MATHEMATICS IN THE NURSING PROFESSION: STUDENT AND PROFESSIONAL NURSES' PERSPECTIVE

Ugorji Iheanachor Ogbonnaya[1], Florence Awoniyi[2]
[1)]University of Pretoria, Hatfield, SOUTH AFRICA
[2)]University of Ghana, Legon Accra, GHANA

Correspondence email: ugorji.ogbonnaya@up.ac.za

ABSTRACT

Mathematical knowledge and skill are needed by all students in their studies and future careers. Students' perceived relevance of mathematics in their future careers influences their attitude towards learning mathematics. This study explored student and professional nurses' perceived relevance and application of mathematics in the nursing profession. A sample size of 301 nursing students in a University in Ghana and 12 professional nurses participated in the study. Data was collected using a questionnaire and interview and was analyzed using descriptive statistics and thematic analysis. The study revealed that both the professional and the student nurses perceived Statistics, Ratio and Rates, and Percentages as the topics in school mathematics that they find most relevant and applicable to their study and practice of nursing. The nurses apply the mathematical knowledge and concepts mainly in drug administration and compilations of patients' medical reports. It is recommended that the senior high school mathematics teachers may need to always share the professional applicability of any topic they teach, by using authentic and real-life situations in various professions.

Keywords: dosage calculation, mathematics and nursing, statistics

INTRODUCTION

The ability to use mathematical knowledge and skills to solve real-world problems is needed by every student to succeed in school and in his/her future profession (Kyllonen, 2018; Peranginangin, Saragih, & Siagian, 2019). This is particularly true in this digital age, where mathematics is everywhere and in almost everything we do. Mathematical literacy is an important aspect of nursing. Mathematical knowledge and skills involving fractions, decimals, ratios, and percent are often used in clinical calculations such as drug dosage and Body Mass Index (BMI). These mathematical knowledge and skills form part of primary and secondary schools' mathematics curricula in most countries. Hence, one would expect students and professional nurses to have acquired basic and critical mathematical skills and competence in their primary and secondary school education. However, some studies (e.g., Dilles, Vander Stichele, Van Bortel, & Elseviers, 2011; Bagnasco et al., 2016) show that many student nurses and professional nurses lack the basic mathematical competencies and skills essential for clinical calculations. Andrew, Salamonson, & Halcomb (2009) noted that "many nurses demonstrate difficulties with not only basic mathematical operations, but also the conceptual skills required to undertake and interpret clinical medication calculations" (p. 2).

One reason for the observed lack of basic mathematical competencies among nurses could be the nurses' lack of interest in their primary and secondary school mathematics

learning, and mathematical courses in their nursing education. Some studies show that students' interest in mathematics is related to their mathematics achievement (Dada & Akpan, 2019; Heinze, Reiss & Franziska, 2005; Thien & Ong, 2015). Furthermore, students' lack of interest in a subject, and consequently poor performance in the subject, is found to be related to their low perceived relevance of the subject to them (Massolt & Borowski, 2020). Hence, student nurses' success in their future careers, especially concerning their aptitude for the application of mathematical skills in their professional life, could be related to their perceived relevance of mathematics to their profession.

This study explored student and professional nurses' perceived relevance and application of mathematics in the nursing profession. The study addressed the questions: 1) what mathematics topic(s) do student nurses perceive as relevant in nursing? 2) what mathematics topic(s) do nurses find most applicable in nursing? and 3) where do nurses apply the mathematics topics in nursing?

LITERATURE REVIEW
Mathematics in nursing

Nurses use mathematical knowledge and skills in various aspects of their work. Boyd (2018) noted that "nurses routinely use addition, fractions, ratios, and algebraic equations each workday to deliver the right amount of medication to their patients or monitor changes in their health" (para. 1). Boyd (ibid) further noted that even in state-of-the-art medical facilities, successful nurses must have sharp mathematical skills". Drug administration (drug dosage calculations), which is a critical component of nursing, involves a range of mathematical concepts, including measurement and estimation as well as ratio and proportion (Hoyles, Noss & Pozzi, 2001; Stolic, 2014). Concerning drug dosage calculations, Simons (2014) found that nurses need a basic understanding of algebra to correctly administer medications. Galligan et al. (2017) noted that some research studies with student nurses and qualified nurses show a relationship between nursing skills and certain mathematical skills, including number, ratio and proportion, scale, decimals and fractions, rates, measurement, algebra, graphing, and problem-solving.

Perceived relevance of mathematics

Researchers use the term "perception" synonymously with terms such as attitude, disposition, belief, opinion, and values (Slavik, 2015). Vincenzi et al. (2018), described perception as humans' awareness or interpretation of the environment. It must, however, be noted that perception may sometimes occur without necessarily being influenced by an external receptor stimulus, but rather, it may result from an evolutionary adaptation of innate knowledge (Akurugu, 2010). A person's perceived relevance or usefulness of mathematics is the degree to which the person believes that mathematics will enhance his or her life, career, or job performance. It is a person's belief in the utility of mathematics in his or her life. For this study, the student nurses' perception of the relevance of mathematics in nursing is their appreciation of the utility of mathematics for meaningful engagement in the nursing profession. A major finding of the informal nature of workplace mathematics is that the mathematics taught in school settings is typically not the mathematics people use to be successful in their workplace (Marr & Hagston, 2007). Hence, some people may not perceive the relevance of some school mathematics content in work life.

The perception of students about mathematics as a subject determines their approach to studying the subject. Studies have shown that many students approach mathematics with disdain because of the perception that mathematics is a procedural and rule-oriented subject (Mensah, Okyere & Kuranchie, 2013) that has no bearing on real life activities. Some researchers (e.g., Marks, Hodgen, Coben & Bretscher, 2015) believe that the real-world calculation contexts and methods used by practicing nurses are far different from the academic and formulaic focus of some numeracy for nursing courses. From the foregoing, students' perceptions of mathematics and its relevance may either be innately determined or may be based on their experiences in learning the subject.

Students' perceived usefulness of mathematics is identified by Wigfield and Cambria (2010) as a measure of students' beliefs about the applicability of mathematics to their current and future goals, and about their school, career, and everyday life. If a student perceives that learning mathematics will increase his/her job opportunities, he/she will likely have a positive attitude towards mathematics learning (Guy, Cornick & Beckford, 2015; Syyeda, 2016).

Consequently, it could be concluded that students ascribe value to activities they find to have direct bearings on their daily lives and future goals. Students' perceived relevance of mathematics could be a motivational factor for their engagement in mathematics learning. The student nurses' perceived relevance of school mathematics topics, as explored in this study, is the students' beliefs that the mathematics topics will provide meaningful support to their nursing careers. In other words, their perceived relevance of the mathematics topics is the value the students attach to the mathematics topics. Some research studies have explored people's (students' and professionals') beliefs about the relevance of mathematics in real life (Ikeda, 2018, Maaß 2010, Schukajlow et al. 2012). Awoniyi (2018) in a study on Grade 11 students' (Form 5, secondary school students) motivation to learn mathematics in some Ghanaian secondary schools revealed that fifty percent of the students (interviewees) who participated in the study claimed that they do not see the relevance of mathematics in real life.

In a study on engineering students' perceived relevance of mathematics in engineering, Flegg, Mallet, & Lupton (2012) found that most students perceived mathematics as relevant to their future engineering careers. On the contrary, Zavala and Dominguez (2016) found that most engineering students in their studies did not appreciate the importance of mathematics in engineering. Since people attach importance to activities and practices that they see as relevant to their lives and critical to their survival (Anderson & Kriesler, 2018), exploring student nurses' perception of the relevance of mathematics topics and professional nurses' application of mathematics in nursing might help to provide an insight into ways of encouraging potential nurses to learn mathematics better.

Unfortunately, literature search seems to suggest that the perceived relevance of mathematics to potential professionals in Ghana has not caught the attention of researchers. Therefore, there is a need to find out from future nursing professionals their perceived usefulness of mathematics in their programmes of study and triangulate the findings with the application of mathematics by nursing professionals. Therefore, this study explored student nurses' perceived relevance of mathematics topics in nursing and the mathematics topics they find most applicable in nursing, and where professional nurses (that is, nurses who have completed their nursing training and are licenced and practicing) apply mathematics in nursing.

METHODOLOGY

This descriptive study explored student and professional nurses' perceived relevance and application of mathematics in the nursing profession. The participants were 301 undergraduate nursing students and 12 professional (licensed practicing) nurses. The selection of the sample of the student nurses was limited to nursing students from levels 100 – 300 because the Level 400 students were not available at the time of data collection. The Census sampling technique (Saunders, Lewis & Thornhill, 2007) was used to select all levels of 100 – 300 nursing students at the university as a sample for the study. A Census sampling technique was employed because of the small population size of the nursing students at the university. Even though 414 students were sampled to participate in the study, 113 could not complete the questionnaire. Hence, a response rate of 73% was recorded. Linear snowball sampling was used to recruit participants for the interviews. The researchers recruited a practicing nurse, while the recruited nurse helped to recruit the second nominee, and the second nominee recruited the third participant (Etikan, Alkassim & Abubakar, 2016). Table 1 presents data on the demographic profile of student nurses.

Table 1. Demographic profile of the student nurses

Variables	Frequency	Percentage
Gender		
Male	106	35
Female	195	65
Age		
16-20	120	40
21-25	162	54
26 and above	19	6
Level of study		
100	94	31
200	118	39
300	89	30

Out of 301 respondents, 106 (35%) were males while 195 (65%) were females. The majority (162 or 54%) were 21 – 25 years old, 120 (40%) were 16 – 20 years old and 19 (6%) were 26 years old and above. There were 94 (31%) level 100 students, 118 (39%) level 200 students and 89 (30%) level 300 students. For the professional nurses, 12 (5 males and 7 females) nurses between the ages of 26 to 35 were interviewed. All but one of the nurses have more than 2 years of professional nursing experience in hospitals and different units of hospitals. The nurses work in different hospitals and various units/departments (e.g., maternity, paediatric, surgical, chronic care, theatre, and ENT) of the hospitals.

Data for this study were collected using a questionnaire for the student nurses and an interview for the professional nurses. The questionnaire was divided into two (2) main sections. Items in section A obtained information on the demographic characteristics of the respondents, namely gender, age, and academic level. Section B elicited information on the mathematics topics that the student-nurses perceived relevant to their programme of study (nursing) and the topics they found applicable to nursing. Here, the respondents were provided with all the 25 mathematics topics, and they were required to indicate those that were relevant to their programme. To ensure the face and content validity of the instrument, the items were vetted by mathematics education researchers and pilot tested. All changes and suggestions were incorporated before the main study was carried out.

The instrument was pretested on 98 students (49 each from 200 and 300 levels) in the Cape Coast Nursing and Midwifery Training since they exhibit the same characteristics as the student-nurses of the University of Cape Coast. This was made up of 29% and 71% of males and females correspondingly. Most of them (83%) were aged between 21 – 25 years, about 7% and 10% were aged between 16 – 20, and 26 and above respectively.

Data from the professional nurses were collected through a structured interview (Nieuwenhuis, 2016). The interview sessions were audio-recorded (permitted by the participants). The participants were asked the department and hospitals/clinics they work in, the number of years they have worked as nurses, the mathematics topics/concepts find applicable in their work, the aspect of their work they apply the topics and concepts?

ANALYSIS AND DISCUSSION

This study explored student and professional nurses' perceived relevance and applicabilion of mathematics to nursing by addressing the following research questions: (1) what mathematics topic(s) do student nurses perceive as relevant in nursing? (2) What mathematics topics do student-nurses find most applicable in their programme of study? And (3) where do nurses apply the mathematics topics in nursing?? The quantitative data were analysed using frequency count and percentages, while the data from interviews were analysed qualitatively and presented as narratives with some examples.

Mathematics topics relevant to nursing

The student nurses were asked to indicate in order of relevance the secondary school's mathematics topics to nursing. Table 2 shows the listed three topics that they perceive to be the most relevant to their programme at the university.

Table 2. Respondents' perceived relevance of mathematics topics

Mathematics topics	1st Relevance		2nd Relevance		3rd Relevance	
	F	%	f	%	f	%
Statistics	72	23.9	48	15.9	43	14.3
Ratio and Rates	45	15.0	41	13.6	23	7.6
Percentages	44	14.6	29	9.6	38	12.6
Logical reasoning	26	8.6	42	14.0	44	14.6
Trigonometry	17	5.6	16	5.3	9	3.0
Sets and operations on sets	14	4.7	10	3.4	10	3.3
Relations and functions	13	4.3	16	5.3	9	3.0
Mensuration	8	2.7	10	3.3	10	3.3
Algebraic expression	5	1.7	9	3.0	5	1.7
Variations	5	1.7	16	5.3	10	3.3
Construction	3	1.0	2	.7	2	.7
Indices and logarithms	3	1.0	13	4.3	15	5.0
Linear equations and inequalities	3	1.0	1	.3	8	2.7
Plane geometry	3	1.0	0	0.0	2	.6
Quadratic functions	3	1.0	5	1.6	11	3.7
Bearings and vectors in a plane	2	.7	4	1.3	3	1.0
Number bases	2	.7	0	0.0	2	.7

Modular arithmetic	1	.3	0	0.0	0	0.0
Real number system	1	.3	2	.7	7	2.3
Rigid motion	1	.3	1	.3	1	.3
Sequence and series	1	.3	0	0.0	7	2.3
Simultaneous linear equations	0	0.0	4	1.4	6	2.0
Enlargement	0	0.0	1	.3	1	.3
Surds	0	0.0	3	1.0	5	1.7

*The mathematics topics were copied from the mathematics syllabus by the Ministry of Education [MoE] (2010)

The result (Table 2) shows that Statistics, Ratio, and Rates, Percentages, and Logical reasoning are the four most perceived relevant topics in mathematics to the study of nursing at university. Some topics (e.g., Rigid motion, Sequence and series, Simultaneous linear equations, Enlargement and Surds) were perceived by the students to be least relevant to nursing.

School mathematics topics applicable to nursing

The second research question explored the mathematics topics that nurses (student and professional nurses) find more applicable to the nursing profession. It was found necessary to investigate this because sometimes perceptions may be different from reality. The results are presented according to the categories of nurses.

Student-nurses

Table 3 presents the school mathematics topics applicable to nursing as indicated by the student nurses.

Table 3. Respondents' choices of Applicable Topics in Nursing

Mathematics Topics*	F	%
Statistics	201	66.8
Percentages	195	64.8
Ratio and rates	188	62.5
Logical reasoning	183	60.8
Relations and functions	126	41.9
Sets and operations on sets	112	37.2
Variations	99	32.9
Algebraic expressions	93	30.9
Indices and logarithms	92	30.6
Trigonometry	91	30.2
Simultaneous linear equations	87	28.9
Linear equations and inequalities	83	27.6
Quadratic functions	82	27.2
Real number system	80	26.6
Sequence and series	79	26.2
Mensuration	71	23.6
Number bases	52	17.3

Mathematics Topics*	F	%
Bearing and vectors in a plane	52	17.3
Surds	41	13.6
Constructions	37	12.3
Enlargement	36	12.0
Plane geometry	35	11.6
Modular arithmetic	31	10.3
Rigid motion	28	9.3

*Mathematics topics as presented in the senior high school mathematics syllabus (MoE, 2010)

The result (Table 3) shows the pattern of the respondents' indication of the application of the school mathematics topics in nursing. At least each of the topics was found applicable in nursing by a minimum of 28 (9%) respondents. The student nurses found Statistics, Percentages, Ratio and rates, and Logical reasoning as the four most applicable mathematics topics in their nursing studies. Enlargement, Plane geometry, Modular arithmetic, and Rigid motion were reported by the respondents as the least four applicable school mathematics topics in nursing.

Professional nurses

All the nurses interviewed indicated that mathematics applies to the nursing profession. For example, one nurse believed without mathematics, it would be difficult to compare the heartbeat, body temperature, and blood pressure of their patients to the vitals that are considered normal in medicine. According to her, *'checking of vitals like BP, pulse, temperature, etc. is crucial to patients' treatment when they report a health condition at any facility.* Similarly, another nurse declared, "*math is everywhere, we apply math everywhere".*

The nurses found statistics, ratio and proportion (ratio and rates), percentages, fractions, measurements involving metric and units, algebraic expressions, and arithmetic (involving +, −, ÷, x) applicable to nursing. A nurse stated that after statistics, ratio and proportion, percentage is the next mathematical concept mostly used by nurses in their profession. He stated:

..when you check the person's temperature and pulse, you use the statistics to plot the graph. The ratio and proportion are used to convert drugs from one unit to the other or to calculate the dosage required. This is only necessary when the drug is not in the unit of interest or when children are involved. Otherwise, there would be no need for any conversion. However, when a patient's oxygen concentration in the blood is calculated, the value is quoted in percentage. This helps to determine if a patient requires oxygen due to a low level of oxygen in the blood or not. In all, Statistics cut across every patient, inpatient or outpatient.

One nurse claimed that the four arithmetic operations are very important for the nurses' work. They add, multiply, divide, and subtract. In his words: *our calculation is all-inclusive. It is not just about multiplication but also about addition, subtraction, and division.*

The weight of the patient x the dose y number of times to take the drug z number of days = the quantity of tablets or syrup to give. He explained that ratio and proportion are used side by side with statistics. For instance, recording how many hypertensive patients, diabetes patients, and HIV patients are reported at the hospital makes use of statistics, but finding the ratios or percentages of each of the ailments to the other chronic diseases uses ratios and proportions, or percentages

In summary, one of the nurses said "the maths used in nursing depends on the unit involved. Nonetheless, statistics uses cut across every unit".

Where professional nurses apply mathematics topics in nursing

The nurses were further asked to explain where they apply mathematics in nursing. This was to elicit the aspects of nursing they apply mathematical knowledge. The nurses revealed that they apply mathematics knowledge and concepts in nursing especially in drug administration, compilations of patients' medical reports and forecasting healthcare needs.

Drug administration

The nurses expressed that to administer drugs they make use of ratios in their calculations. For example, Nurse 5, stated that: *If a doctor prescribes a certain quantity of drug per day for a patient on admission, the nurses must establish how the medication is to be applied, whether it will be every 4, 6, 8, or 12 hours. This is based on the maximum quantity of the drug the body can accommodate.*

Percentage is used in so many ways by nurses. For example, to establish how many patients reported to the facility with a particular health condition, the statistics of all the patients are noted, the different categories of ailment are noted, and the age group with a particular health condition is also noted. These figures are used to calculate the percentage of a particular group or ailment in relation to the others. Nurse 2 explained: *we report the number of people who came to the facility and the type of condition presented. We then calculate the percentage in relation to the general attendance and present the information on a pie or bar chart. This helps us to know the percentage of cases that were reported within a particular period of a year compared to the same period in the previous year.*

Another respondent, Nurse 3, stated that: *Percentages also help us to calculate the appropriate quantity of medication to administer to patients. If the doctor indicates that we should give 1000ml a day at 250ml per administration, then we divide 1000ml by 250ml and conclude that the medication will be administered 4 times daily.*

A nurse who works in the paediatric unit said that she uses ratio to calculate the quantity of children's medication. Another respondent gave an illustration of how ratio and proportion are very useful in health delivery to children. The female nurse who works in the Paediatric unit said that she uses fractions, an aspect of ratio, and rates to calculate drug quantities for children.

Similarly, another respondent who works in the Chronic Care unit, expressed that *'without Statistics, Fractions, and Percentages, I cannot function properly as a nurse. I use*

math to set up drips for patients. In fact, giving IV to children would be impossible without fractions. Thus, the fraction is used in calculating certain medications and Intravenous fluid (IV).

Another nurse emphasised the use of ratio and proportion in calculating dosage for children. The nurse works in the maternity ward, where they do a lot of measurements regarding the weight and length of the babies. According to him, statistics helps them to report data accurately.

One of the nurses pointed out the danger involved when nurses lack basic mathematics skills. According to her

sometimes doctors may give a wrong prescription, for example, an overdose or under dose. If nurses do not have knowledge of basic mathematics, and go ahead to administer the overdose drug, this may have a very bad effect on the patient. If an underdose was prescribed, the patient's condition may worsen due to the lack of impact of the drug on the patient's ailment. Thus, good health service delivery requires basic mathematics, especially Statistics, Ratios, and Proportions and percentages….

Compilation of patients' reports and Forecasting healthcare needs

The nurses indicated that they make use of mathematical knowledge and concepts to compile patients' medical reports. For example, every patient on admission has a record sheet attached to his/her bed on which the nurses record all the patient's vital medical information like the treatments administered, temperature and blood pressure readings, and other relevant medical observations. The nurses use the information on the record sheets to compile the medical reports at the unit and hospital levels on a weekly and monthly basis. The collation of all the medical data at the district level is used to generate the regional data and the combined regional data is used to generate the national medical data. To compile the medical reports according to the nurses, they apply mathematical knowledge and concepts. One of the nurses stated, "*We do compile the number of patients who come to the unit (maybe monthly), the type of cases that come to the unit (maybe), malaria, hypertension, diabetes, acute abdomen, and other conditions*". The nurse further stated … "*We may then present our data on a pie or bar chart to determine whether there was a rise or fall in the patronage of the facility for those with a particular kind of condition*".

The compilation of the patients' medical records helps invariably in forecasting or projecting the activities of the units and the hospitals. As asserted by one of the nurses "*It helps to forecast. It also helps to give a red alert when there is a possibility of an outbreak. Because as more people with the same symptoms report to the facility, the nurses will raise the alarm of imminent danger based on the data at their disposal*".

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In summary, of the 12 nurses interviewed, eight nurses believed that Statistics is more applicable to the nursing profession than any other mathematical concept, while three indicated that Ratios and Proportions or Rates are mostly used in their units and as such, the

most applicable. Nevertheless, one of the nurses maintained that the unit of the hospital that a nurse works determines the most applicable mathematical concepts to the nurse. For example, nurses in the children's ward make use of ratio and proportion more than any other mathematical concept because they use ratio and proportion to calculate the dosage of the drugs for the children based on their weights. Nonetheless, Statistics was found to be used by the nurses in all the units in the hospital. In addition, Percentage is also necessary for the nursing profession as the third most applicable.

The results of this study indicate that student nurses perceive statistics, ratios and rates, and percentages as the topics in school mathematics that the respondents find most relevant to the study of nursing at university. This finding implies that students appreciate the utility of concepts and skills for meaningful engagement in the nursing profession. Furthermore, the three topics are the most applicable mathematics topics in nursing, according to the students. These findings indicate a strong connection between the topics in the school mathematics curriculum that student nurses perceive as most relevant to nursing and the applicable mathematics topics in the nursing profession. The strong connection between the students' perceived most relevant topics and the most applicable topics to their profession found in this study corroborates with the view of Wigfield and Cambria (2010) that perceived usefulness of mathematics is a measure of belief about the applicability of mathematics in one's current or future life.

The mathematics topics (Statistics, Ratio and Rates, and Percentages) perceived by the student nurses in this study as most relevant and applicable to nursing have also been identified by many authors and researchers (e.g., Boyd, 2018; Hoyles, Noss & Pozzi, 2001; Pierce, Steinle, Stacey & Widjaja, 2008) to be relevant for a successful nursing career. The topics and the concepts associated with the topics are particularly critical for drug administration, which is "an important and essential nursing function with the potential for dangerous consequences if errors occur" (Stolic, 2014). Likely, student nurses regularly experience the use of the knowledge and skills of those mathematics topics in their training and practice, hence they could generally perceive them as relevant and applicable in nursing.

CONCLUSION

The purpose of this study was to explore professional and student nurses' perceptions of the relevance and application of mathematics in the nursing profession. The result of the study showed that the student nurses perceived Statistics, Ratio and Rates, and Percentages as the topics in mathematics that they perceived as most relevant to their nursing studies. In addition, Statistics, Ratio and Rates, and Percentages were also indicated by the students and the professional nurses as the most applicable mathematics topics in nursing. Based on the findings of the study, we recommend that mathematics teachers should make students see and appreciate the relevance of mathematics in real-life situations and various professions in their teaching. This could be achieved by using authentic examples in teaching mathematics. This will probably arouse the students' interest in learning mathematics. Often, students at the secondary school level perceive mathematics to be too abstract and divorced from real life and many professions that they

aspire to join in the future. This wrong perception of the nature and usefulness of mathematics makes students not show much interest in learning mathematics.

We also recommend that the applicable mathematics topics and concepts to the nursing profession should be included in the core nursing education curriculum. This would probably help those nursing students who did not have a thorough grasp of the topics in their secondary school education to have another opportunity to learn the concepts and topics before being fully licensed to join the nursing profession.

Limitations of the study and suggestions for further studies

The data for this study was derived from a questionnaire and interview guide only. A combination of different data collection techniques (for example, surveys, interviews, and observation) could produce better results than what has been produced by the two instruments (questionnaire and interview guide alone). An observation schedule could also help to bring out the different ways that those applicable topics are beneficial to the potential nurses.

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