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# Improving simulation performance through Self-Learning Methodology in Simulated Environments (MAES©)

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ABSTRACT

*Background:* One of the main challenges faced by nursing educator is using the best strategy for students to learn. In MAES© (Self-learning methodology in simulated environments), the students are guided by a facilitator, and perform their simulations in a knowledge-specific area in a self-directed learning manner.
*Method:* The performance by the students in the MAES© simulation was compared to traditional Simulation-based learning (SBL). With this aim in mind, a study was conducted which quantitatively analyzed and compared the scores in SBL and MAES© scenarios from 274 students enrolled in the 4th year of the nursing degree. The students were assessed with the Clinical Simulation in Nursing Assessment Questionnaire (CLISINAQ) and the Knowledge Management Scale (KMS).
*Results:* The students received a higher score in the scenarios with the MAES© methodology in clinical and non-technical skills.
*Conclusions:* When compared to SBL, MAES© granted students a better degree of performance in learning with simulation.

## 1. Introduction

Research is being conducted that seeks to find the best ways in which health professionals can train in real and simulated clinical environments (Rhodes et al., 2016).

The acquisition of appropriate competence is the main objective of learning in nursing. Competence can be considered as the ability to perform a task with desirable outcomes (Benner, 1982). Kane (1992, p.166) defined the level of competency as "the degree to which the individual can use the knowledge, skills and judgement associated with the profession to perform effectively in the domain of possible encounters defining the scope of professional practice". Competence can be acquired through diverse pedagogic strategies, although at present, those that use creative methods of teaching in the nursing degree are on the rise (Herrman, 2015). One of the main methods used for improving the development of competence in nursing education is clinical simulation. In simulation, students "learn by doing" in a simulated environment and later reflect on their actions while guided by a facilitator.

The Self-Learning Methodology in Simulated Environments (MAES©) (Díaz et al., 2014; Díaz et al., 2016) is an active education method where students are guided by facilitators to learn independently about specific areas. Student operational units or independent work teams are established, the students choose a situation or a reality to conduct research on in teams, establish their basal level of competence, choose their learning objectives, design a simulation scenario, test it and reflect on it (The MAES© elements are explained on Table 1).

MAES© complies with all the INACSL Standards of Best Practice: Simulation[SM] (The INACSL Standards Committee, 2016). The 4th year nursing students from the Catholic University of Murcia (Spain) must learn, in equal parts, with MAES© simulation scenarios and with Simulation Based Learning (SBL) as well. When learning with SBL, the students have available a large number of simulated clinical scenarios (designed by the education team) that permits learning based on nursing competence. In each model of simulation conducted in the 4th year of the nursing degree, about 30 different clinical simulation scenarios are dealt with (15 MAES©, designed and led by the students, and 15 SBL, designed and led by the facilitators). The average duration of each scenario in both of the methodologies is approximately 60 min

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**Table 1**
Description of the stages and elements of the MAES © methodology.

| Session | MAES© element | Description |
|---|---|---|
| Session 1 (240 min) | (1) Selection of the work groups and establishment of the group identity | The group identity is structured. 6 2-member work groups are established, with a joint identity that is superior to the individual on the basis of values (group essence). This is about creating an environment of positive competitiveness between the different work groups. Different group dynamics activities are conducted. |
| | (2) Voluntary choosing of the study topic | The facilitator presents the students with a group of possible interesting cases for their learning, that are related to the competence they hope the students will acquire (conspicuously, using different means). After a discussion session, each team voluntarily chooses the topic to be worked on. If there are 6 teams, 6 cases are chosen. |
| | (3) Establishing the basal line of competence and programming of the competence to be acquired through a joint brainstorming session | Once each case has been chosen voluntarily, the programming of the objectives to be reached is done with a brainstorm session where all the teams' participants participate, showing the knowledge possessed to later discuss what is unknown and that they want to present in the second session. |
| Work at home | (4) Design of a scenario of clinical simulation where the competence to be acquired will be explored. | Each team designs a simulation scenario. Previously, they have been trained on how to design simulation cases according to professional competence and the learning results. Each team has a minimum of a week to design the scenario, and will have to search for information in different databases and scientific evidence on the topic proposed, and have to resolve the objectives proposed initially. Whenever the team has a doubt, they can always get in contact with the facilitator via email or in person through a tutoring session. The students will have send the case to the facilitator two days before the session. |
| Session 2 (240 min) | (5) Conducting the clinical simulation experience | In the second MAES© session, a presentation is done by the team in charge of its design (*briefing*). Next, the staging of the case is conducted. A team other than the one who designed the simulation conducts the simulation in the simulation room, which makes it so that everyone is involved in the experience. Some in the design of the simulation, and the other by conducting it. |
| | (6) Debriefing and presentation of the competence acquired | A structured, GAS (*gather-analyze-summarize*) debriefing session is conducted, or any other that results in reflective and meaningful learning. This stage of MAES© is important for learning; besides the discussion on what occurred in the scenario, and the presentation of scientific evidence, other resources within the *debriefing* can be used to reach the learning objectives that were presented previously through a presentation phase before the summary phase. The students can provide the information for the presentation phase through a presentation (Powerpoint®), patient interviews or interviews to professional workers recorded with a video camera, organize games bases on questions on the case, or practical demonstrations. In general, the duration of each scenario with the posterior debriefing is 60 min (10 for the simulated scenario and 50 for debriefing). |

(20–25 min for preparation and simulation, and 35–40 min for structured debriefing). With both methodologies, different areas of knowledge are specifically worked on, such as mental health, geriatrics, obstetrics-gynecology nursing, pediatrics and emergencies.

In each simulation session, the group is composed of 12–15 students maximum, divided into 6 operational teams comprised of 2–3 students each and a facilitator.

## 2. Theoretical framework

The pedagogic strength of MAES© comes from the synergistic union of various models: Self-directed learning (Hiemstra and Brockett, 2012), problem-based learning (Barrows and Tamblyn, 1980), collaborative learning (Barkley et al., 2014; Dewey, 1986) and peer education (Damon, 1984). All these models are used in a highly-realistic simulated environment.

With self-directed learning (Hiemstra and Brockett, 2012), the students set their own learning objectives, and relate them to their educational and personal needs. This is one of the main elements that characterizes the MAES© system. Self-directed learning is nurtured by the student's need to learn independently in a world that is constantly changing (Kranzow and Hyland, 2016).

The collaborative learning methodology is confined within constructivist learning (Johnson and Johnson, 1991; Kagan, 1985; Slavin, 1978), in which the student plans, designs the contents and thereby constructs his or her learning. The MAES© implements a series of initial group dynamics that are based on solid theoretical frameworks such as the General Systems Theory (Hanson, 2014); the Social Identity Theory (Smith and Haslam, 2017) or the Field Theory (Senge, 2014). All of these frameworks have the basic aim of understanding and stabilizing the group, as well as the selection of autonomous (independent) workgroups that are sustainable and committed to the latter sessions.

Peer education is a pedagogic methodology with a diverse epistemological base (Damon, 1984; Lasry et al., 2008), and is founded on the construction of competence in students who have the same profile through "zones of proximal development" (ZPD) (Vygotsky, 1978). Vygotsky (1978) defined ZPD as the distance between the real competence of the student and the potential competence that the student would be able to acquire with the help of another student (the skills the student has almost mastered and could attain with a skilled partner).

Problem-based learning, another of the pedagogic antecedents of the MAES© methodology, is based on learning, research and reflection by the students until they arrive at an answer to a real or fictitious problem. The problems shape the starting point for the acquisition and integration of new knowledge (Tawfik, 2015). In MAES©, the students work with situations that originate from the real world or the fictional situation that the students choose voluntarily as the starting point for the design of a simulation scenario that another team will experience in a simulated manner.

## 3. Research question (RQ)

Do nursing students who learn with MAES© perform better in a simulation scenario than when they learn with the SBL methodology, as determined by their scores in clinical, non-technical and knowledge management areas?

## 4. Material and methods

### 4.1. Design

A descriptive study was conducted on a university population who experienced two different styles of learning with clinical simulation in the 4th year of the Nursing degree.

The design of the present work was based on three complementary descriptive methods in order to explain the object of study. These were: observational, case-study and survey methods. The perspective of the trained evaluator helped to determine the performance of the students who took part in the simulation in an objective (external) manner. For this, validated tools were utilized (survey method), which will be explained below. Finally, it a case study method was used, as the work describes, explores and analyzes the object of study within its context, which in this case, it was the impact of two learning methodologies on clinical simulation (SBL vs MAES©).

The simulation is considered in this study as the manner in which students are able to achieve an appropriate performance in their learning with simulation (achieving an adequate clinical, non-technical competence and managing knowledge in the group reflection session of the simulated scenarios). The students were assessed with the Clinical Simulation in Nursing Assessment Questionnaire (CLISINAQ) (Sánchez Expósito et al., 2018a, 2018b) and the Knowledge Management Scale (KMS) (a tool created by the Faculty of Nursing at the UCAM that is used to assess the management of knowledge by simulation students).

The evaluation scales used were the ones that are habitually utilized by the facilitators to evaluate the performance of the students in a simulation at the UCAM. The results of this study originate from the observations (compliance with the evaluation scales) by the 4 facilitators who administered the simulation in the 4th academic year (2015/2016). The CLISINAQ and KMS scales were designed to be used by the facilitator/evaluator through the observation of the student's behaviors, either in the simulation experience or in the debriefing session. Both scales are utilized for evaluating the students in SBL as well as MAES© scenarios.

The CLISINAQ was based on a model of assessment of simulation performance using the Nursing Interventions Classification (NIC) (Butcher et al., 2013). The nursing taxonomy was utilized as it is a standardized language that makes possible the assessment of learning based on nursing professional competence in simulation environments. Also, the NIC interventions were validated before they were accepted and published at the international level. The students were assessed in terms of clinical and non-technical skills similar to those that should be developed in a real clinical practice, but in a safe environment for both the patient and the students themselves. The first dimension assessed was related to non-technical skills, and was composed of 5 items that measured communication skills (with the patient and the team) and teamwork (through the subjects of prioritization, re-assessment and coordination). Each item was assessed using a Likert scale with 5 possible answers (rarely, sometimes, usually, almost always and always). A minimum score of 1 and a maximum score of 5 could be obtained for each item. The second dimension assessed was related to clinical skills, which used a verification list (Yes/No), with the 5 most-important activities from the NIC intervention assessed, as selected through expert consensus. Each activity that was correctly conducted was scored with 1 point. Thus, in each intervention, a minimum score of 1 and a maximum of 5 could be obtained. Each scenario had a number of interventions that was equivalent to the number of students that comprised the team (for example: 2 students/2 interventions/10 NIC activities). At the end of the assessment process, the scores obtained in the questionnaire were multiplied by 2 in order to obtain a mean from 10 points. The CLISINAQ has been shown to have the appropriate reliability metrics (Sánchez Expósito et al., 2018a) with good inter-observer agreement (ICC between 0.71 and 0.90) and construct validity according to the Connect Identify-Understand Agree-Help questionnaire (Spanish acronym: CICAA) (Gavilán et al., 2010).

The Knowledge Management Scale was designed by expert consensus, by six simulation facilitators from the UCAM with clinical experience and training in the health sciences. The Content Validity Index for Items (I-CVI) was calculated before proceeding to its use in the students' assessment. KMS is commonly used in the UCAM nursing simulations to assess the students through observation. The topics analyzed were related to: the students appropriately answering the questions on the theoretical content of the case that arose during the debriefing session, the description and analysis of the scenario and their actions, quality of the sources used to justify the actions, and if the students justified their actions with scientific evidence. Each item was scored with a Likert-type scale with 5 answer alternatives (almost never, sometimes, usually, almost always and always). Students could obtain a minimum score of 1 and a maximum of 5. At the end of the assessment process, the scores obtained in the questionnaire were multiplied by 2 in order to obtain a mean from 10 points instead of 5.

Cheng et al. (2016) created a guide for structuring the presentation of research studies conducted with simulations in order to improve the reporting of the results. In this article, we have tried to follow these guidelines. The following paragraphs will be used to specify and justify the key elements of research with simulations (environment, type of simulation, role of the patient, design of scenarios, type or style of debriefing, role of the facilitator, etc.). The key elements for justifying the research with simulation (Cheng et al., 2016) were as follows:

The participants performed simulations with 3 clinical scenarios in 4-hour sessions. Each team of students experienced 10 sessions (5 MAES© and 5 SBL). There were various simulation rooms (including control and Debriefing rooms). The patients' role was performed by advanced simulator mannequins (SimMan 3G®, SimMan Essential®, SimBaby®), or standardized patients (actors who had previously been trained by the teachers/students from the Dramatic Arts School of Murcia-Spain).

Clinical scenarios were designed by the students (MAES©) or facilitators (SBL) with standardized scripts. The learning objectives were chosen by the students in a session prior to the simulation (MAES©), through a brainstorming session, or by the teaching team (SBL), through consensus of experts, following the guidelines set by the nursing faculty. The scenarios were experienced by teams comprising two or three students. A facilitator with previous experience in clinical simulation/MAES©/SBL, was in charge of monitoring the simulation and the development of the scenario through the use of specific computer software in the control room. The scenarios were conducted only once. After they were finished, a structured debriefing using the Gather, Analyze and Summarize (GAS) debriefing tool (Phrampus and O'Donnell, 2013) was conducted. In the MAES© sessions, a presentation phase was added to the debriefing session, where the learning targets chosen by the students in the previous session were dealt with.

### 4.2. Study subjects

The participant group was a convenience sample of 4th year nursing students from the university. They were students who attended the simulation course in the 4th year of the Nursing degree at the UCAM during the 2015/2016 academic year (n = 300).

### 4.3. Participants

From the cohort of 300 students, a sample population of 274 participants (91.3%) was obtained. We found a higher prevalence of females (199) and the average age was 22.12 (SD = 2.43) years.

The inclusion criteria were: 1) Being a 4th year student and 2) having previously signed, at the beginning of the course, the authorization form for the use of their academic data for research purposes. The exclusion criteria were: 1) abandoning their studies or course within the data-gathering period, 2) dropping the class due to an illness, and 3) being enrolled in an exchange program. The study subjects had previous simulation experience from previous academic years. The UCAM nursing students took part in low-fidelity simulations in their 2nd year, especially in their training of technical skills. In their 3rd year, they learn with more complex scenarios and the SBL methodology, aside from low-fidelity simulations. In their 4th year, they learn with high-fidelity simulations (SBL and MAES© methodology).

### 4.4. Data analysis

To process the quantitative information, a database was created with the Statistical Package for the Social Sciences (SPSS®) v21, and the analysis was conducted with different statistical tests.

For the analysis of the characteristics of the participants and the simulation performance of the students in the SBL and the MAES© scenarios, descriptive statistics (i.e., mean, standard deviation, frequencies and percentages) and a *t*-test were used. The Content Validity of the Knowledge Management Scale was calculated by computing an Item-level Content Validity Index (I-CVI). Lynn (1986) recommended an I-CVIs no lower than 0.78 when there are six or more judges.

Before performing the *t*-test, the assumption of normality and homogeneity of variance was verified. The alpha was set to 0.05 for all analyses.

### 4.5. Ethical considerations

The research was approved by the Ethics Committee from the Catholic University of Murcia (UCAM), having been evaluated with a positive verdict (reference number: 5939 02/02/2016). No fundamental human rights were violated, and ethical criteria were followed throughout the study. The participants signed informed consent documents. The confidentiality of the data was respected, and the privacy of the participants was ensured.

## 5. Results

The results of the panel of experts showed that the I-CVI of the Knowledge Management Scale calculated through the evaluation by the six experts was 0.968, which indicated a high score, with the selected items considered relevant by all the experts (Table 2).

With the aim of analyzing the simulation performance through the use of the MAES© methodology as compared to the SBL methodology, Table 3 shows the descriptive statistics of the scores obtained in the non-technical, clinical and knowledge management dimensions.

As identified in Fig. 1, the students obtained a better score in the scenarios that utilized the MAES© methodology, with these differences being statistically significant in the non-technical dimension ($t(273) = 3.674$, $p = .000$) and the clinical dimension ($t(273) = 3.900$, $p = .000$) (Table 2). Statistically significant differences were not found ($p = .172$) in the Knowledge Management Scale. Furthermore, in the Non-technical dimension, the students obtained a better score with the MAES© methodology in items related to communication, with these differences being statistically significant ($t(273) = 6.899$, $p = .000$).

Finally, there were no statistically-significant differences ($p > .05$) between the simulation performance according to the sex variables through the use of the MAES© methodology as compared to the SBL methodology.

**Table 3**
Descriptive statistics of the scores obtained in the CLINISAQ dimensions and Knowledge Management Scale.

| Dimension | SBL | | MAES© | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | p[a] |
| Non-technical | 8.56 | 0.86 | 8.79 | 0.861 | .000 |
| Teamwork | 9.12 | 0.83 | 9.11 | 0.85 | .853 |
| Communication | 7.99 | 0.98 | 8.79 | 0.86 | .000 |
| Clinical | 8.24 | 1.03 | 8.57 | 0.974 | .000 |
| Knowledge Management | 8.24 | 1.09 | 8.33 | 1.13 | .172 |

[a] *t*-test.

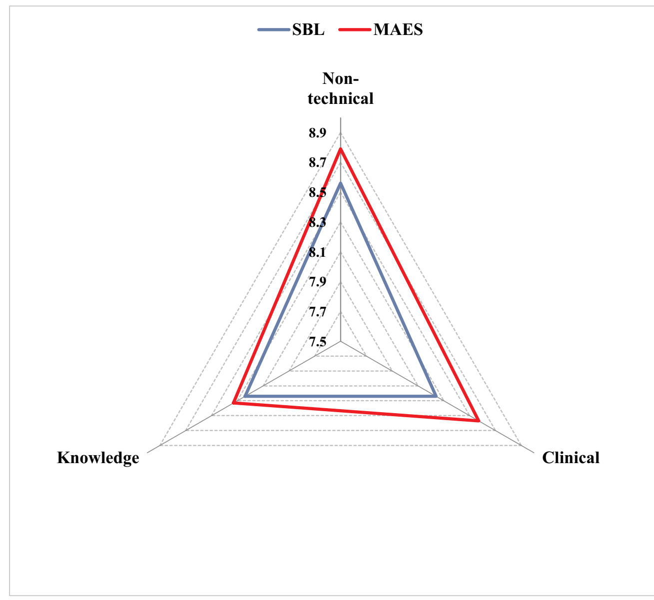


**Fig. 1.** Average scores of the simulation performance through the MAES© and SBL methodologies.

## 6. Discussion

The main finding of this study was related to the overall improvement in the simulation performance by the students when using MAES©. This could be due to the reflection exercise being conducted even prior to the simulation and the experiencing of the case. The brainstorming session where existing knowledge was identified illustrated a reflection activity. This reflection continued with the research conducted on the design of the scenarios, the experience of the simulated situation, culminating in the debriefing session which involved the whole team (Díaz et al., 2016).

It was also possible that the MAES© facilitated meaningful learning (Ausubel, 2012) as this method is based on the student's basic

**Table 2**
Computation of an item-level CVI for a 4-Item scale (Knowledge Management Scale) with 6 expert raters.

| Item | EXPERT 1 | EXPERT 2 | EXPERT 3 | EXPERT 4 | EXPERT 5 | EXPERT 6 | ITEM CVI | NUMBER IN AGREEEMENT (3–4) |
|---|---|---|---|---|---|---|---|---|
| 1. Students appropriately answering the questions during debriefing | 4 | 4 | 4 | 4 | 3 | 4 | 0,958 | 6 |
| 2. Description and case analysis in debriefing phase | 4 | 4 | 4 | 3 | 4 | 4 | 0,958 | 6 |
| 3. Quality of the sources used to justify actions | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 6 |
| 4. Students justified their actions with scientific evidence | 3 | 4 | 4 | 4 | 4 | 4 | 0,958 | 6 |
| Proportion relevant | 0,93 | 1 | 1 | 0,93 | 0,93 | 1 | | |
| | | | | | TOTAL CVI | | 0.968 | |

I-CVI, item level content validity index for the scale. Lynn (1986). Ratings of 1 = not relevant; 2 = somewhat relevant. 3 = quite relevant; 4 = highly relevant.

knowledge. Thus, the group investigates a topic based on what the students already know, and this previous knowledge is used to find to answers to unknown topics, resulting in more active, meaningful learning.

Previous studies on the MAES© methodology (Díaz-Agea et al., 2017; Leal Costa et al., 2018) revealed that the empowerment of nursing students during the simulation favored their interest for learning, while also having a positive impact on their overall training. The MAES© methodology lets the intrinsic motivation of the students to flourish towards learning, and distances them away from the "means to an end" implied by the extrinsic motivation that is based on scores or assessment. The intrinsic motivation is linked to tasks that are performed due to an interest on the activity itself, as an end in itself, and not as a means for reaching other goals (Csikszentmihalyi and Rathunde, 1993; Ryan and Deci, 2000). This results in an innate tendency to search for novelty and challenges, to widen and exercise their own abilities, to explore and learn, as it is the students who choose the topics of study that interests them. We believe that this methodology results in driving and/or increasing the student's self-motivation to learn, and this is where we find the increase in the acquisition of an improved degree of simulation performance.

Although there was an increase in knowledge management, the results were not statistically significant. However, this could imply that both MAES© and SBL were tools that had a similar impact on the knowledge and information management by the Nursing students, as in both methodologies, the debriefing session was crucial for developing a conceptualization that was based on reflection over action. This was because learning does not occur mainly during the simulated experience, but in the subsequent guided reflection (Shinnick et al., 2011).

### *6.1. Limitations*

The most evident limitation of the study came from the difficulty in controlling the desirability bias of facilitators in relation to their preference for a certain model (MAES©/SBL). However, the students were assessed by four different facilitators throughout the academic year, which reduced the potential for single observer bias. Despite the sample used being large, it was not possible to generalize the results of this study, as the sample was not representative of the university population of nursing students in Spain. Another limitation was that the Knowledge Management Scale only had content validity. Thus, more validation work is needed in order to be used in the future to measure knowledge management in simulations.

## 7. Conclusion

The study results indicated that the simulation performance was better when the nursing students learned with MAES© as compared to the simulation-based learning methodology (SBL), especially in clinical and non-technical skills. The skills where the highest increase in the scores were found were Clinical Skills, which in every case were related with the evaluation of NIC activities associated to each simulated scenario. As for the non-technical skills, the students obtained a better score with the MAES© methodology in items related to communication. An increase was produced in the management of knowledge in the students who learned with MAES©, but this increase was not significant. Even though more precise evidence is needed, it can be deduced from the results of this research that MAES© was a learning method in which the overall performance of the students was greater, as compared to other ways of learning in a simulation.

### *7.1. Future proposals*

Research on the use of MAES© should be extended to other disciplines where learning is conducted with clinical simulation, such as medicine. It would also be interesting to approach the learning with MAES© when learning is conducted in multidisciplinary teams. Despite the UCAM being the university with the greatest number of students who have learned using the MAES© methodology, it has also been implemented in other Spanish, Brazilian and Portuguese universities. This could lead to research with larger cohorts for comparing between universities, in order to corroborate the results obtained in our study.

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