Analysis of the Intelligence Structure in Nursing Students

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Abstract: Preparation for the profession of a nurse requires, in addition to knowledge, the development of specific skills; many of them are primarily connected to cognitive abilities. In the context of effective education, one of the key facts is to recognise the intelligence structure of nursing students. The aim of the research was to analyse the intelligence structure in nursing students, to compare scores in individual areas of intelligence with the norm, to identify problematic areas of intelligence, and to suggest possibilities for intervention in education. The research sample consisted of 266 women aged 19 to 43 years old (average age = 20.10 years) - current students of the study field of nursing at the bachelor's degree. Data collection was carried out in the years 2014 - 2019. To measure the structure of intelligence, a standardized IST-70 questionnaire was used, focusing on two meta constructs - reasoning and memory. Subtests of numerical, verbal, and figural intelligence were analysed within the meta construct of reasoning. The value of the gross score of the total intelligence level of the examined group ($M = 84.95$; $SD = 19.87$) is comparable ($t = -1.58$; $sig. = 0.114$) with the population norm ($M = 87$; $SD = 25$). The research sample of nursing students scored statistically significantly higher in the meta construct of memory ($t = 7.84$; $sig. = 0.000$) and significantly lower in the meta construct of reasoning ($t = -3.876$, $sig. = 0.000$). The most significant deficits were present in figural and numerical intelligence. In view of the results achieved, we recommend introducing interventions in the area of training future nurses, which should be aimed at compensating for deficits in figural and numerical intelligence.

Keywords: *Higher education, nursing, structure of intelligence.*

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1. Introduction

The profession of a nurse in the Slovak Republic (hereinafter SR) belongs to the regulated professions with specified conditions of education and attainment of qualifications (Act No. 578/2004 Coll., Government Regulation of the Slovak Republic No. 296/2010 Coll.). The qualification is obtained by completing either higher vocational education in the field of study - a graduate general nurse - or by a bachelor's university degree in the field of nursing. Currently, the study program Nursing in Slovakia is accredited in 10 higher education institutions. Nursing is included in non-medical study fields with the possibility of studying all 3 levels of higher education, as well as with possible habilitation and inauguration. It is a professionally oriented field of study. In accordance with § 56 of Act no. 131/2002 on Higher Education Institutions, the main prerequisite of the enrolment for the study field of Nursing, is a successful completion of secondary education. It means that the applicants and subsequently students are not only graduates of secondary nursing schools, but also graduates of grammar schools and other secondary schools with different specializations.

The work of nurses in the system of health (and other) care is very demanding and complex. From the available research in Slovakia it is clear that there are several factors that have a negative effect on the work of nursing staff - from social (low social status – Judicakova et al., 2013), population (increasing number of sick and elderly individuals requiring care – Bleha et al., 2013) through economic (low financial compensation - Tupa, 2020), or technical (lack of material and equipment) to psychological (burnout syndrome - Dimunova et al., 2018; personality variables - Rojkova, 2013) and so on.

However, experience shows that there are also negative factors that appear immediately after starting work and are related to the readiness of nursing students for real work practice immediately after graduation. Research abroad, but also in Slovakia, confirms that the correlation between the level of education of nursing staff and the level of patient safety is positive and statistically significant (Sovariova et al., 2017). It is also clear from the current data that education in the field of nursing at universities is trying to adapt to current trends and is interested in increasing the readiness of graduates for real conditions of the profession, such as by establishing simulation laboratories used in practical teaching (Dernarova et al., 2013). However, successful vocational training does not depend only on the

flexibility of educational institutions and their ability to respond to the changing demands of the professional practice.

The decline of the population curve (Bleha et al, 2013) and the higher mobility of young people (their outflow to study and work abroad) annually reduce the number of students at Slovak universities (Najvyšší kontrolný úrad SR, 2018). In nursing, this trend is also complicated by the growing demands of the profession with the current social need for an increasing number of nursing staff. These trends are changing the choice of candidates and, consequently, the characteristics of nursing students. Some changes (e.g. lack of secondary school knowledge) are responded to quickly by educational institutions as they are relatively easy to identify. However, intervention within the others (e.g. motivational or intellectual) can be much more complicated - not only because of their more hidden nature, but also because of the lack of data on their specifics. However, these characteristics are also important for the study and subsequently for the professional practice - e.g. the ability to logically identify the cause-and-effect relationship is the key to determining the aetiology of the diagnosis (errors in the aetiology of nursing diagnosis are considered to be the most common mistakes in the work of a nurse – Spacilova et al., 2018).

2. Problem

It is clear from the above facts that the structure of the intelligence of nursing students and the level of development of its individual components are particularly important for the preparation and subsequent professional performance of a nurse. In examining the structure of intelligence, we start from the concept of a hierarchical model of intelligence, which assumes the existence of specific, relatively independent abilities, which are then grouped into higher, more general meta constructs. This is one of possible views on the issue of intelligence; at present, the scientific literature records more than 70 different definitions of intelligence (Legg & Hutter, 2007). Common features of different definitions of intelligence include the ability to interact appropriately with the environment, including an adequate degree of adaptability (Kaliska et al., 2018).

In the context of intelligence structure as a multi-component concept, it is important to monitor not only the overall level of intelligence, but it is necessary to focus on the level of intelligence in each of its components. Partial deficits (even if maintaining a relatively good level of overall intelligence) can complicate the study and, consequently, the

professional performance of a nurse. E.g. verbal intelligence is important to understand the text as well as the information provided by a doctor or a patient and to express the instructions to a patient in a clear and comprehensible manner; numerical intelligence for drug dilution and dosing calculations; logical reasoning and analytical thinking to make a correct nursing diagnosis or a memory component to store important information related to a patient's health, medical subscriptions or planned nursing interventions. Another particularly important role in a nursing profession plays dexterity - the ability to manipulate objects, and personal intelligence, as in the centre of its interest is a person.

Apart from sporadic data on the nature of problems, mistakes or errors related to the performance of the profession (from which it is possible to indirectly infer, for example, the failure of logical reasoning), or verbal references of university lectures teaching in the field, there are no scientific studies describing the nature of the intelligence structure of nursing students. At the same time, such data could help to understand the difficulties and errors in the training and practice of the nursing profession and potentially identify areas of desirable intervention to prevent the occurrence of difficulties and failures.

The aim of this pilot research is:

- to obtain data on the structure of intelligence of nursing students in Slovakia;
- to compare scores in individual areas of intelligence with the norm;
- to identify problematic areas of intelligence that differ statistically significantly from the norm in the sample of nursing students;
- to interpret the findings in the context of the occurrence of possible difficulties in the education and practice of a nursing profession.

2.1. Research questions

Q1: What is the overall level of intelligence of nursing students compared to the norm?

Q2: What level of verbal, numerical and spatial intelligence is reached by nursing students compared to the norm?

Q3: In which subtests did nursing students perform the weakest?

2.2. The Research Sample

A typical student of a nursing study program is a woman, a graduate of a secondary nursing school (from previous analysis it is clear that men account for about 1.5 percent of the total number). Therefore, the research group consisted of 266 women aged 19 to 43 years, with the average age of the respondents was 20.10 years. All respondents were students of the first year of the bachelor's degree in nursing at 2 state universities in the SR. Data collection was carried out in the years 2014-2019. In terms of education, the group consisted of graduates of a secondary nursing school.

2.3. Methodologies

Data were collected through a questionnaire. The first part consisted of information focused on basic demographic data of respondents, the second part was a standardized questionnaire IST-70 (Amthauer, 1992).

The R. Amthauer IST-70 (Intelligence-Structure Test) is a test aimed at examining the structure of intelligence in adolescents and adult population. The method is determined for group use for subjects older than 13 years of age.

It assumes that intelligence is a structured whole of mental activity, it is hierarchically arranged and has its dominant centres manifested in various activities (Stancak, 1996). The test allows to measure two meta constructs: 1) Reasoning and 2) Memory (ME subtest). The meta construct of Reasoning consists of three areas of intelligence (Amthauer, 1992, Svoboda, 1999).

- Numerical Intelligence covering intellectual abilities related to the use of numbers (subtests: NC – Numerical Calculations – explores practical mathematical thinking, NS – Numerical Series – explores inductive thinking with numbers, theoretical mathematical thinking, rhythmical moments);
- Verbal Intelligence covering intellectual abilities related to the use of language (subtests: SC – Sentence Completion – explores the ability to create judgement, accentuation of a “concrete practical aspect”, sense of reality, VA – Verbal Analogies – explores the ability to combine, agility and convertibility in thinking and understanding of relations, GE – Generalization – explores the ability of abstraction, construction of terms, the ability to express oneself, WE – Word Elimination – explores inductive lingual thinking, sense of perception of various word meanings, the ability to empathize);

- Spatial Intelligence, covering figural-spatial intellectual abilities (subtest CU – Cubes – measuring space visualization, FS – Figure Selection – explores imagination, variability of images, complex opinion making and constructive moments in thinking).

Metaconstruct memory requires the ability to work with words as symbols (subtest ME – measures the ability to remember, memorize learned words, measures the length of concentration intervals and the ability to bear pressure).

In regard to the use of IST-70 it is necessary to realize that the test is challenging in terms of speed of thinking; it is suitable for people with average or above-average intellectual performance. Although the length of time reserved for the solution of individual tasks is fixed, the allowed time limit is deliberately set not to be met by most respondents. A profile of the structure of intelligence is crucial in regard to the interpretation of IST-70 (Svoboda, 1999).

IST is a standard tool for measuring the structure of intelligence in SR and abroad and is often used in connection with determining the abilities for a profession or the success of university studies (König et al., 2007; Berkowitz & Stern, 2018).

We decided to use a standardized IST-70 questionnaire because of its value in complex exploration of the structure of intelligence. Its use was determined by its availability and the content of the inquiry corresponded in principle with the objectives of our pilot research.

2.4. Procedure

Data collection was carried out by the method of deliberate selection - the participants were students of the second semester of the bachelor's degree in the field of nursing at two state universities. Basic principles of research ethics concerning voluntariness, confidentiality and privacy were applied during the process of data collection.

Prior to the administration of the questionnaire, students were acquainted with the content of the research and had the opportunity not to participate in it, as well as to withdraw from it during or after its administration. Participants were granted the option to leave the study, without any consequence, at any time and for any reason if they wished to do so. In order to prevent any future use of such participants' material and data in new research projects, the withdrawal of consent led to the deletion of all their data. Due to the fact that participants in the research were

students (subordinates), competent academic representatives and employees took steps to protect them from any negative consequences if they decided to withdraw from the project.

Data collection took place anonymously and in groups during teaching. Data collection was carried out annually in the same semester of bachelor's study in the years 2014 – 2019. All subtests of the standardized IST-70 questionnaire were written on a test sheet and students filled in their answers on a special form. Duration of individual subtests was precisely determined. The overall time reserved for administration of the tests was 90 minutes.

2.5. Data Analysis

Data analysis was performed using the statistical program IBM SPSS 22. A One-sample T-test was used to compare the achieved score in individual subtests, areas of intelligence, and meta constructs with the norm. The significance of its results was further determined by the value of Cohen's d of the Effect size. The level of statistical significance (α) was set at 0.05 level in the analysis of all data.

3. Results

3.1 Research question 1

From the result of the One-sample T-test comparing the gross score of the total level of intelligence (all IST-70 subtests) (IST) of the research sample (RS) with the norm (NO), it is clear that the achieved values (MIST-RS = 84.95; SDIST-RS = 19.87) are not statistically significantly different from the norm (MIST-NO = 87; SDIST-NO = 25) ($t = -1.58$; sig. = 0.114). Thus, the overall performance in the intelligence test corresponds to the standard, and nursing students score within the average range (Amthauer, 1992). However, the analysis of the intelligence structure shows different performance in the basic IST-70 meta constructs (Table 1).

Table 1. Gross scores of meta constructs - memory and reasoning - of the research group and their comparison with the norm example of a table

Gross score	Research sample ($N_{RS}=266$)		Norm ($N_{NO}=1046$)		T-test		
	M	SD	M	SD	t	df	Sig.
Memory	13.23	5.05	10.8	4.4	7.84	264	0.000**
Reasoning	61.9	15.76	65.9	26.3	-3.876	238	0.000**

** $p < 0.005$

It is clear from Table 1 that while nursing students score statistically significantly higher than the population average in the area of memory, the situation is the opposite in the area of reasoning - their results are statistically significantly lower.

3.2 Research question 2

A more detailed analysis of the meta construct of reasoning provides an insight into the structure of intelligence, in which it is clear which areas contribute to poorer performance in reasoning of the research group of nursing students (Chart 1).

Chart 1. Gross scores of individual areas of intelligence of the researched group and their comparison with the norm

In the field of Verbal Intelligence (VI), the researched sample of nursing students (RS) ($M_{VI-RS} = 31,95$; $SD_{VI-RS} = 7,79$) scored higher than the norm ($M_{VI-NO} = 31,0$; $SD_{VI-NO} = 0,8$). Taking into account the determined level of α , this difference is on the border of statistical significance ($t = 1.96$; sig. = 0.051). In contrast, levels of Numerical (NI) ($M_{NI-RS} = 13,12$; $SD_{NI-RS} = 5,84$) and Figural (FI) ($M_{FI-RS} = 17,27$; $SD_{FI-RS} = 5,98$) Intelligence are statistically significantly lower ($p = 0.000$) than the norm ($M_{NI-NO} = 15,2$; $SD_{NI-NO} = 7,4$; $M_{FI-NO} = 19,7$; $SD_{FI-NO} = 7,2$). When assessing the effect size differences of NI (Cohen's $d_{NI} = -0.356$) and FI (Cohen's $d_{FI} = -0.406$) against the norm, it is clear that the effect is moderately strong in both cases (Sawilowsky, 2009). However, the

performance of RS in the area of FI was weaker (Cohen's $d_{FI} >$ Cohen's d_{NI}). Therefore, it can be concluded that in the research sample the performance in the meta construct Reasoning was increased by the area VI, while the areas of NI and FI significantly reduced it.

3.3 Research question 3

Within IST-70, each area of NI and FI is measured by two subtests - NI is covered by subtests NS (Numerical Series) and NC (Numerical Calculations); FI by subtests FS (Figure Selection) and CU (Cubes). A closer look at the performance in the individual subtests allows a deeper analysis of the areas of degraded RS performance in the area of reasoning (Chart 2).

Chart 2. Gross scores of RS in individual subtests NI and FI their comparison with NO

From the graphical representation of the RS performance profile in the NI and FI subtests compared to NO, it is clear that the examined sample largely copies the profile of the standard, but in most of the monitored parameters (except NS) it is shifted below its level. The One-sample T-test evaluated this level compared to NO as statistically significantly lower in three parameters – numerical calculations ($t = -17.667$; sig. = 0.000), figure selection ($t = -5.85$; sig. = 0.000) and cube rotation ($t = -5.85$; sig. = 0.000). The strength of the effect of these differences is moderately strong in the subtests of figural intelligence (Cohen's $d_{PL} = -0.388$; Cohen's $d_{SP} = -0.388$), but in the numerical calculations subtest it is large (Cohen's $d_{AR} = 1.128$) (Sawilowsky, 2009). This means that the drop in the performance in this type of intelligence is in the monitored sample compared to the standard the largest.

4. Discussion

The analysis of the intelligence structure of nursing students carried out by the standardized IST-70 (Intelligence-Structure-Test) questionnaire by R. Amthauer showed that the above-average areas of intelligence in future nurses are their memory and verbal intelligence. These are the areas that can significantly contribute to the acquisition of the necessary knowledge in the process of preparation for the profession and in the professional performance to manage communication with a patient and a doctor. Verbal intelligence represents the ability to deal with speech when reasoning, not only in the form of building and using vocabulary and the overall level of language acquisition but also in identifying the interrelationships between various concepts (Plhakova, 2005). The ability to express clearly and accurately, as well as the ability to understand speech (whether written or spoken), is extremely important for the nurse's interaction with the environment.

On the contrary, in the areas of numerical and figural intelligence, the research sample scored statistically significantly lower. In the context of the intelligence model presented in the IST-70 questionnaire, numerical intelligence represents a set of number-related intellectual abilities and figural intelligence a set of figural-spatial intellectual abilities (Amthauer, 1992). Numerical intelligence includes the ability to understand quantitative concepts and manipulate with numerical symbols. People with high numerical intelligence have a good understanding of basic mathematical principles, are able to work effectively with numbers, and can use these skills to solve practical problems involving numbers and / or their relationships in any form (Assessment Systems, 2020). Figural intelligence is a term that, in the context of Guilford's model of intelligence, relates to an individual's ability to perform manipulation with objects in mental space (Piirto, 2004). In general, it allows individuals to manage tasks requiring spatial imagination, orientation in mental space, allows to plan and visualize movements, anticipate them, or manipulate imaginative objects (Piirto, 1999). It involves reasoning about the relationships between objects in space and the ability to rotate three-dimensional objects in mind (Belohlavek, 2016).

These skills are essential in the context of a nurse's work, specifically when planning and following the process of each nursing intervention. Nurses must perceive each nursing procedure comprehensively, in terms of performance indication, assessment and preparation of the patient, anticipation of potential complications, preparation of correct aids, logical

sequence and justification of individual steps, recording documentation and provision of post-intervention care (Bobkowska et al., 2018). An example would be the treatment of a wound in a patient with reduced mobility. The nurse must place the patient in the correct position, prepare aids at the side that is closer to her dominant hand, have the aids neatly and logically placed to avoid mistakes, e.g. violation of sterility or forgetting the device, perform actions in such a chronological and logical procedure that is in accordance with respecting the principles of asepsis, e.g. she must first remove the old dressing from the wound, then put on sterile gloves and apply a new dressing. The ability of spatial intelligence is important, e.g. when inserting a gastric tube, bladder coil, extraction of secretions from the airways (probe or coil is not visually inspected during insertion), manipulation with an immobile patient during positioning, verticalization, training of self-service activities (must be able to imagine where and how to hold the patient, how to fix him in order to prevent the occurrence of an adverse event such as a fall or injury), in the preparation of instruments and assistance during surgery so that the procedure is performed quickly and without errors. Collection of blood and administration of drugs intravenously requires imagination related to the anatomy of the venous system and based on this, the selection of a suitable injection site. Numerical intelligence is related to e.g. the preparation of the correct dose of drugs, dilution of antibiotics, monitoring and evaluation of vital functions, fluid balance, nutritional parameters, and the results of laboratory tests.

In addition to these specific areas, which are affected by numerical and figural intelligence, other research (see e.g. Bühner et al., 2008; Süß & Kretzschmar, 2018) also shows their wider impact on solving work problems. A study assessing the ability to solve complex problems occurring in a real working life of various professions revealed that of the wide range of areas of intelligence structure, the most important areas for successful problem solving are numerical and figural intelligence (Süß & Kretzschmar, 2018).

Performance in the field of numerical and figural intelligence not only influences specific nursing interventions, but also have an impact on the management and solution of complex nursing problems within the nursing process. For this reason, it is desirable to apply an effective intervention to improve numerical and figural intelligence in the training of future nurses.

At the same time, the findings represent an important impulse for

education and preparation of future nurses. Interdisciplinary and international studies increasingly emphasize the necessity to respect the needs of practice in the educational process (Edmond, 2001; Nemire & Meyer, 2006; Drexel et al., 2015) and require the removal of graduates' deficiencies (Sinche et al., 2017; Thompson et al., 2018). In this context, the outcomes of our study are in accordance with foreign papers (Wilson et al., 2015; Kyriakoulis et al., 2016; Horntvedt et al., 2018; Kim et al., 2019) and thus contribute greatly to knowledge of how to improve the education of future nurses.

More specifically, the results of researches show that numerical intelligence performance can be improved through training (Siegler et al., 2011; Ramani et al., 2019). Likewise, increasing the time allocation for practical teaching focused on the development of skills in areas related to numerical and spatial (figural) abilities could be one of the appropriate tools.

5. Conclusions

Education of the young generation is a key element in the stability and future development of every country. Although there are various educational strategies and approaches, their common goal is to prepare students for a certain type of profession in the best possible way. For this reason, there is a strong need for constant intensive communication between the requirements of practice and educational institutions. Disharmony between the preparedness of students and needs of practice, however, does not have to be caused only by changing conditions in the professional environment but may also be associated with the changing abilities and skills of the generation of people preparing for their professional career. Therefore, finding an optimal kind of preparation of students requires focus on both areas.

The conducted study drew attention to the specific problem of unbalanced levels of individual factors of intelligence among students of nursing. Above-average level of memory skills was combined with below-average level of metaconstruct reasoning, with future nurses failing mainly in the area of numerical and spatial intelligence. Seemingly the most suitable solution to this is for them to use their abilities to the maximum and to decrease their shortcomings through greater education in difficult areas and more intense practice in those fields where there is a higher risk of failure in students' future professional careers. Discussion about the solution to this concrete problem has shown how it can be implemented in a wider context.

Educational curricula of any specialization can be purposely adjusted to take advantage of the potential of individual educated groups and compensate for their possible limitations. Changes in the educational process of this kind have the potential to improve the preparedness of students for their future professional career and prevent any potential failures in practice. Detailed analyses and their interpretation as well as discussion opportunities and proposals for implementation of findings into the educational process can also serve as a model for educational improvement in other disciplines and countries.

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