Nurse Education in Practice 36 (2019) 13–19

Contents lists available at ScienceDirect

Nurse Education in Practice

journal homepage: www.elsevier.com/locate/nepr

Original research

Using emotion recognition to assess simulation-based learning

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ARTICLE INFO

Keywords:
Assessment
Education
Simulation
Emotions
Emotion classification

ABSTRACT

Simulation-based assessment relies on instruments that measure knowledge acquisition, satisfaction, confidence, and the motivation of students. However, the emotional aspects of assessment have not yet been fully explored in the literature. This dimension can provide a deeper understanding of the experience of learning in clinical simulations. In this study, a computer (software) model was employed to identify and classify emotions with the aim of assessing them, while creating a simulation scenario. A group of (twenty-four) students took part in a simulated nursing care scenario that included a patient suffering from ascites and respiratory distress syndrome followed by vomiting. The patient's facial expressions were recorded and then individually analyzed on the basis of six critical factors that were determined by the researchers in the simulation scenario: 1) student-patient communication, 2) dealing with the patient's complaint, 3) making a clinical assessment of the patient, 4) the vomiting episode, 5) nursing interventions, and 6) making a reassessment of the patient. The results showed that emotion recognition can be assessed by means of both dimensional (continuous models) and cognitive (discrete or categorical models) theories of emotion. With the aid of emotion recognition and classification through facial expressions, the researchers succeeded in analyzing the emotions of students during a simulated clinical learning activity. In the study, the participants mainly displayed a restricted affect during the simulation scenario, which involved negative feelings such as anger, fear, tension, and impatience, resulting from the difficulty of creating the scenario. This can help determine which areas the students were able to master and which caused them greater difficulty. The model employed for the recognition and analysis of facial expressions in this study is very comprehensive and paves the way for further use and a more detailed interpretation of its components.

1. Introduction

Simulation is a technique that consists of creating artificial situations that replicate the experience of real-life situations, with the goal of allowing students to understand and manage such situations in order to learn, practice, assess, test, or develop an understanding of human systems and behaviors. It is an important teaching and learning strategy, in which learners incorporate new concepts into prior knowledge and increasing of that knowledge (Clayton et al., 2016). During simulation, one can “learn how to learn” or “learn by doing”, overcoming mistakes and unlearning what is irrelevant when needed.

In professional health education, simulation allows for the development of psychomotor and communication skills and interaction between the cognitive and affective domains; it is also an effective form of cognitive and behavioral education. It is generally used for a variety of teaching and learning objectives, such as developing concepts and competencies, and acquiring technical, problem-solving, clinical reasoning, decision-making, teamwork, and conflict resolution skills (Jeffries, 2012; National Language National League for Nursing, 2013; Clayton et al., 2016; McRae et al., 2017).

In recent years, simulation has become an innovative alternative to nursing education, as it provides trainees with clinical experience that can benefit learning in a consistent, controlled and predictable learning environment. National League for Nursing (NLN) has adopted simulation as a pedagogical approach that is needed to prepare students for the demanding role of professional nursing (National League for Nursing and April 20, 2015). Moreover, it is able to provide valuable active learning experiences that include complex and specific scenarios

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https://doi.org/10.1016/j.nepr.2019.02.017
Received 8 March 2017; Received in revised form 18 July 2018; Accepted 18 February 2019

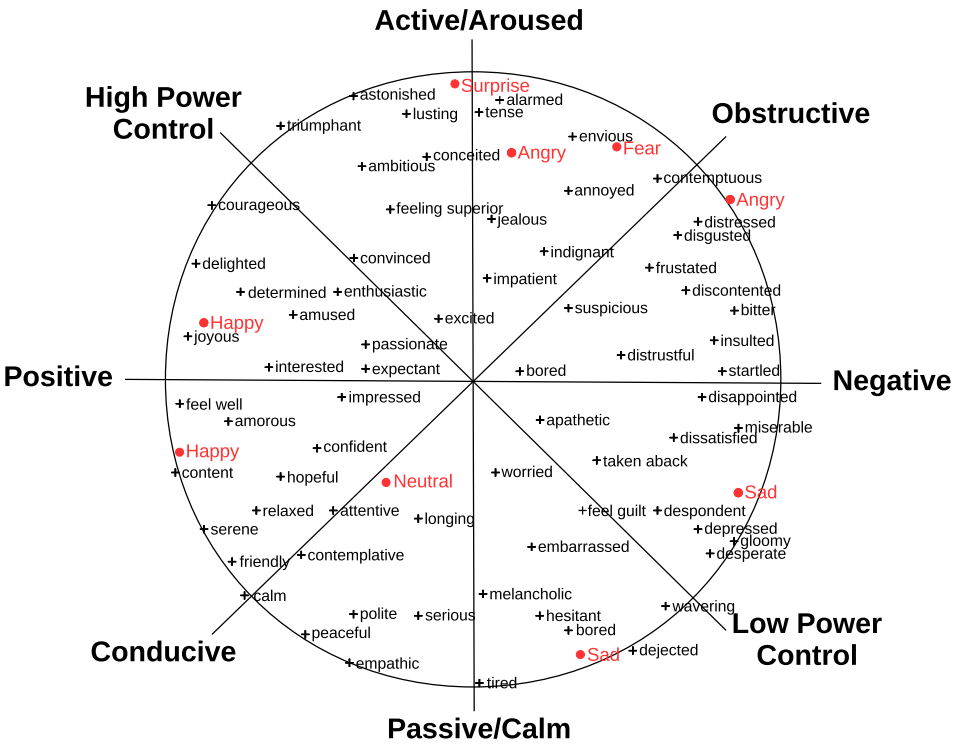

Fig. 1. Scherer's circumplex model (Scherer, 2005).

that cannot easily be obtained in the classroom. These allow the students to be trained to a high standard, while at the same time, reflecting on and discussing their failings, whenever possible, and learning how to avoid putting the patient's life at risk (Zapko et al., 2018).

In this teaching-learning method, several human and material resources can be used; coupled with the work of facilitators, this helps learners reach the proposed aims of the activity. For simulation to work, a fictional contract is established between facilitators and students so that they can understand and actively participate in the planned didactic process within simulation scenarios, as if they were happening with actual patients. Better fictional contracts result from the use of creativity to set up simulations and access to a wide range of technological resources. This method has been widely discussed, and when followed systematically, leads to positive results for learners and learning.

Assessment of simulation-based learning provides and respects the behavioral and cognitive performance of learners and identifies the effects of the simulation activity (Reed, 2010; McRae et al., 2017).

Properly executing an assessment process requires good activity planning. Adequate planning includes four phases: 1) preparing simulations and scripts; 2) personal development and orientation of students; 3) executing simulation scenarios; and 4) assessing simulations. The assessment of simulated activities must include all four phases, as well as learning objectives (Lioce et al., 2015).

Assessment of students who undergo simulated practice tends to emphasize student knowledge acquisition, satisfaction, confidence, and motivation, among other aspects. These dimensions are usually measured with scales that have been recommended and validated by several authors (Baptista et al., 2014; Almeida et al., 2015). Generally, these instruments are completed at the end of simulated practice. However, a majority of these instruments are considered subjective and can be influenced by variables such as: personal characteristics of facilitators and learners; general or personal complications during simulation scenarios; and even the availability of material and technological resources. A set of different assessment instruments tends to be used in order to minimize these difficulties, and to differentiate levels of knowledge and skill, gathering data on the progress of the activity, which helps correct distorted observations, fill in detected gaps, and reinforce correct assessment (Brazeal et al., 2016).

In general, assessment of simulation-based learning is complex, comprehensive, and multidimensional. It should seek to improve the execution of the skills required in the simulation scenario and correct errors, solve difficulties, and maintain satisfactory conditions and processes (dos Santos and Leite, 2010; Page-Cutrara, 2014). In a learning context as significant as simulation scenarios, assessment must take into account the prior knowledge and experience of learners and their personal characteristics, providing an ongoing reflection of performance analysis (Stevens et al., 2012; Nilsson and Lindström, 2017).

Assessment should contribute to improving comprehension and involve all the students' dimensions, mobilizing converging attributes. The purpose is to improve implicit knowledge, and assessment should be conducted continuously as part of a dynamic and ongoing educational training process (Marinho-Araujo and Rabelo, 2015). However, evaluations are usually isolated and are related only to the assessed facts, people, and phenomena. In this context, analysis of emotions can help expand the nature of simulation assessment. Exploring emotions can provide students and teachers with a different understanding of the process, focusing on defined learning objectives and creating action plans that can sustain the ensuing teaching and learning processes (Brazeal et al., 2016).

Emotions are subjective reactions to given environmental events, whether internal or external, and are characterized by physiological, cognitive, experiential, and behavioral changes that allow individuals to attribute meaning to their experience and prepare for given actions (Fonseca, 2016).

The aim of the present study was to assess the emotions of nursing students via a component related to motor expressions, specifically facial expressions, during high-fidelity clinical simulation.

1.1. Assessment of Emotions – theoretical framework

Several models of affect have been proposed throughout the history of affective science. Among these models, the two main branches of emotional modeling are the dimensional and cognitive theories of

emotion (Russell and Pratt, 1980). The first resulted in continuous models, while the second led to discrete or categorical models. Discrete models are concerned with grouping similar labels under the same emotional category, while continuous models seek to describe the relationship between such categories. One of the most widespread continuous models is the circumplex model of affect proposed by Scherer (2005) (Fig. 1), which states that all basic emotions can be placed somewhere on a bi-dimensional continuum. These axes are: "valence," corresponding to the type of emotion and representing how humans feel (horizontal axis – positive or negative), "arousal", which corresponds to the intensity of emotion and measures the propensity of an individual to act based on an emotional state (vertical axis – level of energy or arousal associated with emotion). Furthermore, there is "coping potential", which measures how much control an organism feels over a given event (main diagonal) and "goal attainment", which assesses the ease of reaching one or more goals (secondary diagonal).

Scherer (2005) defined emotional behavior as a dynamic process, not a stationary state. The following behavioral components are involved in this process: 1) relevance – determining the importance of an event and how it can affect the person involved; 2) implications – consequences of the event and how it affects one's goals; 3) Action potential – how an individual reacts to the event; and 4) normative significance – whether the event abides by the individual's social norms. For each component, Scherer (2005) defined intensity of emotional responses that varied as a function of expressed emotions. Emotional responses depend on individuals and how they assess events.

Among the discrete or categorical models, the most widespread is the model of affect proposed by Ekman and Oster (1979), who initially defined six basic emotions – anger, happiness, sadness, surprise, fear, and disgust – and a set of corresponding facial expressions. Later, contempt was added to the list. Ekman and Oster (1979) argued that these basic emotions are universally recognized and easily interpreted by observing specific facial expressions, regardless of the language or culture of the people involved in communication. This component of emotions implies that facial expressions change as a response to people's experiences. In this context, the face changes according to the level of arousal. Emotional responses can include a look of hatred, a frowning forehead, pressed lips or even a smile. All other emotional categories are constructed based on a combination of these basic emotions. Continuing in this direction, Mano et al. (2015) added a neutral state, a facial expression with no apparent emotion, using it as a reference point for detecting emotional states.

The main advantage of using a categorical model is that people tend to describe emotional demonstrations observed in their day-to-day life very similarly. Thus, these models facilitate the association of emotions with the facial expressions that represent them. According to earlier studies (Martinez and Du, 2012), humans identify emotions in different ways. In turn, discrete models require the definition of a finite number of emotions, not including all possible emotions that can be demonstrated during human interactions (Zeng et al., 2009).

The emotions analyzed in this study were based on the model proposed by Ekman (2006). Disgust, contempt, and neutral (baseline expression) were not included, as they are part of a more recent approach. The expressions investigated are presented in Fig. 2.

It is important to note that both representations of emotions have been used in several computer applications with good results (Scherer, 2005; Mano et al., 2015, 2016). The broad spectrum of applications and the constant increase in the capacity of computer processing have been motivating researchers to attempt to identify emotions and use this information in the analysis of decision-making, satisfaction, and task execution. In fact, classification procedures have contributed to the analysis of emotional responses, aiding in the diagnosis of depression and behavior changes, among other aspects, and also enabling the analysis of emotions in simulated environments.

2. Methodology

In a clinical simulation, it is possible to reproduce real-world practical scenarios that arouse feelings and emotions that are very close to those found in clinical practice and find the best strategy for reaching a satisfactory final outcome in the treatment of the patient. The purpose of this study is to evaluate emotional factors in patient care during clinical scenarios of varying complexity, through facial analysis.

In this sense, the present article describes a quantitative and descriptive study conducted with 24 regularly enrolled nursing undergraduate students from different schools, who were over the age of 18 and involved in a simulation scenario.

2.1. Study development

The present study was developed during a simulated workshop that took place at a Brazilian public university. The event was publicized online, on the web page of the institution where it was held. The central theme was "nursing care for hospitalized clinical patients." Enrollment was free of charge and all students received reading material on the topics covered at the event. During the workshop, students were invited to participate in the study and there were no refusals.

In the workshop, students took part in a high-fidelity clinical simulation using role play ("nursing care to patient presenting with ascites and respiratory distress followed by vomiting"). The scenario was constructed, tested and validated, achieving 100% consensus from a group of experts before its application. The students participated in groups of three. After completing the scenario, the students were debriefed and then answered a questionnaire providing personal data.

During the development of the scenario, video cameras were placed to record the student's faces for posterior analysis and determination of the emotions displayed. The analysis consisted of three steps (Mano et al., 2015):

1. Face detection: consists of automatically identifying the facial region. This process is influenced by head movements, lighting, and the presence of hair or glasses.
2. Extracting facial features: this step is based on geometric features. Methods based on such features are used in facial modeling (motor expressions) with the objective of developing an approach similar to how humans interpret facial elements. The program is fed different facial representations (happiness, fear, neutral, anger, surprise and sadness) to identify and classify emotions, and is capable of coding

Fig. 2. Basic emotions proposed by Ekman (Ekman, 2006), with the neutral expression.

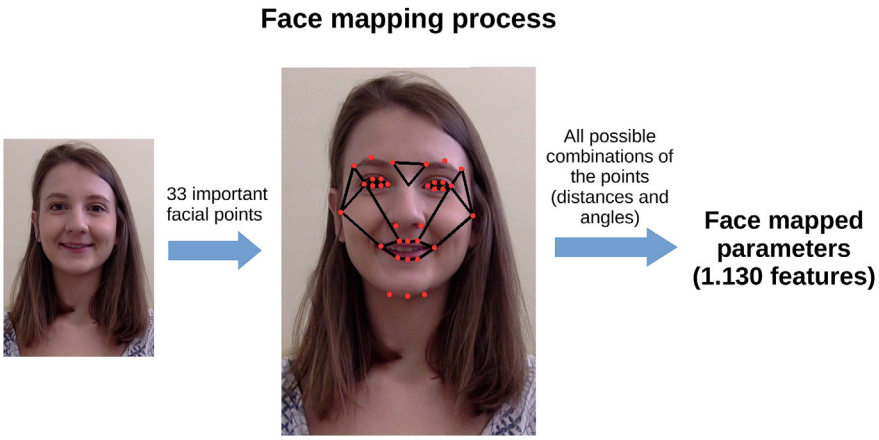

Fig. 3. Face mapping process by FaceTracker (Mano et al., 2015).

facial configurations of individuals (Tian et al., 2005). The researchers in the present study chose to use FaceTracker (Saragih et al., 2011). This software is a computer vision system that gathers facial information based on 33 mapped feature points: eight points around the mouth, six on each eye, three on each eyebrow and the chin, two on the nostrils and two outlining the lateral extremities of the face.

3. Classification: conducted using a set of algorithms based on machine learning and grounded in a facial reference model composed of 33 feature points. The algorithm seeks to align the analyzed facial elements with those in the reference model (Mano et al., 2015).

Fig. 3 presents an example of facial mapping conducted with FaceTracker.

2.2. Data processing and analysis

Participants were called "subjects" and numbered from 1 to 24. Each set of students was called a "Group" and numbered from 1 to 8. The facial images were analyzed individually at six critical points in the clinical simulation as identified by the researchers: 1) student-patient communication, 2) approaching the patient's complaint, 3) clinical assessment of the patient, 4) vomiting episode (distractor attributed to the scenario), 5) nursing intervention (oxygen therapy), and 6) reassessment of the patient.

Thus, through an examination of the facial expressions of the students obtained from the recordings of the simulated scenarios, it was possible to conduct an analysis of their emotional features and relate them to the emotional theory, as discussed in the "Assessment of Emotions" section (see Section 1.1). This division allowed the researchers to assess more latent emotions and the time spent on each area of the simulated scenario, by including emotional cues that can help the students and teachers to improve their learning in the clinical simulation.

2.3. Ethical procedures

The present study was submitted to and approved by Research Ethics Committee of the Ribeirao Preto School of Nursing under resolution no. 155/2013. The subjects signed the forms granting the researchers permission to use their personal information.

3. Results

Twenty-four nursing students participated, of whom 23 were female (95.8%) and 1 (4.2%) male. The mean age was 22.6 years, with a minimum age of 19 years, maximum of 25.4 years, and median of 22.9 years. Among these students, 2 (8.3%) were in their second year of the program, 10 (41.7%) in their third year, and 10 (41.7%) in their fourth year. All 24 (100%) had already participated in lab practices and 20 (83.3%) had already participated in simulation practices.

The researchers analyzed the emotions identified by the recognition software at the six previously identified critical points in the simulation. In all, 83,215 emotions were identified throughout the entire simulation scenario.

Fig. 4 illustrates these observations, and Table 1 presents the results as percentages.

Based on the analysis of the identified emotions, Fig. 5 shows the representation of the emotions identified in the scenario (Table 1) and their relation with the dimensional model of emotions – the circumplex model (Fig. 1). Moreover, Table 2 presents all of the values (%) for the emotions that emerged at the critical points distributed in their respective octants.

In Fig. 5, most of the emotions were concentrated in octant 1, except at point 3 (clinical assessment of patient), which was concentrated in octant 5. According to the circumplex model, it can be said that:

- At points 1, 2, 4, 5, and 6 of the proposed simulation scenario, the students exhibited emotions specifically associated with octant 1. These emotions represent negative valence, high arousal, mean coping potential and high level of goal obstruction. Thus, emotions such as anger, fear, tension, impatience, indignity, alarm, and jealousy, among others, are connected to the characteristics presented by this octant.
- At point 3, the students presented emotions associated with octant 5. These have positive valence, average-to-high passivity, mean coping potential, and high level of goal attainment. This octant includes emotions such as neutral, empathy, polite, nostalgic, and peaceful.

4. Discussion

Emotional factors play a decisive role in both the organic and social stage of each individual. In the process of teaching-learning, emotions play a key role in the construction of meanings and relating them to the interests and motivational factors of the students. During the simulated clinical scenarios and the circumstances that have to be faced, the students experience emotions and direct attention to by channeling their feelings, which puts them in an ideal position to respond to a particular situation.

When the emotions are analyzed, they can become an essential tool in handling the most wide-ranging situations. In addition, the analysis of emotions can enable both the teacher and the students to acquire the skills needed when undertaking an effective training course and assist

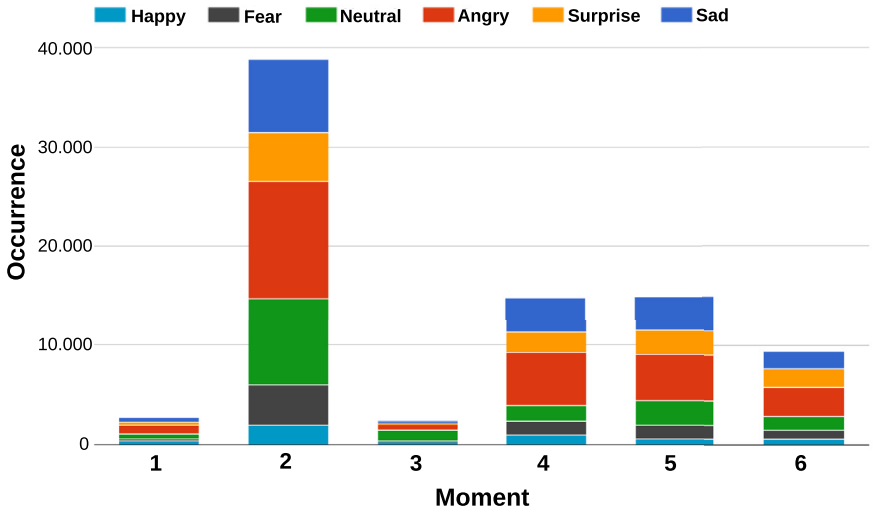

Fig. 4. Number of emotions identified by moments.

Table 1
Relationship of moments and emotions (%).

Moments	Emotions					
	Happy	Fear	Neutral	Angry	Surprise	Sad
1	15,62	4,42	20,41	**32,90**	8,66	17,98
2	5,08	10,37	22,46	**30,29**	12,66	19,15
3	11,60	4,03	**46,63**	22,82	4,53	10,39
4	6,61	9,58	10,48	**35,62**	13,82	23,90
5	4,16	9	16,50	**31,16**	16,35	22,83
6	6,45	9,27	14,73	**30,69**	19,81	19,04

Caption: 1 - student-patient communication, 2 - approaching the patient's complaint, 3 - clinical assessment of the patient, 4 - vomiting episode, 5 - nursing intervention, and 6 - reassessment of patient.

Table 2
Relation of emotions and the octants (%).

Octant	Moments					
	1	2	3	4	5	6
1	**37,32**	**40,66**	26,85	**45,20**	**40,16**	**39,97**
2	32,90	30,29	22,82	35,62	31,16	30,69
3	17,98	19,15	10,39	23,90	22,83	19,04
4	17,98	19,15	10,39	23,90	22,83	19,04
5	20,41	22,46	**46,63**	10,48	16,50	14,73
6	15,62	5,08	11,60	6,61	4,16	6,45
7	15,62	5,08	11,60	6,61	4,16	6,45
8	8,66	12,66	4,53	13,82	16,35	19,81

Caption 1: Moments: 1 - student-patient communication, 2 - approaching the patient's complaint, 3 - clinical assessment of the patient, 4 - vomiting episode, 5 - nursing intervention, and 6 - reassessment of patient.
Caption 2: Octant: 1 - Emotions related to anger and fear, 2 - Emotions related to anger, 3 - Emotions related to sadness, 4 - Emotions related to sadness, 5 - Emotions related to neutral, 6 - Emotions related to happiness, 7 - Emotions related to happiness, and 8 - Emotions related to surprise.

them in providing the necessary care for patients in the future, by ensuring they are given effective and contextualized learning.

Emotions are part of all human experience; therefore, studying and understanding this component of human life is essential to guide decisions and relationships. Facilitators who want to conduct meaningful teaching and learning processes that involve learners must have an understanding of the emotional factors involved (Zhou et al., 2011; Fonseca, 2016).

In the present study, the analysis of the emotions experienced by the students during the high-fidelity simulation scenario showed the presence of various feelings throughout the activity practice, some positive, some negative, and others neutral. These emotions may or may not be intimately related to the learning process, but they must be taken into account in the students' final performance.

High-fidelity simulations involve clinical reasoning, decision-making, and the integration of the scenario and the resources it

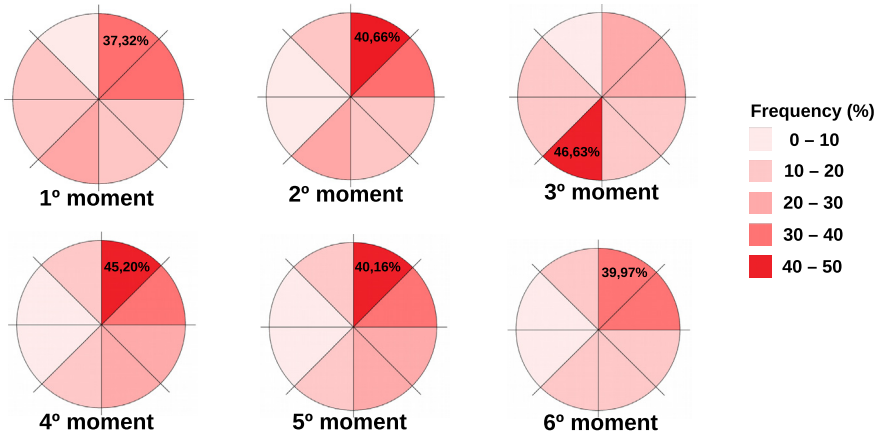

Fig. 5. Frequency of emotion per quadrant.

contains. The more realistic the scenario, and the clearer the information made available to learners, the greater the possibility of success and reaching the learning objectives (Baptista et al., 2014). When preparing a scenario, facilitators must provide students with objective information about the clinical data to be worked on and provide resources for problem solving. Similar to what occurs in actual clinical practice, simulations conducted with quality fictional contracts present high levels of veracity and different phases of interaction with the simulated patient and simulator. Also, the outcome of the activity can cause different reactions that can interfere positively or negatively, according to students' stress levels.

Thus, detailed analysis of the simulation process can help, not only in professional training, but also in minimizing errors that could occur with actual patients. According to the data found in the present study, at six critical points, the students manifested different feelings, which were highlighted by the significant length of time spent on the activity at point 2 (approaching the patient's complaint) and the short length of time spent at point 3 (clinical assessment of patient), as shown in Fig. 4. The footage showed that the students did not expect the patient's complaint of dyspnea to worsen (point 2) and were very insecure about proper conduct. At the clinical assessment of the patient (point 3), they performed a brief physical exam focused on the thoracic cavity; however, they soon realized they had to take some form of action.

Approaching patient complaints and interacting with patients are the starting points for diagnosing the situation. This depends on effectively gathering data via the patient's medical history and physical exam for decision making, with greater likelihood of correctly diagnosing the patient and selecting the proper treatment. Most of the emotions experienced at this point were classified as anger. In the model proposed by Scherer (2005), anger is not a restricted affect, but rather indicates negative valence, with high goal attainment, average coping potential and high level of goal obstruction. The video footage clearly showed the students' hesitation about the diagnosis and therapeutic conduct. Controlled levels of stress aid in the teaching and learning process and induce accurate cognitive processes (Schwabe et al., 2012; Valentin et al., 2015). However, students who are not well primed on the theoretical content or have not received proper practical training can present goal obstruction. The neutral state showed at point 3 (clinical assessment of patient) is related to emotions such as empathy, peace, patience, and tranquility, all associated with positive valence, average-to-high level of passivity, average coping potential and high level of goal attainment (Scherer, 2005), which can be considered highly adequate in clinical assessment processes, which are more common daily situations in nursing practice. However, in light of its importance in solving clinical cases, significant time is required to collect data, which was not what occurred in this sample when students were faced with the patient's worsening condition.

Fig. 5 and Table 2 show that during the entire scenario (at the six critical points assessed), the students presented emotions mainly related to octant 1, except at point 3, associated with octant 5. Octant 1 includes emotions such as anger, fear, tension, and impatience, related to negative feelings expressed by the difficulty of completing the scenario, while octant 5 indicates more indifferent feelings, expressing a brief time in the scenario when students had more control over the situation.

Furthermore, Fig. 5 and Table 2 show that addition of an element of surprise (distractor) to the scenario (point 4 – complication – vomiting) can function as an adverse aspect, altering already structured thinking and readapting clinical reasoning. Unexpected situations are not always comfortable to cope with, but when they occur, they help learners restructure and reanalyze situations. This represents a positive component in the development of critical thinking and decision-making skills, which favors learning (Cant and Cooper, 2011; Mariani et al., 2013).

It is also worth noting that fewer representations and lower values of emotions found were concentrated in octants 6 and 7. These octants represent feelings associated with positive valence, average arousal level, high coping potential and high level of goal attainment, such as happiness, determination, interest, courage, and serenity. This represents greater cognitive and attitude mastery in facing the simulated scenario; however, this was not the case in the present study.

These findings indicate that the simulated scenario was more associated with negative and arousing emotions (Schwabe et al., 2012; Valentin et al., 2015) than casual activities. Such negative emotions can also emerge during the practice of health professionals in an improper manner. However, it is important to control the level of negativity of situations so that they do not cause emotional instability. Excess imbalance can lead to an inability to cope with situations; depending on the normative meaning (whether the situation abides by the individual's social norms) described by Scherer (2005), this can lead to emotional exhaustion, depersonalization and burnout syndrome.

Simulation can be used both as a learning method and an assessment tool. Students' performance is usually measured using standardized checklists, whose items they either meet or do not meet. For the most part, these items consist of the communication, psychomotor and decision-making skills that students need to demonstrate in order to receive positive scores.

When simulation is used as a learning method, debriefing techniques are used to discuss how students felt during the scenarios; they self-report both the positive aspects and flaws in their professional performance. When simulations are used as a form of assessment, quantitative measurements determine whether students passed or failed. Emotion recognition can be used for both learning and assessment purposes as part of debriefings. The information provided by this technology can help identify points of greater difficulty or mastery, which can be compared with the analysis of the students' self-assessment. It can also be used to assess coping potential when facing the regular situations and distractions planned in simulations.

A limitation of the present study is that the movement of students during the scenario sometimes hindered the extraction of facial expressions, which resulted in the loss of some data.

5. Conclusion

It is essential to take emotions into account in the teaching and learning process. However, it is extremely difficult to appraise emotions reliably, since they are subject to several factors that complicate unbiased analysis by teachers in their relationships with students.

By using emotion recognition and classification through facial expressions, the researchers were successful in analyzing the emotions of students during a simulated clinical learning activity. This suggests that this approach can be used in simulation-based teaching and assessment. This was the first study of its kind to conduct an assessment of facial expressions in simulated scenarios.

The students demonstrated a predominance of restricted affect while completing the simulated scenario. Further research is needed to assess to what extent this process is or is not beneficial to learners. Also, facilitators should consider these results when creating and developing scenarios. The critical points of the activity must be well-defined so that data analysis and comprehension allows for reaching the research objectives.

The model of facial expression recognition and analysis used in the present study is highly comprehensive and paves the way for other uses and more specific interpretations of its components.

Conflicts of interest

None.

Funding

This work was supported by the Sao Paulo Research Foundation - FAPESP [process ID 2016/04261–1, 2015/21642–6 and 2016/14267–7].

Acknowledgements

To the São Paulo Research Foundation - FAPESP for the funding received during the research period.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nepr.2019.02.017.

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