

# Cooperative Learning and Hand Disinfection in Nursing Students



Original article



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## Cooperative Learning and Hand Disinfection in Nursing Students

**Objective.** The study sought to evaluate the effectiveness of an educational intervention based on cooperative learning on the acquisition of knowledge and skills on hand washing. In addition, the interest and self-perception was studied of the participants on the acquisition of knowledge and skills. **Methods.** This was a pre-post intervention study with 49 students from the second course of the Nursing degree, evaluating: i) *acquisition of knowledge* with an *ad hoc* questionnaire; ii) *skills on hand washing* by conducting the technique with reagent solution and verification with fluorescent lamp; and iii) *interest and self-perception of the importance of acquiring knowledge and skills* with specific questions. **Results.** The mean age was 21.8 years, 83.7% were women, and 32.6% had prior studies related with health. Significant post-intervention improvement was evident in the level of knowledge ( $p < 0.001$ ) and skills ( $p < 0.001$ ). Interest for the intervention ( $m = 4.1 \pm 0.6$ ) and perception on the acquisition of knowledge ( $m = 4.4 \pm 0.6$ ) and skills

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( $m=4.3\pm 0.5$ ) were scored high (scale from 1 to 5). **Conclusion.** The cooperative learning intervention improved knowledge and skills on hand washing in nursing students and awakened their interest.

**Descriptors:** nursing; education, nursing; students, nursing; hand disinfection; hydroalcoholic solution; learning.

## Aprendizaje cooperativo e higiene de manos en estudiantes de enfermería

**Objetivo.** Evaluar la efectividad de una intervención educativa basada en el aprendizaje cooperativo sobre la adquisición de conocimientos y habilidades en lavado de manos. **Métodos.** Estudio pre-posintervención realizado con la participación de 49 estudiantes de segundo curso de grado en enfermería. Se evaluaron los siguientes aspectos: i) *adquisición de conocimientos* con un cuestionario *ad hoc*, ii) *habilidades en lavado de manos* mediante la realización de la técnica con solución reactiva y verificación con lámpara fluorescente, y iii) *interés y autopercepción de la importancia de adquisición de conocimientos y habilidades* con preguntas específicas. **Resultados.** La edad media fue 21.8 años, 83.7% mujeres y el 32.6% tenía estudios previos relacionados con salud. Hubo una mejoría significativa post-intervención en el nivel de conocimientos ( $p<0.001$ ) y habilidades ( $p<0.001$ ). El interés por la intervención ( $m=4.1\pm 0.6$ ) y la percepción sobre la adquisición de conocimientos ( $m=4.4\pm 0.6$ ) y habilidades ( $m=4.3\pm 0.5$ ) se calificaron como elevados (escala de 1 a 5). **Conclusión.** La intervención de aprendizaje cooperativo mejoró los conocimientos y habilidades sobre lavado de manos en estudiantes de enfermería, además, despertó su interés.

**Descritores:** enfermérica; educación en enfermérica; estudantes de enfermérica; desinfección de las manos; solución hidroalcohólica; aprendizaje.

## Aprendizagem cooperativo e higiene de mãos em estudantes de enfermagem

**Objetivo.** Avaliar a efetividade de uma intervenção educativa baseada na aprendizagem cooperativa sobre a aquisição de conhecimentos e habilidades no lavado de mãos. Ademais, se estudou o interesse e a auto-percepção dos participantes sobre a aquisição de conhecimentos e habilidades neste assunto. **Métodos.** Estudo pré-pós intervenção realizada com a participação de 49 estudantes de segundo curso de grau em enfermagem. Se avaliou: i) *aquisição de conhecimentos* com um questionário *ad hoc*, ii) *habilidades em lavado de mãos* mediante a realização da técnica com solução reativa e verificação com luz fluorescente, y iii) *interesse e auto-percepção da importância de aquisição de conhecimentos e habilidades* com perguntas específicas. **Resultados.** A idade média foi 21.8 anos, 83.7% eram mulheres e 32.6% tinham estudos prévios relacionados com saúde. Houve uma melhoria significativa pós-intervenção no nível de conhecimentos ( $p < 0.001$ ) e habilidades ( $p < 0.001$ ). O interesse pela intervenção ( $m = 4.1 \pm 0.6$ ) e a percepção sobre a aquisição de conhecimentos ( $m = 4.4 \pm 0.6$ ) e habilidades ( $m = 4.3 \pm 0.5$ ) foram qualificados como elevados (escala de 1 a 5). **Conclusão.** A intervenção de aprendizagem cooperativo melhorou os conhecimentos e habilidades sobre lavado de mãos em estudantes de enfermagem e ademais despertou seu interesse.

**Descritores:** enfermagem; educação em enfermagem; estudantes de enfermagem; desinfección das mãos; solução hidroalcohólica; aprendizagem.

# Introduction

Infection associated with health care is a substantial problem for patient safety and its prevention is of priority importance. Lack of adequate hand disinfection is the cause of spread of multi-resistant organisms, significantly contributing to infection associated to health care, also being one of the basic methods to reduce the transmission of microorganisms,<sup>(1)</sup> and is well-accepted due to being a procedure whose technique improves with attendance to continuous formation processes.<sup>(2)</sup> Furthermore, reduced indices of crossed transmission and infections are lowered with improved practices de hand disinfection.<sup>(1)</sup>

In spite of the importance of hand washing and the good results of the formation in health professionals, deficit still persists in knowledge and skills related with this procedure in students from health sciences,<sup>(3,4)</sup> and specifically in nursing.<sup>(5-6)</sup> In a study,<sup>(7)</sup> after analyzing the level of knowledge of nursing students on hand washing, it was concluded that it was necessary to improve existing formation programs in hand disinfection to fill voids in knowledge and obtain highly qualified nurses in the future. These results coincide with those from another research,<sup>(8)</sup> which found that attendance to training and seminars on hand disinfection is one of the predictors of better hand disinfection.

Cooperative learning is a way of working in small groups based on the collective construction of knowledge, where each member of the group is responsible for their learning and that of the group.<sup>(9)</sup> The internal dynamics that allow cooperative learning to function are based on characteristics that enable professors to structure activities so that students become positively interdependent and individually responsible to perform their part of the work and use social skills appropriately.<sup>(9)</sup> This method is applicable to a vast variety of subjects, as well as in the specialization in a task. Empirical evidence available on the basis, benefits, and characteristics of cooperative learning is sufficient to encourage its use to improve the knowledge and skills of nursing students on hand washing.<sup>(10)</sup>

One of the best known and used techniques of cooperative learning is probably the Jigsaw method or Aronson puzzle.<sup>(11)</sup> This cooperative-learning technique has been used in nursing education to teach research methods<sup>(12)</sup> or cardiac physiology<sup>(13)</sup> among other contents, although the literature has not identified studies applying the Aronson puzzle on formation about hand washing in nursing students or other professions in health sciences.

Thus, the principal objective in this study was to determine the efficacy of an educational intervention based on cooperative learning, through the Aronson puzzle technique to acquire knowledge and execute the hand-washing technique in students from the second course of the Nursing degree. Additionally, it was studied if the intervention stirred interest in the participants and their perception on the acquisition of knowledge and skills in hand washing.

## Methods

A pre- and post-intervention study was conducted to evaluate the effectiveness of an educational intervention based on cooperative learning, through the Aronson puzzle technique, on the acquisition of knowledge on hand disinfection and the execution of the hand-washing technique with hydroalcoholic solution in students from the second course of the Nursing degree program at the public Universidad Jaume I de Castellón (Spain). The study took place between January and July 2017.

The study included students who accepted to participate and who were registered for the first time in the assignment “Basic nursing care” from the second course of the Nursing degree at Universitat Jaume I, given that it is the assignment that covers the contents related with hand washing ( $n=49$ ). The educational intervention was based on the Aronson puzzle technique.<sup>(11)</sup> In this technique, professors divide the subject they wish to teach into unique and essential parts to comprehend the theme, and prepares the material of each of the parts. Students are divided into heterogeneous teams of 5 or 6 members (mother groups), thereafter, each student receives a part of the theme (one piece of a puzzle) and has to join it to the parts held by their classmates to complete the learning (complete the puzzle). For this, students study individually their part, discuss it among their group of experts (members from other groups with the same piece of the puzzle), and return to their mother group to teach the rest.

As result variables, knowledge on hand washing and execution of the hand-washing technique with hydroalcoholic solution were established. In addition, it was studied if the intervention awakened interest by the participants in hand washing and their perception on acquiring knowledge and skills. In the first place, a two-hour theoretical class was given on hand washing. After the class, the students were allowed two days to answer an on-line ad hoc questionnaire on knowledge on hand washing through the assignment’s virtual classroom. The

questionnaire had five test-type questions, with four response options and only one was true; these were: 1. what is the principal measure to prevent hospital infection? (a. perform correct hand disinfection, b. wear sterile gloves; c. wear lab coat and face mask; d. wear double gloves); 2. In hygienic washing of the hands, it is necessary to: (a. Use antiseptic soap; b. Use a nail brush and dry with sterile towel; c. Follow a given technique using water, soap, and disposable paper towels; d. Use a spatial tap); 3. Is hand disinfection indicated when removing the gloves? (a. only in case of patients with infections; b. No, if they were washed before putting them on; c. Only if the hands have been contaminated with organic fluids; d. Yes, because the flora of the hands increases when remaining too much time wearing gloves); 4. Wearing gloves is indicated to: (a. Reduce the transmission of microorganisms among patients and prevent on-the-job risks for the health personnel; b. Reduce the number of hand washings; c. Transfer patients to other units; d. Avoid contamination of the hands when distributing medication, trays with food, picking up the telephone...). 5. Surgical washing: (a. It is the same as antiseptic hand washing; b. It is done before placing a bladder catheter; c. Can be done with hydroalcoholic solution; d. It is done at the start of the work shift). The questions were selected through consensus of the three professors of the assignment and were based on the theoretical contents taught, taking as reference the recommendations on hand washing by the Center for Disease Control (CDC) in the United States<sup>(14)</sup> and those by the World Health Organization (WHO).<sup>(1)</sup> This questionnaire served to measure the level of pre-intervention knowledge. The students were asked prior to the following phase to read at home the clinical practice guide on hand disinfection for health professionals based on these very recommendations.<sup>(15)</sup>

In the second place, a two-hour practical session was conducted in which student performed hand washing with hydroalcoholic solution that included a stain reactive to ultraviolet light to verify if the technique had been done correctly. The zones with incorrect application of

hydroalcoholic solution that remained exposed under the ultraviolet light were reflected for each student on a template with the back and palm of the left and right hands. This template was used as pre-intervention measurement of the execution of the hand-washing technique. The regions of the hand were grouped for analysis into palm, back, thumb, interdigital, wrist, and fingers,<sup>(16)</sup> the nail-pulp region was added, as proposed in another study,<sup>(17)</sup> and it was decided to differentiate the “fingers” region into back fingers and palm fingers, given that in the technique for hand disinfection proposed by the WHO<sup>(1)</sup> these are two differentiated steps, leaving finally eight regions for each hand. The score received 1 point if the region had been correctly exposed to the hydroalcoholic solution and 0 if the contrary was found, being able to obtain a maximum score of 16 points, 8 for each hand.

Thereafter, in the same session, groups with five students (mother groups) were created and each member of the group was assigned a type of hand washing as parts of the piece of the puzzle (hygienic washing, antiseptic washing with soapy solution, antiseptic washing with hydroalcoholic solution, surgical washing with antiseptic soap, surgical washing with hydroalcoholic solution). During a second time, these were reorganized into groups of experts to exchange knowledge with the rest of the classmates from the other groups who had worked on the same type of hand washing. Once completed, each expert returned to their mother group, where they explained to the rest of the members the corresponding type of hand washing. To end, the groups of experts were again formed, who explained and executed their respective types of hand washing to the rest of the class. The intervention was supervised at all times by the professors in the assignment, clarifying issues whenever necessary.

Lastly, after five days, in the following practical session, each student again performed hand washing with hydroalcoholic solution and the execution was tested with ultraviolet light. The template was used again with the palm and back of each hand to indicate those zones with

incorrect application of the hydroalcoholic solution that remained exposed to ultraviolet light, serving as post-intervention mean. After this session, the students had six days to again answer the knowledge questionnaire (post-intervention mean of knowledge). Additionally, the questionnaire included three more questions to know the interest and perception on the acquisition of knowledge and skills by the students which were answered through a 5-point Likert-type scale (1=nothing; 5=maximum). Also, sociodemographic variables were collected (age and gender), along with prior formation in health, and students were asked if they had attended the theoretical class and if they had read the clinical practice guide on hand washing.<sup>(15)</sup>

A descriptive analysis was performed of the variables according to their nature. The effectiveness of the intervention on the level of knowledge and skills was studied through Student's t test for paired data and with the Mann-Whitney U test and average ranges, obtained by dividing the sum of ranges of each group by the amount of cases in the group, verifying if significant differences existed in the pre- and post-intervention results in function of the sociodemographic variables. The McNemar test was used to if there were differences in the percentage of right answers in each of the questions of the pre- and post-knowledge questionnaires as with the zones marked by the ultraviolet light after performing the technique. Interest and self-perception on the acquisition of knowledge and skills were studied in descriptive manner. The SPSS program version 21 for Windows was used. The level of statistical significance in the hypothesis contrasts was  $p < 0.05$ .

The study was approved as an educational innovation project at Universitat Jaume I (Spain) (code 3311/16). All the participants granted consent and no personal data were used that permitted their identification. A random code was assigned to each student that was only known by them to perform the analysis of paired data. At all times, the study respected the Spanish legislation with regarding the protection of data and the ethical principles of the Helsinki Declaration (beneficence, non-maleficence, autonomy, and justice).



# Results

The sample comprised 49 students, 2 subjects were discarded for using the same identification code, 2 for not responding to any of the questionnaires, and 2 for not monitoring the technique, which is why the study had a final sample of 43 subjects. The mean age was  $21.8 \pm 5.8$  years, with a minimum age of 19 years and maximum age of 50 years; 83.7% were women. Among the subjects, 32.6% reported prior studies related with health; 83.7% of the students attended the theoretical class and 88.4% read the guide before attending the laboratory.

The mean score obtained in the questionnaire on pre-intervention knowledge was  $3.8 \pm 0.7$  (95%CI=3.6-4.0) and post-intervention knowledge of  $4.6 \pm 0.4$  (95%CI=4.4-4.9), with significant differences between both moments of the questionnaire's application ( $p < 0.001$ ). The mean post-intervention score of the test of knowledge showed no significant differences in function of gender ( $p = 0.425$ ), if the students had prior studies related with health ( $p = 0.786$ ), if they attended or not the theoretical class ( $p = 0.425$ ), or if they read the clinical guide on hand washing ( $p = 0.172$ ). Significant differences were also not found in the mean score

of the questionnaire on pre-intervention knowledge in function of the same variables ( $p > 0.05$ ). Table 1 shows the analysis of the responses from each question of the questionnaire on knowledge before and after the intervention.

The mean pre-intervention score was  $8.07 \pm 2.3$  (95%CI=7.3-8.8) of 16 maximum possible points, while the mean post-intervention score was  $13.2 \pm 2.1$  (95%CI=12.6-13.9), showing significant differences ( $p < 0.001$ ). The question, What is surgical washing?, obtained the lowest percentage of right answers during pre-intervention (9.3%), increasing significantly after the intervention (83.7%;  $p < 0.001$ ), followed by the question, When hygienic hand washing necessary? (76.7%), which also increased significantly after the intervention (93%;  $p = 0.016$ ).

No significant differences were found in function of gender in the score of pre ( $p = 0.149$ ) and post-intervention ( $p = 0.501$ ) skills; nor in function of attendance or not to the theoretical class (pre-intervention  $p = 0.44$ ; post-intervention  $p = 0.118$ ), or the reading of the clinical practice guide on hand washing (pre-intervention  $p = 0.802$ ; post-intervention  $p = 0.786$ ). Subjects with prior studies in health obtained higher scores in pre-intervention skills (average range=28.32) against those without

**Table 1. Pre- and post-intervention comparison of the level of knowledge of 43 students from the second year of Nursing**

Question	Pre-intervention <i>n</i> (%)		Post-intervention <i>n</i> (%)		<i>p</i> *
	Correct	Incorrect	Correct	Incorrect	
1. Principal measure to prevent hospital infection	42 (97.7)	1 (2.3)	42 (97.7)	1 (2.3)	1
2. When is hygienic hand washing necessary?	33 (76.7)	10 (23.3)	40 (93)	3 (7)	0.016
3. Is hand disinfection indicated when removing gloves?	41 (95.3)	2 (4.7)	39 (90.7)	4 (9.3)	0.625
4. When is it indicated to wear gloves?	43 (100)	0 (0)	43 (100)	0 (0)	-
5. What is surgical washing?	4 (9.3)	39 (90.7)	36 (83.7)	7 (16.3)	<0.001

(\*)Hypothesis contrast having performed McNemar test

prior health studies (average range=18.95) ( $p=0.019$ ), although no significant differences post-intervention were noted for this variable ( $p=0.58$ ).

A detailed comparison was made per zones of the hand pre- and post-intervention (Table 2). In the right hand, the zones with the worst exposure to the hydroalcoholic solution prior to the intervention were the thumb and wrist,

followed by back of the hand and nail-pulp, all with statistically significant post-intervention improvement ( $p<0.05$ ). In the left hand, the zone with the worst result was the wrist, followed by the thumb, the back of the hand and nail pulp. As with the right hand, all had statistically significant improvement ( $p<0.05$ ). The thumb continued being the zone with the highest amount of errors in both hands after the intervention.

**Table 2. Pre- and post-intervention comparison of the skills of 43 students from the second year of nursing (exposure of the hands under a fluorescent light lamp after hand disinfection with hydroalcoholic solution)**

Region	Pre-intervention <i>n</i> (%)		Post-intervention <i>n</i> (%)		<i>p</i> *
	Correct	Incorrect	Correct	Incorrect	
<b>Right hand</b>					
Hand palm	36 (83.7)	7(16.3)	42 (97.7)	1 (2.3)	0.031
Back of Hand	15 (34.9)	28 (65.1)	36 (83.7)	7 (16.3)	<0.001
Fingers Palm	43 (100)	0 (0)	41 (95.3)	2 (4.7)	-
Fingers Back	20 (46.5)	23 (53.5)	28 (65.1)	15 (34.9)	0.152
Nail-pulp	15 (34.9)	28 (65.1)	42 (97.7)	1 (2.3)	<0.001
Thumb	6 (14)	37 (86)	25 (58.1)	18 (41.9)	<0.001
Interdigital	32 (74.4)	11 (25.6)	38 (88.4)	5 (11.6)	0.146
Wrist	6 (14)	37 (86)	32 (74.4)	11(25.6)	<0.001
<b>Left hand</b>					
Hand palm	37 (86)	6 (14)	41 (95.3)	2 (4.7)	0.219
Back of Hand	15 (34.9)	28 (65.1)	36 (83.7)	7(16.3)	<0.001
Fingers Palm	42 (97.7)	1 (2.3)	41 (95.3)	2 (4.7)	1
Fingers Back	20 (46.5)	23 (53.5)	27 (62.8)	16 (37.2)	0.210
Nail-pulp	17 (39.5)	26 (60.5)	43 (100)	0 (0)	-
Thumb	8 (18.6)	35 (81.4)	24 (55.8)	19 (44.2)	<0.001
Interdigital	30 (69.8)	13 (30.2)	39 (90.7)	4 (9.3)	0.012
Wrist	5 (11.6)	38 (88.4)	34 (79)	9 (21)	<0.001

(\*)Hypothesis contrast having performed McNemar test

Table 3 shows the frequency distribution and percentages of the evaluation of the students, showing high interest for the intervention with a mean score of  $4.2\pm 0.6$  of a possible 5

points. Additionally, students evaluated that the intervention had increased their knowledge, with a score of  $4.4\pm 0.6$ , and their skills with  $4.3\pm 0.5$ .



**Table 3. Perception and evaluation of the students on the methodology used regarding the interest awakened, skills, and knowledge acquired**

Categories	Interest		Knowledge		Skills	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Sufficient	4	9.3	3	7	2	4.7
Very much	27	62.8	19	44.2	28	65.1
Maximum	12	27.9	21	48.8	13	30.2

## Discussion

Hand disinfection is the principal measure to prevent infection associated with health care and reduce antimicrobial resistance.<sup>(1)</sup> However, it has been noted that the level of knowledge and skills on theme are deficient in students in health sciences<sup>(4-5)</sup> and specifically with nursing students.<sup>(5-6)</sup> In this sense, the objective of this study was to evaluate the effectiveness of an educational intervention based on cooperative learning in the acquisition of knowledge and execution of the hand-washing technique in students from the second course of the Nursing degree program. The results obtained indicate that the cooperative learning methodology, based on the Aronson puzzle,<sup>(11)</sup> improved significantly the level of knowledge and skills of students. Other experiences have demonstrated the efficacy of this technique, like a study<sup>(18)</sup> which improved significantly the academic results in English classes with respect to the control group. It also turned out to be an effective method<sup>(19)</sup> to introduce medical students to the long-stay institutional environment.

Regarding knowledge, significant improvement was obtained after the intervention. In this sense, a cross-sectional descriptive study<sup>(17)</sup> with 398 medical students and 141 nursing students, based on classroom sessions and simulation workshop, concludes that the role of education is fundamental to set the bases of good practices in hand disinfection, in theoretical knowledge and in the development of skills; however, this study did not evaluate improvement at the level of theoretical

knowledge. Another study<sup>(20)</sup> conducted a pre- and post-evaluation of the technique, knowledge and attitudes of the participants toward hand disinfection, in a sample of 40 students from health sciences (medicine, nursing, and physical therapy), the authors evaluated through ad hoc questionnaire the attitudes and knowledge, and through direct observation the performance of the disinfection technique and the quality of the process by using ultraviolet light and reagent solution. They did not use the Jigsaw technique, but – however – did coincide in part with the methodology in our study, given that in their case the laboratory was imparted by students. This study concludes that knowledge, technique, and attitudes improved toward hand washing after the conducting the educational intervention. Our study did not evaluate attitudes and the use of questionnaires ad hoc should be considered a limitation in both cases, in spite of the good results.

To evaluate the skills, one of the hand disinfection techniques was monitored, specifically hand washing with hydroalcoholic solution, through visual evaluation of the hands under ultraviolet light, methodology used in different studies.<sup>(16-17,20)</sup> With respect to the results by zones of the hand, a study<sup>(17)</sup> concludes that the zones with the worst application are the thumb and back of the hand. This study does not distinguish the “wrist” region. Another study,<sup>(16)</sup> which consisted of an evaluation of hand disinfection on a sample of 293 health professionals from different categories and work shifts employing reagent solution under ultraviolet light, the zones with the worst results were the fingers (includes pulp and interdigital space), wrist

and thumb. As a limitation in both studies,<sup>(16-17)</sup> it must be mentioned that a pre-post intervention comparison was not made, rather, only a post-intervention measurement. In our study, the zones with the worst post-intervention application were the thumb, followed by the back-fingers region, a zone that did not show statistically significant improvement with respect to the pre-intervention measurement. Another study<sup>(20)</sup> does distinguish between pre-intervention and post-intervention, with the zones with the worst post-intervention exposure being the pulps, which did not have significant differences between round 1 and 2, the backs of the hand and thumbs. A study aimed at nursing and medical students concludes that the back of the hand areas; interdigital spaces; thumb; fingertips, and periungual region had an error rate >50%.<sup>(21)</sup> It is observed that in the different studies reviewed,<sup>(16-17,20)</sup> and in the present study, the thumb appears as one of the zones with worse exposure to the hydroalcoholic solution, both during pre-intervention and post-intervention, which is why special attention should be paid to this anatomical region when imparting formation on hand disinfection.

With respect to the satisfaction obtained, the students were asked on the interest awakened by the educational intervention, the perceived improvement in their knowledge, and the perceived improvement in their skills, satisfactorily responding in each of the items, which is why the methodology used, besides being effective in improving knowledge and skills, was perceived satisfactorily by the students.

Several cooperative learning experiences at the university have assessed students' opinions on the methodology employed, showing majority satisfaction by the students in different careers and cooperative learning techniques. In the study conducted in the pedagogy and social education careers,<sup>(22)</sup> comparison was made with a control group of the use of cooperative learning, specifically a case study in which a positive evaluation was obtained regarding the methodology, skills acquired, and functioning of the group, by the students. Another case<sup>(23)</sup>

employed cooperative learning in the civil engineering career at Universidad de Salamanca and the students considered adequate the methodology employed to work the skills of the study area and of the profession. The Aronson puzzle technique has also been used in students from the teacher training for childhood education<sup>(24)</sup> with positive evaluation by the alumnus. The students agreed that the methodology employed surpasses the limitations of group work. The Aronson puzzle was also a methodology well-received by the medical students to be introduced in extended-stay institutions.<sup>(19)</sup> However, the students reported that they had not learnt more than with other techniques, that it had meant greater workload and more effort, and preferred that it not be used in the following courses.<sup>(12)</sup>

The results in this study must be considered with caution due to the different limitations it presents. Regarding the use of an *ad hoc* knowledge questionnaire, we propose using a previously validated questionnaire to determine the effectiveness of future educational interventions, as well as the possibility of broadening the sample size, and comparing the methodology employed with a professor-led methodology through a control group. Additionally, it must be kept in mind that the study has only been conducted with nursing students and in a single institution, which hinders generalization of the results. In spite of this, the results are favorable and invite to continue assessing the effectiveness of the intervention to improve learning of future professionals. Moreover, in spite of the significant improvement of skills and knowledge, the second round still detected shortcomings in carrying out the procedure and in the questionnaire of knowledge. It cannot be stated that this methodology is better than other professor-led methodologies, given that no comparison has been made, but it may be stated that the cooperative methodology is a valid methodology that has permitted improving knowledge and skills of students with statistically significant differences, and with their positive perception regarding that learnt and the interest awakened.

In conclusion, according to the results in this study, development of the educational intervention based on cooperative learning, specifically with the Aronson puzzle technique, improved in nursing students the hand disinfection technique and

related knowledge, which is why it is recommended to continue applying this methodology to impart knowledge on hand disinfection at Universitat Jaume I, while encouraging future research to solve the limitations posed.

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