POSSIBILITY OF OBJECTIVE KNOWLEDGE LEVEL MEASUREMENT IN HEALTH SCIENCES HIGHER EDUCATION

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1. INTRODUCTION

Realistic assessment of students' knowledge with traditional questionnaires, tests, worksheets is doubtful. [1] Teacher's subjectivity may occur in educational assessments. [2] "Mathematical and statistical theories, models primarily enable the development of tests as measuring instruments, and also the development of better tests, from which we can deduce indicators which are able to characterize the goodness of tests." [3, 4, 5, 6, 7]

Reliability: how well does it measure what measures. Cronbach's α is one of the most commonly used indicators of reliability in pedagogical practice. Validity: that feature of a test, that it measures whether what we want to measure with it. Objectivity: it means that " the results are determined only by the features of the tested person, and the different components of his/her knowledge are independent on who used the test and who evaluated the received data." [8]

What is the problem?
There’s no universal knowledge scale → The teachers’ grades/marks may be subjective → In nursing science we have no objective measurement tool to the measurement of knowledge

Benefits of the application of objective knowledge level measurement
The students' knowledge's domestic or international comparability → it is becoming increasingly important in science-based training development → there is justification for their use in medical- and health sciences researches.

Modern test theory
With the traditional/usual tests just raw points or % overall achievement reached by the persons can be compared with each other, but this does not give a complete picture of the real knowledge level of persons. So that’s why we should analyze the...
achievement of the persons with modern probability test theories (IRT) not only overall, but in details (per item). The one-parameter Rasch model is appropriate for analyzing dichotomous data (correct answer=1 point, wrong answer=0 point) as a commonly used method. [9]

**Other modern test theoretical instruments**

- Masters’ partial credit model (1982) - proper for analyzing non-dichotomous data. [10]
- Andrich’s rating scale model (1978) - proper for analyzing measured data in Likert scale. [11]
- Wilson’s ordered partition model (1992) - proper for analyzing dichotomous- and non-dichotomous data as well. [12]
- Fischer’s linear logistic test model (1983) - extension of the simple Rasch model. [13]

**Basic concept of new type knowledge evaluation in pedagogy (Figure 1).**

- Persons' knowledge profile with the same total scores may vary considerably depending on which questions, question groups were answered correctly by them.

- Certain questions' (items') degree of difficulty are not equal, many person solved the easy questions, but only a few people can solve the difficult tasks correctly.

- The probability of someone can solve a given task correctly, it depends on his/her general knowledge and the difficulty of the certain task/question.

*Figure 1: Basic concept*

**What does a probability test theory “know”?**

It reveals the relationships between questions/tasks (items) and illustrates with characteristic curves that parallelly with the increasing of the respondent's level of knowledge how to grow the probability that the respondent answers to the certain question correctly. [17] (Figure 2)
Figure 2: Rasch model’s characteristic

If one plotted probability as a latent dimension, the result would be a smooth S-shaped curve such as shown in Figure 3. This S-shaped curve describes the relationship between the probability of correct response to an item and the ability scale.

Figure 3: Some typical S-shaped curves of probability distribution [18, 19]

Some examples of the modern test theoretical instruments’ and objective knowledge level measurement’s application in medical/health science-related researches

- **Hierarchical cluster analysis:**
  - Cluster Analysis in Patients with GOLD 1 Chronic Obstructive Pulmonary Disease [20]
  - Cluster analysis of key diagnostic variables from two independent samples of eating-disorder patients [21]

- **Modern test theoretical instruments (Item Response Theory (IRT)):**
  - Classical and modern measurement theories, patient reports, and clinical outcomes [22]
  - Applications of modern test theory in medical education [23]

- **Use of Rasch model:**
  - Measurement of change in health status with Rasch model [24]
  - Rasch analysis as a tool for rehabilitation research [25]
2. AIM

The aim of our study was to use a modern test theory instrument and objective measurement in a nation-wide nursing-related research at first time in national-international researches of nursing sciences.

3. MATERIAL AND METHODS

Objective assessment of nurses' knowledge in relation to our survey

- National Survey:
  - between 19 November 2014 and 20 February 2015 [26]
  - \( N_o = 657 \) (nurses, head nurses)
- Data Processing:
  - IBM SPSS (version 20.0),
  - Microsoft Office 2013 programs
  - R program family ltm program modul

4. RESULTS

Some examples from our research results:
*Figure 4* shows the results of the correct-incorrect answers’ rate with logit results and odds ratios.

<table>
<thead>
<tr>
<th>number of the question</th>
<th>rate of incorrect answers</th>
<th>rate of correct answers</th>
<th>logit</th>
<th>odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>ik1</td>
<td>0.0959</td>
<td>0.9041</td>
<td>2.2437</td>
<td>9</td>
</tr>
<tr>
<td>ik2</td>
<td>0.4262</td>
<td>0.5738</td>
<td>0.2975</td>
<td>1.35</td>
</tr>
<tr>
<td>ik3</td>
<td>0.6545</td>
<td>0.3455</td>
<td>-0.6388</td>
<td>0.53</td>
</tr>
<tr>
<td>ik4</td>
<td>0.3242</td>
<td>0.6758</td>
<td>0.7345</td>
<td>2.08</td>
</tr>
<tr>
<td>ik5</td>
<td>0.6819</td>
<td>0.3181</td>
<td>-0.7625</td>
<td>0.47</td>
</tr>
<tr>
<td>ik6</td>
<td>0.0776</td>
<td>0.9224</td>
<td>2.4751</td>
<td>11.88</td>
</tr>
<tr>
<td>ik7</td>
<td>0.6758</td>
<td>0.3242</td>
<td>-0.7345</td>
<td>0.48</td>
</tr>
<tr>
<td>ik8</td>
<td>0.8706</td>
<td>0.1294</td>
<td>-1.9065</td>
<td>0.15</td>
</tr>
<tr>
<td>ik9</td>
<td>0.1355</td>
<td>0.8645</td>
<td>1.8535</td>
<td>6.38</td>
</tr>
<tr>
<td>ik10</td>
<td>0.7428</td>
<td>0.2572</td>
<td>-1.0604</td>
<td>0.35</td>
</tr>
<tr>
<td>ik11</td>
<td>0.7108</td>
<td>0.2892</td>
<td>-0.8993</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*Figure 4: The rate of correct and incorrect answers (knowledge) with logits and odds ratios*

The respondents answered correctly in the highest proportion to **ik6** question (92.24%) and **ik1** question (90.41%). (ik6 question = blood group determination, ik1 question =
Incorrect answers occurred in ik8 question (pre-transfusion tests) in the highest proportion (87.07%). Logit values indicate the ratio of correct and incorrect answers’ logarithm, in the case of negative logit the number of wrong answers exceeded the number of correct responds. The odds ratio express the proportion of correctly and incorrectly answers by respondents.

**Figure 5** is about the items’ difficulty indicators.

<table>
<thead>
<tr>
<th>item</th>
<th>estimated value</th>
<th>lower CI</th>
<th>upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ik1</td>
<td>-2.216</td>
<td>-2.463</td>
<td>-1.968</td>
</tr>
<tr>
<td>ik2</td>
<td>-0.210</td>
<td>-0.367</td>
<td>-0.052</td>
</tr>
<tr>
<td>ik3</td>
<td>0.808</td>
<td>0.641</td>
<td>0.975</td>
</tr>
<tr>
<td>ik4</td>
<td>-0.668</td>
<td>-0.832</td>
<td>-0.504</td>
</tr>
<tr>
<td>ik5</td>
<td>0.947</td>
<td>0.777</td>
<td>1.118</td>
</tr>
<tr>
<td>ik6</td>
<td>-2.452</td>
<td>-2.723</td>
<td>-2.181</td>
</tr>
<tr>
<td>ik7</td>
<td>0.916</td>
<td>0.746</td>
<td>1.085</td>
</tr>
<tr>
<td>ik8</td>
<td>2.302</td>
<td>2.059</td>
<td>2.544</td>
</tr>
<tr>
<td>ik9</td>
<td>-1.818</td>
<td>-2.034</td>
<td>-1.603</td>
</tr>
<tr>
<td>ik10</td>
<td>1.288</td>
<td>1.105</td>
<td>1.471</td>
</tr>
<tr>
<td>ik11</td>
<td>1.103</td>
<td>0.927</td>
<td>1.278</td>
</tr>
</tbody>
</table>

**Figure 5: Some items’ difficulty indicators (knowledges)**

- Difficulty indicators: on logit scale between -5 and 5:
  - Negative values indicate easy questions, the positive logit values (above 2.5-3) those whereby a few people knew the correct answer

Some items’ difficulty indicators in the case of questions regarding certain knowledge

**Easy questions:**
  - Patient Information Statement and Consent Form sample (ik1)
  - Blood group serology testing: blood sample, tube (ik2)
  - Start of blood products administration (ik4)
  - Blood group determination in the case of chosen/selected blood (ik6)
  - Nursing tasks in relation to the administration of blood products (ik9)

**Difficult questions:**
  - Temperature limits of blood products (ik3)
  - Pre-transfusion blood sample (ik5)
  - Clinical blood group determination (ik7)
  - Biological probe (ik10)
  - Post-transfusion tasks (ik11)

**The most difficult question:**
  - Pre-transfusion examinations (ik8)
Beside a certain level of knowledge (latent dimension), the correct answer may be born most likely to:

- **Blood group determination in the case of chosen/selected blood (ik6),**
- **Patient Information Statement and Consent Form sample (ik1),**
- **Nursing tasks in relation to the administration of blood products (ik9).**

There was the lowest probability of correct answers in the case of **pre-transfusion examinations (ik8)** (Figure 6).

**Figure 6: Items’ characteristic curve based on the one-parameter Rasch model (knowledges)**

The group of **ik_1,6,7** (consent forms + blood group determination in the case of chosen/selected blood + clinical blood group determination) leads the field; the group of **ik_9,11** (nursing tasks in relation to the administration of blood products + post-transfusion tasks) was the 2nd; there was the biggest level of lack of knowledge in the group **ik_8,10** (pre-transfusion examinations + biological probe). (Figure 7)

**Figure 7: Distribution of correct answers depending on the number of correctly answered question groups**
Those who responded correctly to the question \textit{ik1}, typically knew the right answer to the question \textit{ik6} too, or vice versa. Responses to the \textit{ik9}, \textit{ik4}, and \textit{ik2} questions has joined to this cluster.

The parallel cluster block built up from \textit{ik8, ik10, ik11, ik5, ik3} and \textit{ik7} questions. \textit{(Figure 8)}

\textit{Figure 8: Dendrogram of the transfusion therapy related knowledges}

Its purport: which questions had similar responses; that is, how did the various answers to questions fall far from each others. It represents the hierarchical arrangement of clusters.

\textit{Transfusion therapy related knowledges’ cluster blocks}

\textbf{1st Cluster block}
\begin{itemize}
  \item Patient Information Statement and Consent Form sample (\textit{ik1})
  \item Blood group determination in the case of chosen/selected blood (\textit{ik6})
  \item Nursing tasks in relation to the administration of blood products (\textit{ik9})
  \item Start of blood products administration (\textit{ik4})
  \item Blood group serology testing: blood sample, tube (\textit{ik2})
\end{itemize}

\textbf{2nd Cluster block}
\begin{itemize}
  \item Pre-transfusion examinations (\textit{ik8})
  \item Biological probe (\textit{ik10})
  \item Post-transfusion tasks (\textit{ik11})
  \item Pre-transfusion blood sample (\textit{ik5})
  \item Temperature limits of blood products (\textit{ik3})
  \item Clinical blood group determination (\textit{ik7})
\end{itemize}
5. DISCUSSION AND CONCLUSIONS

Areas for improvement in order to the objective measurement implementation

- We should break up with the analysis with classical test theory methods with an excessively long history in Hungary
- Knowledge and personal experience obtainment in this field on the part of the teachers
- Multidisciplinar participation in knowledge level measurement (pl: mathematician, biostatistician)
- Development of the possibility of objective measurement in connection with theoretical trainings
- Independent evaluation of knowledge level by more teachers – more teachers who are able to do this type of evaluation
- Development of the possibility of objective measurement regarding practical trainings
- Independent evaluation of practical skills level by more teachers – more teachers who are able to do this type of evaluation
- Development own reliable and valid measurement instrument(s)
- Development of widely available, measured at national level tests

Using the modern test theory instrument and objective measurement:

- we can actually judge the concrete knowledge of colleagues/students
- we can judge the nurses’/students’ skills
- we can detect the degree of difficulty of the tasks and questions,
- we can get picture of the distribution of received correct and incorrect answers for questions,
- furthermore, from these, the calculated logit and odds ratio were based on the possibilities of correct-incorrect responses.

References:

[18] Typical S-shaped curve of probability distribution 1. elérhető: https://upload.wikimedia.org/wikipedia/commons/thumb/3/31/DichotomeRaschExample03_Wikibooks.png/400px-DichotomeRaschExample03_Wikibooks.png