Use of high-fidelity simulators in healthcare education

Doctoral theses

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Introduction

The education of healthcare professionals is a highly important factor to ensure the appropriate quality of health services and to provide the safety of patient care. The healthcare has changed significantly in the past decades. The transition in healthcare claims for changes in the education of healthcare professionals, the education should be adapted to the changed demands. The use of high-fidelity simulators in the education program meets the criteria of these new challenges. These modern devices are able to give a realistic model for various physiological signs; they are able to react for interventions like humans do. The simulation education in the curriculum serves patient safety in an indirect way; this is the reason why it is inevitably important in the gradual and post-gradual education of healthcare professionals. The first high-fidelity simulator arrived at the Faculty of Health Sciences, Semmelweis University in September 2007. At that time started that still ongoing developing work that aims to create the optimal practice of simulation education.

The aim of this thesis is to present the history of simulation education, the theory and the practice of the currently used methods, the determining steps of the development of the curriculum at the Faculty of Health Sciences at Semmelweis University. Also, this thesis presents that three-part study that contributed to the development of simulation education and to the determination of the most appropriate position in the curriculum of this new educational strategy.

Objectives

The main aim of this thesis is to investigate the application of simulation education strategy at the Faculty of Health Sciences at Semmelweis University in order to develop the most effective way of education with high-fidelity simulators.

The most important objectives of the three-part study are the following:

1. To observe the students' attitude related to simulation education.
2. To define the applicability of the tool and the educational strategy in our practice.
3. To investigate the effectiveness of simulation education integrated into the curriculum from the students' perspective.

4. To evaluate objectively the performance of the students after the simulation courses.

5. To define those skills and capabilities that can be improved the most at the actual knowledge of students with simulation education.

6. To evaluate the appropriate place of the simulation courses in the curriculum.

7. To observe the reliability and content validity of the measuring instruments translated to Hungarian.

Methods

The education with high-fidelity patient simulators is not standardized on an international level; there is no agreed method or mandatory practice of usage. During our work we developed a new education strategy that considers the recommendations of the literature and takes into account our education structure, the characteristics of our students and resources. Considering all these factors this strategy would ensure the optimal use of these modern tools in the curriculum of healthcare professionals. Our usual strategy during simulation is demonstrated in Figure 1.

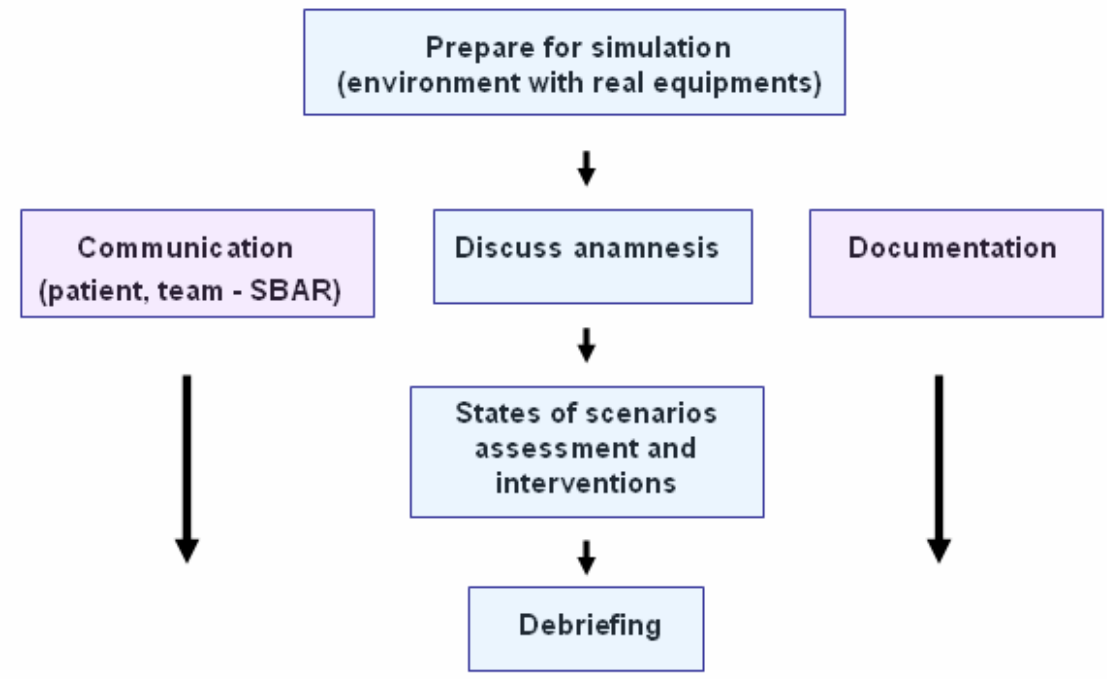

Figure 1. Our usual strategy during simulation lessons

Study I. - The observation of students' attitude related to simulation education

Sample selection and method

Our questionnaire was filled out by the students after finishing 'Clinical simulation' course in the 2012/13 and 2013/14 academic year. In the study 158 students (107 midwifery students, 51 nursing students) participated without clinical experience. We analyzed the data of their questionnaires.

The description of the questionnaire: 17 closed and 5 opened questions, self-completed, on paper. During attitude observation, the participating students rated the characteristics of simulation education strategy with Likert scale.

Reliability and validity analysis

To measure the reliability of the questionnaire we applied the Cronbach's alpha (reliability coefficient), which rated 0.805. According to this, the questionnaire is a reliable tool.

In the assessment of validity we considered to determine the content validity as the most appropriate indicator. In our study we determined the content validity index (CVI). Two types can be calculated - the first type involves the index of the content validity of individual items (I-CVI) and the second one involves the index of the content validity of the overall scale (S-CVI).

Six experts (who teach simulation for 2-7 years) were involved in the study of validity. I-CVI was between 0.83 and 1.0 when we examined the 8 most important aspect of attitude. The index of the content validity of the overall scale (S-CVI) can be computed as the average of all individual content validity index (I-CVI). In our case the result was 0.96, which shows adequate content validity on the whole scale. The measuring tool can be considered valid.

Study II. – The investigation of the effectiveness of simulation education integrated into the curriculum from the students' perspective

Sample selection and method

In our study we applied the METI Simulation Effectiveness Tool (SET) as a measuring tool.

Data were collected during 8 semesters (between December 2010 and May 2014) after the completion of two subsequent courses ('Clinical simulation' and 'Case studies in simulation') integrated into the curriculum. Nursing and midwifery students were enrolled in the study. For

data analysis we had 428 completely filled, reliable measuring tools. In the study 232 students participated (181 midwifery and 51 nursing students).

The measuring tool contained 13 statements, the students had to rate these statements by 0-1-2 points. (0 = disagree, 1 = somewhat agree, 2 = strongly agree, NA = not applicable). The statements of the tool can be divided in two subscales: 'learning subscale' and 'self-confidence subscale'. The 'learning subscale' is based on the perception of the students regarding the knowledge and skills gained as a result of the simulated cases. The 'self-confidence subscale' also reports the gained skills and characteristics based on perception. The students can rate the statements from 0 to 26 points. In the study the distribution of the given points by frequency of each statement and the total scores were compared.

Reliability and validity analysis

We applied the Cronbach's alpha (reliability coefficient) to measure the reliability of the Hungarian translated measuring tool. It was 0.842, accordingly the METI SET can be considered reliable.

At the validity analysis we evaluated content validity, as written in study I. In case of METI SET I-CVI scored between 0.83 and 1.0. The content validity index for the whole scale (S-CVI) measured 0.98, which shows an adequate content validity for the whole scale. The measuring tool can be considered valid.

Study III. – Objective evaluation of the students' performance after completing simulation courses

Sample selection and method

To evaluate the students' performance we applied the measuring tool 'Creighton Simulation Evaluation Instrument' (C-SEI) developed by Creighton University, School of Nursing (USA).

Data was collected from 180 students during their examination with C-SEI.

- in the fall semester of 2013/14 academic year after completing 'Clinical simulation' course 67 midwifery students and 32 nursing students, altogether 99 students
- in the spring semester of 2013/14 academic year after completing 'Case studies in simulation' course 58 midwifery and 23 nursing students, altogether 81 students

We evaluated the students' performance during examination (the teachers filled out the measuring tool), later at the analysis of the video recordings we re-evaluated their performance.

With the application of C-SEI the students' performance can be evaluated in 22 aspects. The 22 aspects appear in 4 subgroups ('assessment', 'communication', 'critical thinking' and 'technical skills'). The behavior of the students can be rated as 0 (no competency) or 1 (shows competency) in every aspect. The measuring tool can be applied at every level of the students' knowledge. The minimum total performance to obtain was 75%.

Reliability and validity analysis

The Cronbach's alpha coefficient was 0.818 for the Hungarian translated measuring tool, thus C-SEI is considered a reliable measuring tool.

At the evaluation of content validity of C-SEI I-CVI was between 0.83 and 1.0. The index of the content validity of the whole scale (S-CVI) measured 0.98, which shows adequate content validity on the whole scale. The measuring tool can be considered valid.

Statistical methods

For data collection we used the program Excel 2010 (Microsoft Office). The analysis of the data with descriptive statistical methods (calculation of mean, SD, median, mode, and relative frequency) was presented by the data analysis program of Excel 2010 (Microsoft Office). IBM SPSS Statistics 22 was used for statistical testing.

We determined the Cronbach's alpha (reliability coefficient) for the measurement of the reliability of the questionnaire/measuring tool. To assess the significant differences between the two groups (nursing, midwifery students) we utilized the independent t-test. (To examine the applicability of the t-test we used the Levene's test. It did not show significant difference in variances.) The level of significance was $p \leq 0.05$.

In the study of effectivity, we used the one-way analysis of variance (ANOVA) for our three study phase. The level of significance was $p \leq 0.05$. When we examined the performance of student groups, we used the one sample t-test to show the difference between the mean values and the expected values. In the correlation analysis we used the Pearson's correlation coefficient. The level of significance was $p \leq 0.01$.

Results

Study I. - The observation of students' attitude related to simulation education

When observing the application of simulation education strategy we concluded that the activities which are the basic tasks of 'Clinical simulation' course (patient history, assessment of vital signs, complex patient observation, basics of oxygen therapy) appeared in 100% in the questionnaires of the students.

Nursing and midwifery students gave 4 points ('strongly agree') in the biggest ratio (33.64%-43.14%) that they perceived lifelike cases during simulation practices. However, only 21.57%-22.43% of the students marked the cases shown during the courses as completely lifelike. The nursing and midwifery students both rated the lifelike environment of the simulator with 4 points ('strongly agree') in the biggest ratio (35.29%-44.86%). 21.5%-33.33% rated this same issue with the maximal 5 points.

We assessed the students' opinion about how simulation education helped/may help their improvement. When we look at the mean scores given by the students, the most highly rated item was 'practice without risk' (4.44). This is followed by the 'recognition of abnormal findings' (4.41), and the 'recognition of symptoms' (4.28). The mean scores were also above 4 points it the rating of 'help in the preparation for clinical practice' (4.1) and 'assessment of complex cases' (4.03). The obtained results completely met our expectations, because at the actual knowledge (novice) of the students they could experience these advantages mostly during the courses. The item „rare cases in the clinical practice" was rated with the less mean points (2.58). This is not a surprise, because the aim of the course „Clinical simulation" is the contrary of this statement – the aim is to demonstrate the most frequent scenarios. To experience the real benefit of the other statements requires a higher knowledge, when beside patient observation other skills should be improved (e.g. critical thinking, decision making, communication, teamwork).

We observed the difficulties experienced by students during the simulation courses. The main problem was the 'high number of students'. In the answers of nursing and midwifery students there were a significant difference ($p<0.001$) regarding the number of students. We also found significant difference in 'communication with team members' ($p=0.027$) and 'implementing

activities' (p=0.045). In all of the three cases midwifery students reported the difficulties with higher points. The obtained data shows that simulation education causes some difficulties for the students (but not to a great extent).

According to the students' opinion regarding the different educational tools and methods nursing and midwifery students prefer practical courses to theoretical courses. It is clear from the distribution frequency of the students' answers that the largest portion (65.19%) considers practicing with simulator as the most effective method.

Study II. – The investigation of the effectiveness of simulation education integrated into the curriculum from the students' perspective

We divided the study during 4 semesters for 3 distinct phases, according to the realization of the most important developments and changes (phase 1: the beginning of the integration, phase 2: revision of the daily practice, implementing modifications, phase 3: the optimization of the practice). In case of the course 'Clinical simulation' we found significant differences ($p<0.001$) in the result of the analysis of variance when comparing the three phases (based on the effectiveness from the students' opinion), which shows the positive effect of the developments and modifications in the simulation education practice. The course 'Clinical simulation' was followed by the course 'Case studies in simulation'. In this case we found a weak significant difference (p=0.05) in the comparison of the three phases.

In the study we wanted to answer whether there is a difference in the perception of the effectiveness of the two groups (nursing and midwifery students). We did not find any significant differences in the courses, the two groups found the simulation course effective equally.

From the 13 statements of the effectiveness measuring tool (METI SET) the nursing and midwifery students gave the maximal 2 points in the highest ratio after each course for the following: 'promotion of critical thinking' (78.4%-91.3%), 'preparing to care for real patients' (52.9%-60.7%), 'improvement in understanding pathophysiology' (57.9%-72.8%), 'improvement in assessment skills' (57.9%-84.3%), 'confidence in the recognition of changes in the patient's condition' (45.8%-64.7%), 'helping to understand the classroom information

better' (66.7%-83.5%), 'utility of debriefing' (68.2%-89.5%). With the other statements of the measuring tool the students agreed in a lower extent.

Study III. – Objective evaluation of the students' performance after completing simulation courses

The mean results of the groups in all of the 4 courses significantly exceeded the required level ($p<0.001$) considering the students' performance (when comparing to the required 75%). At the exam after the course 'Clinical simulation' midwifery students achieved a mean score of 88.84% (SD: 9.14), nursing students achieved a mean score of 83.38% (SD: 9.92). At the exam after the course 'Case studies in simulation' midwifery students obtained a mean score of 86.63% (SD: 14.87), the nursing students obtained a mean score of 81.69% (SD: 13.82).

In case of the course 'Clinical simulation' when we compared the mean results in the subgroups of the midwifery and nursing students we experienced significant difference ($p=0.005$) only in the item of 'technical skills'. In the other examined items ('assessment', 'communication', 'critical thinking') there was no significant difference in the two groups. In case of the course 'Case studies in simulation' we found significant difference ($p<0.001$) also in 'technical skills'. There were no significant differences in other items.

The performance at the examination of 'Clinical simulation' of the midwifery students was considerably consistent, 7 students out of the 67 did not reach the minimal 75% - this means the 10.44% of the students. There was no extremely low performance. 15 students (22.3%) showed an excellent performance, they reached over 95%. In the analysis of subgroups the lowest mean result was the 'critical thinking' subgroup: 85.07% (SD: 15.48).

There was a quiet consistent performance also at the course 'Clinical simulation' for nursing students. Out of the 32 students 8 students did not reach the minimal 75%; this means the 25% of the students. There was no extremely low performance. 2 students (6.2%) showed an excellent performance (more than 95%). In the analysis of the subgroups the lowest mean result was at the 'technical skills' subgroup: 78.12% (SD: 16.49).

The results after the course 'Case studies in simulation' of the midwifery students were less well-balanced as the performance at the course 'Clinical simulation'. 8 students (13.79%) did

not reach the minimal 75%. 2 students achieved 50% and one student only 30%. 14 students (24.1%) obtained an excellent (more than 95%) result.
In case of the subgroup analysis the lowest mean results were measured at the 'critical thinking": 80.29% (SD: 18.11).

After the course 'Case studies in simulation' for nursing students at the examination 8 students (34.78%) out of the 23 did not reach the minimal 75%. The worst performance was 52.62%. 2 students (8%) had excellent results (more than 95%). In the subgroup analysis the lowest mean result was at the 'technical skills': 78.26% (SD: 17.36).

In our study we were trying to give an answer for the question if there is a correlation between the results at the examination of 'Case studies in simulation' and the results at the examination of 'General nursing care'. The correlation between the results of the two courses and its strength was observed with the Pearson's correlation coefficient.

In case of midwifery students the mean result of the course 'Case studies in simulation' was 86.63% (SD: 14.87), the mean value of the grades after the course 'General nursing care' was 4.2 (SD: 0.8). There was a moderate, positive significant correlation ($r=0.34$, $p=0.009$) between the results of the grades in 'General nursing care' and the results after the course 'Case studies in simulation'. In case of nursing students the mean result after the course 'Case studies in simulation' was 81.69% (SD: 13.82), the mean value of the grades after the course 'General nursing care' was 3.6 (SD: 0.98). There was a moderate, positive significant correlation ($r=0.64$, $p=0.001$) between the results of the grades in 'General nursing care' and the results after the course 'Case studies in simulation'.

Conclusions

Conclusions regarding the practice of simulation education

1. The strategic elements of simulation education that we elaborated fully occurred in the practice.
2. As a result of the questionnaires utilized among nursing and midwifery students we can conclude that in general they appreciate the new simulation educational strategy in a positive way.
3. The improvement in skills that demands for a higher knowledge (critical thinking, decision making, teamwork, communication, manual skills) was less recognized as a benefit, because novice students got less experiences regarding these skills during the courses.
4. Working in groups with large numbers cause a main difficulty for the students, this can greatly influence their activity and reduce the effectivity of the course and prevent to reach the educational aims.
5. Students support the realization of practice oriented education and claims to increase the number of practical courses (especially the number of simulation courses).
6. We can conclude that using high-fidelity simulators with a simultaneous use of a valid evaluation tool can be a proper method to evaluate the students' performance in the education of health care professionals.

Conclusions regarding the integration of simulation education into the curriculum

1. The integration of simulation education into the curriculum successfully evolved at the Faculty of Health Care Sciences as a result of a developing process that lasted for years.
2. The appearance of simulation course as an independent course provides equal possibilities to all students to join the classes and necessitates the utilization of the common education strategy by the teachers.
3. Simulation education strategy cannot be maximally effective if it is not properly scheduled in the curriculum.
4. Comparing to other institutes, at our Faculty the utilization of high-fidelity simulators in the education occurred in a uniquely wide range (when comparing to other Hungarian institutes).

Conclusions regarding the effectiveness of simulation education

1. Based on our results we can state that we experienced significant improvement regarding the effectiveness of the courses in the three developmental phases that we defined afterwards, according to the students' opinion. The results show the successful realization of developments and changes and prove the necessity of the common education practice.
2. The common simulation education strategy was equally effective at both specializations.
3. We can observe that several skills and capabilities can be effectively improved at any level of knowledge by simulation practices, but the improvement in some skills and capabilities (e.g. decision making, teamwork) could have been improved more efficiently with a higher knowledge.

Conclusions regarding the students' objective evaluation

1. We can state that Creighton Simulation Evaluation Instrument (C-SEI) is an applicable measuring tool in our practice. It provides the possibility to evaluate the students objectively after simulation courses in the aspect of data collection – assessment, communication, technical skills and critical thinking, considering actual knowledge.
2. Based on the mean results of the groups the performances of the students were appropriate after simulation courses.
3. The ratio of those students was higher than the acceptable that did not have the required competencies at the time of the measuring, based on the individual results in the study.
4. If the simulation courses are not scheduled in the curriculum at the proper time, the students may have worse results when assessing the required skills and capabilities.
5. The coherent set up of the simulation courses and the equal evaluation system is an important part when we develop a standardized simulation practice. Beside this, we have to determine the proper ratio of the activities during the course according to those skills and capabilities that we would like to improve. The proper ratio – in our opinion – should not be generally determined; the teachers have to suit it for the skills and capabilities of their students.
6. Based on the result of the correlation analysis of the courses „General nursing care' and 'Case studies in simulation', the learned skills during the two courses might stronger each other.

Conclusions regarding quality parameters of the measuring tools used in the study

1. The reliability and validity of our questionnaire to assess attitude was proven.
2. We proved the reliability and validity of the Hungarian translation of METI Simulation Effectiveness Tool used for the assessment of the effectiveness of simulation education.
3. The reliability and validity of the Hungarian translation of Creighton Simulation Evaluation Instrument (C-SEI) was proven.

Overall, we can conclude that after the initial attempts, we realized the developments by utilizing our experiences and settled the basics of evidence-based education in our practice regarding simulation education.

Publications related to the topic of thesis

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3. **Eszter Borján**, Judit Mészáros: Assessing the Effectiveness of a Simulation Course for Midwife Students. HPSN Europe - Simulation and Education Conference, 2011. november 25-26., Mainz, Németország
4. **Eszter Borján**: Simulation in healthcare education. International Week 2012 – Laurea Tikkurila, 2012. március 05-09. Finnország
5. **Eszter Borján**, Zoltán Balogh, Judit Mészáros: Development of simulation strategies and curriculum in the field of healthcare education. COHEHRE Conference, 2013. április 17-19., Kuopio, Finnország
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3. **Borján Eszter**: Innovatív oktatási módszerek demonstrációs babán, workshop – a Nutricia cég szakdolgozói továbbképzése, 2011. november 10., Budapest

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