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The Effectiveness of a Self-Directed e-Learning Module on Trainee Knowledge and Confidence during Plastic Surgery Clinical Rotations

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Background: Exposure to plastic surgery is limited during medical school. This makes rotations for clinical clerks and off-service residents challenging. Available resources are often too detailed and overwhelming. Having an accessible, concise, and interactive plastic surgery e-learning module reviewing core plastic surgery topics could help prepare incoming trainees for their rotations.
Methods: An e-learning module was created using text, images, and in-house recorded video recordings. Two cohorts were recruited: control cohort (n = 9), who completed their plastic surgery rotation without use of the module, and an interventional cohort (n = 18), who completed the rotation with use of the module. A demographic survey, a 20-question multiple-choice knowledge test, and self-reported confidence score were completed by both cohorts at the end of their plastic surgery rotations. The intervention cohort also completed the knowledge test at the beginning of their rotation to establish baseline. Knowledge and confidence scores were compared using two-tailed, unpaired, nonparametric analyses (Mann-Whitney test).
Results: Learners from the intervention cohort reported a 95% module completion rate and found the resource "extremely helpful" (average Likert of 4.8/5). Learners indicated that they were very likely to recommend the resource to others (average Likert 4.9/5). The intervention cohort scored significantly higher on the knowledge test compared with the control cohort ($P = 0.008$), and on average reported higher confidence levels; however, this was not statistically significant ($P = 0.057$).
Conclusion: An accessible and concise module on core plastic surgery concepts enhances learner knowledge and confidence during plastic surgery clinical rotations.
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INTRODUCTION

Plastic surgery encompasses a wide range of subspecialty topics, most of which are not comprehensively covered during medical school, and sometimes not at all.[1–4] Often, medical students or junior residents new to plastic surgery clinical rotations with no prior experience can be overwhelmed with the breadth of new knowledge and skills demands. This may limit their educational experience and ability to participate meaningfully in clinical duties.[1–4] Although elective medical students and on-service plastic surgery residents are typically more proactive and study detailed resources such as plastic surgery textbooks and available digital resources, these may be too detailed and dispersed for many students and off-service residents on core rotations.[5] The educational goals of these trainees are simply to gain exposure to basic concepts and procedural competencies, a task made even more difficult at institutions that do not have a plastic surgery residency

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program that can provide mentorship to the rest of the clinical teaching unit.[6–8] Consequently, the onus often falls on attending surgeons to be even more "hands-on" with respect to ensuring quality of patient care and teaching.

It can often take some time for trainees to get acclimated to their clinical rotation. However, given that most rotations are typically 2–4 weeks, there is often an urgency to have a strong start.[9,10] Although there are various education tools available, interactive e-learning modules have been shown to be effective in such settings, as they offer remote access, user-friendly navigation, and integration of interactive features such as videos.[2,11–17] As such, we aimed to create an e-learning plastic surgery training module that is easily accessible and reviews basic plastic surgery concepts most relevant to clinical clerks and off-service residents who are new to plastic surgery.[18] Our module promotes independence and confidence by preparing students for the start of their rotation, and acts as a concise reference guide throughout the rotation.[18] Here, we assess the effectiveness of this e-learning module in helping trainees to build their plastic surgery knowledge and confidence during their clinical rotations.

Takeaways

Question: Does a plastic surgery e-learning module enhance knowledge and confidence of off-service residents and medical students during plastic surgery rotations?

Findings: Participants who used the module (n = 18) found the module extremely helpful and scored significantly higher on a plastic surgery knowledge test compared with those who did not (n = 9). Difference of confidence levels between the cohorts was not statistically different.

Meaning: Relevant e-learning modules can serve as an important adjunct to medical school curricula to enhance knowledge acquisition on plastic surgery rotations.

METHODS

Module Overview

The module was created by medical students and members of the division of plastic surgery at Queen's University, Kingston, Ontario, Canada, from September 2018 to April 2020. Overview of this module is provided via supplemental video. Core plastic surgery topics were chosen based on those most relevant to general/emergency medical practice, standardized examinations, and overlap with other surgical specialties. The depth of detail covered in each topic was at the level of knowledge expected of senior medical students/junior off-service residents. For example, the subsection reviewing hand trauma includes the approach to a detailed history, physical examination, and basic management such as wound closure and splinting without the details of surgical management. It was created as an interactive module and could be navigated via a side menu with the following subheadings: consults, rounding, wounds, microvascular patients, facial trauma/fractures, hand infections, pathways, skin malignancy, hand trauma, breast cancer reconstruction, thermal injuries, reconstructive techniques, suturing, and suture selection. Although the objectives of residents and medical students are different on their rotations, the listed module subheadings aim to address both. They include level-appropriate exposure to the specialty of plastic surgery that would be relevant to a medical clerkship learner and initial evaluation, workup, and management relevant to an off-service or junior plastic surgery level resident trainee. The pathways subheading involved six full-length videos (approximately 10 minutes each) of staff plastic surgeons reviewing the following topics: hand physical examination, craniofacial physical examination, facial bones CT analysis, basic hand splinting technique, basic aseptic wound care technique, and punch biopsy technique. The content of the module is accessible and easy to edit from a teacher's perspective, and the creative direction is flexible. (**See Video [online],** which shows an overview of the plastic surgery e-learning module.)

Participant Recruitment

All participants provided informed consent according to the study protocol approved by the Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board (6028611). All participants were recruited between January 2021 and September 2022 and were compensated with a $15 Starbucks gift card upon completion of both prerotation and postrotation components. Participants in the control cohort (n = 9) were contacted after they had completed their rotation and thus were recruited retrospectively. Participants in the intervention cohort (n = 18) were contacted before the start of their rotation with the module link, consent forms, demographics survey, and prerotation tests, and thus were recruited prospectively. Participants ranged from medical students in their third and fourth year (MS3 and MS4, respectively) to residents in their first and second year (R1 and R2, respectively). Participants were e-mailed within 1–4 days before the start of their rotation for the prerotation survey and test, and 1–4 days after completing their rotation for the postrotation test. All participants who responded to recruitment and completed the appropriate surveys and tests were included in the study.

Survey Overview

A survey was created using the Qualtrics software (Qualtrics, Provo, Utah). It contained REB approved consent page, demographic questionnaire, and a 20-question knowledge test (**See appendix, Supplemental Digital Content 1,** which shows the module knowledge test with self-reported confidence scores. **http://links.lww.com/PRSGO/C869**). The questionnaires, the knowledge test, and the module were all created by the same team of researchers, which included medical students and staff plastic surgeons. The questions included in the survey test were chosen based on relevant general plastic surgery knowledge that would have been covered in the module. Completed forms

were then deidentified and transferred to a password-protected Microsoft Excel spreadsheet. The knowledge test examined core basic concepts covered in the module and was developed by the members of the division of plastic surgery. Each question was in multiple-choice format consisting of four options and was accompanied by a confidence assessment using a Likert scale 1–5 rating (ranging from 1 indicating "not at all" to 5 indicating "extremely"). The module was estimated to take approximately 3–4 hours to complete, and each survey, approximately 20–30 minutes.

Statistical Analysis

Knowledge test scores (scored out of 20) were expressed as percentages, and self-reported confidence scores were expressed using a 1–5 Likert scale. The distributions of the datasets were evaluated for normality using the D'Agostino & Pearson test with alpha value set at 0.05.[19] Comparisons between control and intervention cohorts were performed using unpaired, two-tailed, nonparametric analyses—given failed normality test. Within the intervention cohort, prerotation scores and confidence levels were compared with postrotation equivalents via two-tailed, nonparametric analysis. All statistical analyses were performed using GraphPad Prism version 9.4.1 for MacOS (GraphPad Software, San Diego, Calif.) and *P* values of less than 0.05 were considered statistically significant. Box-whisker plots were generated using the same software.

RESULTS

As depicted in Figure 1, of the 48 incoming trainees who were contacted before the start of their rotation, 18 individuals responded and completed the interventional arm of the study (37.5% participation). For the control arm of the study, nine of 12 people (75% completion) who were contacted completed the study. Demographic information of the control and intervention cohorts is shown in Table 1. Both cohorts mainly composed of participants between 20 and 30 years of age (78% and 88%, respectively). The majority (56%) of participants in the retrospective cohort were MS4's, with the remainder being split evenly between R1 and R2 trainees. The intervention cohort had a wider range of trainee levels enrolled, with 44% MS3, 22% MS4, 17% R1, and 17% R2. Within the control cohort, 78% had completed a bachelor's before pursuing their medical degree, whereas the remainder had completed a master's degree. These degrees were primarily (67%) in the biological/physical sciences. Comparatively, education levels in the intervention cohort are composed of mostly bachelor's degree graduates before medical school entry (61%), followed by high school graduates (17%), master's graduates (17%), and doctorates (6%). Similar to the control cohort, most of these degrees (83%) were also in the biological/physical sciences. The majority of rotation lengths were 2 weeks in duration (56% in the control cohort; 67% in the intervention cohort), with the remainder split evenly between 3 and 4 weeks. No participants in the control cohort were interested in plastic surgery as a career, whereas 17% of the intervention cohort expressed interest in pursuing plastic surgery as a career.

The feedback section of the survey revealed that trainees found it "extremely helpful" (average Likert score of 4.8/5). Learners indicated they were very likely to recommend the resource to others (average Likert score 4.9/5) and were overall very satisfied and likely to use the module again (Fig. 2). Participants felt more confident in managing consults, and somewhat more confident in their physical examination skills. They did not feel more confident in their procedural skills.

Table 1. Study Cohort Characteristics

Control Cohort	**N = 9**
Age	20–30 (n = 7) 31–40 (n = 1) 41–50 (n = 1)
Level of training	MS4 (n = 5) R1 (n = 2) R2 (n = 2)
Area of study before medical school	Biological/physical sciences (n = 6) Other (n = 3)
Highest level of education before medical school	Bachelor's (n = 7) Master's (n = 2)
Interested in plastic surgery career	None
Duration of plastic surgery rotation	2 weeks (n = 5) 3 weeks (n = 2) 4 weeks (n = 2)
Experimental cohort	**N = 18**
Age (y)	20–30 (n = 16) 31–40 (n = 2)
Level of training	MS3 (n = 8) MS4 (n = 4) R1 (n = 3) R2 (n = 3)
Area of study before medical school	Biological/physical sciences (n = 15) Other (n = 3)
Highest level of education before medical school	High school (n = 3) Bachelor's (n = 11) Master's (n = 3) PhD (n = 1)
Interested in plastic surgery career	n = 3
Duration of plastic surgery rotation	2 weeks (n = 12) 3 weeks (n = 3) 4 weeks (n = 3)

MS3, medical student in year 3; MS4, medical student in year 4; R1, first year resident; R2, second year resident.

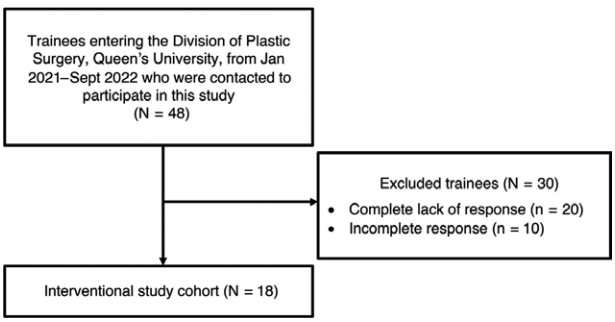

Fig. 1. Flow diagram depicting inclusion and exclusion within the intervention cohort.

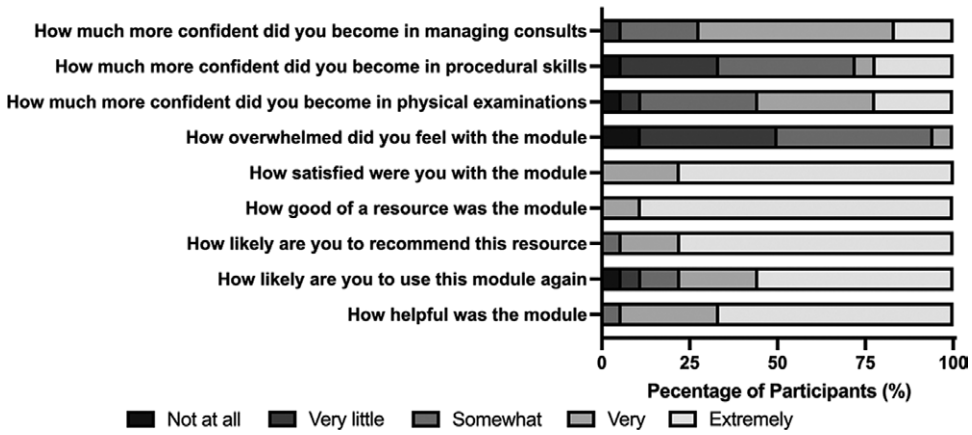

Fig. 2. Summary diagram of feedback responses amongst those that had completed the plastic surgery e-learning module (intervention cohort).

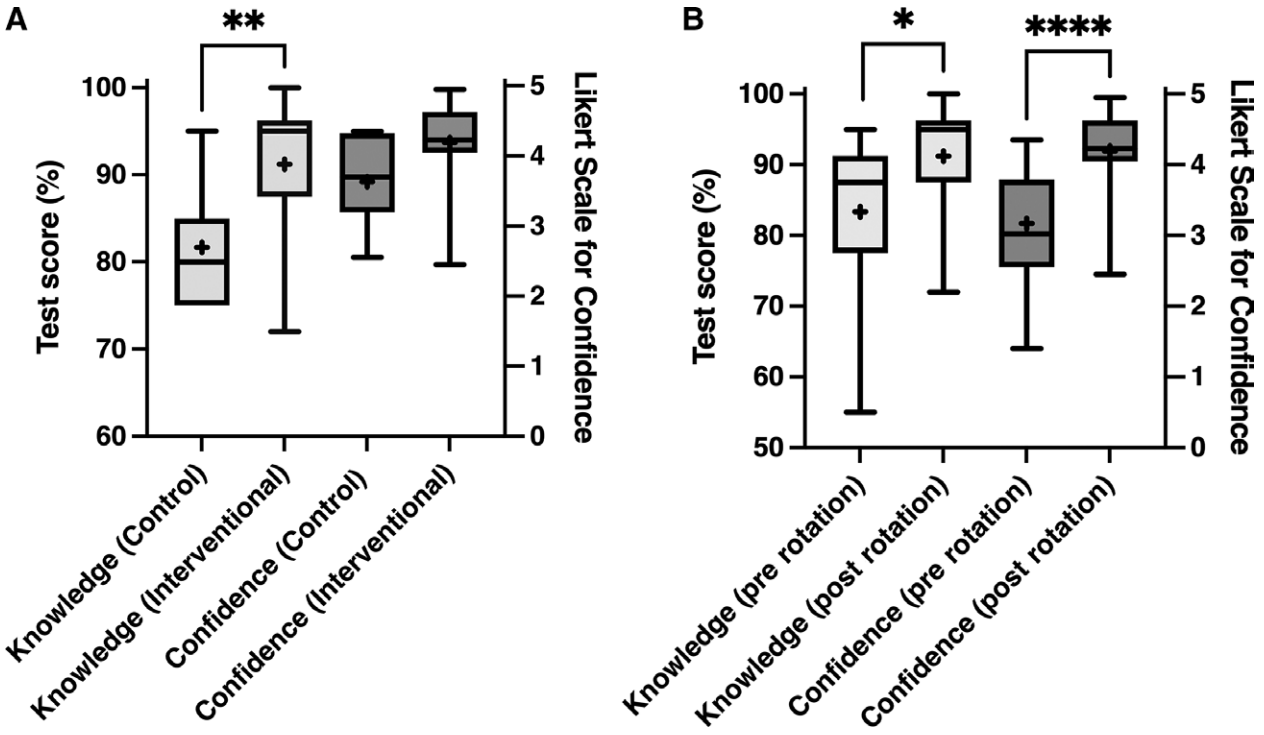

Fig. 3. Comparison of knowledge gained and trainee confidence levels to use of plastic surgery e-learning module. A, A box-whisker plot comparing end-of-rotation test scores and self-reported confidence levels between those that completed (intervention) or did not complete (control) the plastic surgery e-learning module. B, A box-whisker plot comparing the pre- and postrotation test scores and self-reported confidence levels amongst those trainees who completed the module (intervention cohort). The upper and lower borders of the box represent the first and third interquartile range, respectively, whereas the horizontal line represents the median, "+" represents the mean, and the whiskers are the minimum and maximum values. * $P < 0.05$; ** $P < 0.01$; **** $P < 0.0001$.

Comparison of knowledge between the control and experimental cohort revealed a significant difference (Fig. 3A, $P = 0.008$). The participants who used the e-learning module during their rotation had significantly higher test scores at the end of their rotation compared with those who did not use the e-module. Comparison of self-reported confidence levels between the control and postrotation intervention cohorts did not reveal a statistically significant difference ($P = 0.057$).

Knowledge and confidence within the intervention cohort were also examined at two timepoints: before the rotation and after the rotation. This comparison was made to help quantify the absolute difference in test scores by considering variation in trainee baseline and prior knowledge of plastic surgery concepts. Comparison of the pre- and postrotation tests scores (Fig. 3B) reveals significantly higher postrotation scores ($P = 0.007$) and confidence levels ($P < 0.0001$) among the intervention

cohort participants at the end of their rotation. As seen in Figure 3B, the increase in confidence appears to be greater than that of knowledge; however, it is important to note that the scales of these two measures are different, and that an inter-parameter analysis to elucidate whether the Dunning-Kruger effect is at play is not appropriate.

DISCUSSION

Starting an off-service or new rotation in plastic surgery can be challenging due to minimal specialty-specific teaching during preclerkship medical school curriculae.[1,20,21] This issue is exacerbated in schools without a plastic surgery residency program, where the clinical teaching unit does not have plastic service residents to help navigate the start of a new rotation or be a resource for clinical questions throughout. Given that rotations are typically 2–4 weeks long, trainees are only beginning to acclimate by the end of their rotation, which detrimentally impacts their learning and the service they provide. To address this issue, we created an accessible and concise module of high-yield plastic surgery content that trainees could review before and during their rotation and become more familiar with important concepts and clinical pathways before the start of their rotations. Participants who used the module reported an average completion rate of 95% with high satisfaction rates and the vast majority feeling that this was a valuable resource that they would very likely use again and recommend to other trainees (Fig. 2).

Previous descriptions of plastic surgery modules have focused on familiarizing with the breadth of plastic surgery referral patterns, merging plastic surgery with dermatology teaching for increased efficiency, and procedure-specific modules used for informed consent.[2,16,22] There have also been e-learning modules with an emphasis on general surgical skill acquisition and less so with specialty-specific clinical knowledge.[23] Altogether, there are no resources that we know of specifically aimed at practically preparing junior trainees for plastic surgery rotations, in managing plastic surgery inpatients, triaging referrals, and providing basic approaches to managing common presentation in a hospital setting.

With regard to the module objectives, participants also felt the module taught them how to conduct plastic surgery consults, perform physical examinations, and initiate a basic management plan in an accessible manner (Fig. 2). This was reflected objectively in the study metrics that indicated the module helped participants acquire greater knowledge of plastic surgery by the end of their clinical rotations (Fig. 3B). Although the higher median, first, and third quartile values of confidence seen in the interventional cohort may indicate students gain confidence with module use, these differences were not statistically significant. In light of this, it is important to consider the limited number of participants (n = 9) in the retrospective control cohort. As such, additional investigations in the form of multi-site studies where more participants could be recruited would be of value. Baseline variation in the module cohorts' prerotation level of knowledge as a confounder was examined using a pre- and postrotation test that also revealed consistent significant increase in test scores and confidence (Fig. 3B). Length of rotation as another potential confounder was explored to rule out whether longer rotations were associated with higher test scores and confidence. We observed that the average length of rotation for the intervention cohort was in fact shorter (average of 2.4 weeks per participant) than that of the control cohort (average of 2.7 weeks per participant). Lastly, seniority/experience as a potential confounder for test scores and confidence were examined, and we observed that intervention cohort by percentage comprised of more junior level trainees compared with the control cohort (44% versus 0% MS3's).

Based on participant feedback, the only area where the module did not significantly help trainees was procedural skills. Interestingly, this has previously been identified in the literature, whereby e-learning platforms provided variable levels of technical skill satisfaction rates amongst users.[4] This feedback could be specific to our module due to its limited content and detail on procedural techniques (three 10-minute videos). Alternatively, it could echo a more general inherent limitation of e-learning platforms and the irreplaceability of kinesthetic learning and in person procedural skills teaching and practice. To address the former, we aimed to develop more videos on procedural skills, such as suturing videos and sterile field preparation.

There were several limitations to this study that are inherent with studying educational interventions. Firstly, the study is subject to nonresponse bias because not all trainees who rotated through the service chose to participate in the study. Secondly, this study was carried out at a single, academic center that does not have a plastic surgery residency program. Additionally, there are inherent limitations in administering a standardized test to participants who have nonstandardized backgrounds which may impact measured test performance. Here, the authors a priori impression was that this was a very valuable clinical tool for use on rotation, and rather than restrict access to a significant number of trainees coming through the rotation over the study period, this study relied upon a historical control group that would have, for some of its participants, had several months elapse between rotation and posttest administration. The $15 incentive, which was provided to all who completed the study, may have also introduced a positive bias in the performance and self-reported confidence of those participating. Lastly, there were also analytical limitations due to disparate measurement scales of knowledge and confidence. Although previous studies have also used similar descriptive scales, using a consistent scale of measure across all parameters would enable additional inter-parameter analyses.[24]

For future directions, a multi-site study design where additional participants could be recruited to increase sample size and improve external validity of the study would be of value. An increased sample size can help definitively address whether learner confidence is increased with the use of an e-learning module. Additionally, it would be useful to introduce a clinical "performance" parameter to the study variables, and to standardize the scales of measurement across all study parameters—knowledge,

performance, and confidence—to enable inter-parameter analyses. This would help elucidate whether the knowledge gained is in proportion to enhanced clinical performance and increased confidence, or whether the Dunning-Kruger effect is at play.

CONCLUSIONS

Positive feedback on the module, improved test scores, and higher levels of self-reported confidence demonstrate the effectiveness of our plastic surgery module in orienting, preparing, and supporting trainees through their plastic surgery rotation. Similar studies involving other institutions need to be completed to help identify site-specific benefits. Additionally, follow-up studies investigating the relationship between knowledge and confidence are needed. Overall, we recommend the development and implementation of e-learning modules into plastic surgery rotations for junior trainees.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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