LIVE. DIE. REPEAT: a novel instructional method incorporating recursive objective-based gameplay in an emergency medicine simulation curriculum

Kharmene Sunga,[1] Benjamin Sandefur,[1] Usha Asirvatham,[2] Daniel Cabrera[1]

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[1]Department of Emergency Medicine, Mayo Clinic, Rochester, Minnesota, USA
[2]Mayo Clinic Multidisciplinary Simulation Center, Rochester, Minnesota, USA

Correspondence to
Dr Kharmene Sunga, Department of Emergency Medicine, Mayo Clinic, 200 1st St SW, Rochester, MN 55905, USA; Sunga.Kharmene@mayo.edu

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BACKGROUND

Medical educators must develop instructional methods suiting the learning styles of their students. Simulation-based curriculums are popular among resident physicians, and have been shown to improve information recall and diagnostic abilities, and to sustain proficiency of procedural skills.[1] The gamification of learning, a mechanism that engages students by integrating serious-game elements into the educational environment, has recently been explored.[2] At our emergency medicine residency, we aimed to create a hybrid of the two models that would profit from each method's individual strengths.

Recursive objective-based gameplay (ROBG) is a serious-game scheme in which participants are allowed infinite *lives* so that they can achieve predetermined criteria for progression through multiple levels of increasing difficulty. The concept resembles time loops, a plot device used in the film *Edge of Tomorrow* (Warner Bros Pictures 2014). We named our simulation/ROBG hybrid instructional method 'LIVE. DIE. REPEAT.'(LDR), after the tagline featured on promotional materials for the aforementioned film.

We designed a LDR curriculum targeting critical management concepts in emergent pulmonary conditions. In this manuscript, we describe the LDR concept and design, and present initial evidence supporting the effectiveness of this model in training emergency medicine residents.

METHODS

The LDR design and pulmonary scenario was developed and piloted for the Mayo Clinic Emergency Medicine Residency at the Mayo Clinic Multidisciplinary Simulation Center in Rochester, Minnesota, USA. A single-session high fidelity simulation-based intervention was produced and administered four times to provide exposure to available cohort members (postgraduate year 1 through 3 residents) in small groups. Each session lasted 4 hours and was completed with five resident physicians and one emergency nurse. Participants were notified of the novel LDR structure in advance but were blinded to the topic. Residents were encouraged to watch *Edge of Tomorrow* beforehand to become familiar with the concept and to alleviate any potential stress the new instructional design might create. Participants were given detailed instructions at the start of the day, describing the gameplay, with special focus on the task-oriented and recursive nature of the instrument. The study was deemed exempt by the Mayo Clinic Institutional Review Board.

The LDR case design for the pulmonary educational module is described in figure 1.

A team included two emergency medicine residents and one emergency nurse. Inactive participants observed via live video feed. If the team achieved the indicated task within the designated time frame, the game was *paused* due to level completion. If the team failed the critical action, the game was declared *over* due to patient decompensation. Regardless of *game pause* or *game over* status, all learners underwent a 20 min debriefing between each level, focusing on self-assessment and critical action performance review. Participants were switched to a new resident/nursing team with each subsequent level. Owing to the ROBG style, each level began with the events of the level immediately preceding it to allow rehearsal of concepts discussed during the prior debriefing.

We administered a modified version of the Simulation Effectiveness Tool (see online supplementary material 1) described by Elfrink *et al*[3] to the emergency medicine residents to assess the LDR concept and pulmonary scenario. Nursing participants were not included.

RESULTS

See online supplementary material 2 for numeric representation of overall Modified Simulation Effectiveness Tool (MSET) results and online supplementary material 3 for verbatim invited free text learner commentary. Of 20 possible respondents, 17 (85%) emergency medicine residents completed the MSET. Satisfaction scores and narrative commentary were positive, with learners unanimously choosing to 'strongly agree' with 6 of 13 MSET domains. Learners opted to 'somewhat agree' or 'strongly agree' with each of the remaining domains, excepting domain 6, for which a single learner indicated disagreement.

DISCUSSION

We found that the LDR format achieved level 1 of the Kirkpatrick Model for evaluation of training methods. This is the reaction stage, or the 'degree to which participants find the training favourable, engaging and relevant'.[4] Learners reported placing value in the increasing complexity of the progressive levels given its pertinence to the field of emergency medicine. Previous studies have documented increased learner motivation with gamified educational programmes due to simultaneous competition and collaboration between participants.[2]

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LDR Pulmonary Case Design

Level #1 – Presentation: Severe respiratory distress / Extremis
- Critical action: Emergently initiate non-invasive positive pressure ventilation
- Time for critical action: 1 minute
- Initial vital signs: T 37, HR 135, BP 90/70, RR 42, PulseOx 58% NRB
- Vital signs after critical action: T 37, HR 100, BP 110/60, RR 30, PulseOx 89% BiPAP
- Flow rules: If no immediate BiPAP support, patient arrests, case ends.
- Debriefing topic: Use of NIPPV in the emergency department

Level #2 (Starts at beginning of Level #1) – Presentation: Respiratory decompensation after initiation of NIPPV
- Critical action: Needle decompression or finger thoracostomy
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 140, BP 60/30, RR 52, PulseOx 80% NRB
- Vital signs after critical action: T 37, HR 100, BP 110/60, RR 30, PulseOx 95% BiPAP
- Flow rules: Need to perform immediate needle decompression or finger thoracostomy (ideally at left axillary line) and verbalize chest tube placement. If they order X-ray before procedure, patient arrests, case ends.
- Debriefing topic: Management of complications of ventilated and NIPPV patients

Level #3 (Starts at beginning of Level #2) – Presentation: Hemodynamic decompensation in a patient with right heart failure
- Critical action: Initiation of bolus IV fluids and vasopressors
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 140, BP 60/30, RR 52, PulseOx 80%
- Vital signs after critical action: T 37, HR 100, BP 110/60, RR 30, PulseOx 90% BiPAP
- Flow rules: Aggressive volume resuscitation, vasopressors through IO or peripheral IV; if delayed resuscitation or central line attempt, patient arrests, case ends.
- Debriefing topics: Management of acute right heart failure, peripheral vasopressor safety

Level #4 (Starts at beginning of Level #3) – Presentation: Diagnosis of massive pulmonary embolism
- Critical action: Bedside ECHO diagnosis
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 45, BP 89/30, RR 42, PulseOx 89%
- Vital signs after critical action: T 37, HR 140, BP 89/30, RR 42, PulseOx 89%
- Flow rules: Need to diagnose massive PE at bedside with ECHO, patient will have large thrombus in-transit. If no diagnosis, patient arrests, case ends.
- Debriefing topic: Presentation of massive PE

Level #5 (Starts at beginning of Level #4) – Presentation: Management of massive PE
- Critical action: Systemic thrombolysis
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 140, BP 89/30, RR 42, PulseOx 89%
- Vital signs after critical action: T 37, HR 110, BP 109/30, RR 32, PulseOx 92%
- Flow rules: Patient is unstable requiring systemic thrombolysis. If resident chooses ECMO this is acceptable but not immediately available. ECMO team will suggest pursuing alternative therapy. If no thrombolysis, patient arrests, case ends.
- Debriefing topic: Management of massive PE

Level #6 (Starts at beginning of Level #5) – Presentation: Recognition of ARDS and alveolar hemorrhage
- Critical action: Recognize ARDS
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 140, BP 89/30, RR 52, PulseOx 69%
- Vital signs after critical action: T 37, HR 140, BP 89/30, RR 52, PulseOx 79%
- Flow rules: Requires recognition of ARDS. ICU attending to call saying he/she has a bed for the patient in 1 hour, wants specific diagnosis. If resident is unclear of the problem, patient arrests, case ends.
- Debriefing topic: Presentation and ventilator management in ARDS

Level #7 (Starts at beginning of Level #6) – Presentation: Initiation of ECMO
- Critical action: Recognize cardiorespiratory failure and need for ECMO
- Time for critical action: 15 minutes
- Initial vital signs: T 37, HR 140, BP 89/30, RR 52, PulseOx 79%
- Vital signs after critical action: Not applicable (no longer in ED, in ICU)
- Flow rules: Patient develops ARDS refractory to ventilator management, ECMO indicated; the team may call back advising availability. If resident does not consider ECMO, patient arrests, case ends.
- Debriefing topic: Indications and contraindications for ECMO and types of ECMO (VA, VV)

Legend: T = temperature, HR = heart rate, BP = blood pressure, RR = respiratory rate, PulseOx = pulse oximetry, NRB = non-rebreather, BiPAP = bilevel positive airway pressure, NIPPV = non-invasive inspiratory positive pressure ventilation, IV = intravenous, IO = intraosseous, ECHO = echocardiogram, PE = pulmonary embolism, ECMO = extracorporeal membrane oxygenation, ARDS = acute respiratory distress syndrome, ICU = intensive care unit, ED = emergency department, VA = veno-arterial, VV = veno-venous

Figure 1 LIVE. DIE. REPEAT. (LDR) pulmonary case design.

This too was demonstrated in learner comments regarding LDR's team-switching component.

Within its ROBG framework, LDR utilises short debriefings in between levels to provide performance feedback and then introduces an immediate opportunity to apply learned concepts with each subsequent level. This incorporates the idea of deliberate practice, an established method to achieve superior performance through recognition of defined measurement standards, rote experience, analysis of behaviours and repetition of skills.[5]

While emotional learning can enhance retention of information, the LDR design strikes a much-desired balance of tension, as demonstrated in the narrative results. Learners reported being less anxious knowing that the LDR format is per definition a

Gordian Knot situation, where the case always concludes with patient decompensation. This fatalistic approach allows learners to concentrate on critical actions instead of the unavoidable conclusion. The use of emergent scenarios in this LDR module further provides a form of stress inoculation training in a simulated environment, which can help to quell performance anxiety for future in situ patient encounters.

LIMITATIONS

Three residents (15%) forewent completion of the MSET survey, and their perception of LDR is not recognised in the outcomes reported. The results of this small study may not necessarily be reproduced in a larger setting. The applicability of LDR to other learner groups or instruction involving non-emergent medical conditions is unknown. Efficacy of LDR with regard to Kirkpatrick Model levels 2–4 (knowledge acquisition, behaviour change and outcomes) was not evaluated with this project.

CONCLUSION

A novel simulation-based educational scheme incorporating ROBG has been produced. Our pilot work suggests the LDR format is an acceptable alternative for training emergency medicine residents in the diagnosis and management of emergent pulmonary symptoms in complex decision-making scenarios. The current experience aims to be a proof-of-concept, and further work is needed to determine whether LDR can improve retention of learned concepts, affect future performance and contribute to positive patient-based outcomes.

Contributors DC conceived and led the study, and supervised the write-up. BS and UA supported the design, led the delivery of the intervention and co-drafted the manuscript. KS supported the design, aided analysis and drafted the manuscript.

Competing interests None declared.

Ethics approval Mayo Clinic Institutional Review Board.

Provenance and peer review Not commissioned; internally peer reviewed.

Data sharing statement The pertinent results of the study are examined in the discussion section of the paper. Detailed survey results and learner commentary regarding the LDR case design for a pulmonary module are available on request to the corresponding author at Sunga.Kharmene@mayo.edu.

REFERENCES

1 Okuda Y, Bryson EO, DeMaria S Jr, *et al*. The utility of simulation in medical education: what is the evidence? *Mt Sinai J Med* 2009;76:330–43.
2 Yunyongying P. Gamification: implications for curricular design. *J Grad Med Educ* 2014;6:410–12.
3 Elfrink Cordi VL, Leighton K, Ryan-Wenger N, *et al*. History and development of the simulation effectiveness tool (SET). *Clin Simulation Nurs* 2012;8:e199–210.
4 Kirkpatrick DL, Kirkpatrick JD. *Evaluating training programs: the four levels*. 3rd edn. San Francisco, CA: Berrett-Koehler Publishers, Inc, 2006.
5 Ericsson KA. Deliberate practice and acquisition of expert performance: a general overview. *Acad Emerg Med* 2008;15:988–94.

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