of 16 min 45 sec to complete this case study. It was found that 2 students left their case studies running for more than 34 hr and these two data points were not included in the calculation. Students took longer on their first attempt (averaging 23min 13sec) and then less time on their subsequent attempts (with Attempt 2 averaging 10min2sec).

Prior to going through the case study, students could opt to complete the survey depicted in Figure 4 in which they rated their level of understanding of the risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical treatments of hypertension, angina pectoris, and heart failure. This case study was given to students after we had a class in this unit so it was not surprising that "I Haven't Learned Yet" was selected the least often in answer to these questions and "Poor" was selected by only 2-6 (5-18%) students depending on the question. Additionally, survey results show that prior to the case study, most students felt they had room for improving their mastery of this course content in each area, which was also anticipated. Only 23-35% (9-14) of respondents selected "Excellent" in response to these questions.

When considering future course enhancements, it was noted that, prior to the case study, students were least confident in their understanding of diagnostic tools for congestive heart failure and typical outcomes for hypertension and angina pectoris, with 7 and 6 students selecting "Poor" in answers to those questions respectively. This is not surprising as there are many diagnostic tools for CHF and many typical outcomes for both hypertension and angina pectoris depending on duration and severity making these complex topics to learn with confidence. On the other hand, students were most confident in their ability to identify risk factors for hypertension which are concepts that are more intuitive and commonly known.

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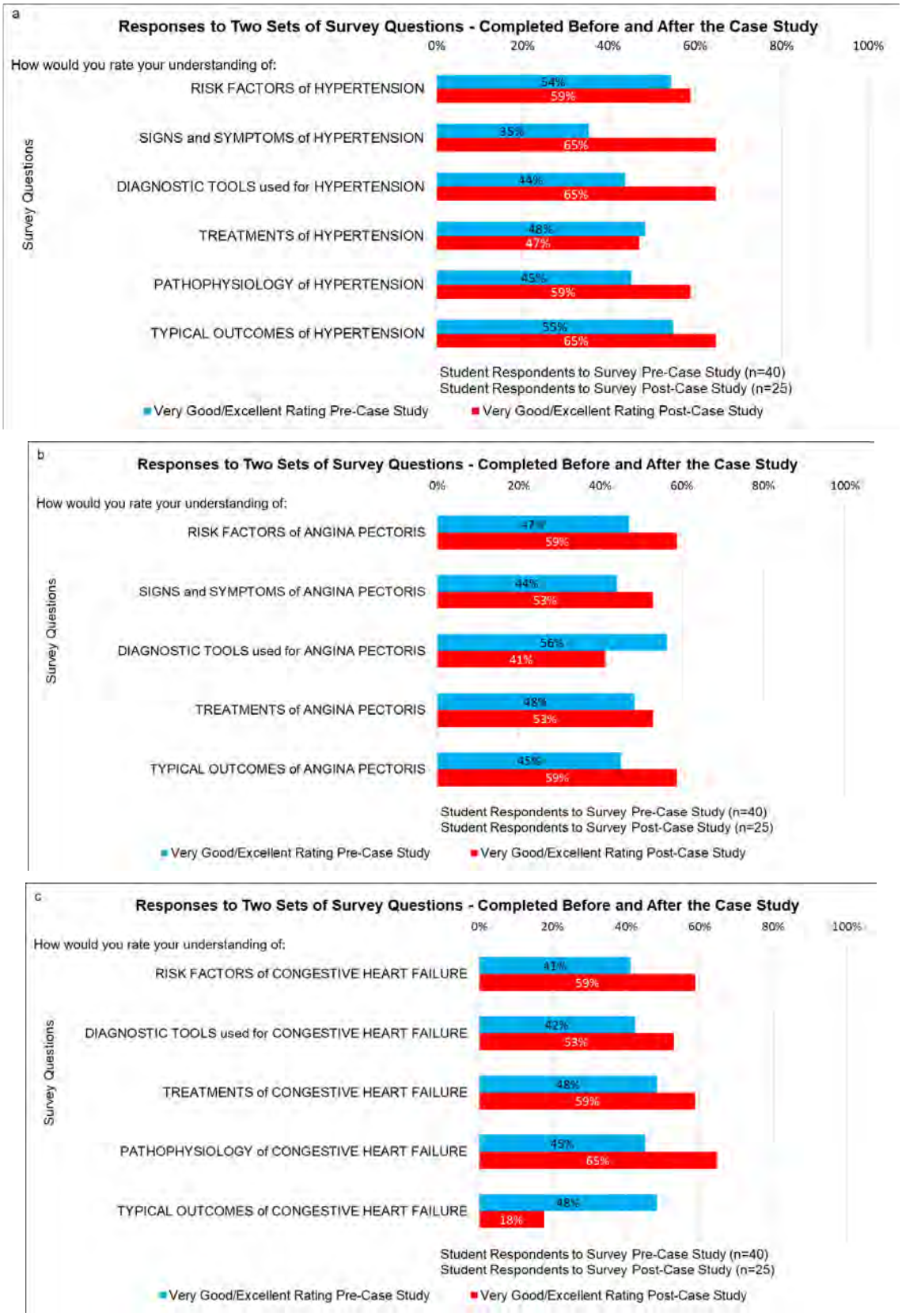

Figure 4. *Student Reflective Knowledge Survey - Completed Before and After the Heart Diseases and Disorders Case Study. Students were asked to rate their understanding of aspects of a) Hypertension, b) Angina Pectoris, and c) Congestive Heart Failure. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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In the post-case study survey (Figure 4), the majority of respondents reported that they improved in the mastery of each topic after completing their first attempt at the case study. Between 28-40% (7-10) of respondents selected "Excellent" in response to these questions. Only 0-3 (0-12%) respondents selected "Poor" when rating their understanding of various aspects of hypertension, angina pectoris and heart failure.

The average score of the 40 respondents on Attempt 1 of the case study was 26.67/31 (86%) and the average score of the 25 respondents on Attempt 2 was 27.58/31 (89%). For the 25 students that completed the 2nd attempt, there was an average improvement of 1.1 points (3.5%). The difference between Attempt 1 and Attempt 2 scores was not found to be statistically significant (with alpha=0.05). Specifically, results of paired t-tests between Attempt 1 and 2 scores found the t-statistic value to be 0.26 and the t-critical value to be 2.06 (and therefore the null hypothesis was accepted). It should be noted that students that scored high on their first attempt, were less likely to repeat the case study compared to students who scored lower. This is likely a factor in both overall score improvement was well as survey responses.

Once the students had completed the Heart Disease Case Study, they were invited to complete a second set of optional survey questions which were designed to assess the student's perceived level of understanding of the risk factors, signs and symptoms, pathophysiology, diagnostic tests of hypertension and heart disease. Additionally, students were asked if this case study helped their level of understanding of angina pectoris, peripheral artery disease, different types of CVA, and the effects of hypertension on the kidney, brain, and eyes. This set of survey results is shown in Figures 5 and 6.

The responses indicated that the majority of students (79-100% or 33-42 of 42 student responses to this set of 10 questions) agreed that this case study helped them understand all of those specific topics. The lowest score, though still very favorable had 33 (79%) of students agreeing that the case study's coverage of CVA was helpful. It is not surprising that students weren't able to learn as much about the various types of CVA from this case study compared to other topics. CVA was covered predominantly during class and is only briefly mentioned during the case study. The case study's depiction of the effects of hypertension on the kidneys, eyes and vision was almost unanimously reported to be helpful, which was wonderful, as our students typically find nephrosclerosis and retinopathy as a result of hypertension difficult to picture and understand. It is thought that the plastic eye and kidney disease models were helpful with this.

The topic of peripheral artery disease (PAD) in the case study was reported 2nd most often (by 39 or 93% of respondents) as being helpful in their understanding. This topic did have the most pictures incorporated into the case study which may have contributed to this success. Specifically, there were 3 different pictures of PAD (a drawing, a Doppler ultrasound image and an angiogram) in addition to a picture of blood pressure readings in the leg, making this topic the most visual in the case study.

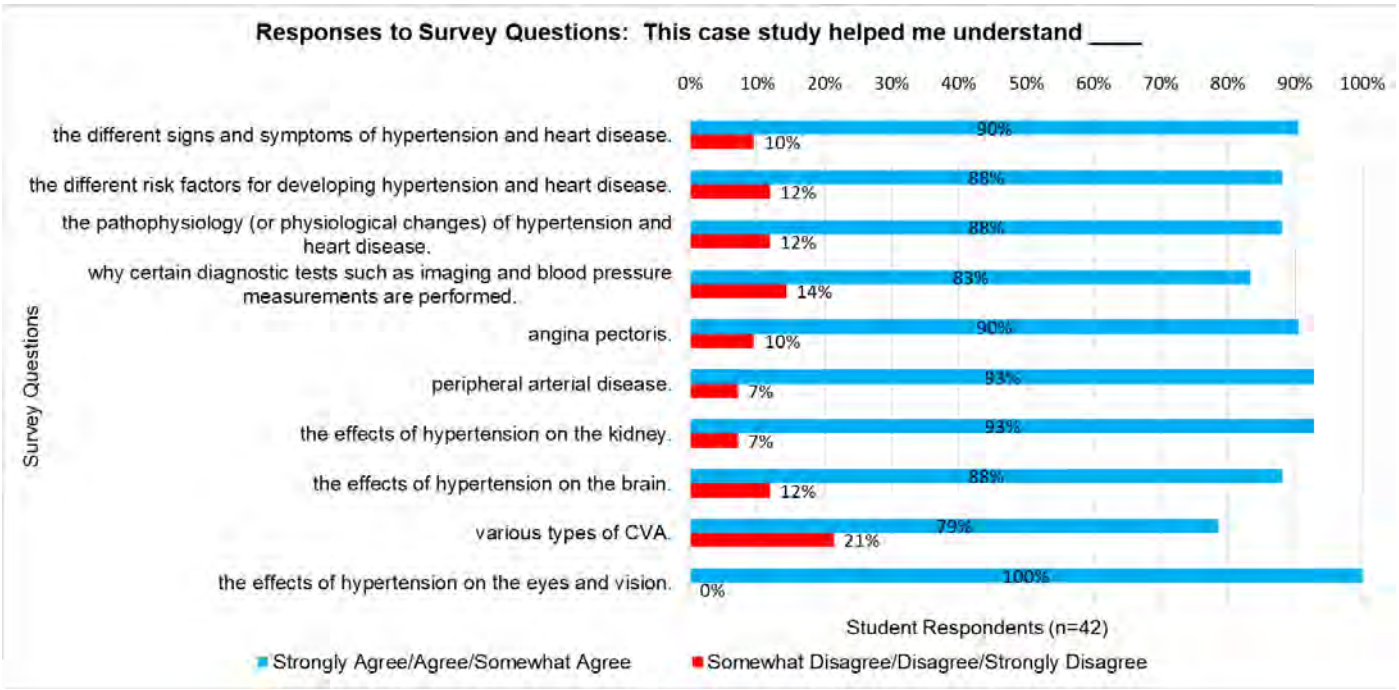

Figure 5. *Student Satisfaction Survey - Completed After the Heart Diseases and Disorders Case Study. 2nd year nursing students rated the case study's abilities to help the learning of different facets of heart diseases and disorders. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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As depicted in Figure 6, the majority (37 or 88%) of the respondents agreed that this case study should be used in the future. Most students (32-39 or 76-90%) agreed that the pictures, plastic models, real histology pictures, angiograms, Doppler imaging, and creation of study table during this case study were helpful in their learning. One of the goals of the class is to make connections between the cardiovascular system and the health of all organ systems. Most students (95%) agreed the case study helped them appreciate how the cardiovascular system is important to all organ systems. Additionally, 86-90% of students found the visual and interactive aspects helpful and engaging.

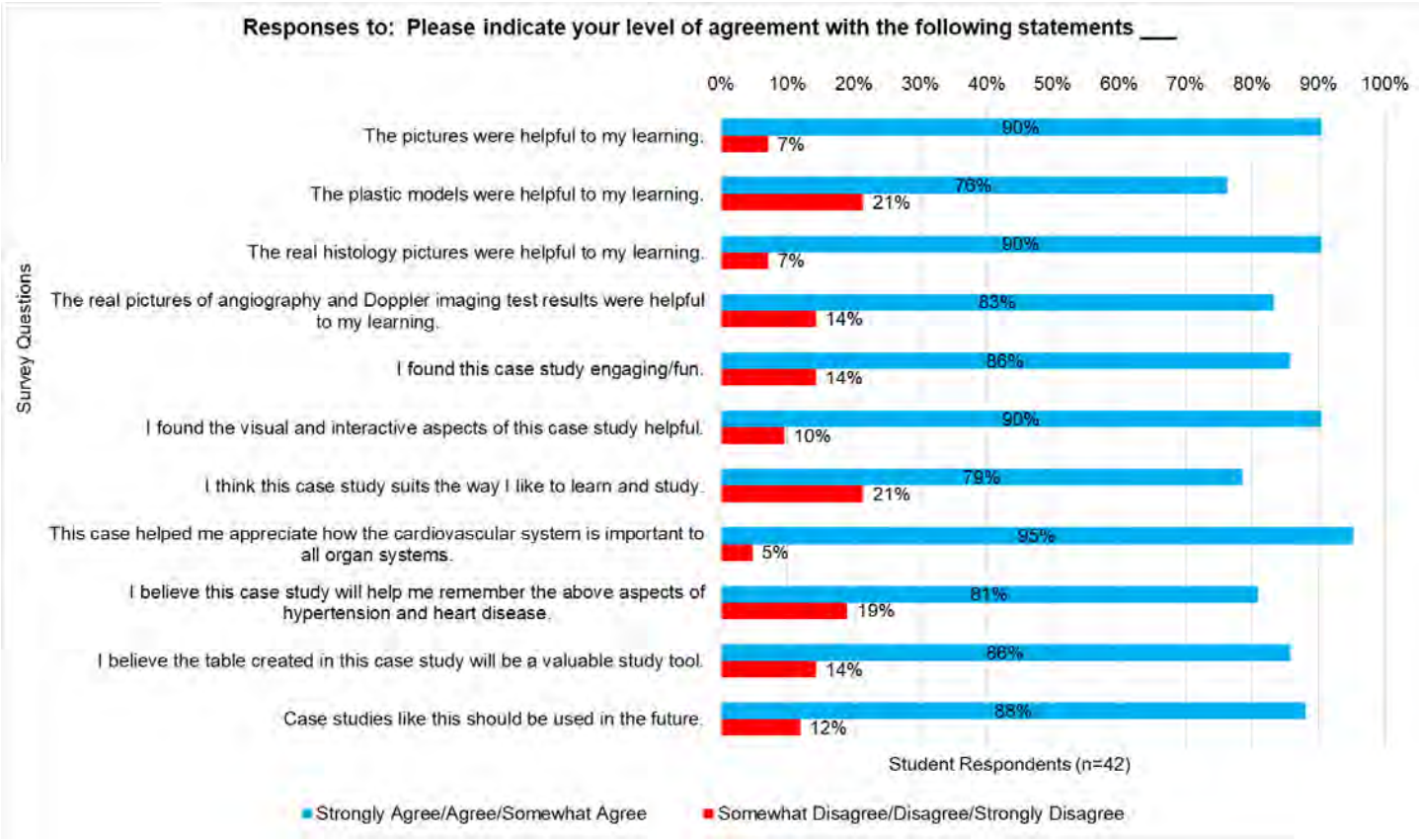

Figure 6. *Student Survey on Heart Disease Case Study Components. 2nd year nursing students rated the usefulness of the various multimodal aspects of this case study. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

Students were able to leave comments in this survey (Appendix, Table 2). Most comments were favorable, citing appreciation of the interactivity, the mock real life situation, the pictures, the compartmentalization of a specific topic, and the ability to test and reflect on one's own knowledge. Suggestions again included providing immediate feedback after every question instead of at the end.

C. Diabetes Case Study

In this case study, 2nd year nursing students were introduced to a story in which three members of a family are each experiencing a different type of diabetes (Type 1, Type 2, and gestational diabetes). Over the course of the case study's questions, students were taken through the risk factors, pathogenesis, diagnostic tests, treatments, possible

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complications, and outcomes that are typically associated with gestational diabetes. The interactive components of this case study consisted of: step-by-step pictures of urinalysis and pictures of blood testing and fetal monitoring. Also, in addition to completing this first part of this case study which was largely dedicated to gestational diabetes, students also completed "The Role of Insulin Video Quiz" and "The Diabetes Pathophysiology Video Quiz", both of which focused on both Type I and Type II diabetes. These two video quizzes are 5 and 23min. videos embedded with quiz questions.

Prior to going through the case study and associated video quizzes, students completed an optional survey (Figure 7), in which they rated their level of understanding of the risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical treatments of gestational diabetes. The responses before the case study, indicated that the majority of the respondents felt that they still had room for improvement in the mastery of each topic. Specifically, only 17-26% (9-14) of respondents selected "Excellent" in response to these questions. The most common response to these questions was "Good", which was chosen by 16-22 (30-42%) students. "Poor" and "I Haven't Learned Yet" were selected least often which is not surprising as this case study was delivered after the material was covered in class, and class attendance is close to 100%.

For future consideration in course design, it was noted that students were least confident in their understanding of pathophysiology and typical outcomes for diabetes, with 8 (15%) students selecting either "Poor" or "I Haven't Learned Yet" in answer to those two questions respectively. On the other hand, students were most confident in their ability to identify risk factors for diabetes with only 5 (10%) students selecting either "Poor" or "I Haven't Learned Yet".

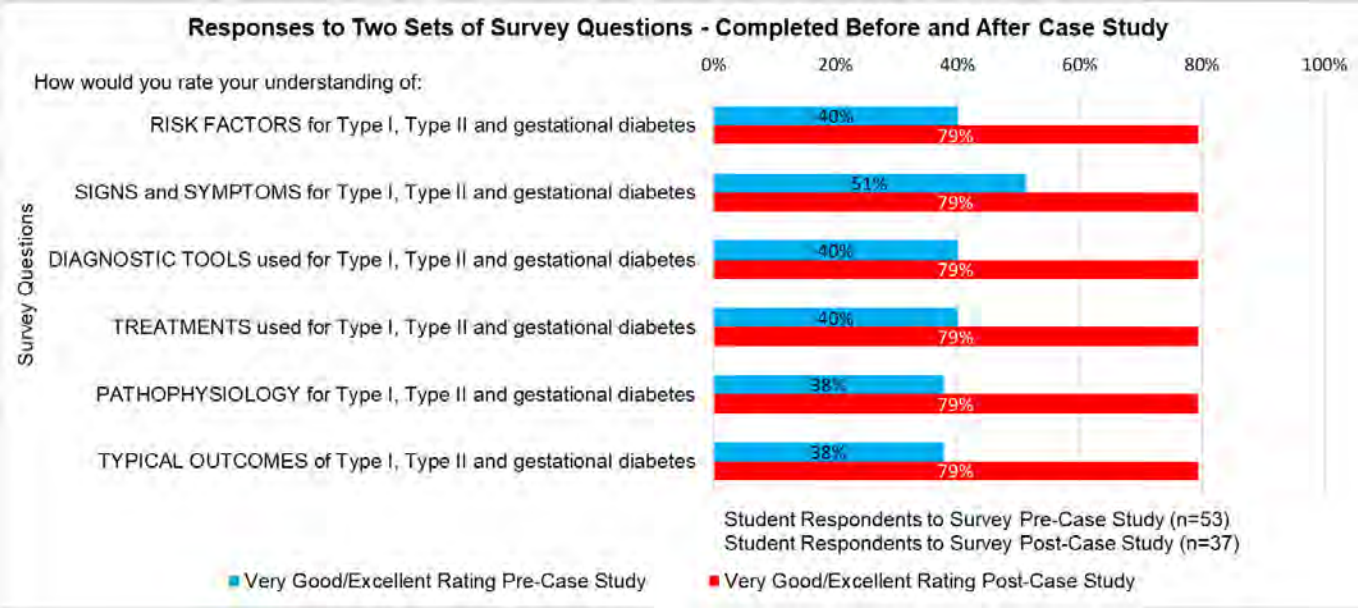

Figure 7. *Student Reflective Knowledge Survey - Completed Before and After the Diabetes Case Study. Students rated their understanding of aspects of Type 1, Type II, and gestational diabetes. Possible answers to each question were: Excellent, Very Good, Good, Poor and I Haven't Learned Yet.*

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When students completed the case study a second time they filled in the survey at the beginning again and the results are shown in Figure 7 (labeled "post-case study"). It was found that the majority of respondents felt that they improved in the mastery of each topic after completing their first attempts of the case study. Between 57-59% (21-22) of respondents selected "Excellent" in response to these questions. None of the respondents selected "Poor" or "I Haven't Learned Yet" when rating their understanding of various aspects of diabetes.

There were 9 questions in the non-video component of the case study and students took an average of 13min 24sec to complete it. This calculated average does not include the times of 4 students that let their case studies run for over 50 hr. Students took an average of 31min 24sec on their first attempt and 2min 52sec on their second attempt. The average score of the 53 respondents on Attempt 1 was 7.03/9 (78%) and of the 37 respondents on Attempt 2 was 7.28/9 (81%). For the 37 students that completed the 2nd attempt, there was an average improvement of 0.5 points (6%). For students with two attempts, the difference between Attempt 1 and Attempt 2 scores was not found to be statistically significant (with alpha=0.05). Results of paired t-tests between Attempt 1 and 2 scores found the t-statistic value to be -1.12 and the t-critical value to be 2.03 (and the null hypothesis was accepted).

17 Students completed the diabetes case study a 3rd time and of the 13 that completed the survey, 12 (92%) of the students selected "Excellent" in response to these questions, with the remaining students selecting "Very Good". None of the students selected "Good", "Poor", or "I Haven't Learned Yet" indicating they now felt confident in the material.

As mentioned, the students also watched 2 videos that had been created for them. The Role of Insulin is 5min 50sec long and is embedded with 10 multiple choice questions. The Diabetes Video is 23min 38sec and contains 27 multiple choice questions. Both video quizzes were designed to enhance interactivity, engagement, and Q&A practice of the content being presented on Type I and Type II diabetes as well as the normal role of insulin within the body. The students were invited to participate in a survey to gauge the helpfulness of these two activities (Figure 8). Only 1 student responded that the Diabetes Pathophysiology quiz was not necessary.

On the first survey, many students (15-18 or 28-34%) hadn't completed the video quizzes yet. Of the respondents who had completed the video quizzes, 19 (73%) students found the Diabetes Pathophysiology Video quiz was either helpful or very helpful and 25 (83%) students found the Role of Insulin Video quiz was either helpful or very helpful. after completing the diabetes case study a second time, more students had completed both video quizzes with only 5 selecting "I haven't done it yet" (Figure 8). Most students (20) that had completed the video quizzes found them "very helpful". Additionally, 2 students found them to be "helpful", meaning that 22 (92%) of respondents that had used the video quizzes found them to helpful or very helpful.

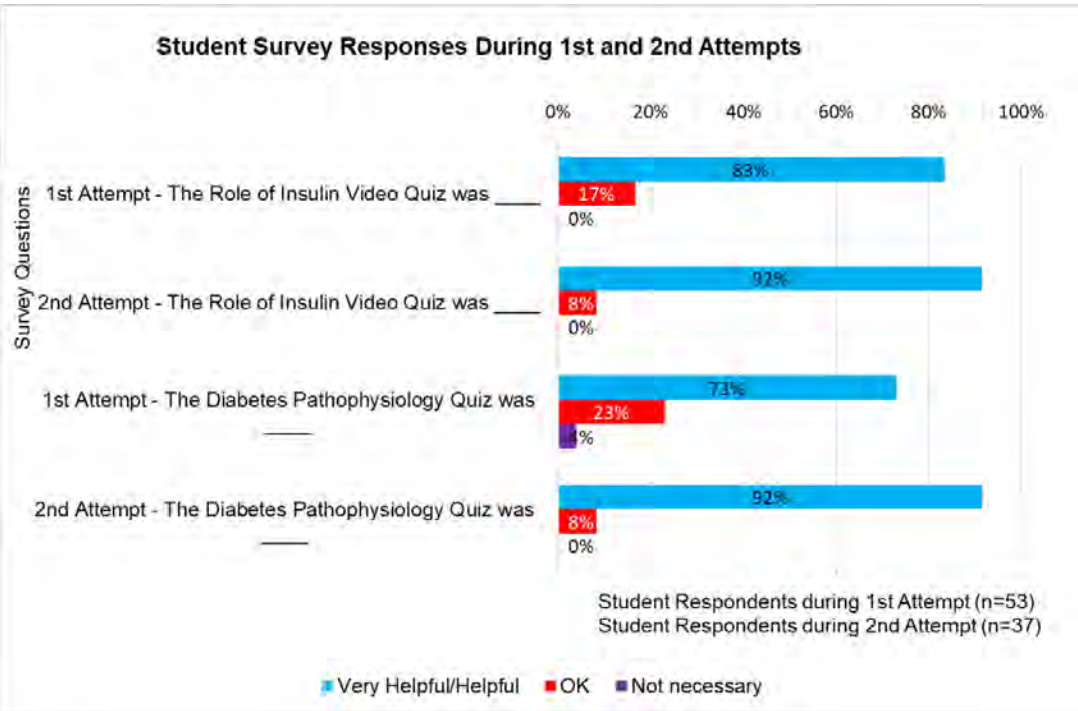

Figure 8. *Student Survey Assessing Insulin and Diabetes Video Quiz Components. Possible answers to each question were: Very helpful, Helpful, OK, Not necessary, and I haven't done this yet.*

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Once the students had completed the Diabetes Case Study they were invited to complete a second set of optional survey questions to assess their perceived level of understanding of the signs and symptoms, risk factors, pathophysiology, treatments, diagnostic tools, and possible complications including diabetic ketoacidosis and hypoglycemic shock (Figure 9). The majority of students agreed that this case study helped them understand the role of insulin in the body (86%), the signs and symptoms, risk factors, and pathophysiology of diabetes (77%), the diagnostic tools (82%), and possible complications as well as treatments for both Type I and II diabetes (59-73%).

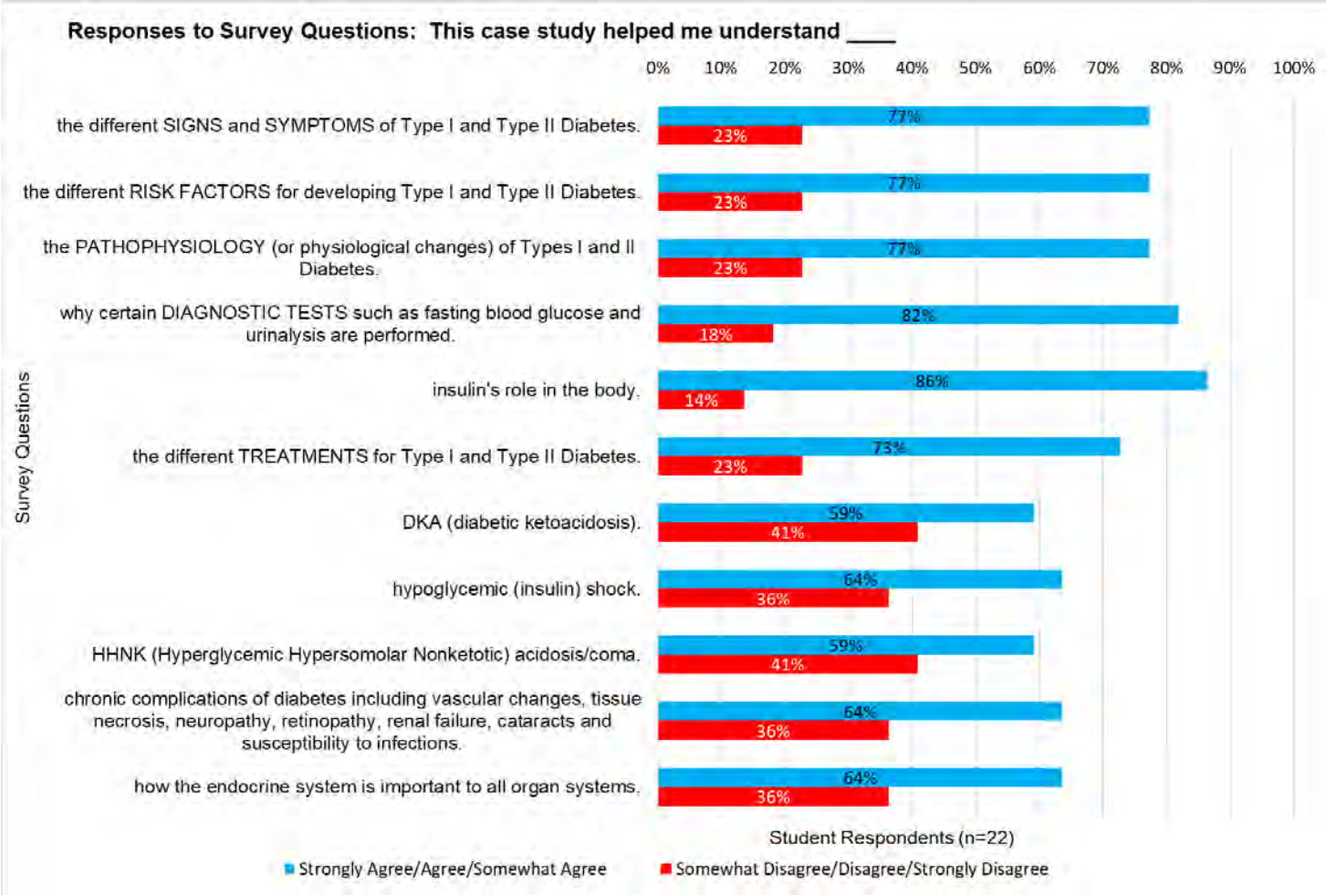

Figure 9. *Student Satisfaction Survey - Completed After the Diabetes Case Study. 2nd year nursing students rated the case study's abilities to support the learning of different aspects of the diabetes case study. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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Included in this survey were questions (Figure 10) to assess the helpfulness of the various components of the case study. The responses indicated that the majority (64-82%) of students agreed that the visual (video clips, histology pictures, instrument display pictures, and figures), as well as the interactive and hands-on components (plastic models) of this case study were helpful in their learning. 82% of students agreed that this case study would help them remember specific details of diabetes and 91% of students agreed that case studies like this should be used in the future.

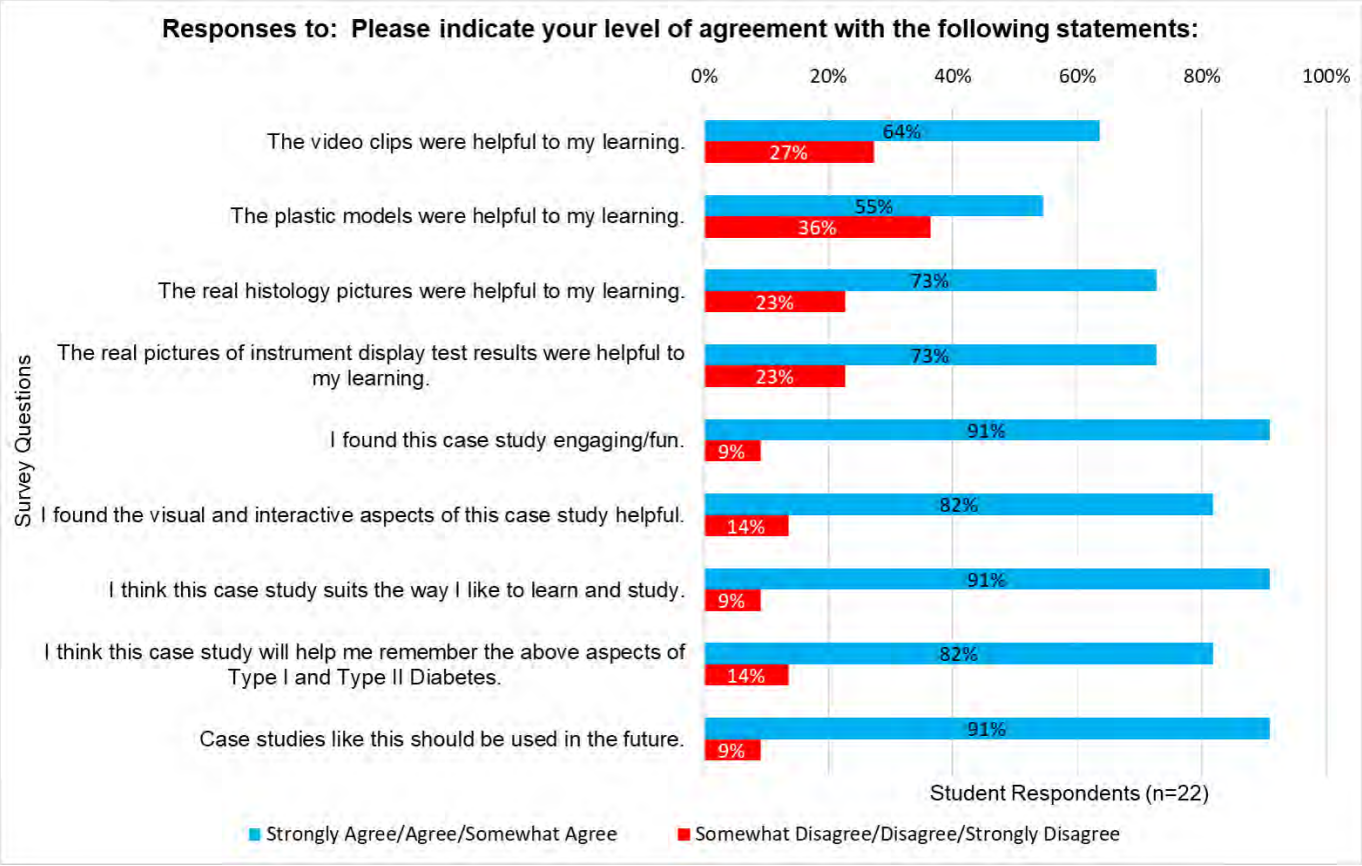

Figure 10. *Student Survey Completed After the Diabetes Case Study. 2nd year nursing students rated the usefulness of the various multimodal aspects of this case study. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

D. Abdominal Pain Case Study

In this case study, 2nd year nursing students were introduced to story in which a 29-year-old female smoker starts to have abdominal pain. Over the course of the case study's questions, students were taken through the risk factors, pathogenesis, diagnostic tests, treatment, possible complications, and healing that is associated with peptic ulcers. Prior to going through the case study, students completed a survey in which they rated their level of understanding of the risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical treatments of gastric cancer and peptic ulcer disease. The interactive components of this case study consisted of: 3 images, 1 x-ray, 3 video clips (0.5-1.5min. each) and 1 plastic model depicting 4 progressive stages of peptic ulcer disease in comparison to normal gastric lining.

Figure 11 displays the results of the survey conducted before and after the Abdominal Pain case study. The responses indicate that before the case study, the majority of students

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felt that they had room for improvement in the mastery of each topic. Only 32-41% (7-9) of students selected "Excellent" in response to these questions, though most respondents did have some confidence in their knowledge prior to the case study. Most respondents rated their level of understanding of risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical outcomes of peptic ulcers and gastric cancer as "Good", "Very Good", or "Excellent", with only 1-2 students selecting "Poor". Most students attended every class, so would have already had some exposure to these topics though this topic was at the end of term and attendance was dropping a bit.

When thinking of future improvements in the course, it was noted that students were least confident in their understanding of typical outcomes of both gastric cancer and peptic ulcers; these topics were not covered extensively during class time. Reassuringly, students were most confident in their ability to identify treatments for gastric cancer and peptic ulcers, which is something that we had spent more time on during class.

This case study was 17 questions and there was no time limit. LMS reporting indicated that students took an average of 16 min 45 sec to complete this case study (a single data point of almost 151 hr was omitted from the calculation). Again, students took longer on their first attempt (averaging 18min 52sec) compared to subsequent attempts (averaging 7min 28sec).

The average score of the 22 respondents on Attempt 1 was 9.42/17 (55%) and the average score of the 16 respondents on Attempt 2 was 16.22/17 (95%). For the 16 students that completed the 2nd attempt, there was an average improvement of 7.44 points (44%) which was found to be statistically significant (with alpha=0.05). Results of paired t-tests between Attempt 1 and 2 scores found the t-statistic value to be -8.00 and the t-critical value to be 2.131 (and the null hypothesis was rejected). 3 Students completed the case study a 3rd time and improved their scores.

It is not surprising that only 22 students opted to take part in the optional surveys for this case study, as this case study was the given near the end of term during the Digestive System Diseases and Disorders unit. By that time, typically students are fatigued, have end-of term papers and lab reports due for other courses, and have mounting stress with final exams rapidly approaching.

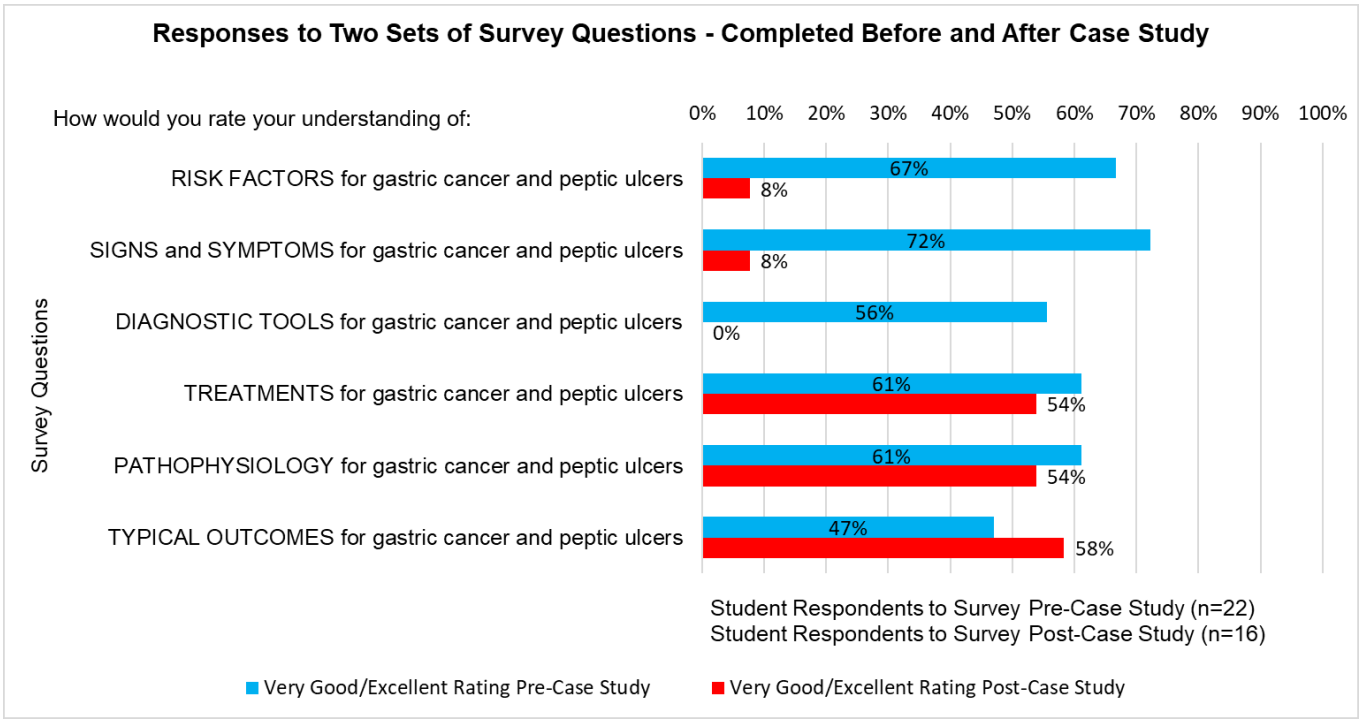

Figure 11. *Student Reflective Knowledge Survey - Completed Before and After the Abdominal Pain Case Study. Students were asked to rate their understanding of aspects of gastric cancer and peptic ulcers. Possible answers to each question were: Excellent, Very Good, Good, Poor and I Haven't Learned Yet.*

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16 of the 22 students (36%) opted to complete the case study a second time and completed the survey at the beginning again. The survey results therefore depict student responses after they had completed one attempt at the case study and are shown in Figure 11 (labeled "post-case study"). 7 (44%) respondents selected "Excellent" when rating their understanding of pathophysiology, treatments and typical outcomes for gastric cancer and peptic ulcers. 7 (44%) respondents selected "Poor" when rating their understanding of risk factors, signs and symptoms, and diagnostic tools for gastric cancer and peptic ulcers. The reasons for an overall drop in knowledge confidence are unclear, especially as the case study scores were higher than on the first attempt. It may be that only students who felt they needed more review took the case study a second time. We did not have students complete this particular survey again after their 2nd attempt, so it is only speculation.

Though once the students had completed the Abdominal Pain Case Study they were invited to complete a second set of optional survey questions to assess their perceived level of understanding of the risk factors, pathogenesis, treatments, diagnostic tools, knowledge of vocabulary words (e.g. occult blood, hematemesis, melena), and possible complications of peptic ulcers (Figure 12). The majority of students agreed that this case study helped them understand the location of peptic ulcer pain, signs and symptoms as well as possible complications (82%), the main two risk factors of peptic ulcers, typical treatments, what occult blood is and how the fecal antigen test and barium x-rays can be used in the diagnosis process of peptic ulcers (73%), and the urea breath test, endoscopy diagnostic tests, and the specific vocabulary words hematemesis and melena (55-63%).

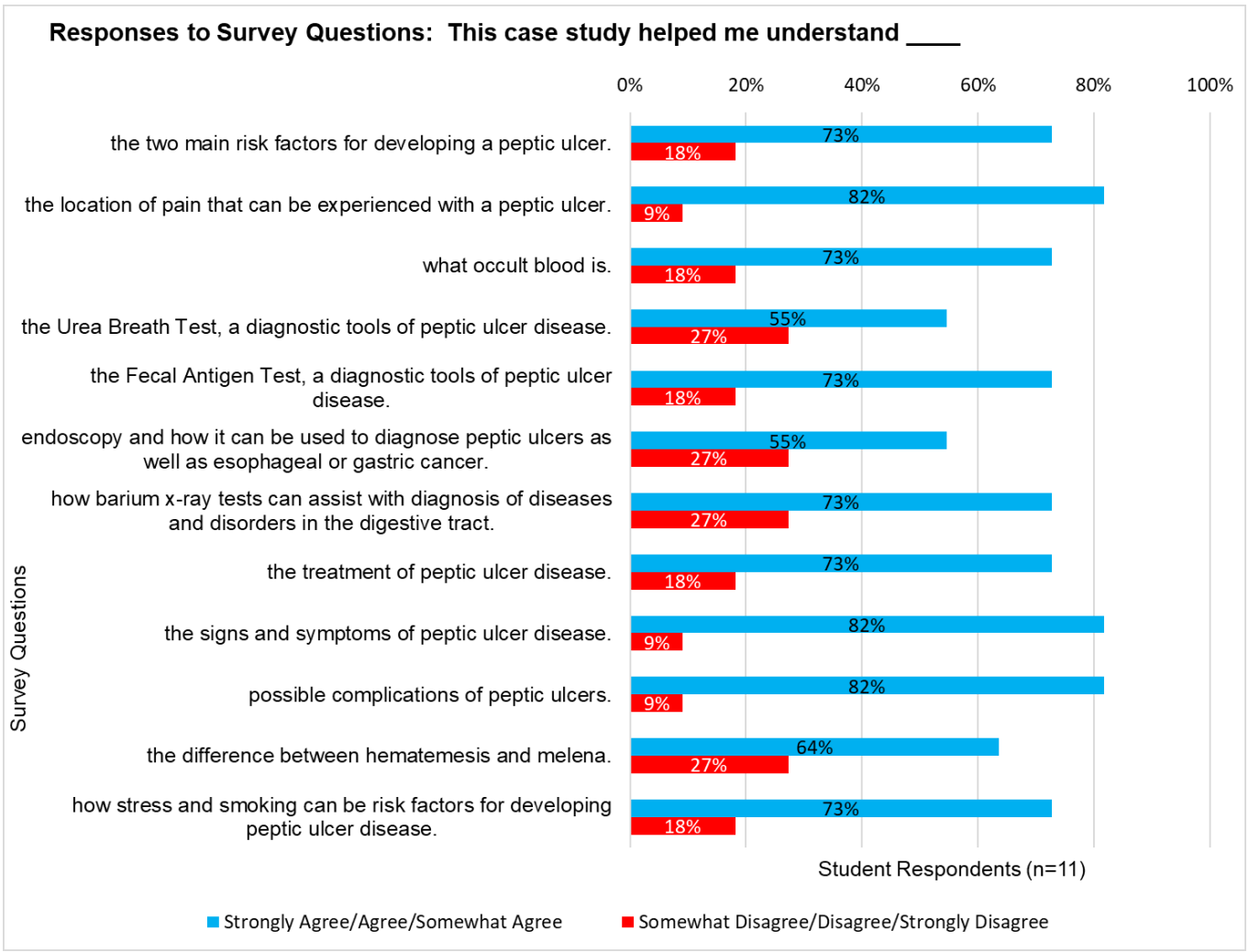

Figure 12. *Student Satisfaction Survey - Completed After the Abdominal Pain Case Study. 2nd year nursing students rated the case study's abilities to promote learning of different parts of these topics. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

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The results of the case study component survey are shown in Figure 13. This was the last case study and there were fewer participants than in the preceding case studies. In addition, if students had completed previous assignments, this case study was optional with the sole purpose of being used by students to make up for marks and/or help in their preparation for the final exam. This, as well as student fatigue, likely influenced the number and spectrum of participants taking part in this case study. 50-60% of students agreed that the various components of the case study (plastic models, x-ray) and should be used in the future. 58% of students thought it would help them remember various aspects of peptic ulcer disease and 67% of students found the case study engaging and/or fun.

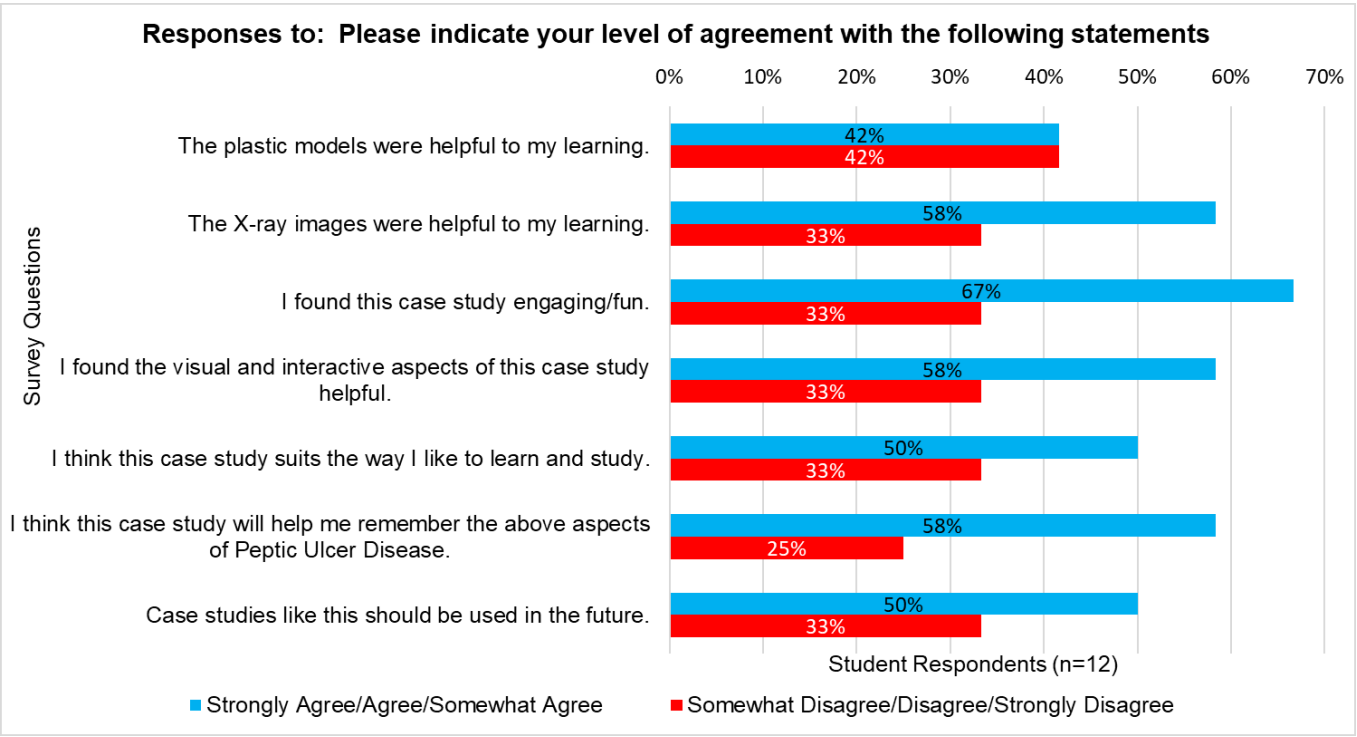

Figure 13. *Student Survey on Abdominal Pain Case Study Components. 2nd year nursing students rated the usefulness of the various multimodal aspects of this case study. Possible ratings to each statement were: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree.*

In addition to the questions asked in Figure 12 and 13, students were able to fill in an optional comment box as well (Appendix, Table 3). Student comments are difficult to interpret overall, as case study material was covered in class and there was the complicating factor of reduced attendance. In addressing the comments, Question 9 did require critical thinking and problem solving from what was portrayed in the case study. Specifically, the students were asked to write down why the patient gained weight (due to over-eating as eating reduced pain). In addressing comments that the plastic models were confusing, it is true that the plastic stomach and small intestine models did have more (13) labels on them, compared to all of the previous models, meaning more patience would be required. The labels were clear, so it is likely that students were in a rush. And these were questions that required looking at the model in order to provide an answer. Overall, it is believed that students were fatigued by the end of term and therefore this case study will be modified or given more time in class in the future, to ensure all the students answer the model questions before rushing out the door.

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E. Four 2nd Year Nursing Case Studies – Final Exam Question Analysis

After the final exam, question results were compared to see if students who completed each of the case studies had higher grades on related questions on the final exam. There were 4 osteoporosis and fracture questions, 5 heart disease questions, 1 peptic ulcer question, and 5 diabetes related questions on the final exam. Both Pearson correlational analysis and paired two-tail t-test analysis (results not shown) revealed that there were no significant correlations between scores of case studies and related final exam questions for case study participants and non-participants.

Looking more closely, there were only very weak correlations* found between the final exam questions Q3, Q8, and Q15, and the osteoporosis and fracture case study, the heart disease case study and the abdominal pain case study results respectfully. In the diabetes case study, scores of the 3 case study components (Images & Plastic Models, Insulin Video Quiz and the Diabetes Video Quiz) were separated for correlational analysis (and paired two-tail t-test analysis). The final exam diabetes related questions, Q10, Q12, and Q13 scores weakly correlated with scores for the insulin video and diabetes video components. The final exam peptic ulcer question, Q13 score having a very weak correlation with the Abdominal Pain Case study score. The total final exam scores very weakly correlated with scores of the osteoporosis and fracture case study, heart disease case study and diabetes case study images and plastic model component. As might be expected, the total final exam scores exhibited weak correlations* with final exam question score of Q3, Q6, Q7, Q8, Q11, Q13, and Q15 and medium strength** correlations with Q2, Q5, Q9, Q10, Q12, and Q14.

F. Heart Disease Case Study – for 3rd Year Human Kinetics Students

3rd year Human Kinetics (HK) students also cover cardiovascular disease in their pathophysiology course and were therefore given a similar heart disease case study as the 2nd year nursing students with some significant modifications. There were 19 questions and students were taken through the risk factors, signs, symptoms, and diagnostic tests associated with both peripheral artery disease and coronary artery disease. Possible complications and pathogenesis of angina pectoris, myocardial infarction, hypertension, congestive heart failure, nephrosclerosis, retinopathy, as well as ischemic and hemorrhagic stroke were explored.

The interactive components of this case study consisted of: 15 images and 7 plastic models which depicted atherosclerosis, angina pectoris, myocardial infarction, congestive heart failure (CHF), nephrosclerosis, retinopathy, and ischemic and hemorrhagic strokes. The images included both a CT angiogram and a Doppler ultrasound image of peripheral artery disease (PAD) in the leg.

This class had two sections with 102 students in Section 001 and 99 students in Section 002. This case study was optional and one of several ways of earning points toward the final class grade. It was hoped that students would use this case study as they started studying for the final exam. Students could complete this case study regardless of whether they needed those points or not. They were allowed unlimited attempts and their highest score was counted.

Prior to going through the case study, students could complete the optional, ungraded, and confidential survey (Figure 14). In this survey, students rated their level of understanding of the risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology as well as typical treatments of hypertension, angina pectoris, and heart failure. This case study was given to the students after they had a class in this unit, so it was not surprising that "I Haven't Learned Yet" was selected the least often in answer to these questions (1-6 (1-9%) students depending on the question). On average, most students felt they had room for improving their mastery of this course content in each area with only 3-7% (2-5) of respondents selecting "Excellent" in response to these questions.

When considering future improvements to the course, it was noted that prior to the case study, students had low confidence in their understanding of CHF risk factors and pathophysiology for hypertension, with 23 (34%) and 19 (28%) students selecting "Poor", respectfully in answers to those two questions. This is not too surprising as these are complex topics to learn with confidence. On the other hand, students were most confident in their ability to identify risk factors for hypertension. It should be noted that class attendance for both sections is estimated to be approximately 60% on most days as many students chose to watch the class recordings instead. As attendance is not taken during class it is impossible to determine if there is any correlation between attendance and participation in this case study.

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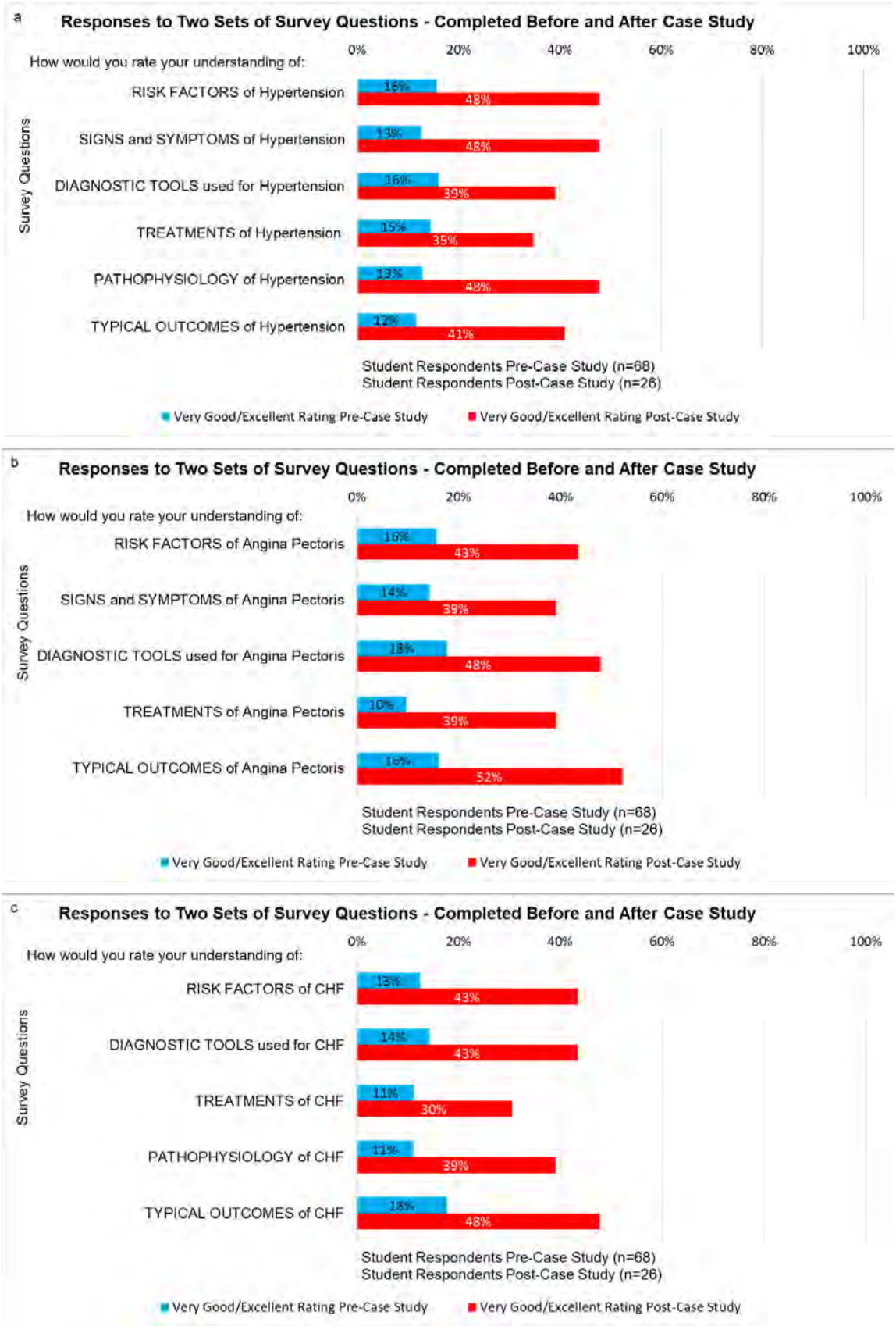

Figure 14. *Student Reflective Survey - Completed Before and After the Heart Diseases Case Study. Students rated their understanding of aspects of a) Hypertension, b) Angina Pectoris and c) Congestive Heart Failure (CHF). Possible answers to each question were: Excellent, Very Good, Good, Poor and I Haven't Learned Yet.*

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26 students opted to complete the case study a second time and completed the survey at the beginning again. This survey depicts how students were feeling after their first attempt on the case study and their responses are shown in Figure 14. It was found that the majority of respondents felt that they improved in the mastery of each topic after completing the case study. Between 27-46% (7-12) of respondents selected "Excellent" in response to these questions. Only 1-6 (4-23%) respondents selected "Poor" when rating their understanding of various aspects of cardiovascular disease.

In terms of time spent on the case study, there were 31 students that likely left the case study running on their computers unattended, clocking in times ranging from 1hr 59min to 483hr 4min. Without including those times, the average time for the students' first attempt was 25min 26sec and 8 min 9 sec for the second attempt.

The average score for the 68 respondents on Attempt 1 was 16.28/25 (65%) and the average score for the 26 respondents on Attempt 2 was 23.75/25 (95%). For the 26 students that completed the 2nd attempt, there was an average improvement of 6.26 points (25%) which was found to be statistically significant (with alpha=0.05). Results of paired t-tests between Attempt 1 and 2 scores found the t-statistic value to be -6.01 and the t-critical value to be 2.06 (and the null hypothesis was rejected). 9 Students completed the case study a 3rd time and had an average score of 24.80/25 (99%).

G. 3rd Year HK Heart Disease Case Study – Final Exam Question Analysis

There were 16 heart disease related questions on the final exam. Both Pearson correlational analysis and paired two-tail t-test analysis (results not shown) revealed no significant correlations between scores of the heart disease case study (or case study participation) and related final exam questions. Very weak correlations* were found between final exam questions, Q4, Q5, Q9, Q26, Q27, Q28, and Q50, and the Heart Disease case study scores. Not surprisingly, weak* to moderate** correlations were found between many of the heart disease final exam questions and the total final exam score (Q2**, Q4*, Q5**, Q8**, Q13*, Q15**, Q16*, Q26**, Q27**, Q28*, Q40**, Q50**, Q63*).

Conclusions

We found that in both 2nd year Nursing Pathophysiology and 3rd year Human Kinetics Pathophysiology courses, students reported that the interactive case studies were beneficial to their learning. Most students stated that they enjoyed the multimodal and interactive components of the case studies (pictures, videos, tactile and hands-on, and electronic). Students appreciated the time flexibility, the opportunities to repeat the case studies and reflect on their knowledge, as well as visualize real life situations. Students cited the case studies as engaging, fun, and a good way to parcel and help remember newly gained knowledge. The majority of students also stated that the case studies should be used in the future.

As expected, each student found different modalities of the case study the most helpful (e.g. plastic models, video clips, video quizzes, x-rays, images, personal stories, interactive webpages, and instrument read-outs). It was noted that student ratings of their understanding increased in all of the various aspects of each disease and disorder with every attempt they took of the case study with the exception of a few topics in the final peptic ulcer case study. The majority of students stated that the case studies helped them understand each aspect of the diseases and disorders covered (e.g. risk factors, signs and symptoms, diagnostic tools, treatments, pathophysiology and typical outcomes). Student comments stated that participants also valued the metacognitive pieces embedded in each case study, and found it allowed for reflection on what they knew well and what they needed to review.

We found only very weak positive correlations between case study scores (and case study participation) and the scores on related questions in the final exams. It is unclear if these weak correlations are due to the case studies themselves, or if any converse effects would have occurred if they were not used. It may be that students who completed the case studies scored better on the final exam than they would have without participating in the case studies. It may also be that the case studies helped in a way that any additional Q&A practice would help when studying. Therefore, students that didn't participate in the case studies may have used other course resources to achieve the same benefit. Moreover, it may be that the case studies helped develop critical thinking, problem solving, and overall question answering skills, in addition to the learning and memory of the content – skills that may not have been tested for on the final exam. The final exam questions used in this current study were completely multiple choice. Further studies would need to be done to determine exactly what benefit the case studies may have on critical thinking, problem solving, confidence and motivation.

Another limitation of the study is that it was not possible to readily determine which of the four case studies was better in the eyes of the 2nd year nursing students as the number of survey participants for each case study decreased during the term.

Future considerations for research include creating case study questions in the final exam to encourage higher order thinking, as was done by successfully by Smee and Cooke (2018).

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Acknowledgments

We would like to thank all of the 2nd and 3rd year students who volunteered their time to take part in these surveys.

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Megan Lauridsen is a recent B.H.K graduate. At the time of this study, Megan was a 4th year undergraduate UBCO research student who assisted with this study during her capstone research project course.

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APPENDIX

Student Suggestions:
Two students: I think it would be more helpful if it gave immediate feedback after each question. Also some of the content did not align with the course. Also, I enjoyed it.
One student: I found it distracting and interruptive to the methods of study that I prefer. The pictures took up too much space and as I scrolled back and forth from the pictures to the answers I often got distracted between what I was looking at and what I was looking for. Too much going on.
Three students: It should be shorter
One student: I found I had to cheat (Google) to get the answers. *(The case studies were open book, so I wouldn't consider this cheating.)
Positive Comments:
Two students: engaging and fun
Seven students: i like visual learning so having diagrams helped me
One student: This case study was well done, but it is not my personal preferred learning style
Two students: It was helpful because it allowed a chance to test my knowledge.
One student: I didn't have any of the answers in front of me so it is a little hard to tell if I got them correct, or if I was correct in my thinking. I think it would be awesome if you could answer a question and then find out if you're right or wrong immediately after and then move onto the next question.
One student: interactive and engaging
One student: I really enjoyed this because we have not yet done a case study yet in Pathophysiology and it was a different way of learning about this subject.
One student: I found the case study useful as it forces you to think about the situation and apply your learning.
Two students: Good overall and It was well done
One student: I genuinely appreciate how different learning style questions were incorporated in the questions. As a visual learner myself, I enjoyed doing questions involving diagrams. Thank you!
One student: This case study was very helpful in understanding the different learning concepts, as it allowed for critical thinking and analysis of the patient scenario.
One student: I really enjoy getting more information about a situation between questions. It really helps me simplify the information into smaller amount.
One student: I liked the case study background
One student: It helped me learn.
One student: I find this is helpful to apply learning to real world scenarios.
One student: Case study was helpful and easy to answer.
One student: I found the case study helpful and enjoyed the interactive part of the learning.
One student: I believe that the diversity in the formatting of the questions truly helped test my understanding, rather that my ability to memorize the learning concepts.
One student: I found that this case study was helpful because the format really tested by critical thinking skills. I liked having the second retry option because it gave me the opportunity to do the test without any preparation in the beginning. This allowed me to see where I was in my current understanding. Afterwards I felt like I really improved my understanding because I was then focused on the parts that I needed to work on.
One student: Very nice to see a diverse method of knowledge dissemination! I really appreciate the formatting, and it extremely clear that this case study is well-developed. It's very impressive! Thank you!

Table 1. *Student Comments (n = 34 respondents) Written in Case Study Component Survey Completed After the Osteoporosis and Fracture Case Study.*

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It aided in my understanding of diseases and causes
It helped me to think through the knowledge taught in lecture.
I did not get a chance to look at any models so I found the case study somewhat confusing.
Some of the words we have no learned, so some googling was requires
I don't remember seeing plastic models in class
I think it will help me remember for the exam. I didn't get time to look at the models in class but the pictures helped. I like that it adds a story to the learning. I would prefer immediate feedback about the answers instead of waiting until the end.
Maybe have less true/false questions, I didn't find them as helpful as the other questions.
You are required to look up the answers to many questions which helps with active learning and hopefully recall.
Some of the content wasn't found in the lecture notes, but I was able to find it in the textbook.
This case study was helpful because were were able to complete it multiple times and try again if we didn't get it right the first time. It was helpful that it told us why we were wrong instead of just saying we were wrong.
Engaging
I wish I could answer a question and then see if I was right afterwards. That would really help.
I am a very visual person so this case study helped me a a lot
This was very helpful. Thanks
I found it to be more advanced than what we have learned in this course and was quite difficult to understand
pictures helped me learn differences
it's helpful to be able to test yourself to really see what you do and do not understand then you can focus on what you need to cover more in depth
It was helpful to put in my knowledge with a real life situation
a lot more helpful than the regular participation bonus challenges
It was helpful in showing models and images that helped me visualize the information and think through the questions to find the answer.
put in real life examples
I like how it was a different way of learning because I am a more interactive learner, not visual (like in class)
I like case studies because they are interactive and allow me to utilize other forms of learning like kinesthetic for example (not just visual)
I found that the questions related to what we learned in class and that it actually tested my knowledge.
It was helpful because it highlighted the both specific symptoms and broader effects. Also helped me realize that I need to study more to get a better understanding
It was helpful to learn about the disorders associated with the heart and hypertension incrementally through stages , as well as to have the models and their descriptions was very helpful in the skill testing knowledge questions asked about the material afterwards
Pictures are helpful for learning + additional review of material covered in lecture
it was helpful in compartmentalizing the different information by presenting it in a nice order!
being able to read out a full scenario helped to understand
Going into it blind, and having not studied the material at all gave me a good measuring stick about my base knowledge, and shows me what I have committed to memory and what I need to brush up on and review in greater depth
I find I get too distracted with the various options to look at and just start guessing the answers instead of focusing on the questions
plastic model used was confusing
I think this case study would be more effective if there was a background story and more detailed patient information. I think it utilizes more specific critical thinking skills instead of having to check off the list of S&S that we go over in class.
Some of the questions were worded/presented in a confusing way.
too much going on for me to stay interested in regards to a "quiz"
I would have found it more helpful to have more hints in the question to figure out the answers, and then be able to see the right answer immediately!
it was helpful as it incorporated visual material as well, I also find it helpful to apply it to scenarios
not 100% a refection of the current course
This was really helpful, it helped review the material and helped indicate what I still need to do more review on. The pictures and explanations gave a good visual and assistances in answering the question
As of filling out this survey I don't know what i got correct or incorrect, so I'm not sure what I think I might know vs what i don't know for sure.
I like a different approach to the learning
I think this should be utilized more often!
I think you should incorporate case studies into class more often!

Table 2. *Student Comments (n = 42 respondents) Written in Case Study Component Survey Completed After the Heart Disease Case Study.*

continued on next page

I felt that question 9 was non applicable to the content covered in class. I also did not have time to look at the models in class and we didnt really go over that content so it was not a good way to reinforce learning (because we didnt learn it in the first place)
It helped me remember the information by applying it.
I didn't find this case study very helpful. The models were a little confusing and didn't help with my learning.
It provided different ways of learning (i.e. looking at models, reading the case study, providing extra information, videos).
The questions in this case study were a bit like a guessing game for me, which means I need to brush up on and reinforce the content from this lesson.
The models did not fit on my screen and I was scrolling back and forth too much to recall what I was looking at/answering
I had a lot of trouble identifying specific stages of peptic ulcers on the stomach model
These case study quizzes are very helpful
I did not find the stomach diagrams useful at all as I didn't know what I was looking at. I also wish answers were given after each question so we know right away what we were right or wrong about while it is still fresh in our minds.

Table 3. *Student Comments (n = 10 respondents) Written in Case Study Component Survey Completed After the Abdominal Pain Case Study*

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