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High fidelity, low cost moulage as a valid simulation tool to improve burns education

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ABSTRACT

Simulation allows the opportunity for repeated practice in controlled, safe conditions. Moulage uses materials such as makeup to simulate clinical presentations. Moulage fidelity can be assessed by face validity (realism) and content validity (appropriateness). The aim of this project is to compare the fidelity of professional moulage to non-professional moulage in the context of a burns management course.

Four actors were randomly assigned to a professional make-up artist or a course faculty member for moulage preparation such that two actors were in each group. Participants completed the actor-based burn management scenarios and answered a ten-question Likert-scale questionnaire on face and content validity. Mean scores and a linear mixed effects model were used to compare professional and non-professional moulage. Cronbach's alpha assessed internal consistency.

Twenty participants experienced three out of four scenarios and at the end of the course completed a total of 60 questionnaires. Professional moulage had higher average ratings for face (4.30 v 3.80; $p = 0.11$) and content (4.30 v 4.00; $p = 0.06$) validity. Internal consistency of face ($\alpha = 0.91$) and content ($\alpha = 0.85$) validity questions was very good.

The fidelity of professionally prepared moulage, as assessed by content validity, was higher than non-professionally prepared moulage. We have shown that using professional techniques and low cost materials we can prepare quality high fidelity moulage simulations.

1. Introduction

Simulation has been used in medical training for over 50 years [1] and allows the opportunity for repeated practice in controlled and safe conditions [2]. It involves creating a replica of the desired situation [3] and in surgical training can be used to mimic real patient interactions by substituting real patients with standardised patients (trained lay people, actors or real patients), virtual (computer-based) patients or electronic manikins [4]. These substitutes are referred to as simulators and the environment created for them to be used for training is known as simulation [5]. Simulation can be used to realistically replicate clinical situations and has been used to improve communication skills, team training, technical skills and management of low frequency, high acuity

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situations [6]. Simulation has become widely recognised and accepted as an training modality and the British Chief Medical Officer has highlighted the importance of incorporating simulation into surgical speciality training [7].

The controlled and safe environment of simulation allows training to be specifically tailored to the trainee's needs whilst always ensuring patient safety [8]. Equipment and other resources can also be re-used or expended as required, which acts to limit waste and optimise cost efficiency. Visibility can be adjusted to draw interest to some areas of the situation or away from others, while situations can be sped up, slowed down or paused as required. This encourages trainees and faculty to focus on areas important to the training aims and allows for strict time control [4].

By withdrawing the potential consequences of practice on patients, trainees have the opportunity to make errors and learn from their mistakes. These skills are transferrable into a clinical setting [9] and there is evidence that following simulation training in laparoscopy, trainees can obtain similar results to expert surgeons [10].

Despite its benefits, good simulation can be cost and resource intensive. Costs are broadly categorised in an economic sense into those associated with research and development, initial investment and maintenance [11]. Research and development and initial investment costs are already committed to established training programmes [4] but maintenance costs can be reduced by using low cost materials and methods, thereby lowering the overall cost of the simulation.

Although low-cost simulation is highly desirable, it can only be successful if it is realistic enough to allow the trainee to be immersed into the environment. Fidelity describes the extent to which the appearance and behaviour of the simulation matches the appearance and behaviour of the simulated system [3]. High fidelity simulations are associated with fewer interventions by the trainer during the simulation and a reduced mental strain experienced by participants [12]. However, high fidelity simulations typically come at a premium cost and with increasing economic demands being placed on ever shrinking hospital budgets, there is now more pressure than ever to produce low-cost, high fidelity simulations [13,14].

Various educational courses utilise simulated scenarios with actors to teach emergency skills in the context of resuscitation, trauma or burns, such as the Advanced Life Support (ALS), Advanced Burn Life Support (ABLS) and Emergency Management of Severe Burns (EMSB) courses.

Moulage is a technique that uses makeup and other materials to simulate injuries to a standardised patient or an inanimate mannequin [15]. Previous studies have demonstrated the successful utilisation of simulation in burn care education, such as in ''The Burns Suite'' project,[5] and moulage techniques have been demonstrated on mannequins such as ''Burnie'' in simulations [16,17]. However, there is no evidence in the literature regarding whether moulage techniques actually increase the fidelity of burns training simulations and whether they have a higher fidelity when specialist techniques are used. There have also not been any studies investigating the use of moulage techniques in standardised patients.

When evaluating the fidelity of a simulation, face and content validity need to be assessed [18]. Content validity is present when the content of a simulation is appropriate for the desired training objective; face validity is present when the simulation is sufficiently realistic to convey a sense of 'presence' to the user. Customised questionnaires have been used to evaluate the fidelity of simulations in laparoscopy [19–21], robotic surgery [22], laryngoscopy [23] and burns surgery [5].

The primary aim of this research is to examine the face and content validity of professional moulage techniques prepared by a trained professional compared to a non-professionally trained course co-ordinator in the context of a burns management course. We will also attempt to examine the impact of the level of fidelity of moulage using standardised patients on trainee educational experience. Finally, we will attempt to illustrate some low-cost professional moulage techniques that can be used in simulation.

2. Methods

2.1. The course

This project was conducted in the context of a burns management course that utilises actor-based moulage simulation scenarios. It is a one-day course of lectures and small group practical sessions where trainees are educated on the principles of emergency burn management. In order to pass the course, trainees must pass a written exam and a clinical simulation, consisting of standardised patients presenting as burns victims.

2.2. Standardised patients and moulage

Four standardised patients were recruited by word of mouth and were predominantly medical students known to the faculty. Each actor was informed of the study and written consent obtained for participation and publication of audio-visual material. The course supervisor selected four scenarios that were distributed to the standardised patients detailing their background and details of the burn injury sustained. The four selected scenarios were as follows:

- Scenario 1: A Fisherman gets caught in an explosion
- Scenario 2: A drug dealer sustains a flame injury from his lab
- Scenario 3: A pregnant lady suffers a scald burn from a hot kettle
- Scenario 4: A golfer gets struck by lightning

Once the standardised patients had been given their scenarios, they were assigned randomly to either a professional make-up artist or a course faculty member for moulage preparation such that two were in each group. Scenarios 1 and 2 were allocated to the professional make-up artist and 3 and 4 to the course co-ordinator. The make up artist was a trained professional with forty years experience providing make-up in the film industry and for medical simulation. The course co-ordinator had no formal training but had experience in preparation of moulage simulations at previous burns

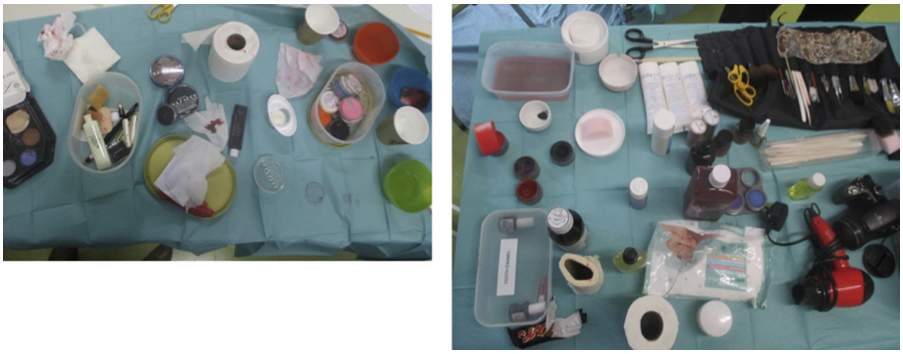

Figure 1 – Moulage equipment.
Some of the equipment available for the make-up artist (right) and course co-ordinator (above).

management courses. The make-up artist simulated burn injuries using make-up techniques and material similar to those described by Swan et al. [16], whereas the course co-ordinator used basic equipment such as face paints and toilet paper (Fig. 1). The make-up artist and the course co-ordinator were free to use any of their practised techniques to create wounds, blisters and eschars (Figs. 2, 3 and 4).

The equipment required by the make-up artist is readily available online or at most fancy dress shops and include face paints, petroleum jelly, moisturising cream, toilet paper, artificial blood, powered charcoal, latex solution and sponges. (Fig. 1) For added realism, Dermawax (Grimas, Holland) was used. This is a substance originally created by Sir Archibald McIndoe for scar contouring but is now more commonly used in combination with artificial blood to create ''wounds''. Glatzan (Kryolan, UK) is a vinyl plastic solution typically used in the home manufacture of bald caps but was used in this study to simulate eschars.

To begin with, the make-up artist used white face paint in modest quantities to provide the appearance of shock and blue face paint around the lips to simulate cyanosis. Where appropriate, yellow face paint was used to demonstrate bruising and powdered charcoal as soot. Superficial burns to the epidermis were created by gently applying red face paint with a sponge to the required area. This was also used to create a base layer for deeper burns.

For superficial dermal burns, blisters were created by applying a piece of 1-ply toilet paper over a small ''olive'' of petroleum jelly and gently covering with latex solution. A barrier such as a moisturising cream is recommended in case of allergies. Once the latex solution dried, with the help of a hairdryer if required, it acted to stabilise the ''blister'' and adhere it to the skin. Red and black face paint and powdered charcoal were then applied and small holes could be made in the latex with a blunt tool and filled with artificial blood. The ''blisters'' were able to tolerate movement of the ''patient'' but

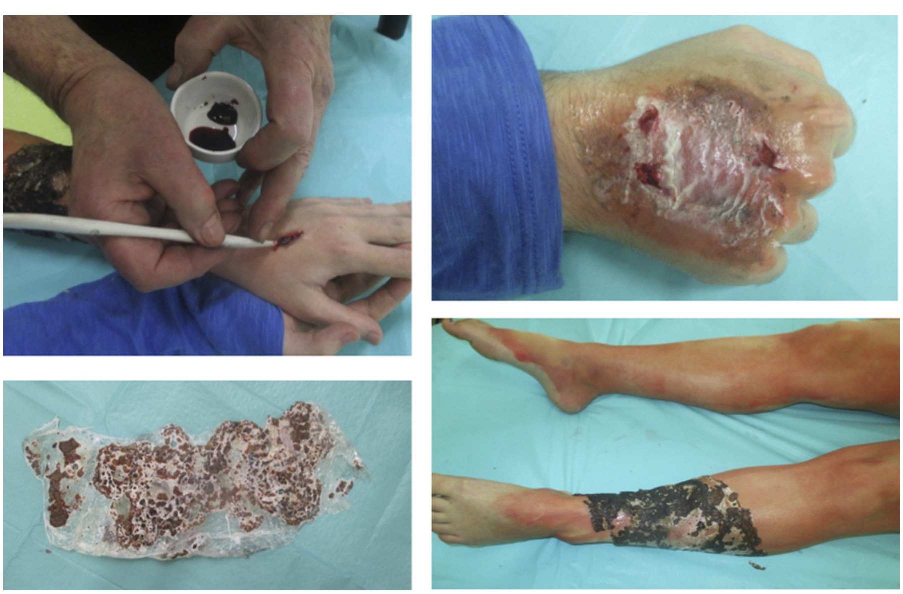

Figure 2 – Professional techniques.
Examples of professional techniques used by the make up artist to produce wounds (top left), blisters (top right) and eschar (bottom).

Figure 3 – Existing techniques.
Examples of existing techniques used by the course co-ordinator to create superficial burns and base layer (top left), blisters (bottom left) and full thickness burns (right).

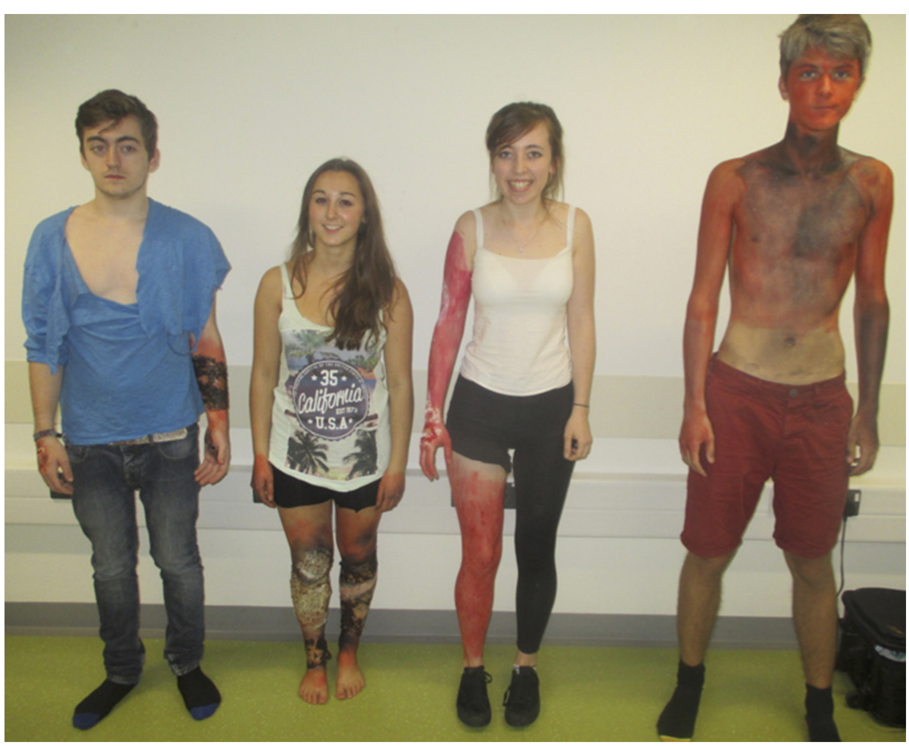

Figure 4 – The finished moulages.
From left to right: Fisherman, drug dealer, pregnant lady and golfer.

Table 1 – Questions asked of participants to assess validity of the moulage.

Face Validity	Content Validity
1. This simulation was a realistic representation of a burn	6. The simulation compares favorably with other simulation experiences I have had
2. The burns victim used was a realistic representation of a burn	7. This simulation would offer a good learning opportunity for training and assessment of burns management
3. The burns victim looked similar to a real burns victim	8. The appearance of the victim contributed positively to the training experience
4. The appearance of the actor made me feel like I was in a real burn situation	9. The use of an actor instead of a mannequin in the simulation was useful
5. It was easy to treat the actor as a burns victim	10. The use of simulated burn injuries in the scenario was useful

if mistreated would burst and the petroleum jelly, liquid due to the heat of the skin, would ooze out.

Glatzan (Kryolan, UK) is a highly flammable liquid plastic that floats on water, which makes it ideal to ''create'' full thickness eschars (Fig. 2). A flameproof container is half filled with water and then the plastic is poured over the water and set alight. It will burn readily and all precautions must be taken. Leave it to extinguish by itself and once cooled you will have a charred, malleable plastic that can be easily applied to the skin using spirit gum. Face-paint and charcoal is then applied to blend the ''eschar'' into the surrounding skin. Dermawax (Grimas, Holland) was applied in small amounts to create wounds. Using a blunt instrument, indents were made in the wax and artificial blood applied.

The course co-ordinator was limited to the equipment and moulage strategies that had previously been provided on the course. Red face paint was applied liberally for superficial burns and as a base coat. Superficial dermal blisters were also created using the toilet paper method but latex solution was not used. Instead, face-paint and make up was applied directly to the toilet paper to blend it into the surrounding area. To provide the appearance of full thickness eschar, black and yellow face paint was used. Black powder make-up was used around the mouth and nose to simulate inhalational injuries (Fig. 3).

2.3. Participants and simulation

Twenty participants attended the course. All were briefed on the study and written consent was obtained for their involvement. All data collection was anonymous. Participants were blinded to the simulation scenarios and were not aware who prepared the scenarios. They moved around the simulation circuit in groups of three, with one group of two, and saw three out of four possible simulated burn victims. On entering the simulation environment, participants were given a brief history of the nature of the injury and were then asked to assess and manage the standardised patient. The participants were asked to treat the patient as if they would in a ''real-life'' situation with the understanding that they were not required to perform invasive procedures such as intravenous cannulation or intubation.

2.4. Face and content validity

A ten-question Likert-scale questionnaire was specifically designed to assess the validity of each simulation (5 questions for face validity; 5 questions for content validity)R Core Te. The face validity questions asked whether participants thought the moulage was realistic and how easy it was to treat the standardised patient as a real burns victim (Table 1). The content validity questions assessed whether participants thought the simulation was a good learning opportunity, how the appearance of the ''victim'' contributed to this and how the simulation compared to other experiences (Table 1). Each of the twenty participants received three questionnaires corresponding to each of the three scenarios they encountered. Therefore 15 questionnaires were completed for each of the four scenarios. Since the course was assessed, it was required that questionnaires were filled out at the end of the day so that the participants were not interrupted during the course. Since the moulage scenarios were the final part of the day, and participants were examined separately, there was no opportunity for discussion.

2.5. Data analysis

The participants' responses to each scenario were scored on the Likert scale (1: Strongly Disagree to 5: Strongly agree). A linear mixed effects model with group fitted as a fixed effect and scenario as a random effect was used to compare ratings between the professional make-up artist and the course co-ordinator. This analysis was performed using R (v 3.2.2) [24] using the following packages: reshape [25], nlme [26], and lsmeans [27].

The ideal analysis of this study would have additionally included participant as a fixed effect in the model to account for the fact that participants filled in three questionnaires and therefore observations from any given participant are more correlated to each other, than observations from another participant. However, since the questionnaires were anonymised, the necessary data doesn't exist. As a result, a pragmatic approach has been taken and the data analysed as described above. Scenario was fitted as a random effect to account for the fact that some of the observations for each group relate to one scenario and some to the other.

Cronbach's alpha was used to measure internal consistency of face and validity questions [28]. This was performed using Microsoft Excel (Microsoft, USA).

3. Results

Twenty participants experienced three out of the four available moulages. In total sixty questionnaires were distributed and all were completed. Therefore, fifteen questionnaires

Table 2 – Mean (and CI) validation ratings scored on 5 point Likert scale.

	Professional (n = 2)	Novice (n = 2)
Face Validity	4.26 (3.70,4.82)	3.75 (3.34,4,17)
1. This simulation was a realistic representation of a burn	4.37 (3.73,5.00)	3.90 (3.43,4.37)
2. The burns victim used was a realistic representation of a burn	4.30 (3.65, 4.95)	3.73 (3.25,4.22)
3. The burns victim looked similar to a real burns victim	4.23 (3.11,5.35)	3.70 (2.87,4.53)
4. The appearance of the actor made me feel like I was in a real burn situation	4.20 (3.55,4.85)	3.63 (3.50,4.11)
5. It was easy to treat the actor as a burns victim	4.20 (3.68,4.72)	3.80 (3.41,4.19)
Content Validity	4.34 (4.09,4.59)	4.01 (3.83,4.20)
6. The simulation compares favorably with other simulation experiences I have had	4.13 (3.32,4.95)	3.70 (3.10,4.30)
7. This simulation would offer a good learning opportunity for training and assessment of burns management	4.23 (3.60,4.87)	3.80 (3.33,4.27)
8. The appearance of the victim contributed positively to the training experience	4.33 (3.89,4.78)	4.07 (3.74,4.40)
9. The use of an actor instead of a mannequin in the simulation was useful	4.53 (4.04,5.03)	4.27 (3.90,4.64)
10. The use of simulated burn injuries in the scenario was useful	4.47 (3.97,4.96)	4.23 (3.87,4.60)

were completed for each scenario, thirty each for professional and non-professional moulage. For the professional scenarios, mean face and content validity ratings were 4.30 (95% CI = (3.70, 4.82)) and 4.30 (95% CI = (4.09, 4.59))respectively. For the non-professional scenarios, mean face and content validity ratings were 3.80 (95% CI = (3.34, 4.17)) and 4.00 (95% CI = (3.83, 4.20)) respectively. The ratings for the professional moulage techniques were higher on average for face validity (p = 0.11).and for content validity (p = 0.06) although this was not statistically significant.

All five of the face validity questions had a higher rating in the professional group compared to the non-professional group although this was not statistically significant. The realism of the simulation and the ''burns victim'' was rated at 0.5/5 and 0.6/5 points higher respectively, and the similarity of the actor to the real patient was 0.5/5 higher. The immersion of the scenario was higher in the professional group with better ratings for feeling like they were in a burn situation and ease of treating the actor like a victim, an improvement of 0.6/5 and 0.5/5 respectively.

Similarly, each question on content validity had a higher, but statistically non-significant, average rating for the professional group. The professional simulation compared more favourably with the participant's other simulation experiences (0.4/5 point improvement compared to non-professional simulation) and participants felt that it offered a better learning opportunity for training and assessment of burns management (0.4/5 point improvement).

The highest ratings in both the professional and non-professional group were for the actor being better than a mannequin (4.5 and 4.3 respectively), as compared with the participants' previous experiences with mannequin-based simulations, and for the usefulness of the simulation (4.5 and 4.2 respectively). The breakdown for each question is available in Tables 2 and 3. The internal consistency of the face and content validity questions was very good (Cronbach's alpha coefficient 0.91 and 0.85 respectively).

4. Discussion

As shown from the results of this project, the face and content validity of professional moulage techniques is higher than existing non-professional techniques. However, both methods of moulage were shown to have high validity in the setting of a burns management course. Participants felt that the use of both professional and non-professional moulage to simulate burn injuries contributed positively to the training experience and was very useful in the scenarios.

Table 3 – Mean and SD of the 4 individual moulage subjects.

	Professional				Non-Professional			
	Drug dealer		Fisherman		Golfer		Pregnant Lady	
Question	Mean	S.d.	Mean	S.d.	Mean	S.d.	Mean	S.d.
Face	4.23	0.58	4.29	0.61	3.93	0.74	3.57	1.04
1	4.47	0.64	4.27	0.70	4.00	0.65	3.80	1.15
2	4.27	0.59	4.33	0.62	3.87	0.83	3.60	1.18
3	4.20	0.56	4.27	0.70	4.07	0.80	3.33	1.11
4	4.07	0.59	4.33	0.62	3.80	0.68	3.47	0.99
5	4.13	0.52	4.27	0.46	3.93	0.80	3.67	0.82
Content	4.29	0.56	4.39	0.59	4.08	0.82	3.95	0.80
6	4.00	0.65	4.27	0.59	3.93	0.80	3.47	0.92
7	4.20	0.56	4.27	0.80	3.80	0.94	3.80	0.94
8	4.33	0.49	4.33	0.49	4.13	0.64	4.00	0.65
9	4.47	0.52	4.60	0.51	4.27	0.88	4.27	0.59
10	4.47	0.52	4.47	0.52	4.27	0.80	4.20	0.68

Due to the nature of the study having only 4 subjects, and therefore a low statistical power, the results obtained were not statistically significant at the 95% confidence level. However, despite this low power, there are still higher ratings for professional moulage when comparing the results of all 10 validity questions. Combined with a p-value closely approximating significance at 0.06, this suggests that professional moulage techniques are beneficial to participants in the context of a burns management course.

The professional moulage received very high ratings and the perceived reality of the simulation and the burns victim really encouraged participants to feel engaged in the scenario. This supports published work by Sadideen [5] and Yaeger [29] that claims high fidelity simulation encourages trainees to suspend their disbelief and become immersed in hands-on scenarios. Standardised patients are able to comply with instructions and respond to stimuli and this encourages participants to interact with the simulated patient and ignore the examiner. Actors' real breath sounds, heart sounds and pupil reactions all help to draw the participant into the scenario and the high fidelity moulage made the extent and depth of the burn injury apparent. Standardised patients show great similarities to real patients and provide a holistic experience allowing participants to find it easy to treat them as burn victims.

The general opinion amongst participants was that standardised patients were more useful in simulation than mannequins. This was noted, regardless of whether the simulated patient had professional or non-professional moulage applied. Although we have not looked at simulation with mannequins in our study, work done by Grice et al shows that trainees are less satisfied with mannequins and feel they would learn better in simulation involving standardised patients [30]. However, Grice does highlight that there was no difference in trainee's performance whether using mannequins or standardised patients.

In this study, we have focused on a burns management course that begins with lectures and small group practical sessions to teach participants. The knowledge and skills learnt are then formally examined using simulation. A multinational randomised study performed by Li et al looked at simulation performance with or without preceding didactic style lectures and found that participants performed better in the simulation if they had the preceding lectures [31]. These findings have also been shown in burns simulation. Sadideen found that participants undertaking a burn management simulation agreed that low-fidelity simulation, small group teaching and didactic style lectures should be used to teach important technical skills such as Total Body Surface Area assessment and knowledge such as nationally accepted guidelines and fluid resuscitation protocols before the formal simulation assessment [5]. Both studies highlight the importance of consolidating these skills in the simulation setting by allowing practice in a safe and controlled environment. Our study supports the usefulness of this with participants feeling the simulation offered a good learning opportunity that compared favourably to previous experience. The purpose of this study, though, was not to assess the didactic material or educational outcomes of the course but to compare the fidelity of professional versus non-professional moulage.

In these scenarios, participants were being formally assessed and therefore it may have been in their best interests to allow themselves to become immersed in the scenario in order to treat the standardised patient as a real burn victim. This could have led to falsely high feelings of realism. However, in previous studies [5], participants from EMSB and ABLS courses have felt that assessors often hover around the room and their constant presence often distracts from the realism. It is therefore unlikely that the artificially high pressure on the outcome of the examination has had a significant effect on the validity ratings.

Although the study is limited in terms of number of subjects and participants and having purely quantitative results, rather than qualitative feedback from participants which could have provided a deeper understanding of the participants' experience of the simulation, it shows that professional moulage techniques have superior results when it comes to face and content validity, which significantly enhances the realism of simulation. The techniques used by our expert can be easily translated to others in education by means of an ''instructing the instructor'' course or ''moulage manual''. This would allow the demonstrable benefits of professional moulage to improve the fidelity of simulation-based courses such as EMSB, ALS and ABLS as well as other simulations, such as in a distributed simulation environment [5].

Moulage as a concept is extremely versatile and offers many opportunities within medical training. It has already been used in head and neck surgery [32], critical care [33] and dermatology [34,35]. Educational courses based on simulation scenarios using moulage have become very popular in modern surgical training. However, current moulage techniques used in simulation scenarios such as those at ABLS and EMSB courses pay minimum attention to realism. The techniques described here are very cheap methods of providing high-fidelity moulage that can achieve a more realistic representation of a burn injury, thereby increasing the immersion in these simulated scenarios. Modifications of the techniques described here could be used as low-cost simulations of other trauma injuries, such as wounds and open fractures. On a smaller scale, moulage could be used to add pallor, jaundice or altered pigmentation in medical and intensive care simulations. Elements of moulage can be used in almost any simulation-based teaching to improve face and content validity.

Moulage in simulation-based training offers a lot of research possibilities. It is a relatively new concept and although a few moulage models have been discussed in the literature, there is limited evidence of the validity of using moulage as a simulation tool. In fact, one study by Lee et al suggests that moulage in standardised patients leads to inferior participant assessment scores compared with an electronic mannequin [36]. Despite this, moulage continues to be researched as a low-cost high-fidelity alternative to mannequins and we continue to use it in simulation scenarios on international courses such as ABLS and EMSB. Our study shows that moulage has very good face and content validity, but there is great need for more research to be done into comparing moulage to other methods of simulation, such as electronic mannequins, ideally looking at validity, cost and translation into practice.

5. Conclusions

This is the first published study to assess the face and content validity of moulage in actor-based simulation. We also assessed the validity of our new moulage techniques prepared by a trained professional compared to existing techniques used by a non-professional course faculty in the context of a burns management course. We have shown that high quality moulage plays an important role in encouraging trainees to suspend disbelief and treat standardised patients as real burns victims. The simple moulage techniques demonstrated here have shown superior validity compared with existing non-professional techniques. These techniques use low cost materials and can be easily taught to faculty through an instructor's course or manual to provide low cost, high fidelity simulation that can be easily translated into other fields of medicine.

Conflict of Interests

The authors have no conflict of interests.

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