

Measuring the Effectiveness of Visual Narrative Illustrations for Learning Pathophysiology Concepts

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Abstract:

Background: Patients' health needs require detailed knowledge of diseases and the associated pathophysiology to understand and manage their complex care. Nurses rely on concepts from anatomy, physiology, microbiology, and pathophysiology to ground their practice. While knowledge of disease processes is a critical requirements for competent practice nursing, students often struggle with learning and applying pathophysiology concepts to clinical practice.

Method: A novel teaching innovation known as "Visual Narrative Illustrations" (VNI) was piloted in a pathophysiology course. Students (n=75), participated in two phases of exploratory study that analyzed the impact of VNI on students' understanding of pathophysiology concepts and assessed whether VNI is an effective teaching method.

Results: Students taught using the VNI strategy performed significantly better on the post-test than students taught using a traditional lecture format.

Conclusion: VNI assist students in learning complex concepts through the use of humor and visual images and facilitate their understanding of pathophysiology processes.

Key Words:

Visual narrative illustrations, pathophysiology, nursing, education.

Introduction to Pathophysiology

Background: At an accelerated rate, patients' health needs are more acute and require detailed knowledge of diseases, co-morbidities and the associated pathophysiology in order to understand and manage their complex needs. As a foundation for this, nurses rely heavily on concepts from anatomy, physiology, microbiology, and pathophysiology to ground their practice (Christensen, Craft, Wirihana & Gordon, 2015; Craft, Hudson, Plenderleith, Wirihana & Gordon, 2013; El Hussein, Salyers, & Osuji, 2016). It is well-documented that science courses such as pathophysiology are considered strong predictors of students' success in nursing programs (Abele, Penprase & Ternes, 2013; Beeman & Waterhouse, 2001). While knowledge of disease processes is a critical requirements for registered nurses, students and new nurses often struggle with learning and applying pathophysiology concepts to clinical practice (Dunn, Osborne & Rakes, 2012; El Hussein, Salyers, & Osuji, 2016; 2017; 2018; Van Horn, Hyde, Tesh & Kautz, 2014).

Nursing students at the university described in this paper also encounter difficulty with learning and applying key pathophysiology concepts. The university, situated in western Canada, has an enrollment of nearly 12,000 students who take a variety of programs and courses leading to bachelor's degrees, applied degrees, university transfer courses, diplomas, and certificates. The baccalaureate nursing program admits approximately 210 per year. Students are required to take two pathophysiology courses as part of their program; these two courses are offered in 6-7 week blocks over one semester and are offered twice each academic year. In order to mitigate some of the challenges associated with learning pathophysiology concepts, a novel teaching innovation known as "Visual Narrative Illustrations" (VNI) was piloted and implemented in the course and findings were published in brief synopsis (El-Hussein, Salyers, & Osuji, 2018). This paper provides a detailed overview of the findings from this exploratory study.

Brief Review of the Literature

Nursing students are required to learn complex pathophysiological concepts for which they often struggle. Furthermore, they enter into the classroom with different learning styles. This combination of teaching complex concepts and students with diverse learning styles creates challenges for nursing faculty. In studies evaluating learning styles among nursing and other students, some researchers have found that differences in learning styles do exist between and among students (Brady, 2013). Ideally, instructional strategies would be matched to learning styles and a variety of teaching methods would be implemented to address individual differences. Researchers have found that matching instructional strategies to student learning styles yields positive learning outcomes, while mismatching these may lead to poorer outcomes (Damrongpanit & Reungtragu, 2013; Fayombo, 2015).

Previous research has identified the need to vary teaching strategies in order to appeal to different learning styles; and the impact of these teaching strategies on learning (Liu & He, 2014; Moore & Hansen, 2012). Moore and Hansen (2012) further suggested that faculty need to use a variety of approaches to help students "embrace who they are, develop a sense of self, recognize their strengths, and capitalize on

talents that will strengthen their self-esteem” (Moore & Hansen, 2012, p.28) and further develop confidence in applying complex pathophysiology concepts in the clinical area (Craft et al., 2013).

Specific to pathophysiology, different strategies that address multiple learning styles have been employed. Traditional lecture and face to face (f2f) formats used for teaching pathophysiology, although widely accepted, have been criticized for their lack of effectiveness as a teaching method when used in isolation (Isseks, 2011; Herman, 2011). Alternative teaching strategies have incorporated podcasts and video streaming (McKinney & Page, 2009), problem-based learning, (Mayner, 2013), concept mapping (Kumar et al., 2011), and a variety of student-centered teaching strategies (e.g. case studies, creative visual demonstrations, games and small group work, and team based learning) (Middleton-Green & Ashelford, 2013; Van Horn et al., 2014). Further research supports supplementing traditional lecture with interactive learning strategies to enhance students learning and conceptual understanding of pathophysiology (Taylor & Littleton-Keary, 2012; Van Horn et. al. 2014).

The utilization of illustrations has been implemented in the past as a teaching strategy, and is emerging again as an effective one that appeals to many learners (Lapum & St-Amant, 2016; Lake & Jackson, 2013). According to Lowe (2004) illustrations offer an *affective* function, by capturing, engaging, and motivating students; and provide a *cognitive* function by supporting students’ cognitive processes leading to a greater understanding of the subject matter. Green and Myers (2010) concluded that illustrations can facilitate efficient and effective communication of intricate concepts and have been successfully used to convey ideas and complex concepts in an amusing and pleasurable manner. Park, Kim and Chung (2011) and Shin, Kim, Park, Jang and Chung (2013) concluded that illustrations are potent visual messages that communicate instant visceral meaning in ways that traditional texts often cannot. Bain (2004) further elaborated on this notion and in his view, when we see, hear, feel, smell, and taste, then we begin connecting all those sensations in our brain to build patterns of the way we think the world works. These patterns are used later to understand new sensory inputs.

In health related disciplines such as nursing & medicine, arts-enriched teaching strategies that include visual images and illustrations actually facilitate critical thinking, critical inquiry and reflective practice (Lapum & St-Amant, 2016; MacDonnell & MacDonald, 2011; Schreiner, Wolf- Boldonaro, 2012). For the purpose of this paper, VNI are brief, narrated stories with images that are used to explain complex scientific, and physiologic concepts in meaningful and scaffolded ways. By using VNI, students make associations between the images, stories, and pathophysiology concepts. It is worth noting that VNI are different from the photos and images typically found in pathophysiology texts (El-Hussein, Salyers, & Osuji, 2016).

Narrative as the Theoretical Framework Guiding VNI

Learning is an active process in which learners construct new concepts based on their current or past knowledge; a premise that is congruent with the narrative notion of enactive cognition. According to Popova (2014) literary narrative is an intersubjective process where the instructor and learner make meaning of a subject. The instructor and the learner bring a myriad of personal, historical, and cultural features that dominate the

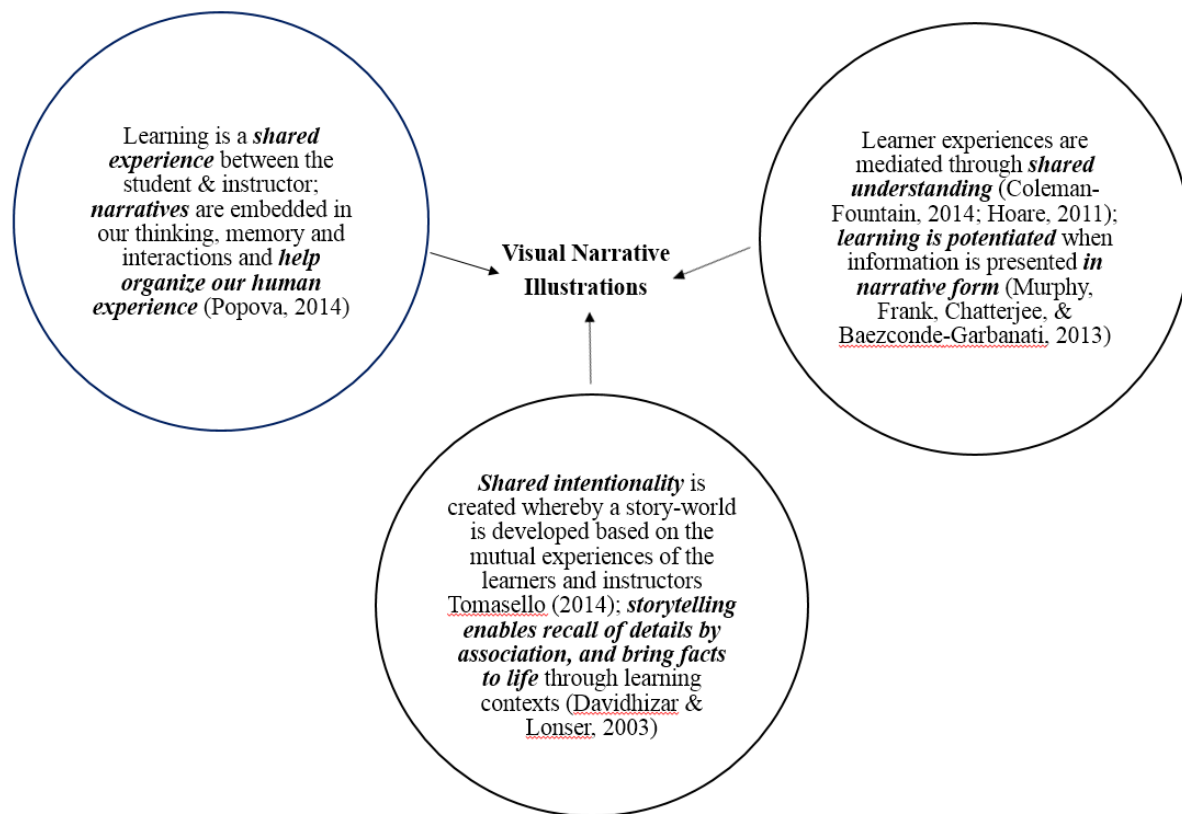
narrative and potentially shape learning. Popova (2014) further added that narratives are embedded in our thinking, memory and interactions and help organize the human experience. Learners' experiences of the world are mediated through narrative understanding (Coleman-Fountain, 2014; Hoare, 2011), and learners' interpretation of reality through memory is guided by narrative principles (Popova, 2014). Therefore the ability to learn is potentiated when information is presented in a narrative form (Murphy, Frank, Chatterjee, & Baezconde-Garbanati, 2013).

Tomasello (2014) described a process known as shared intentionality whereby a story-world is created based on shared experiences of the learners and course professors. Intentionality is at the core of the learning process where meaning is generated by using the learner's mental framework to act as a point of reference or filter that checks if new details are congruent with the student's existing mental repertoire. Narratives describe characters and people who act out events in a particular space and time through the storytelling process (Bamberg, 2012). Through narratives and stories, students are able to tie data, facts and information together in meaningful ways (Green, 2004); moreover, storytelling enables recall of details by association, and bring facts to life through learning contexts (Davidhizar & Lonser, 2003).

VNI are narrated stories with images that are used to explain complex physiologic concepts in meaningful and scaffolded ways. The illustrations are used to capture the attention of the student, trigger their imagination, drive their thinking and create a means by which they can quickly recall complex information. Further, narratives and illustrations become internalized as part of the students' learning experience; associations are made between the images, stories, and pathophysiology concepts (El-Hussein, 2017). The narrative stories that are embedded in pathophysiology VNI used in the pathophysiology course described later: 1) allow the learners to develop a certain level of understanding that is congruent with their lived experiences; 2) facilitate social interactions through the construction of meaning based on the stories; 3) emphasize the active role of learners in building their own understanding of reality; 4) utilize amusing storylines and, as such, open the door for further discussion and intellectual engagement. Thus learning becomes an active process whereby students hypothesize, predict, challenge, engage, resist, and eventually accommodate new information and construct new knowledge.

There were several principles that guided development of VNI for this study. These include that learning: 1) must include the shared experiences, understanding, and organization of knowledge between students and faculty; 2) is potentiated through narratives that describe key pathophysiologic concepts; 4) must include shared intentionality of the learning experience; and 5) extends beyond recall of information and requires associations be made to learn and apply pathophysiology concepts. Figure 1 provides a representation of the theoretical framework by which VNI were framed and developed.

Figure 1. Theoretical Framework Guiding VNI Development



Research Objectives

The purpose of this research was to empirically measure the effectiveness of VNI on nursing students' knowledge and understanding of pathophysiology concepts; and to assess the impact of VNI as a teaching method on students learning outcomes. The following research questions were explored:

1. Do 2nd year baccalaureate nursing students who were taught using VNI perform better on pathophysiology pre and post-tests than students who were taught using traditional teaching methods?
2. How do visual narrative illustrations influence 2nd year baccalaureate nursing students experience with learning complex pathophysiological concepts?

Methods

This exploratory, mixed-methods study elicited perspectives from nursing students enrolled in two pathophysiology courses regarding their experiences with VNI. The mixed methods was used for triangulation and to overcome the limitations of the small sample size (Tashakkori & Teddlie, 2003). Ethics approval was obtained from the institutional review board to conduct the study. Participants were informed of the voluntary nature of their participation, right to withdraw, and anonymity of grouped data in publications.

Phase I: Pre-Study Instrument Validation

One semester prior to the study, a convenience sample of second year nursing students taking the pathophysiology course were invited to evaluate fifteen VNI developed for the pathophysiology course. These VNI were utilized to teach various pathophysiology concepts such as oncotic pressure, HbA1c, acute and chronic renal failure among others.

At the end of the course, students completed a survey composed of 19 Likert items indicating agreement (1=strongly disagree; 5 strongly agree) with statements about the VNI, as well as 4 Likert items regarding the effectiveness of the VNI for teaching key pathophysiology concepts. Students were also asked to provide qualitative comments regarding their perceptions of the effectiveness of VNI as a teaching strategy. Student feedback informed revision of some VNI for use in phase two of the study. Findings from the VNI instrument validation process are described in the Results section of this paper.

Phase II: Pre and Post-VNI Knowledge Gains

In phase two of the study, students enrolled in the pathophysiology course were invited to consent and participate in the study. Two sections of the course were offered and taught by different course professors. In the control group (CG) section, students were taught pathophysiology concepts using a traditional lecture-discussion approach, while students in the intervention group (IG) learned pathophysiology concepts using VNI. Once consent was obtained, a pretest of pathophysiology knowledge was administered to CG & IG students. The pretest consisted of 42 multiple choice questions that were conceptually based on the VNI used to teach pathophysiology concepts during the course. At the end of the semester, CG & IG students took a post-test equivalent to the pretest. Using SPSS 23.0, tests of reliability, normality, homogeneity, and hypothesis testing were conducted.

Results**Phase I: Pre-Study VNI Validation**

Fifteen VNI were developed and pilot tested with a convenience sample of second year nursing students (n=63; 90% response rate) one semester prior to full implementation within the pathophysiology course. Faculty with pathophysiology expertise evaluated the VNI prior to the pilot study and confirmed construct validity. At the end of the course, students were asked to rate their agreement with 19 VNI statements. The following Likert scale was used: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree. Table 1 highlights z-score statistics for the VNI that were evaluated. The alpha coefficient for the pre-study VNI was 0.91 and demonstrates high construct validity (Nunnally, 1978).

Table 1 - Z-Score Statistics for VNI Pilot Study

VNI – Specific Concepts	Mean (SD)	Test Statistic
The Cancer VNI helped me understand the characteristics of cancer cells.	637.5 (103.59)	4.66*
The Renal VNI helped me understand the difference between acute and chronic renal failure.	473.0 (82.82)	3.67*
The Diabetes VNI helped me appreciate the significance of chronic hyperglycemia of blood vessels.	715.5 (112.96)	3.99*
The Diabetes VNI helped me understand the effects of chronic hyperglycemia on immunity.	612.5 (100.53)	4.87*
The HbA1c VNI helped me understand the impact of chronic hyperglycemia on different body organs and tissues.	430.5 (77.17)	3.17*
The HbA1c VNI helped me understand the function of Hba1c and its importance in monitoring blood glucose control.	588.0 (97.50)	4.36*
The Lipids VNI helped me understand and differentiate between LDL and HDL.	612.5 (100.53)	3.09*
The ABG VNI helped me in developing a systemic approach to arterial blood gas analysis (ABG's).	564.0 (94.50)	4.03*
The D-Dimer VNI helped me understand the clotting cascade and associated diagnostics tests.	588.0 (97.50)	3.39*
The Hypertension VNI helped me understand the significance of chronic hypertension on the heart and blood vessels.	410.0 (74.40)	3.68*
The Oncotic/hydrostatic pressure VNI helped me understand the pathophysiology of edema.	588.0 (97.50)	2.71*
The Liver VNI helped me understand the clinical manifestations of liver cirrhosis.	715.5 (112.96)	4.53*
The Circulation VNI helped me understand the process of atherosclerosis and thrombus formation.	715.5 (112.96)	4.60*
The Immunity VNI helped me understand the reaction of the body to harmful invaders and the functions and actions of different immune cells.	689.0 (109.81)	3.96*
The Airway/String VNI helped me understand pathophysiology of emphysema and its relation with chronic bronchitis.	612.5 (100.53)	4.74*
VNI General Comments		
1. Overall, learning pathophysiology concepts using VNI had a high impact on my understanding of	715.5 (112.96)	3.59*
2. VNI helped me to readily recall and apply knowledge.	540.5 (91.53)	2.67*
3. VNI boosted my confidence to understanding client conditions in clinical settings.	517.5 (88.59)	2.41*
4. VNI made complex pathophysiology concepts easier to understand.	637.5 (103.59)	4.75*

*p < 0.05

Effectiveness of VNI as a Teaching Strategy

In addition to the quantitative questions regarding VNI, students were asked to respond to the following items: Please tell us about your experience with Visual Narrative Illustrations. Sixty-three students replied to this item and their responses were analyzed. The overall approach to data analysis followed the method outlined by Miles and Huberman (1994); data collection is followed by data reduction, display of findings, and drawing and verifying conclusions. Each member of the research team independently reviewed the narrative responses obtained at the end of the course. The principal investigators then examined the themes and categories, identified inferences and discerned meanings from the responses, and then agreed on final themes to ensure reliability. Generally, perceptions regarding the VNI were positive although there was a distinct preference for them by self-identified visual learners. Table 2 highlights perceptions of VNI made by students at the end of the course.

Table 2 Student Perceptions of VNI

Theme	Representative Student Comments
The VNI are good learning resources but require some refinement.	<i>I believe VNI have great potential as teaching tools but be sure to create standout images to make them more appealing and understandable.</i>
The VNI are humorous, entertaining, and helped break up complex content.	<i>Provided some laughs and helped breaking up the heavy lectures; these were an awesome way to grasp confusing concepts.</i>
The VNI are particularly helpful for students who are visual learners.	<i>Good for visual learners. My experience with them was a good one. They helped me destress and learn easier.</i>
The VNI furthered my understanding of pathophysiology concepts and solidified my learning.	<i>Definitely a helpful tool to visual harder concepts and understand them later.</i>
Be sure to provide VNI at the beginning of the course and make them accessible.	<i>I would say that these would help future students if added on a permanent basis to the lecture. I wish we had access to view these images again.</i>
The VNI created confusion and did not facilitate my learning.	<i>I don't feel they vastly increased my understanding; I am an auditory learner and generally visuals and drawings don't help much.</i>

Phase II: Pre and Post-VNI Knowledge Gains

Seven students participated in the control group (58.3%) while five students were in the intervention group (41.7%). More than 95% of the students were female, between the ages of 20 and 25, and were taking the course for the first time. The alpha coefficient for the VNI pre and posttests was 0.94 and demonstrated high construct validity Nunnally (1978). Table 3 displays the mean scores, standard error and standard deviations on the pre and posttest by group. A low standard deviation shows that the data points are near the average, whereas high standard deviation shows that much variation exists from the average (Creswell, 2011).

Table 3 Pre and Posttest Scores by Group

		<u>Mean</u>	<u>Std. Error</u>	<u>Std. Deviation</u>
<u>Pretest</u>	Control	24.29	1.30	3.45
	Intervention	24.80	.80	1.79
<u>Posttest</u>	Control	29.71	1.38	3.64
	Intervention	34.20	.58	1.30

Normal Distributions

The skewness and kurtosis for “posttest”, “VNI”, and “satisfaction” were within the values range of minus two through plus two. The skewness and kurtosis for “pretest” and “group” were outside the values range of minus two through plus two. The assumption of normality is not satisfied. Thus, the researchers used the nonparametric alternative to a repeated measures ANOVA to evaluate pre and posttest scores.

Homogeneity

In order to assess equality of variances between the CG & IG samples, a Levene’s test was conducted with results reported in Table 4. The Levene’s test examined the null hypothesis that the population variances are equal (O’Neill & Mathews, 2002). If the p value is greater than .05, then the null hypothesis that the population variances are equal is accepted (O’Neill & Mathews, 2002). A *p*-value of < 0.05 (i.e., posttest) did not validate this assumption.

Table 4 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Pretest	.63	1	10	.44
Posttest	6.10	1	10	.03

Hypothesis Testing

Research Question 1:

Do 2nd year baccalaureate nursing students’ who receive the VNI intervention perform better on pathophysiology pre and post-tests than students who were taught using traditional teaching methods?

The following hypothesis was tested:

H0: There is no difference in 2nd year baccalaureate nursing students' pre and posttest scores using visual narrative illustrations as a contemporary pedagogy when compared to traditional teaching methods.

H1: There is a difference in 2nd year baccalaureate nursing students' pre and posttest scores using visual narrative illustrations as a contemporary pedagogy when compared to traditional teaching methods.

A Kruskal-Wallis Test was conducted for between-subject differences. On the pretest, the p value was equal to .459, which is greater than .05 (α), therefore the null hypothesis was accepted. The intervention group who received instruction using VNI did not differ from the control group, taught using traditional teaching methods, on the pretest. On the post-test, the p value was equal to .011, which was less than .05 (α), therefore the null hypothesis was rejected. The intervention group taught using VNI were significantly different from the control group on the post-test. Table 5 highlights pre and post-test scores and significance by group.

A Friedman's 2-Way ANOVA by ranks was conducted for within-subject evaluation of the group mean scores. The p value equaled .001, which was less than .05 (α), therefore the Friedman's 2-Way ANOVA by ranks revealed a main effect of time. The combined CG/IG group average on the pretest was 24.50 before the VNI treatment, while the combined CG/IG group average on the post-test was 31.58 after the treatment. Therefore, the null hypothesis that there was no difference in pre and post-test scores was rejected.

Table 5 Kruskal-Wallis Test

	Group	Mean Rank	Sum of Ranks	P-Value
Pretest	Control	7	5.86	.459
	Intervention	5	7.40	
Posttest	Control	7	4.29	.011
	Intervention	5	9.60	

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Discussion

Research Question:

Do 2nd year baccalaureate nursing students who were taught using VNI perform better on pathophysiology pre and post-tests than students who were taught using traditional teaching methods?

While the sample was small for this phase of the study, the results are promising. Like at many universities, student participation in research studies are impacted by multiple competing demands. In the School of Nursing and Midwifery in which this study took place, depending on their year in the program, students are asked to complete surveys, questionnaires, and other program evaluation documentations. This may have influenced their willingness to participate in the current study. Students taught using the VNI strategy did perform significantly better on the posttest than students taught using a traditional lecture format. Students commented that the VNI assisted them in learning complex concepts through the use of humor and visual images that created understanding of processes. This reinforces the notion that narratives are embedded in our thinking, memory and interactions and help organize our experiences (Popova, 2014); is potentiated through shared understanding (Coleman-Fountain, 2014; Hoare, 2011); and that storytelling enables recall of details by association and brings facts to life (Davidhizar & Lonser, 2003). While VNI were the means by which learning and understanding of pathophysiology concepts occurred in this course, the authors wish to emphasize the importance of developing scaffolded teaching approaches such as VNI for deconstructing complex concepts with which students often struggle.

Ideally, students in both sections of the course would have been exposed to both traditional and VNI approaches in a quasi-experimental study to further elicit whether VNI had a greater impact on knowledge and understanding of pathophysiology concepts. If there had been more time, it would have been useful to collect data regarding the various learning resources beyond the VNI that students utilized as a means for learning pathophysiology concepts. Based on this study, it was unclear how much the VNI specifically impacted learning outcomes.

Research Question:

How do visual narrative illustrations influence 2nd year baccalaureate nursing students experience with learning complex pathophysiological concepts?

The qualitative data gathered and analyzed in this research project suggested that, overall, students perceived the benefit of VNI as a learning tool. There was unanimous agreement that VNI facilitated their understanding of, and served as a catalyst for learning, complex concepts. Moreover, considering the intensity of the pathophysiology course and the tension and anxiety it created for students, VNI provided a humorous outlet and mental breaks from the difficult material to be learned. However, the students' preoccupation with course grades and their primary focus on passing the course may have influenced their willingness to participate in the study and may have also impacted their responses.

Frequently students commented that VNI were effective for self-identified visual learners, while the non-visual learners had mixed feelings about them. Consistent with the findings of others (Taylor & Littleton-Keary, 2012; Van Horn et. al. 2014), student comments supported the notion that VNI, when used simultaneously with other teaching strategies, would appeal to multiple learning styles and increase opportunities to learn pathophysiology concepts. There were also consistent comments that each VNI could be revised and fine-tuned to make them more understandable and provide even greater links to the concepts learned. Again, these comments supported the importance of

shared knowledge construction, development and understanding (Coleman-Fountain, 2014; Hoare, 2011) described in the theoretical framework. The researchers have begun to incorporate feedback specific to each VNI and redevelop them based on student comments with the intention of further strengthening their potential as a teaching tool.

Limitations

There were several limitations the authors wish to acknowledge. The study was carried out at one academic institution with a small convenient sample of students, therefore results cannot be generalized beyond this population. Two faculty members facilitated the lectures which may have impacted the internal validity of the design and whether post-test scores were exclusively due to the VNI (intervention). An additional factor that may have impacted results relate to the teaching styles and personalities of the two faculty members who taught the course. This may have introduced unconscious bias into the results. Moreover, using the same test material in a repeated fashion for the same cohort of students may have introduced a testing effect (sensitized the student). Demographic factors, such as previous knowledge of pathophysiology, preferred learning style, and resources used to learn course content should have been compared with scores on pre and post-tests to further validate whether VNI were the reason that students in the intervention group performed better on the post-test. Finally, the instruments (e.g. questionnaires, pre and post-tests) used may not have been sensitive enough to identify differences between groups. Standardized instruments might be a more powerful means of determining differences.

Conclusions & Recommendations

Nursing students often struggle to grasp concepts surrounding sophisticated and complex pathophysiological concepts for which they are required to understand. Furthermore, they enter into the classroom with different learning styles. This creates challenges for faculty and individuals who teach them. Ideally, instructional strategies would be matched to learning styles and a variety of teaching methods would be implemented to address individual differences. Applying VNI principles to lectures delivered to nursing students helps to improve knowledge and understanding of pathophysiology concepts and provides a means by which humor, mnemonics, and storytelling can offset the stress and anxiety that often comes with studying pathophysiology.

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