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Low-Cost Biodegradable 3D-Printed Laparoscopic Simulator: A Sustainable Alternative for Surgical Training

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BACKGROUND

Although surgical simulators are a necessary tool for technical skills training, they are often expensive to purchase and maintain, with limited global accessibility. In our study we aimed to develop a laparoscopic surgical simulator that is affordable, compact, and whose design and modules can be shared between institutions. Requiring only a commercial 3D printer and low-cost polymer for production, such a simulator could provide an alternative training option to conventional laparoscopic simulators.

METHODS

We designed and manufactured a 3D-printed laparoscopic simulator kit.
We trained 12 medical students and 2 residents in Task 1 of the FLS exam. Each participant was initially evaluated for their baseline score and completion time using a conventional laparoscopic simulator and equipment, then trained using our 3D-printed simulator. Post-training, a final assessment was conducted on the conventional simulator to evaluate progress from baseline. A paired samples t-test was used to compare task completion times and Pearson's correlation coefficient assessed the relationship between training duration and final task performance. A Likert scale questionnaire evaluated usability, realism, effectiveness, technical difficulties, comfort, and likelihood of reuse, with Spearman's correlation used to analyze relationships between these factors. Cronbach's Alpha was calculated to assess internal consistency and reliability.

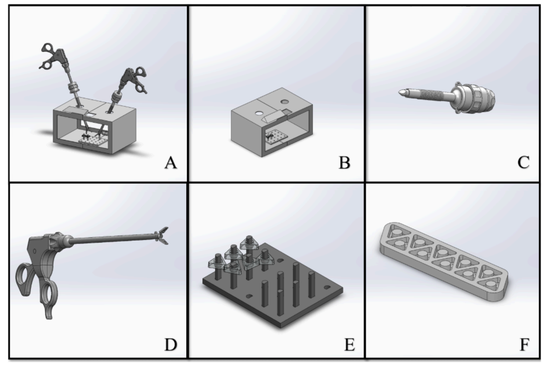
RESULTS

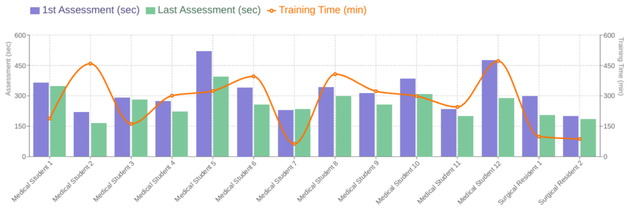
The total cost for producing the 3D-printed laparoscopic training kit amounted to 20.91 USD with an average of 58 hours for printing, post-processing and assembly. The average time of training was 4 hours and 33 minutes. No participants achieved proficiency in FLS Task 1. From baseline, the time to complete the task, decreased from 319.57 seconds to 259.64 seconds ($p < 0.001$ Usability (mean = 3.71) and realism (mean = 3.71) were rated positively, but 78.6% of participants found the simulator inferior to conventional simulators. Technical difficulties varied among participants (mean = 3.29), with a strong correlation between technical difficulties and effectiveness ($\rho = 0.67$), suggesting that perceived difficulty impacted the likelihood of reuse. Despite these limitations, 85.7% of participants expressed a high likelihood of reusing the 3D-printed simulator.

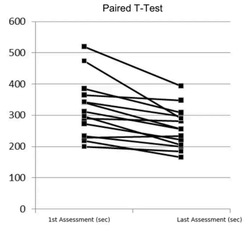
CONCLUSIONS

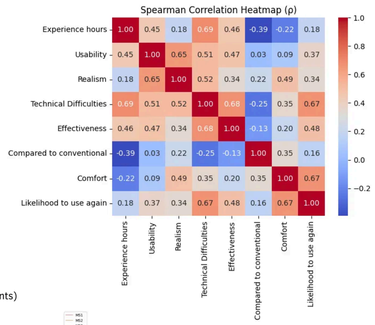
Our simulator offers an economical, customizable but lower quality alternative to conventional laparoscopic training simulators, thereby functioning as a potential training option to institutes and individuals lacking access to conventional laparoscopic simulators. Further testing is required to address the limitation of our study, and highlight any additional potential benefits of utilizing low-cost simulators in resource lacking settings.

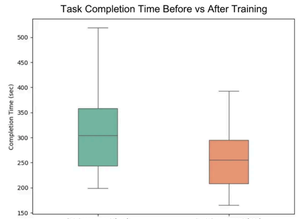


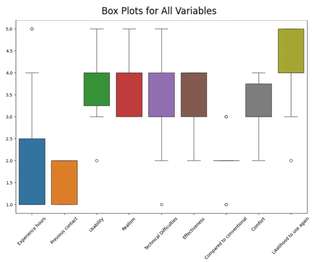


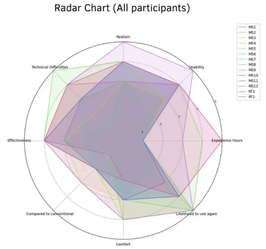


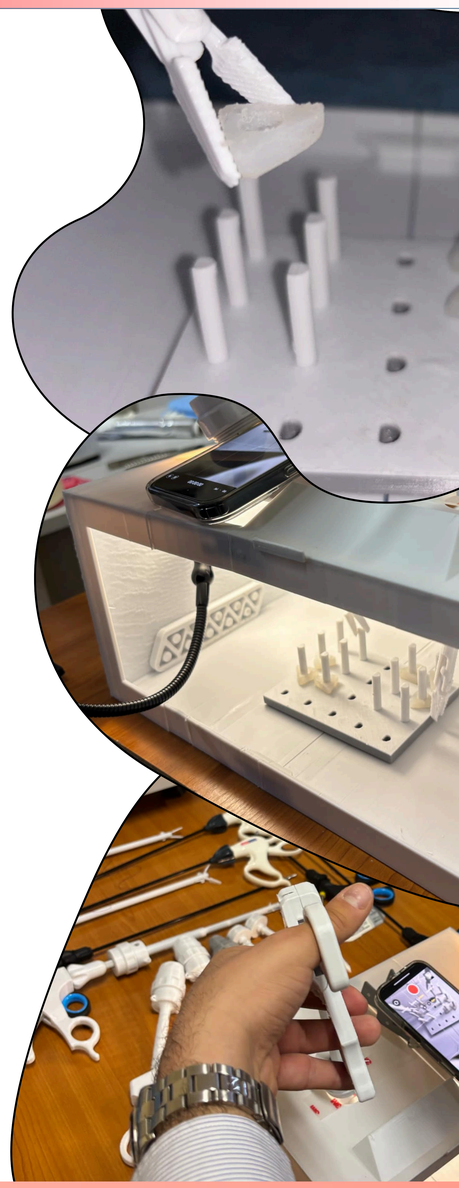












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