VASCULAR INVADERS

Do game elements enhance learning?

Exploring the role of integrated game design elements in a vascular anatomy study aid

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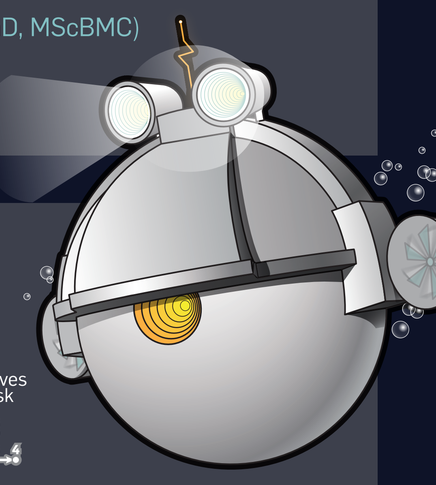
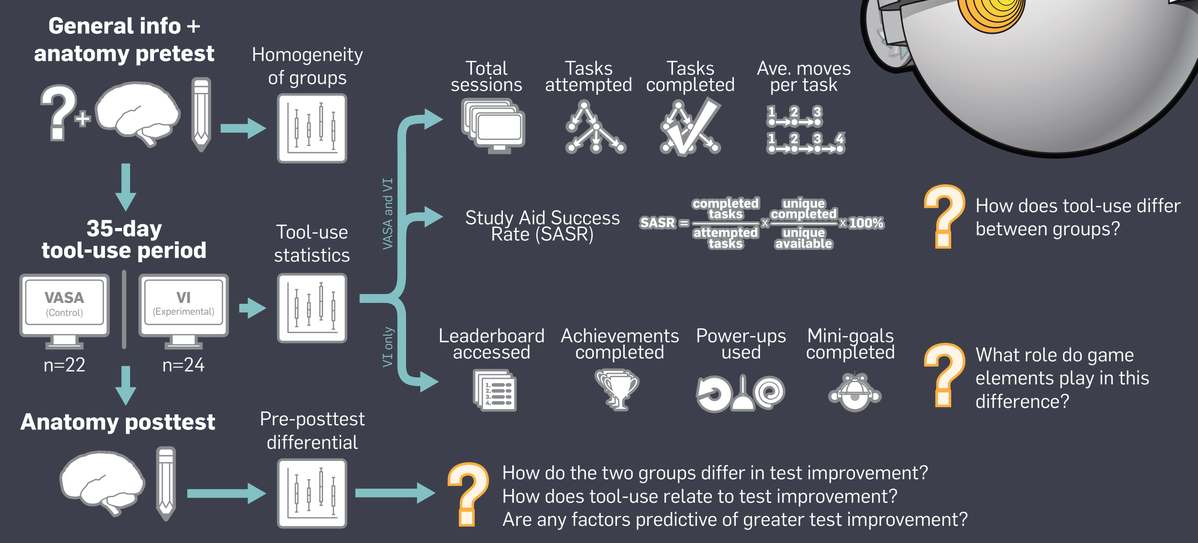


Problem

The study of **vascular anatomy** can be challenging because of diverse branching patterns, anastomoses, vessel supply, and complex spatial relationships between structures. In the past, **games** have been used to aid in **engagement, knowledge retention, and systems-thinking** in anatomy classrooms[1,2,3]. However, there is little evidence that shows whether game design encourages study aid-use outside of the classroom, whether increased engagement leads to improved learning outcomes, and which game elements contribute most to students' desire to use the resource[4,5]. In order to help bridge these knowledge gaps, we developed **two parallel study aids** for students studying vascular anatomy: 1) the **Vascular Anatomy Study Aid (VASA)**, and 2) **Vascular Invaders (VI)**, which incorporates game design elements such as a leaderboard, achievements, mini-goals, rules, penalties, points systems, power-ups, music, etc. These were given to **medical anatomy students** at the University of Toronto to be accessed online on their own time over a period of 35 days, to support their learning of the anatomy of the head and neck.

Methods



Results

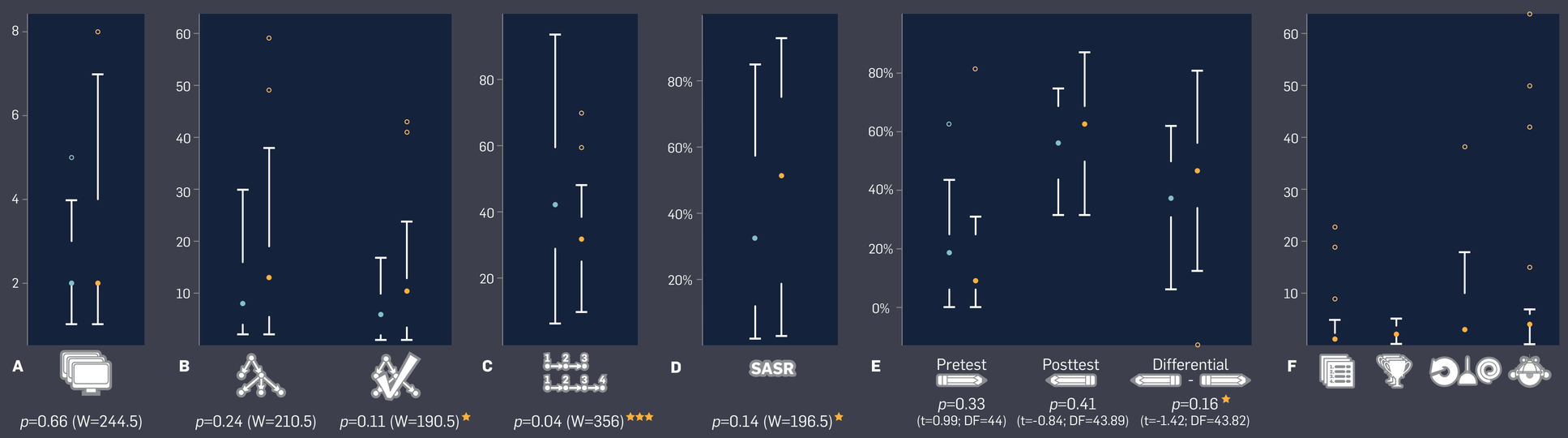


Figure 1 - Comparison of telemetric tool-use data and anatomy test scores for VASA- and VI-assigned groups. **A)** Tool-use sessions (logins); **B)** Attempted and completed path-finding tasks; **C)** Average moves by the user in order to complete a task; **D)** Study aid success rate (SASR); **E)** Anatomy test scores; **F)** Game element interaction statistics (VI only).

Comparisons were made using two-tailed non-parametric Wilcoxon tests (W) for telemetric statistics and two-tailed Student t-tests (t) for anatomy test scores.
DF = Degrees of freedom.

Summary of findings

1 Game elements increase medical students' study aid-use but *not significantly*.

- Moderately higher use seen in experimental group (refer to Figure 1 A and B)
- Use-statistics positively and significantly correlated with interaction with game elements

2 Game elements are not the determining factor for students' learning.

- Moderately higher test improvement seen in experimental group (refer to Figure 1 E)
- Intrinsic motivation in medical students is generally high
- Various other studying resources at disposal

3 Game elements change how *different types of students* use the study aid.

- Age is positively correlated with attempted tasks in VI (*rho*=0.43, *p*=0.04) but NOT in VASA (*rho*=0.07, *p*=0.77)
- Tool-use was **positively** correlated with "good/frequent studying habits" in VI (*rho*=0.59, *p*<0.01)
- Tool-use **negatively** correlated with "good/frequent studying habits" in VASA (*rho*=-0.51, *p*=0.02)
- Gaming habits and gender appeared to have no major impact on tool-use in either group

4 Game elements change the *manner of interaction* within the study aid.

- Control group completed tasks in significantly more moves than experimental group (refer to Figure 1 C)
- VI has rules, incentives, penalties that encourage strategic thinking while completing tasks

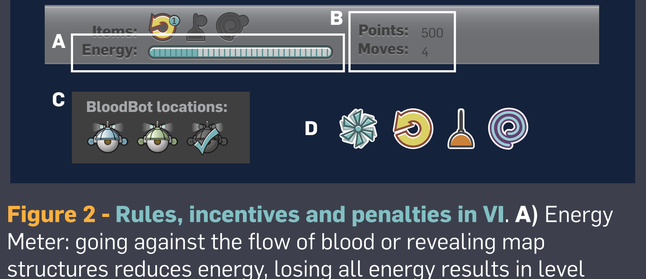


Figure 2 - Rules, incentives and penalties in VI. **A)** Energy Meter: going against the flow of blood or revealing map structures reduces energy, losing all energy results in level restart; **B)** Friends mini-goal: requires extra strategy to find, results in large point bonus; **C)** Move-counter: less moves = more points; **D)** Power-ups/items: aid in efficient task completion.

- VASA lacks such mechanics; student is free to explore
- **Rules as game design elements seem to be more important than standard, measurable, engagement features such as leaderboards or achievements**

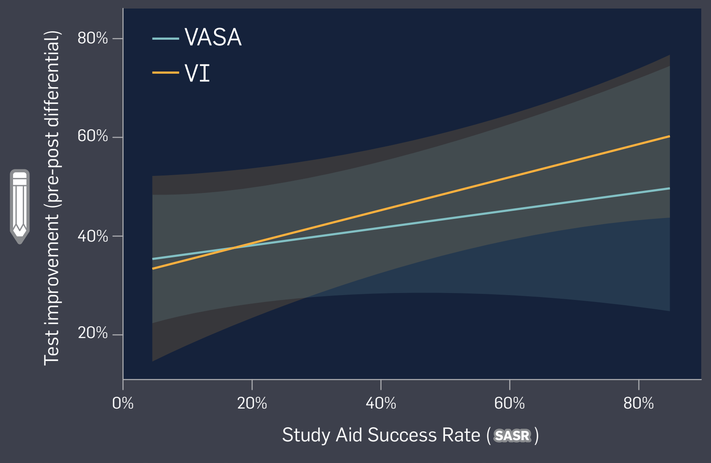


Figure 3 - Study Aid Success Rate (SASR) in VI is more predictive of test improvement than it is in the VASA. This graph (based on a multivariate linear regression model) predicts the outcome of test improvement in relation to SASR for students exposed to either VASA or VI, after adjusting for other covariates.

Adjusted to: Tool-use sessions = 2; Studying habits = 2; Game-playing habits = 1; Age = 23; Gender = male.

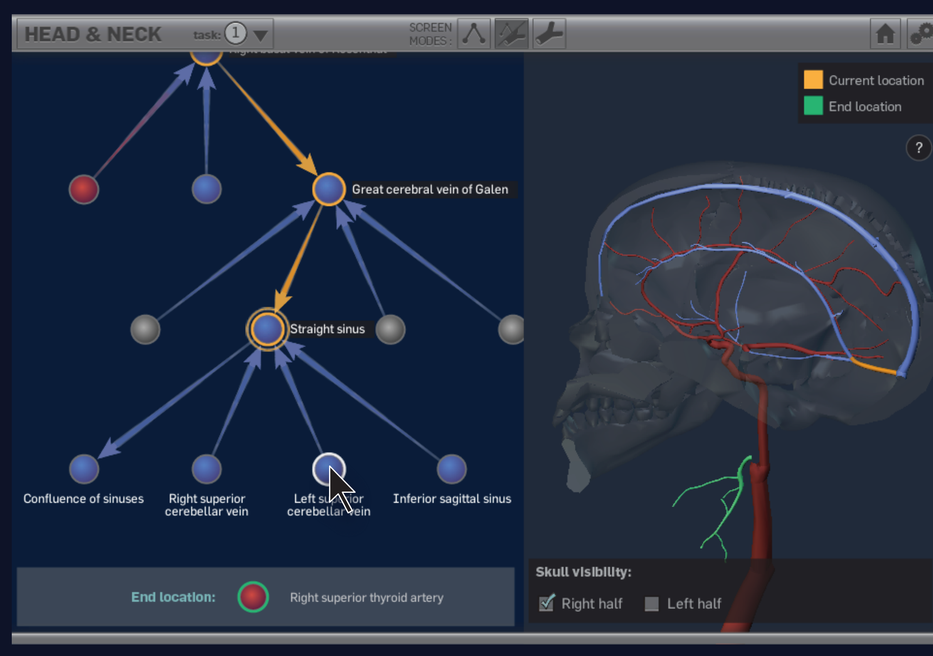


Figure 4 - Control Tool: Vascular Anatomy Study Aid (VASA). Screen shot of path-finding task. This study aid contains 10 predefined tasks, as well as a random task generator, where the user must find their way from one blood vessel to another.

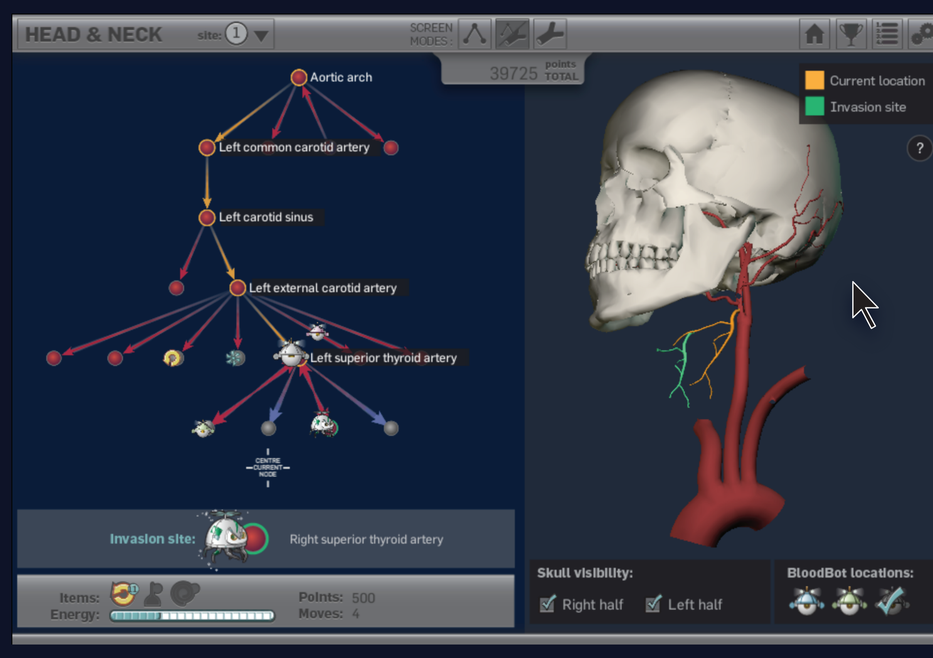


Figure 5 - Experimental tool: Vascular Invaders (VI). Screenshot of game-play. This study aid contains the same tasks as VASA, but incorporates social features, reward and punishment features, as well as narrative features in an attempt to increase engagement.

References

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