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I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.

Effectiveness of gamification in nursing degree education

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Background: Previous research in nursing has found favourable results from the use of alternative teaching methodologies to lectures. One of the complementary methodologies used for university teaching is gamification or the inclusion of game elements, creating of a dynamic learning environment that allows the acquisition of knowledge and the development of other skills necessary for nursing students. The purpose of this study was to evaluate the effect of a gamification session on student satisfaction and knowledge scores in nursing students in simulated laboratory practice. **Methods:** A pre-post quasi-experimental study. 122 students from the Nursing degree program participate at the research. The intervention consisted of four three-hour sessions. In two sessions, participants were trained through a vertical methodology and one hour of clinical simulation, and in the other two sessions, participants received an explanation of the theoretical aspects of the session, one hour of clinical simulation and one hour of gamification, in which they had to pass tests based on the performance of practical activities on the subject of the session. At the end of the gamification session, all the participants received a certificate as winners of the “Nursing game” **Results:** There was an improvement in the satisfaction and the knowledge level in the gamification sessions. Both were statistically significant ($P < .001$). There was an improvement about the items related with the development of critical thinking and the mobilising concepts from theory to practice in the gamification sessions. **Conclusion:** The intervention was effective to improve the motivation to learn and the knowledge development.

Effectiveness of gamification in nursing degree education

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Abstract

Background: Previous research in nursing has found favourable results from the use of alternative teaching methodologies to lectures. One of the complementary methodologies used for university teaching is gamification or the inclusion of game elements, creating of a dynamic learning environment that allows the acquisition of knowledge and the development of other skills necessary for nursing students. The purpose of this study was to evaluate the effect of a gamification session on student satisfaction and knowledge scores in nursing students in simulated laboratory practice.

Methods: A pre-post quasi-experimental study. 122 students from the Nursing degree program participate at the research. The intervention consisted of four three-hour sessions. In two sessions, participants were trained through a vertical methodology and one hour of clinical simulation, and

in the other two sessions, participants received an explanation of the theoretical aspects of the session, one hour of clinical simulation and one hour of gamification, in which they had to pass tests based on the performance of practical activities on the subject of the session. At the end of the gamification session, all the participants received a certificate as winners of the “Nursing game”

Results: There was an improvement in the satisfaction and the knowledge level in the gamification sessions. Both were statistically significant ($P < .001$). There was an improvement about the items related with the development of critical thinking and the mobilising concepts from theory to practice in the gamification sessions.

Conclusion: The intervention was effective to improve the motivation to learn and the knowledge development.

Key Words: Gamification, Nursing Students, Learning, Knowledge, Satisfaction.

Introduction

University teaching has currently changed its focus from an original approach based on the acquisition of a theoretical mastery of the subject to the development of training competences, which can be defined as a set of knowledge, skills and attitudes or predispositions that enable the theoretical mastery of the subject to be mobilized towards a practical demonstration. A competence allows us to observe what students know, understand and are able to apply in order to tackle a real situation (Palomares-Ruiz, 2007)

Previous research such as Delobbe and Long et al. in 2007 have found a significant effect on the level of motivation in achieving the best results in the acquisition of learning; however, when addressing the concept of motivation, we must differentiate some aspects. Teaching motivation is defined as a tendency to undertake certain activities proposed by the teacher, changing the focus

48 from learning centred on content, to prioritising the development of skills, mobilizing what has
 49 been learnt to practical situations (Valenzuela, 2007)

50 Currently, the main methodology used for university teaching is the lecture class, which can
 51 sometimes account for up to 70% of the total number of teaching hours. This methodology is
 52 considered an effective and fast method for the transmission of knowledge. In lectures, the
 53 lecturers in charge play the main role, exposing contents to the students, who play a passive role
 54 as receivers of information; even so, lectures have limitations such as the loss of attention span as
 55 time goes by. In recent years, new teaching methodologies have emerged that attempt to solve this
 56 limitation, such as peer education or flipped learning, learning through scenario simulation,
 57 gamification applied to teaching, or game-based learning (Sadeghi et al., 2014; Safari et al., 2006;
 58 Schmidt et al., 2010; Gómez-Urquiza, 2019)

59 Peer education is an interactive method of teaching and learning in which participants take an
 60 active role teaching each other. Peer education gives us this advantage when dealing with sensitive
 61 issues and to achieve a greater proximity with the rest of the students, achieving a higher level of
 62 attention as the peers are the ones teaching that session (Abdi & Simbar, 2013; Wye et al., 2006).

63 Another complementary teaching methodology is the creation of a simulated scenario that can
 64 accelerate the acquisition of technical skills, knowledge and skills for the management of problems
 65 that may arise when moving from theoretical content to real health situations (LeBlanc, 2012). For
 66 education in the biomedical sciences, it has been seen that education based on real cases or with
 67 simulated examples but based on a healthcare reality, were perceived as significantly more
 68 effective than traditional education based on vertical training (Rohlfen et al., 2020).

69 The teaching methodologies of gamification or game-based learning can be used as synonyms;
 70 however, it is important to differentiate both concepts in order to apply them in the optimal

conditions, thus obtaining the best results. Game-based learning is a methodology where games are applied with formative objectives, while the concept of gamification involves the creation of a dynamic based on games, such as the achievement of objectives to reach rewards, such as winning a medal or establishing a performance ranking of the developed skill (Karagiomas & Niemann, 2017; White & Shellenbarger, 2018).

The review conducted by Nieto-Escámez and Roldán-Tapia in 2021, evaluated the feasibility of incorporating gamification techniques for university teaching during the COVID-19 pandemic, finding high acceptance by students, and obtaining improvements in academic performance; these improvements are associated with the high satisfaction reported by participants, who showed high motivation to overcome the games, as well as the presence of a favourable climate for meaningful learning. The incorporation of this methodology can be done by establishing it as a central element in teaching, or as a complementary element in training together with other teaching methodologies (Jodoi et al., 2021).

There are previous positive results regarding the use of gamification in training for healthcare degrees. The review by Martos-Cabrera et al. in 2020, in which participants were exposed to training through virtual games, found an improvement in glycaemic control, measured by glycated hemoglobin, as well as an increase in the level of knowledge and positive attitudes towards healthy lifestyle habits and health care. Nowadays, virtual devices are one more element to be reckoned with, with social networks being the main mirror where young people are exposed to and visualize information, making it essential to incorporate them into teaching as a complementary element. Furthermore, we found previous experiences of the use of virtual games to address health issues, obtaining a reduction in the level of preoperative pain and anxiety in a sample of children (Suleiman-Martos et al., 2022), or a higher level of knowledge about obstetrics and care in women

(Frid et al., 2021). The use of these games, although effective, has limitations such as the possession of a correct level of motivation for autonomous play.

The aim of this research was to evaluate the effect of a gamification session on student satisfaction and knowledge scores in nursing students in simulated laboratory practice.

MATERIALS & METHODS

Design

A quasi-experimental pre-post study was conducted to evaluate the satisfaction of nursing students and the scores obtained in the evaluation of the simulated laboratory practicals. It followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) and TIDieR (Template for Intervention Description and Replication) guidelines.

Sample and settings.

The target population was young students in the Nursing Degree Program at a Spanish university during the 2021/2022 academic year. As inclusion criteria, we established students enrolled in the Clinical Nursing course who have not previously completed the laboratory practicum.

Participants were divided into 10 groups of approximately 12-15 people each and received two 3-hour sessions about the necessary isolation measures depending on the type of patient to be treated and the techniques for removing foreign bodies in eyes and ears (without integrating any game-based learning aspect). These sessions consisted of a 1-hour theoretical presentation by the lecturer in charge and two hours of clinical simulation in which the students carried out practice on prepared teaching simulators after visualisation of the correct technique by the lecturer. Throughout the learning process, the teacher corrected the students to ensure they learnt the techniques correctly. After these two sessions, the participants were asked to give feedback that

includes sociodemographic data, teaching methodology' opinion and satisfaction and Knowledge level.

The second part of the research consisted of exposing the same students to two 3-hour sessions, using a teaching methodology based on game-based learning on the palpation and assessment of the lymph nodes and the neurosensory and vascular assessment of the feet of a patient with diabetes mellitus. These sessions consisted of a theoretical presentation by the teacher in charge for 1 hour, then an hour of clinical simulation using the theoretical simulators, similar to the previous sessions, where the participants performed the techniques under the supervision and correction of the teacher. Finally, in the last hour of the session, the participants of the same students' group dressed as the participants of the television serie "The Squid Game", that is, with green jumpsuits, which were indicative of being participants in the game, and the teacher in charge dressed in a red jumpsuit as the supervisor of the participants in that series. In this part, the participants had to independently demonstrate their skills at various clinical stations. The first clinical station consisted of 15 clinical cases exposed in documents, in which the students randomly choose one of these cases, and in front of the teacher they would have to present the evaluation techniques of these patients with diabetic foot (previous history of ulcers, presence or absence of peripheral neuropathies, peripheral vascular diseases, possible presence of structural and biomechanical anomalies, and knowledge and attitude towards self-care on the part of the patient), as well as the identification measures of possible neuropathy (Semmes Weinstein monofilament, Rydel-Seifferf graduated tuning fork, Achilles reflex, thermal rod, and cotton swab or brush). Through a checklist, the teacher recorded the corresponding measures or techniques that the students named in each clinical case in question. The second station consisted of performing the exploration of a diabetic foot on a simulator, and assigning the correct nursing care. The teacher was making a checklist

with the interventions and activities proposed by the student in question; as interventions or nursing care were lacking, the final score of the students decreased. Finally, the third clinical station consisted of the assessment and palpation of the lymph nodes through 15 clinical cases; each clinical case was explained to a student in each round who acted as the patient, and a partner who was exposed to the test was the person evaluated; the realisation of this station was also one by one. The professor used a check-list to verify that they had taken all the elements into account (shape and size of the node, sensitivity, mobility, and consistency). All students were subjected to the same level of difficulty in the tests.

The total score of the different check-lists was used for the final qualification of the practice by the students. The students did not know the final mark of the practice until they completed the self-administered questionnaires (sociodemographic data, teaching methodology' opinion and satisfaction and Knowledge level) so as not to condition the answer. All the students, for participating, received a certificate as winners of the "Nursing Game" (Figure 1).

(Insert figure 1 here)

Data collection.

The data were collected by means of a questionnaire designed for research composed of 3 blocks:

- Sociodemographic and opinion's data: This block is composed of 5 variables (sex, age, have not had any previous experience, numerical utility of this activity for its formation, adjectives to describe the activity carried out). All variables had several precoded response categories, with an added option in which students could write another response. Only one response per variable was allowed except for the adjectives variable where participants could indicate several options.

- Satisfaction feedback on the activity developed: We measured the feedback of the participants by means of a scale composed of 10 items measured on a Likert scale (1-5). The scale was made ad-hoc for this research and evaluated by a committee of national experts. The group consisted of four university lecturers of the Nursing Degree and three secondary school teachers in Spanish high schools. They were asked, using a likert scale (1-5), for their evaluation of the relevance of the item for measuring the participants' satisfaction with a teaching activity and the clarity with which they had been written. The degree of agreement among the experts was evaluated by means of Aiken's V statistic, obtaining for the 10 items selected for the version used in the research a value of agreement higher than 0.7 points.
- Knowledge: It was evaluated by means of the questions of the course evaluation test, establishing as test variables 10 items on the course matter of the practical sessions in which the gamification methodology was used and as a test variable the rating of the 10 items of the theoretical-practical sessions in which a vertical methodology was used.

Participants were informed about the objective of this research and were asked to sign an informed consent **form** after agreeing to participate in the study. During data collection, at least one member of the research team was present to answer any questions or problems related to the completion of the questionnaire. Completion of the questionnaire lasted approximately 10 minutes. Anonymity was guaranteed through-out the collection and processing of the information.

Data analysis.

A descriptive analysis of sociodemographic information was carried out, obtaining their distributions in frequencies and percentages. The scores of the two scales were expressed by means of measures of central tendency and dispersion. The normality of the scores distributions was

tested using the Kolmogorov-Smirnov test for the intervention and control scores on the feedback and knowledge variables. Both scales followed a non-normal distribution. A descriptive analysis was conducted of the feedback on the activity developed and knowledge items about the intervention and control sessions. The differences between the scores from the two types of sessions were calculated using the Wilcoxon test and the effect size using the Cliff Delta statistic. The level of significance was set at 0.05. All analyses were performed using SPSS version 27 and JASP version 0.17 for Windows.

Ethical considerations

The Institutional Review Board of the university of Jaen approved this study (DIC.21/14.TFM). An information sheet was given to the participants. If happy to participate students completed and signed an informed consent form prior to undertaking the session. Students were not obliged to participate and were reassured that this would not affect their progress and success on their course of study. Confidentiality of personal data was guaranteed. Participants were informed and agreed to have their data published in a scientific article.

RESULTS

Descriptive analysis

The sample consisted of 122 students from a Spanish university's second year of the Nursing degree program. Most of the participants (79.5%) were females with a mean age of 20.77 years (SD: 5.03). Over half (61.5%) of participants did not know about the concept of gamification, and 75.4% had no previous experience with it (Table 1).

(Insert table 1 here)

The main adjectives used by participants to describe the gamification experience were fun, focused during the game, and motivated. None of the participants felt bored during the gamification

sessions, and all said that they would like to use it in future Nursing degree classes. All the participants completed the game and received a badge as winners of the nursing game (Table 2).

(Insert table 2 here)

Modification of the feedback with the sessions.

The satisfaction scale showed a high internal consistency value for the analysis sample, both in the evaluation of the vertical methodology ($\alpha=0.893$) and for the sessions with gamification ($\alpha=0.840$).

The average score on the feedback on the activity developed scale with traditional methodology was 42.80 (SD: 6.38) points and with the gamification methodology, 47.98 (SD: 3.41) points, improving 12.10%. This difference was statistically significant ($Z = -8.229$, $p < 0.001$; Delta: 0.567; Table 3)

(Insert table 3 here)

There was an improvement in the score for all items with the gamification sessions, with significant differences in all of them, reaching a score of 4.90 points out of 5 points for item 2 “The exercises I have done promote my reasoning and critical skills” and item 5 “The activities have helped me to develop practical technical skills” about the perceived development of critical thinking and reasoning skills and practice (Table 4).

(Insert table 4 here)

A deeper analysis found a statistically significant difference in participants' satisfaction score for learning after the gamification session, with higher satisfaction among females. In the traditional methodology sessions, no differences were found for any of the participants' sociodemographic variables (Table 5).

(Insert table 5 here)

Modification of the knowledge scale.

For knowledge scale, with traditional methodology the score was 7.42 (SD: 2.15) points and with the gamification methodology 8.68 (SD: 1.41) points, improving 16.98% (statistically significant $Z = -5.776$, $p < 0.001$; Delta: 0.341; Table 3).

No statistically significant differences were found in the level of knowledge by any of the participants' sociodemographic variables (Table 5)

DISCUSSION

This study aimed to evaluate the effect of a theoretical-practical session with gamification methodology on the modification of learning satisfaction and the level of theoretical knowledge acquired during the session. After the session, learning satisfaction increased by 5 points, on a maximum scale of 50 possible. An important factor to be studied in learning environments is student satisfaction. It is considered an important outcome and introducing gamification as part of the training process seems to play a positive effect not only on satisfaction but also on motivation, both being important elements in student learning (Ratinho & Martins, 2023). The items that exhibited the highest percentage of satisfaction were those relating to the perceived effectiveness of developing critical thinking. The experience of Jodoi et al. in 2021 found a similar result to our research, finding that participants exposed to a gamification session and using a mobile application significantly increased their rate of success in critical thinking. However, this result was similar to that obtained by the group that used the mobile application exclusively, so we must be cautious when interpreting the results, although a striking result is the significant improvement compared to a control group in those that received training through a master class, highlighting the need to incorporate new teaching methodologies in university teaching. Gamification proved to be effective in mobilising the theoretical concepts presented in the subject into a practical context and applied to reality, finding improvements in the development of healthy lifestyle habits (Pérez-

254 López et al., 2017), the development of empathetic attitudes towards people with functional
 255 diversity (Oliver et al., 2019) or the risk of infection by the human immunodeficiency virus
 256 (Petersen et al., 2011). Gamification is an effective tool for visualising abstract concepts; however,
 257 the modifications must be evaluated to ensure that they are maintained over time, as the effect of
 258 this intervention can be balanced and disappear. Petersen et al., in 2011 states that we must be
 259 cautious when applying it to the modification of attitudes, as these may be influenced by other
 260 variables such as knowledge about the element or experiences prior to the evaluation, which has a
 261 significant effect on the creation of new attitudes, reinforcement of existing ones or modification
 262 of previous ones (Rodríguez, 2004). The creation of a realistic learning climate is a fundamental
 263 element that allows nursing students to develop skills such as teamwork and working under
 264 pressure, which are fundamental for tackling the reality of healthcare, where they will be working
 265 in healthcare teams of people with different theoretical knowledge, and with a high level of
 266 healthcare pressure. In our experience, through the creation of a competitive game where the
 267 students had to pass each test in a given time, not have any penalty in the next test, and get the
 268 final prize as the winner of the "Nursing Game", they were exposed to pressure to perform the
 269 tasks within the time available and to perform them correctly. However, one aspect to highlight is
 270 that colleagues helped each other continue playing the game, highlighting the development of
 271 fellowship skills. During the game, the teachers reported that they could help their classmates,
 272 seeking to create a favourable climate for everyone to play the game and learn together. This result
 273 was similar to that found by Gómez-Urquiza et al., in 2019 who exposed students to an escape
 274 room in which a group of 5 students had to collaborate to leave the room within a given time under
 275 the supervision of the teachers.

During the activity, our participants found themselves focused, having fun, and motivated, similar to what has been found in previous gamification research where the experiences were described as innovative, useful for learning, very satisfying or that they have allowed them to visualise theoretical concepts that will be remembered (Gómez-Urquiza et al., 2019; Pérez-López et al., 2017; Sánchez-Martín et al., 2020).

The second variable of interest in our research, associated with the modification of learning satisfaction, was the level of knowledge developed through the gamification methodology. Our research found a statistically significant difference between the theoretical knowledge of the concepts addressed through gamification and the concepts addressed through a traditional methodology. The gamification methodology was shown to be effective in improving the level of knowledge, assessed by increasing the hit rate (Azhari et al., 2019; Ferriz-Valero et al., 2020; Luchi et al., 2017). Previous studies, such as the one conducted by Ezezika et al., in 2018 on the use of gamification to achieve nutrition knowledge showed similar results with a significant increase in theoretical knowledge acquired that was linked to greater motivation to learn and to relate everyday knowledge to new knowledge. Regarding the level of knowledge, one aspect to highlight is the gender differences found in previous research in which women obtained significantly higher scores than men (Ferriz-Valero et al., 2020). In our research, we found that the level of knowledge of women was higher than that of men, although it did not reach statistical significance. However, the satisfaction for learning did obtain a significant difference in favour of the women, who were more motivated to learn through gamification. This difference may be due to a greater predisposition to learning through mobile applications and social networks on the part of women, as well as their interest in the use of games as teaching tools, while men prefer games with a mainly recreational or recreational interest or application (Holzmann et al., 2020).

299 Among the main limitations of the research, it should be noted that the contents taught using
 300 gamification and traditional methods were different. Hence, we have to be cautious in our
 301 interpretations, as the differences may be overestimated due to the different topics, and the
 302 differences in knowledge could be due to the sessions' content and not the teaching methodology
 303 used. On the other hand, satisfaction was measured after the gamification session and could be
 304 overestimated due to the high level of excitement associated with playing the game. For future
 305 research we recommend assessing the development of practical skills as a result variable.

306 The contents were taught by two different teachers, both carrying out a session with vertical
 307 teaching methodology and another with gamification, in a controlled way the effect of the teachers
 308 themselves when carrying out the activity, since all the groups were exposed to all the contents.

309 As a future line of research, the possibility of evaluating the usefulness perceived by the
 310 participants is proposed, since in our research we found a high level of usefulness and desire to
 311 use gamification in future sessions, but these two variables were not evaluated in the sessions with
 312 traditional teaching methodology. The development of practical skills is another of the future lines
 313 to be measured, seeking to determine the effect both in terms of increasing the level of knowledge
 314 and the development of practical skills useful in the health professions.

315 CONCLUSIONS

316 The students obtained an improvement in satisfaction and the level of theoretical knowledge after
 317 the gamification sessions, in addition to describing their experience with gamification as fun, with
 318 motivation and concentration during the game. All concluded that they would like to continue
 319 using this methodology in the rest of the classes of the nursing degree. The use of gamification as
 320 a complementary methodology in university teaching is an effective element for the acquisition of
 321 theoretical knowledge.

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Table 1 (on next page)

Characteristics of the sample

1 **Table 1: Characteristics of the sample**

Variable	Categories	N (%)
Gender	Men	25 (20.5%)
	Women	97 (79.5%)
Previous experience with a gamification session	Yes	30 (24.6%)
	No	92 (75.4%)

2

Table 2(on next page)

Results on the perception of the activity

1 **Table 2: Results on the perception of the activity**

Variable	Categories	N (%)
Opinion about the gamification session	Fun	106 (86.9%)
	Focus	67 (54.9%)
	Tense	52 (42.6%)
	Tired	1 (0.8%)
	Bored	0 (0%)
	Motivated	89 (73%)
Future use in the Nursing Degree	Yes	122 (100%)
Knowledge about gamification	Yes	47 (38.5%)
	No	75 (61.5%)

2

3

Table 3(on next page)

Characteristics of the sample with both teaching methodologies

Table 3: Characteristics of the sample with both teaching methodologies

Variables	Vertical Methodology	Gamification methodology	P
Opinion on the activity developed*	42.80 ± 6.38	47.98 ± 3.41	Z = 8.229 P < 0.01
Knowledge level*	7.42 ± 2.15	8.68 ± 1.41	Z = -5.776 P < 0.001

* Data expressed as mean

Table 4(on next page)

Item analysis of the opinion scale.

1 **Table 4: Item analysis of the opinion scale.**

Item	Session without gamification		Sessions with gamification		P
	M	SD	M	SD	
1- I consider the information provided necessary	4.35	0.91	4.75	0.54	<0.01
2- The exercises I have done promote my reasoning and critical skills	4.05	1.04	4.90	0.3	<0.01
3- I feel prepared to act in a situation similar to the one presented.	3.78	1.02	4.80	0.53	<0.01
4- The activities carried out have helped me to make associations between the theoretical part and the practical part of the content.	4.06	0.92	4.83	0.38	<0.01
5- The activities have helped me to develop practical technical skills.	4.30	0.95	4.90	0.43	<0.01
6- I found the difficulty of the contents acceptable	4.30	0.89	4.76	0.45	<0.01
7- I found the resources proposed by the teacher to be sufficient.	4.38	0.81	4.57	0.82	0.017
8- The material provided is easily understandable.	4.53	0.79	4.85	0.54	<0.01
9- The demonstrations by the teacher have helped me to learn how to carry out the techniques.	4.48	0.82	4.75	0.65	<0.01
10- I found the information clear and precise.	4.57	0.76	4.87	0.50	<0.01

2

Table 5(on next page)

Characteristics of the sample with the traditional and gamification methodology

1 **Table 5: Characteristics of the sample with the traditional and gamification methodology**

	Variables	Categories	Vertical	Contrast	Gamification	Contrast
Motivation	Gender	Male	41.28 ± 6.22	Z=-1.634	46.92 ± 5.17	Z=-2.113*
		Female	43.19 ± 6.4		48.26 ± 2.75	
	Age			Rho=-0.129		Rho=-0.056
	Have had any previous experience with gamification experiences	Yes	41.70 ± 5.93	Z=-1.511	47.50 ± 3.26	Z=-1.218
		No	43.15 ± 6.51		48.14 ± 3.45	
Knowledge	Gender	Male	6.55 ± 2.53	Z=-1.876	8.4 ± 1.67	Z=-0.715
		Female	7.64 ± 1.99		8.75 ± 1.33	
	Age			Rho=-0.088		Rho=0.031
	Have had any previous experience with gamification experiences	Yes	7.63 ± 2.33	Z=-0.997	8.83 ± 1.31	Z=-0.642
		No	7.35 ± 2.10		8.63 ± 1.44	

2 * P<0.05

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Figure 1

Certificate of the winners of the nursing game

