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Does an Immersive, Technology-Enhanced Course Design Improve Nursing Student's Learning Experience and Pathophysiology Exam Results?

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Abstract

Aim: This study evaluated the impact of an innovative technology-enhanced immersive approach to course design on second-year undergraduate nursing student's learning experience and exam performance.

Background: Two case-based learning modules using LabTutor® an online learning programme were developed to help students link their pathophysiology knowledge with clinical assessment (both taught in theory courses) and clinical practice skills using a high-fidelity simulation manikin and structured debrief.

Methods: This research was conducted in a New Zealand School of Nursing over the 2014 academic year. Qualitative data was gathered using focus groups and coded from responses to open-ended questions gathered by an online survey. Quantitative data from mid-year examination marks were analysed at the end of the academic year.

Results: Participants were second year undergraduate nursing students (N=111): Focus group interviewees (n=71, 64%) and survey respondents (n=82, 73%). Qualitative data indicated that elements of the immersive learning model worked together to reinforce learning. Students found the case studies, particularly the video, tutorial, notes and supporting medical documents highly valuable. Both case studies effectively enhanced students' understanding of pathophysiology. Quantitative analyses showed that the immersive learning group of students (n=52) achieved higher exam marks in pathophysiology.

Conclusion: These findings indicate that a technology-enhanced immersive learning approach using case studies, Labtutor® and high-fidelity simulation enhances the nurse's understanding of pathophysiology.

Keywords: ***Immersive learning, bioscience, pathophysiology, LabTutor®, nursing education, course design, technology-enhanced learning.***

1. Introduction

The aim of this study was to evaluate the impact of an innovative technology-enhanced, immersive, blended teaching approach using Lab Tutor® (a physiological data capture and online learning programme) and high-fidelity simulation on second-year undergraduate nursing student's learning experience and exam performance.

1.1 Background

In our School of Nursing, the first year of the Bachelor of Nursing (BN) degree has two science courses. 'Bioscience' covers normal anatomy and physiology; and 'Pharmacology' introduces the principles and practice of pharmacology and medicine administration for nurses. In the second year, one science course 'Pathophysiology', covers human diseases and disorders at a more advanced level, and includes associated pharmacology content. Despite what was considered an integrative approach to teaching bioscience, students performed badly in the 2012/2013 Pathophysiology exams. Prompted by this concern, we developed an immersive, blended teaching and learning approach that combines lectures, tutorials, case-based learning with LabTutor® (an online learning platform) and clinical simulation using high-fidelity manikins.

1.2 Rationale: Learning the sciences in nursing degrees

Traditional methods of teaching science subjects, i.e., bioscience, pathophysiology and pharmacology, to nursing students include didactic lectures, tutorials and online learning activities (Craft, Christenson, Bakon, & Wirihana, 2016). While these are useful strategies, research has shown that students who understand the relevance of science in the nursing context are more likely to engage, remember and use the information (Van Yorn, Hyde, Tesh & Kautz 2014).

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Nursing students who are predominantly millennial and 'Generation Z' learners (born on or after 1995), prefer using short videos and games for visual contextual learning in science subjects and are energised by case study presentations (Hampton & Keys, 2017, Hampton, Pearce & Moser 2017; Van Yorn et al., 2014). LabTutor® with its multiple short video vignettes, case study and built in do-it-yourself experiments provides students with an enjoyable way to learn science and is used internationally to teach sciences in the medicine, pharmacology, and nursing health disciplines (ADInstruments, nd; McMullan, 2017; Swift, Efstathiou, & Lameu, 2016).

1.3 The immersive learning approach

Immersive learning is a strategy where learners are given a situation that closely resembles the 'real world' so that they can experience the physical aspects of that environment including the sounds, smells, sights and people who would normally be in that place (Roberts, Mason, Williams, et al., 2017). Our approach combined traditional teaching methods: i.e. lectures, tutorials with technology-enhanced online case-study learning and 'hands-on' high-fidelity simulation. Nursing Simulation Suites are designed and equipped to replicate a variety of clinical environments, typically a hospital room or a doctor's surgery. Using predetermined scenarios mimicking a care situation, students care for patients, sometimes a person (an actor who has a scripted role) or a life-sized manikin. Computer operated high-fidelity manikins can be programmed to run through a scenario where vital signs (a facial skin colour) change in response to the nurse's actions. A technician or instructor can also be the manikin's voice and respond to questions and prompts. These immersive and simulation-based technologies contextualise learning and provide the student with opportunities to safely make mistakes whilst caring for a person in a simulated nursing scenario.

1.4 The immersive learning module design

To enhance student learning we designed two case-based learning modules, each featuring a filmed patient story produced by ADInstruments (ADI), a locally based international medical education company that developed the LabTutor® programme (ADInstruments, nd.). LabTutor® is a digital learning platform that incorporates experiments and online tutorials based around a video bank of case studies using actual patient, family members and health care professionals.

Two LabTutor® video case studies were developed for this research project. The 'COPD case' introduces 'Mrs M', admitted to hospital with extreme difficulty in breathing as a result of Chronic Obstructive Pulmonary Disease (COPD). The 'MI case' presents 'Mr M', a young man who has a cardiac arrest following a myocardial infarction. Each video case is accompanied by real clinical data (e.g. the patients' own diagnostic imaging and laboratory test results); associated physiology and pharmacology revision materials, questions and prompts to explore the nursing needs and interventions of the indicial patient presented. Figure 1 shows the five elements of the immersive learning module design for students.

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Immersive learning module design ©

1. **Lecture –** teacher-led directed learning of pathophysiological content.
2. **Case study** – introduces the patient; revises the anatomy and physiology concepts underpinning the patient's presentations. This involves seeing real life patient footage, clinical data, commentaries from the health care professional involved in their care and finishes with a short quiz.
3. **LabTutor® time** – small group work in tutorials. This also involves doing simple experiments on yourself and relating these findings to the patient case study.
4. **Simulated nursing scenario** –you will be introduced to the patient (or a very clever manikin) and be guided through an episode of nursing care. The scenario is designed to evaluate your clinical nursing skills and understanding of the patient's medical condition.
5. **Guided reflection and discussion** – working in small groups the lecturer will debrief the scenario and the case study so far and help you to draw together all of the learning elements.

Figure 1: Immersive learning module design

The module begins with teacher-led lectures covering the pathophysiology and pharmacology relating to the treatment and management of COPD and MI, the conditions of the two case study patients. Lecture content also covers the theory related to the nursing assessment and management of people with these medical conditions. This is followed by a case study tutorial where the more complex aspects of the disease are discussed in context to the patient. In these small group tutorials, students also use the optional LabTutor® classroom toolkit to perform simple experiments on themselves (e.g., individuals can record their heart rate and rhythm via three Electro Cardiograph (ECG) leads and measure their own breathing rates and lung capacity). This hands-on learning assists students to understand how their

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own 'normal' data compares to that of a person who has a chronic medical condition.

The module concludes with a simulated nursing scenario where small groups of students care for their patient, (Mrs M or Mr M) a high-fidelity manikin that has a pulse, can blink, and speaks through an intercom system. High-fidelity simulation is an excellent strategy for teaching clinical practice skills, allowing for more direct application of theoretical knowledge than is possible through traditional teaching methods (Neilson, Noone, Voss, & Matthews, 2013). This enhanced realism enables students to use their senses (sight, touch and hearing), assisting them to develop reflective thinking skills. We anticipated that the case-based immersive learning approach and higher level of realism that is possible using the high-fidelity simulation would enhance students' learning experience and improve exam performance in the second year Pathophysiology course.

2. Methods

2.1 Research questions

This article addresses two research questions.

- How effective was student learning relating to the MI and COPD case study? (Assessed by focus group interviews and an online survey).
- Did the technology-enhanced immersive approach improve student's exam performance in their pathophysiology course? (Assessed by analyzing marks)

2.2 Study setting and participants

The study was conducted in collaboration with ADI who supplied the high-fidelity manikins used in this project. Staff worked together to develop and implement the two learning modules used for this study. Academics supported by an ADI staff member and the School of Nursing laboratory technician conducted LabTutor® sessions. The course instructor and others facilitated and debriefed simulations. Research participants were second-year nursing students (N=111) split into four teaching groups (A, B, C, D). Each group had the same immersive learning experience, but at different times of the academic year.

2.3 Ethical considerations

Ethical approval to conduct this study was granted by the institution's Research Ethics Committee (OPREC 2014-577). Students signed confidentiality and consent forms for participating in the simulation scenario and each part of the research study respectively. They were assured that their responses would remain confidential, that participating in this study was not part of course assessment, would have no bearing on their course grades, and that exam marks would not be analysed until all students had completed the academic year.

2.4 Research instruments

2.4.1 Focus groups

Qualitative data was gathered using focus groups and an external facilitator. Group sessions were approximately 50 minutes long, digitally recorded, then transcribed by an administrator who signed a non-disclosure confidentiality agreement. Participants also used a simple scoring sheet to rate their satisfaction with the different teaching and learning components at the end of the interview.

2.4.2 Online survey

Quantitative data were gathered by an online survey that was pilot tested before going live in the last week of the academic year. The survey was accessible through a secured institutional course portal and de-identified data were returned as a computer generated summary report of simple descriptive statistics. Limited demographic data (age, gender) was also collected.

2.4.3 Examination

A mid-year Pathophysiology exam comprising multiple-choice and short answer questions was held in June. Short answer questions covered students understanding of different body systems, for example the respiratory section focused on their understanding of the pathophysiology of COPD, and the cardiovascular question, the pathophysiology relating to a MI. All students completed the same course learning requirements, i.e., lectures, tutorials and five hours of directed learning before the exam. However, because students were divided into four teaching groups to accommodate their different clinical nursing placements; 52 had been placed on a medical rotation (MR) that included three weeks supervised full-time clinical work. This group and had also completed the case-based immersive learning module using LabTutor® (LT) and Simulation (S) in the first semester. Half (n=26) of these students (the early intervention (EI) group) completed the case-based learning module (MR/LT/S) in the first part of semester one. The remainder (n=26), the late intervention (LI) group had the same learning experience in the second part of semester one. Students who had not yet had the MR/LT/S immersive learning experience (n=59) were the no intervention (NI) group. Student's examination results were analysed using SPPS programme and a series of unpaired t-tests ($p<0.05$).

2.5 Study sample

A total of 71 students (64%) participated in focus group interviews. Eighty-two students (73%) completed the online survey. The majority of these respondents were female (male=95%); nearly two thirds (61%) were in the 18-21 year age group; 23%, 9% and 2% respectively, were in the 22-25, 26-30, and 31-45 year age groups. All students (N=111) sat the mid-year examination.

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3. Results

3.1 Focus group findings

Focus group results indicated that elements of the immersive learning model worked together to reinforce learning and in this section, student's comments are reported as direct quotations in italic script. Comments indicated that the experiment where students used a spirometer to measure their own breathing rate, flow and volume helped them to learn about and understand the pathophysiology underpinning the medical conditions presented in the COPD case study. The experiment also provided insights into how a person with COPD lives with the symptoms of such a debilitating condition, i.e., a restricted lung capacity, increased respiratory rate and lower inspiratory volume. These learning activities greatly assisted student learning as reflected in the following student comments.

> "*Actually breathing and pretending we had COPD is really good. I could feel the difference*", and for the MI case study another said,
>
> "*it was good having an ECG. It's good to do it out of placement and then have the experience before doing it in class*".

LabTutor® online learning activities where "*you had to match the diagram with the part of the heart belonged to that name, activities like that"*, were reported as preferable to "*just reading and answering questions*". The following quotes indicate that seeing the video vignettes of the person with COPD clearly enhanced students' learning.

> *"We learned about the disease during the lecture, and then we watched video on somebody who had the disease, and listened to them talking about their own experience with it and what that meant for them and how it affected their life and also their relatives".*
>
> "*For me it was how she was expressing her mind telling me how she is feeling, telling us how long she had been smoking before she stopped. How she breathes when she is going for exercise and gets out of bed. I keep remembering it in my brain, I can't forget it*".

Students also made connections between the elements of the immersive process, i.e., the person, learning activities and the simulation. This learning design helped them to understand and link the pathophysiology to the clinical presentation and patient's experience of their medical condition.

> "*COPD is a chronic disease – so someone is living with it constantly, whereas MI is sort of, like, an event so it happens and is more like an experience rather than a lifestyle. So it is different in that sense, just because when you met the case study guy who had the MI, he was sort of talking about past experience, and the COPD lady was talking about their everyday life*".
>
> "*You kind of already know the patient history before going in whereas with any other simulation you get some information on a sheet and you are expected to retain that going in to the actual room. So it's good to have a lead up to it which is gradual as opposed to a list or handover*".

3.2 Online survey data

Themes identified from the open-ended responses to the online survey were coded manually and comments relating to the two case studies are summarised in Table 1.

Table 1: Themes from open-ended responses to the online survey

What was the *most valuable* part of the COPD learning experience?	Case study/video (31) Pre learning (13) Relating/knowing (12) Tutorial (9) Simulation & debrief (7)
What was the *least valuable* part of the COPD learning experience?	LabTutor®/Experiment (24) Communication problems (10) Failure of equipment (5)
What was the *most valuable* part of the MI learning experience?	Practical application (15) Simulation (14) Tutorial (13) Case study (12) Debrief (6) Pre-learning (5)
What was the *least valuable* part of the MI learning experience?	ECG experiment (10) Lab Tutor (9) Simulation (5)

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3.3 The COPD case

For the question relating to the most valuable part of the COPD learning experience, six themes were identified from a total of 62 responses. Students found the case study including the video, notes and supporting medical documents relating to Mrs M highly valuable. Using a case study benefitted students' learning because "*it was like having a real patient to get to know and learn about and I was able to see the progression of the illness on the patient*". The following student comment indicated that pre-learning, i.e, completing online activities and watching the video was enhanced their learning experience.

> "*I think the best thing about COPD was having the experience with watching the video of the patient while also having all the relevant information in the pre case learning to make the learning more relevant".*

The third theme, 'relating/knowing' i.e., "*being able to relate the signs and symptoms and what nursing actions to take*", suggested that students were building knowledge and that this was assisting them to bridge the knowledge-practice gap that has been previously been identified by other nurse educators such as Neilson, et al. (2013). One student connected theory to practice in the following way; "*I saw how the patient was effected and what they looked like and then relate that to practice, it helped me to understand COPD".*

For the least valuable part of the COPD learning experience, two themes were identified from 49 responses. Firstly, the task that we thought students would enjoy the most, i.e., performing the LabTutor® spirometry experiments for the COPD case and reading and interpreting ECGs, proved challenging for many students. Students stated that: "*we didn't know how to read the graphs, it was hard to know what to do*" and that "*the LabTutor® experiment – the breathing exercise part was confusing*". The second theme related to a lack of communication, this particularly affected the first group of students. Sending emails to students well in advance of the scheduled tutorial and posting clearer instructions of Moodle rectified this issue. Equipment failure, relating to "*a video that wasn't working...and equipment that didn't work at our LabTutor® session*" was another problem that was remedied as staff and students became more familiar with using and troubleshooting the LabTutor®.

3.4 The MI Case

For the most valuable part of the MI case study learning experience, six themes were identified from 73 responses. Firstly, the opportunity to practice emergency nursing skills was greatly appreciated. The case study and simulation gave students a chance to "*have a practice run at what to do in a real life situation*" as they were required to assess, evaluate and respond to a person experiencing the signs and symptoms of a MI and then perform Cardio Pulmonary Resuscitation (CPR). The underlying teaching and learning pedagogy of using a simulated scenario to provide leeway for students to make 'safe mistakes' is well established in the literature (Lewis, Stachan & Smith, 2012; Neilson, et al., 2013). The student experience is captured in the following reflection.

> *"Being able to go through the motions of an emergency without any drastic consequences. I think the most valuable part was having the patient go into cardiac arrest. This hugely helped me to understand what to do in this situation and has widening my learning skills".*

Students also valued small group learning and face-to-face tutorials. The following comment shows how tutorials help some students to learn.

> "*K's class was helpful in tying it all together and ascribing meaning to the material. I find the tutorial helps my learning exponentially! Discussing in groups is perfect for the l way I like to learn".*

For the least valuable part of the MI case study learning experience, five themes were identified from 57 responses. The first related to the experiment, i.e., performing and reading their own ECG. One student commented; "*I did not get much out of the ECG tracing experiment. Reading the ECG was quite complicated and I did not find it that useful*". The next theme related to using LabTutor® and the perceived lack of support for some students as shown in the following comment.

> "*The part for recording heart rates and electrical impulses was confusing. I found the actual interactive tasks extremely difficult to understand. I didn't know what the figures or graphs meant".*

This issue was remedied providing students with more technical support in future LabTutor® sessions.

3.5 Student's exam performance

Figure 2 shows that students the immersive learning group i.e., those who had completed MR/LT/S before sitting the mid-year exam achieved a higher average mark (66%) than students in the NI group (62%) but unpaired *t*-tests ($p<0.05$) showed that this difference (4%) was not significant ($p=0.088$).

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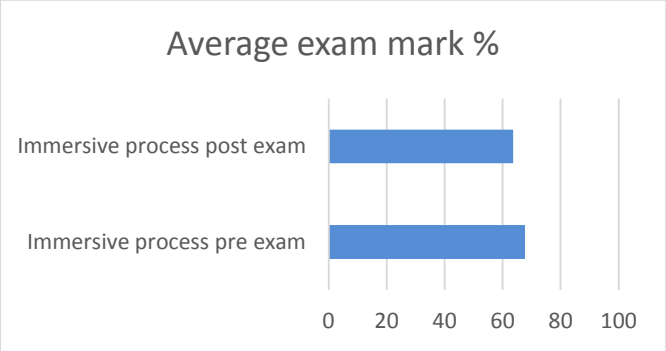

Figure 2: Students' pathophysiology average exam results

Further analyses using unpaired t-tests ($p<0.05$) found significant differences between the immersive learning group (EI & LI combined) and NI for cardiovascular ($p=0.022$) and respiratory ($p=0.0017$), with a trend towards significance compared to overall (EI/LI vs NI). This result indicates that early learning improved exam outcomes, results were significantly different to NI ($p=0.021$) for overall, but not late learning (LI) students.

Figure 3 shows that when broken into the specific content areas, for the immersive learning grou, marks were significantly different to NI for both EI ($p=0.0013$) and LI ($p=0.018$) for the respiratory case (marked out of 4). For the cardiovascular case (marked out of 7) results were significantly different to NI for EI ($p=0.0076$) but not LI. There was also a significant difference ($p=0.033$) between cardiovascular marks for the EI and LI groups.

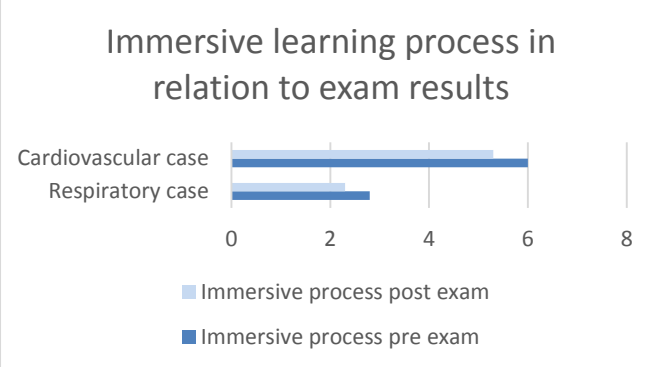

Figure 3: Student's cardiovascular and respiratory content exam marks

4. Discussion

This study evaluated how second-year nursing students responded to the introduction of technology-enhanced case-based learning using LabTutor® and high-fidelity clinical simulations as integral elements of a newly-developed immersive learning approach. Qualitative findings indicated that concentrated learning on a topic related directly to a case study made the learning real for the student. Witnessing, i.e., *"seeing someone who walked such a short distance and was gasping for air…You can read it is a book but unless you see it you can't comprehend it"*, and vicariously being part of the reality of a person's daily life clearly assisted students to link the science to nursing practice.

Students who had completed their immersive learning experience prior to their mid-year pathophysiology exam improved their respiratory and cardiovascular content marks. This finding shows that this learning approach improved student's course outcomes. This raises the question '*when is the best time for students to go on clinical placement, i.e. before or after simulation*?' In our experience, informed by formal course evaluation feedback, students prefer their simulation experience before clinical placement, as this gives them the opportunity to experience a scenario in a safe environment with support from academic staff.

A team approach to providing effective contextualised learning opportunities for students was foundational to the success of this learning initiative. This is supported by Craft et al. (2017) who recognized that team teaching and relating pharmacology and disease process content made the case study more relevant. Another important factor for student success in the nursing sciences is having academics that value and can teach this subject without prejudice. A negative science bias can have an impact on students who may be led to believe that science is difficult where this is no basis for this (Friedel & Treagust, 2005).

Incorporating technology into teaching encompasses education technology pedagogy, information technology, social media and mobile devices. In an era of Bring Your Own Education (BYOE), Bring Your Own Device (BYOD) and Do It Yourself (DIY), 'Generation Z' nursing students are part of the digital and electronically connected generation (Hampton & Keys, 2017). Other advantages of technology-enhanced teaching include the emphasis on learning, development of reasoning and providing personalised education (Rosenkoetter & Smith, 2014; Skiba 2013). LabTutor® provides excellent opportunities for students to demonstrate integration of theory and their readiness for clinical practice. It has been successfully used to teach biosciences in other Schools of Nursing, e.g. in the United Kingdom (Swift, et al., 2016) and Ireland (McMullan, 2017). In these contexts, students were confident about using the equipment and found the sessions enjoyable and helpful. However, while these students liked using LabTutor®, many found performing the spirometry experiments for the COPD case, and recording their own ECG difficult. They also needed tutorial support to interpret the results. In hindsight, this situation could have been remedied by providing more staff to assist with the LabTutor® tutorials.

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The inbuilt synchronous and asynchronous activities of this immersive learning design allowed students to be self-paced learners and provided them with multiple opportunities to engage with and revise the case study and online learning materials. Adapting teaching resources and approaches for different learning styles is an essential skill for all educators. While passive teaching approaches (lectures) may suit learners who find using technology challenging, interactive activities including online group activities, quizzes and games overcome barriers and engage students (Hampton, et al., 2017). Guided learning with interactive experiments, online tutorials all related to specific case studies where students can participate in group work are also beneficial in developing critical thoughtful practice (Swift, et al., 2017).

Nursing skills such as professionalism, critical decision-making, communication, teamwork and interpersonal skills can be demonstrated using a blended or immersive delivery model. For students learning must be authentic and have personal relevance, which includes the use of educational technology. For technology to have meaning it must have instructor support with constructive prompt feedback and contain student interaction and collaboration. Having personal relevance for the learner allows them access to authentic active learning and a degree of student autonomy (Skiba, 2014; Dede, 2013). The advantages of immersive technology enhanced learning is that it incorporates all the aspects that students find important while also reducing fail rates in science courses.

The purpose of the immersive approach was to give a professional nursing context to learning science within a three-year BN degree. Rather than standing in isolation, this model allows students to use their clinical experiences within a case study framework to broaden their theory and practice skill set. It encourages critical thinking within the case study tutorials, which can then be moved into the simulation environment where students can articulate their practice and safely debrief with experience academics. This holistic approach to learning science has had positive outcomes for student success with better grades and course success (Ditzel, Hogarth & Lesa, 2017). The following comment sums up that learning is mastery rather than the one-off opportunity to learn a skill or response.

> *"I thought it was very interesting… having activities immersed in the middle of each thing was nice to be able to test yourself and then go back and check it. It's nice for us to go back and I was actually taking in and it was real nice".*

5. Conclusion

This study offers insight into how an immersive, blended delivery enhanced by technology with theory and practice enhances student success and satisfaction in a nursing Pathophysiology course. Active participation in learning using digital technology can develop student understanding, allow self-paced study, reflection and revision thereby fostering the development of critical thinking skills. This technology-enhanced method provides case-based learning modules that are both kinaesthetic and interactive where students must be able to self-manage, work in groups and contextualize their learning to improve their outcomes, especially in their science courses. Improving nurses' knowledge of bioscience is vital to the nursing profession as an enhanced understanding of pathophysiology, interventions and treatments and should generate improved outcomes for health clients and foster greater inter professional collaboration.

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