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Cover art:

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2025 GAMIFICATION SPECIAL EDITION

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Crossword Puzzles Improve Recall and Familiarity with Terminology for Undergraduate Anatomy and Physiology Students

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Abstract

Anatomy and physiology (A&P) courses are content-dense courses requiring the acquisition of an entirely new vocabulary to refer to body structures. Students struggle with learning the new words, linking terms with their functional anatomy, and spelling those words correctly. Crossword puzzles (CWPs) provide low-stakes opportunities for students to practice recalling these words and, by fitting them into the puzzle, how to spell them. Students (537) enrolled in two sections of a first year A&P course were provided with 4 online CWP assignments while studying the anatomy of the integumentary, musculoskeletal, and nervous systems. The CWPs were custom-made by the author with the clues derived from course content pertaining to those new terms. Each student population (Group 1 and Group 2) had completely different anatomical terms in their four CWPs. Student recall of the terms and their ability to spell those words correctly were assessed using fill-in-the-blank and diagram labeling questions on two midterm exams. Student outcomes were compared, word by word using paired t-test, based on whether or not students had opportunities to practice with that word in their CWP assignments, with a p value less than 0.05 considered a significant effect. Student participation in the assignments was high (90-97%) and students demonstrated better word recall and more accurate spelling if they were provided with that word in their CWP compared to if they were not. CWPs engaged students and supported their learning by providing opportunities to review course content and fit terminology words into the correct number of spaces. <https://doi.org/10.21692/haps.2025.018>

Key words: crossword puzzle, anatomy, terminology, recall, spelling, student engagement

Introduction

The study of human anatomy involves the acquisition of a great deal of new terminology as students learn the names of body structures including bones, bone markings, muscles, and components of the central nervous system. Indeed, many terms, both for anatomy as well as other medical disciplines, are derived from either Greek or Latin (Abuelo et al., 2016), a situation that provides an additional hurdle to students who have had no prior exposure to either of those languages. Many students find the memory work required to familiarize themselves with terminology related to the anatomical and medical sciences challenging and stressful (Abuelo et al., 2016; Patrick et al., 2018; Qutieshat et al., 2022; Saxena et al., 2009).

While lectures can be used to introduce these terms and explain related concepts, this approach is often not sufficiently engaging and does not promote adequate

knowledge retention (Patrick et al., 2018; Saxena et al., 2009; Torres et al., 2022). Indeed, students should be provided with additional enrichment opportunities to repeatedly practice recall and application so that they can become more comfortable with the new terminology and be able to use it accurately and with confidence (Abuelo et al., 2016; Mohan et al., 2018; Saxena et al., 2009).

Gamification, by promoting active engagement in learning instead of passive absorption of information from didactic lectures, is an approach being increasingly used in education. Games, when developed carefully and in accordance with course learning objectives, can increase student motivation and engagement with the potential to improve student outcomes (Massey et al., 2005; Stott & Neustaedter, 2013). Games provide important opportunities for students to actively participate in their learning while reviewing and

continued on next page

applying course content, allow students to identify gaps in their knowledge and understanding before tackling summative exams, and support the process of making links between concepts and terminology (Franklin et al., 2003; Massey et al., 2005; Saxena et al., 2009; Zamani et al., 2021).

Crossword puzzles (CWPs) are games that have been used to give students practice learning terminology, expanding one's vocabulary in concert with spelling new vocabulary words correctly, and making accurate links between terms and their definitions (Moore & Dettlaff, 2005; Orawiwatnakul, 2013; Shah et al., 2010). It has been suggested that CWPs are particularly helpful when students are working with details that need to be committed to memory (Crossman & Crossman, 1983).

CWPs are not new. Indeed, the first CWP was published by Arthur Wynne on December 21 of 1913 in the New York World newspaper (Amlen, 2019; Saxena et al., 2009) and they continue to be used in many ways since those early days. When used in higher education, the clues provided in each puzzle should link to course learning objectives and the content for which students are responsible. This allows CWPs to promote "meaningful learning", not just rote memorization, because the students are working with each new term in the context of what they have been learning in lectures (Mintzes et al., 1997; Qutieshat et al., 2022). Furthermore, it has also been suggested that the simple act of trying to remember factual information from lectures in order to reason out the correct answer for a clue activates learning processes on the part of the CWP solver (Febrina et al., 2014).

An important feature of CWPs is that students have to spell each word correctly to solve the puzzles. Working to fit each answer into the correct number of spaces on their puzzle obliges the student to spend more time thinking about that word and how it is spelled, leading to improved retention (Moore & Dettlaff, 2005). The self-correction property of CWPs allows them to give immediate feedback to the puzzle solver. If the word is not fitting into the puzzle, it isn't the correct answer or it is being spelled incorrectly. This allows the student to think further about the answer they are attempting and to try again (Nirmal et al., 2020; Saxena et al., 2009). The interconnectedness of the CWP answers also provides feedback because words that intersect will share letters with other words in the grid. That sharing can provide helpful hints, but it can also alert a student to an incorrect answer that is being entered so that the student can rethink their answer and try again (Shah et al., 2010).

The results of survey studies have shown that CWPs are received well by students, regardless of their discipline of study. Almost 90% of medical students polled agreed that CWPs enhanced their learning of microbiology and immunology (Mohan et al., 2018) and 94% of survey respondents agreed that CWPs supported their learning of veterinary terminology (Abuelo et al., 2016). Dental students found CWPs an enjoyable and less stressful way to learn (Qutieshat et al., 2022), medical students studying pharmacology enjoyed completing CWPs that helped them

recall the names of drugs (Gaikwad & Tankhiwale, 2012), and Thai students found that CWPs helped them learn English vocabulary in a way that was more interesting and less stressful (Orawiwatnakul, 2013). Students also reported that the opportunities for repetition and practice provided by CWPs was valuable when preparing for exams (Mohan et al., 2018; Orawiwatnakul, 2013).

Studies comparing student outcomes have shown CWPs to be effective as well as engaging. Students who had access to CWPs when studying speech therapy (Zamani et al., 2021), dentistry (Nirmal et al., 2020), veterinary science terminology (Abuelo et al., 2016), English as a second language (Orawiwatnakul, 2013), the history of psychology (Crossman & Crossman, 1983), or the names of antihypertensive and antiepileptic drugs (Gaikwad & Tankhiwale) had better outcomes on tests compared to those who did not have access to the puzzles.

However, a common feature of these studies was that one group of students (intervention group) had access to the puzzles while the other group of students served as the control and did not have access to that learning and self-testing opportunity. In contrast, an important goal of the study described in this paper was to evaluate the effectiveness of practice with crosswords while allowing all students to have access to this learning experience. This was facilitated by the fact that the author was simultaneously teaching two separate large-enrollment classes in undergraduate anatomy and physiology (A&P). Hence, each population of students could have a different set of anatomy-based terminology in their crosswords, while still allowing *all* students to potentially benefit from the practice afforded by CWPs to increase their familiarity with new vocabulary.

Students in each of the two classes were provided with different sets of CWPs drawing on one of two separate word banks that targeted terms associated with the anatomy of the integumentary, musculoskeletal, and nervous systems. Subsets of words from both banks were tested on summative exams, with students in one section having access to only Bank A words in their CWPs while students in the other class had access to only Bank B words. This allowed a direct word-by-word comparison (rather than student group by student group comparison) of the influence of CWPs on recall, content retention and spelling pertaining to the functional anatomy of those body systems.

Materials and Methods

Word Banks, Student Groups, and CWP Creation

Two populations of students studying first year A&P were involved in this study. Group 1 consisted of 242 students enrolled in ANP1106A (228 of them completed the course) and Group 2 consisted of 295 students enrolled in ANP1106C (275 of them completed the course). The author taught the first two-thirds of each of the two course sections with lectures covering the anatomy of the integumentary,

continued on next page

musculoskeletal, and nervous systems. The CWP's targeted the anatomy content of the course and were completed by students at set intervals during the first 2 months of their winter term course. The remaining one-third of each course was devoted to neurophysiology and is not part of this study.

Two separate banks of words (Bank 1 and Bank 2) were created by the author by collecting terms from PowerPoint slides used in lectures teaching students the functional anatomy of the body systems indicated in the preceding paragraph. Words associated with each body system were divided equally between the two banks, taking care to have comparable levels of difficulty (based primarily on word length) between the two banks. Words were selected from Bank 1 to create CWP's for Group 1 students while a corresponding subset of Bank 2 words were used for Group 2. CWP clues for each word came directly from the author's lectures.

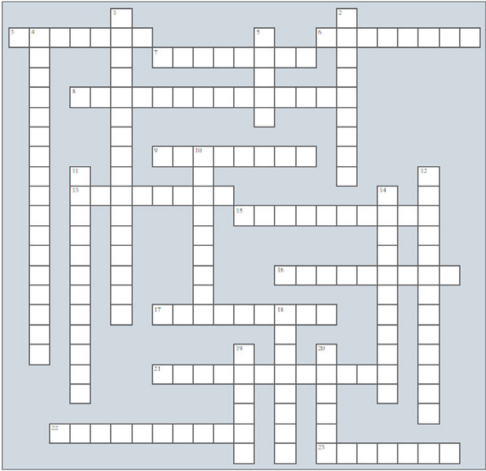
Each class was provided with four CWP's ([1] integumentary system plus bone tissue, [2] bones and joints, [3] muscles, [4] neuroanatomy) to solve online during the first 6 weeks of the course. Each puzzle (20-24 words) was made available on the course learning management system (LMS) after the relevant content had been covered in class; students then had a minimum of one week to complete and submit their puzzle with its attached score sheet. These were low-stakes assignments in that accurate completion of each puzzle was worth only 0.75% toward their final grade in the class. CWP's 1 and 2 dealt with terminology and concepts assessed in

midterm 1 whereas the new terminology words addressed in CWP's 3 and 4 related to midterm 2.

The CWP's were created using EclipseCrossword (<https://www.eclipsecrossword.com/>), a freely downloadable and easy to use software. The puzzles were created by two students (Sam Touma and Armin Farhoudi) completing undergraduate research projects with the author. Words and clues were entered into the program and then the software was prompted to develop an online puzzle with dimensions selected that ensured all words would be included in that CWP while simultaneously supporting a reasonable level of overlap between the horizontal and vertical words (Figure 1). To ensure learning value to the students, the clues were developed from course content pertaining to each new term.

Once the online puzzle was created, students were provided with access to each CWP as an assignment within their LMS. Figure 1 shows the puzzle grid, clues, and correct answers for CWP #2 (bones) provided to ANP1106C students. Figure 2 shows the appearance of the online puzzle when it is first opened by a student. Each time that a student clicked on an empty square, a clue appeared for that word, allowing them to enter their answer into the puzzle. Students continued selecting squares and entering words until the puzzle was complete. The online puzzles were located outside their LMS, so, as a last step and to get credit for their work, each student then submitted a screenshot of their completed puzzle plus the accompanying score box via that same LMS assignment function.

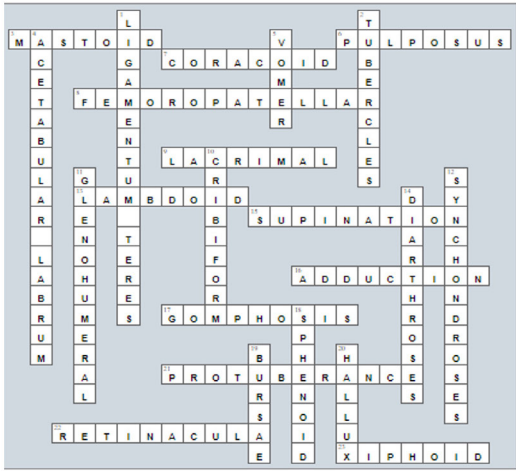
Crossword 2: Bones and Joints



Across

3. process is an attachment area on the temporal bone for some neck muscles.
6. The nucleus makes up the centre of each intervertebral disc.
7. Name of the process on the scapula to which the biceps muscle attaches.
8. The joint is one of the three joints in the knee, articulating the patella to the lower end of the femur bone.
9. Two fingernail-shaped bones that contribute to the structure of the orbit and house the lacrimal sacs.
13. Suture linking occipital bone with parietal bone.
15. If you rotate at the elbow so that the palm of your hand is facing toward the front of your body, this is called
16. Movement of a limb towards the median plane of the body.
17. An example of this type of joint is the tooth embedded in the bone of the maxilla.
21. External occipital is a projection at the back of the head that is more prominent in males.
22. The medial and lateral patellar are ligaments that connect the patella to the tibia.
23. Part of sternum that is cartilaginous in composition.

Crossword 2: Correct Answers



Down

1. Tiny ligament of the head of the femur that runs to the lower lip of the acetabulum.
2. On the humerus, the greater and lesser are sites of muscle attachment.
4. The rim of fibrocartilage that deepens the acetabulum (2 words separated by a space).
5. Single thin bone that contributes to the nasal septum.
10. Name of ethmoid bony plate that contains olfactory foramina.
11. The joint is the shoulder joint.
12. A plate of hyaline cartilage unites the bones at these types of cartilaginous joint. Common example are the epiphyseal plates in long bones of children.
14. Class of freely movable joints.
18. The frontal, maxillary, ethmoid and bones contain sinuses.
19. Flattened fibrous sacs lined with synovial membrane and contain a thin film of synovial fluid. Associated with synovial joints.
20. Anatomical name for great toe.

Figure 1. Puzzle grid, clues, and correct answers for CWP #2 (bones) provided to ANP1106C students.

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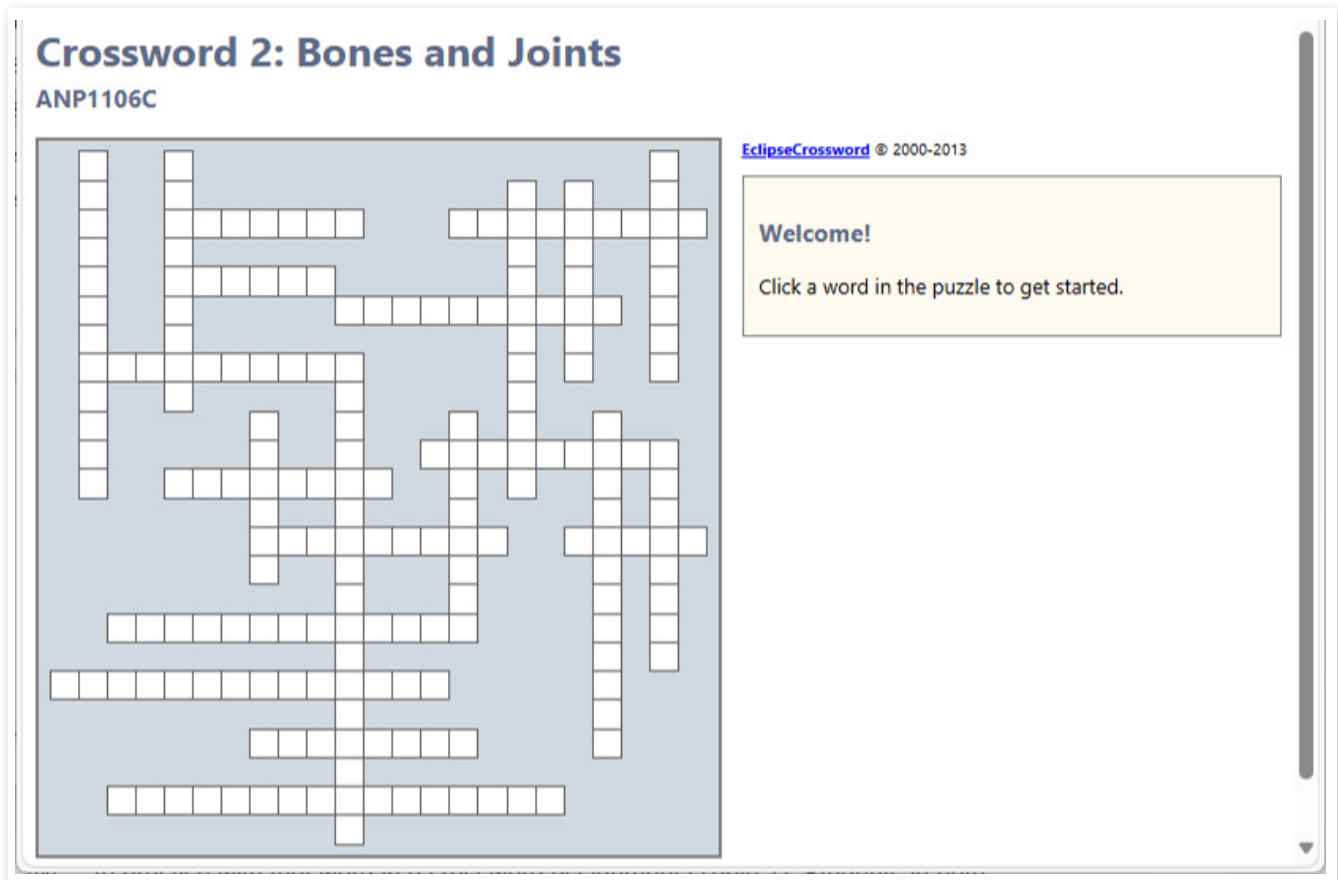


Figure 2. Appearance of online puzzle when it is first opened by a student with the prompt to allow the student to start visualizing the puzzle clues.

Students could try each CWP as often as they wanted before submitting their final product for grading. While they could earn 0.75% of their final grade for each puzzle that had been completed correctly, the puzzle score was reduced by 0.05 for every 2 errors (wrong spelling or wrong word) and by 0.1 for every word left blank (an answer not attempted). While the scores had to be entered manually into the LMS, puzzle by puzzle, this process was facilitated by the fact that each puzzle was automatically scored (number of error and/or blank squares) by the EclipseCrossword software prior to puzzle submission. Puzzles submitted after the deadline were still accepted, but the score was reduced by 0.1 for every 24 hours late.

Influence of CWPs on Student Performance on Midterm Exams

In terms of student outcomes, this study had a 2x2 factorial design (Jhangiani et al., 2019) in that student outcomes in terms of knowledge and understanding of each vocabulary

word were assessed in terms of whether or not students had the opportunity to practice with that word in a crossword assignment (Table 1). Students in both sections of ANP1106 wrote two midterm exams that addressed the anatomy portions of this course. Midterm 1 covered the integumentary system, bone tissue, and the anatomy of the skeleton and joints. Midterm 2 covered the major muscles of the body as well as neuroanatomy. For both exams, fill-in-the-blank questions using either a single sentence of text or a structure in a diagram to be labeled were used to assess student recall as well as spelling of the anatomical term. The spelling outcomes of each of these words were categorized using a rubric (Table 2).

continued on next page

Opportunity for Practice		Exam Outcomes	
		Term Correct	Term Incorrect
	Term in Crossword		
	Term not in Crossword		

Table 1. Outline of 2x2 factorial design to assess student vocabulary outcomes based on whether or not they were provided with opportunities to practice with each term in their crossword puzzle assignments.

Category	Description
Perfect	Correct word and spelled accurately
Minor Errors	Phonetically reasonable; just a letter or two is missing or incorrect
Major Errors	Aiming for the correct word; whole syllable is missing and/or multiple letter errors
Wrong Word	Provided an incorrect answer that may or may not be spelled correctly
Blank	No answer attempted

Table 2. Rubric for scoring of spelling on midterm exam questions.

Midterm 1

For both groups of students, twenty-four words that appeared in the CWP for either Group 1 or Group 2 (Table 3) were evaluated for accuracy of terminology and spelling in midterm 1. Midterm 1 spelling outcomes were scored by Armin Farhoudhi and Sam Touma. Due to the large numbers of students involved and time constraints

for these undergraduate students to finish their research projects on time, they scored terminology outcomes for 100 randomly selected exams from each of the two groups of students. Outcomes in terms of perfect (100% correct) versus the combination of wrong word plus no answer (0% correct) were then compared, word by word, via paired t-test depending on whether that word was in a CWP for that student or not.

CWP Number	In Group 1 CWP	In Group 2 CWP
1. Skin & Bone Tissue	alopecia canaliculi diaphysis osteocalcin perichondrium spinosum	hirsutism hypodermis lunula papillary periosteum sebaceous
2. Skeleton (Bones & Joints)	crista galli dorsiflexion manubrium pterygoid temporomandibular trochanter	gomphosis hallux lambdoid pulposis supination synchondroses

Table 3. Words evaluated in midterm 1 sorted by Group and CWP.

continued on next page

Midterm 2

Considering the encouraging results from data evaluation pertaining to midterm 1, student outcomes were compared more thoroughly (all students) for midterm 2 (Table 4). These evaluations were completed by the author using the same rubric as for midterm 1 (Table 2). After all data had been entered, outcomes in terms of 100% correct versus 0% correct were analyzed word by word via paired t-test depending on whether or not that word was in a CWP provided to the student.

Crossword Puzzle Number	In Group 1 Crossword	In Group 2 Crossword
Muscles	brachioradialis coccygeus gastrocnemius iliopsoas sternocleidomastoid zygomaticus	buccinator calcaneal fibularis latissimus semitendinosus styloglossus
Neuroanatomy	amygdala cerebral aqueduct flocculonodular meninx quadrigemina* substantia nigra	arachnoid decussation hypoglossal ipsilateral pallidus pellucidum

*This word was omitted from the calculations because many students wrote “superior and inferior colliculi” instead of “corpora quadrigemina”. This was also a correct answer, but it took away the ability to assess their spelling of the term (quadrigemina) that was in the CWP for Group 1.

Table 4. Words evaluated in midterm 2 sorted by crossword puzzle.

In a second evaluation, outcomes in terms of minor spelling errors (described in Table 2) were compiled by the author and their incidence subsequently compared based on whether or not the student was provided with that word in CWP 3 or 4. In this case, the denominator was corrected for students who had no idea of the correct word in an effort to ascertain if practicing with the word in a CWP helped with spelling it correctly during the exam when they at least knew the word that they were trying to provide. Again, the data were evaluated using the paired t-test.

Results

Despite the fact that successful completion of each CWP contributed only 0.75% to each student's final grade, the participation rate in the CWP assignments was high, at over 90% and as high as 97% depending on the puzzle (Table 5). It should be noted that the participation rate was calculated as a percentage based on initial enrolment in each course. However, during the first few weeks of the course, class sizes diminished by 6-7% in response to some students deciding to drop the course. This means that the calculation of percent participation (especially for CWPs 3 and 4) is slightly underrepresented.

	Group 1		Group 2	
	Completed	Mean Score (out of 0.75)	Completed	Mean Score (out of 0.75)
CWP 1	234 (97%)	0.73	280 (95%)	0.74
CWP 2	230 (95%)	0.74	269 (91%)	0.73
CWP 3	230 (95%)	0.74	270 (92%)	0.73
CWP 4	227 (94%)	0.73	266 (90%)	0.74

Table 5. Level of participation and mean scores for CWP assignments. For Group 1, 242 students initially enrolled in the course with 228 of them completing it. The corresponding numbers for Group 2 are 295 students initially enrolled and 275 completing the course. Participation rates are given as actual numbers and percentage (based on initial enrolment in the course).

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CWPs 1 and 2 and Midterm 1

The overall class averages for Midterm 1 were 72.7% (Group 1, n=238) and 69.6% (Group 2, n=290). Table 6 summarizes the outcomes (correct word, spelled perfectly versus incorrect word or no answer) for the 24 words that appeared in CWPs 1 or 2 for Group 1 or 2 students. It was found that, on average, $45.5 \pm 3.56\%$ (mean $\pm$ SEM) of answers were 100% correct (correct word and correct spelling) when provided by Group 1 or Group 2 students who had not experienced those

words in their CWPs. On the other hand, $52.1 \pm 3.20\%$ of answers were 100% correct ($t(23) = 4.132, p < 0.001$) if the answers were provided by Group 1 or Group 2 students who had been provided with the opportunity to practice with those words in their CWPs. Similarly, when comparing the percent of students who could not provide the word or gave a completely incorrect answer (Table 6), it was found that more outcomes ($34.3 \pm 3.23\%$) fell into this category if the words were not in a student's CWP compared to if they were ($28.9 \pm 2.68\%$; $t(23) = 2.511, p = 0.019$).

WORD	Perfect Spelling (%)		Wrong Word or No Answer (%)	
	In CWP	Not in CWP	In CWP	Not in CWP
alopecia	64	51	18	38
canaliculi	46	35	28	37
crista galli	63	43	15	38
diaphysis	75	72	17	22
dorsiflexion	58	36	15	31
gomphosis	36	36	42	39
hallux	60	56	26	19
hirsutism	26	23	36	35
hypodermis	82	84	12	9
lambdoid	62	60	25	22
lunula	51	41	10	11
manubrium	54	53	28	36
osteocalcin	46	27	38	66
papillary	71	67	23	22
perichondrium	42	26	51	68
periosteum	61	63	27	22
pterygoid	50	35	33	50
pulposus	30	27	37	35
sebaceous	40	48	40	31
spinosum	68	62	19	27
supination	48	47	46	40
synchondroses	25	26	58	57
temporomandibular	32	25	21	24
trochanter	63	49	29	45
MEAN $\pm$ SEM	$52.1 \pm 3.2^*$	$45.5 \pm 3.6^*$	$28.9 \pm 2.8^{**}$	$34.3 \pm 3.2^{**}$

* $p < 0.001$; ** $p = 0.019$

Table 6. Word-specific comparison of outcomes (spelled perfectly versus wrong word or no answer) on midterm 1 for Group 1 and Group 2 students, depending on whether each word appeared in one of their first two CWPs. (n=100 for each of Group 1 and Group 2).

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CWPs 3 and 4 and Midterm 2

The overall class averages for Midterm 2 were 71.0% (Group 1, n=233) and 66.9% (Group 2, n=283). In this instance, knowledge of terminology and spelling outcomes were compared for 23 words rather than 24. One term (corpora quadrigemina) was omitted from the study because many students instead wrote “superior and inferior colliculi”, which was also a correct answer but not the term for which spelling outcomes were to be evaluated.

Evaluation of spelling and knowledge outcomes led to a stronger positive effect of CWPs on student retention and ability to spell the terms correctly (Table 7). It was found that, on average, 55.7 ± 4.05 % of words were spelled perfectly when Group 1 and Group 2 students had opportunities to work with those words in their crosswords compared to 46.8 ± 3.80 if they did not ($t(22) = 5.867$, $p < 0.001$). Furthermore, only $29.2\% \pm 3.28$ of outcomes involved the wrong word or an answer left blank, if the required term was in students' CWPs, compared to $35.2 \pm 3.79\%$ if it was not ($t(22) = 3.194$, $p = 0.004$).

WORD	Perfect Spelling (%)		Wrong Word or No Answer (%)	
	In CWP	Not in CWP	In CWP	Not in CWP
amygdala	75	63	13	25
arachnoid	61	52	30	42
brachioradialis	33	28	63	68
buccinator	71	73	23	26
calcaneal	72	63	14	20
cerebral aqueduct	65	56	27	32
coccygeus	63	50	25	32
decussation	41	36	49	53
fibularis	50	48	45	46
flocculonodular	13	5	52	81
gastrocnemius	40	34	41	44
hypoglossal	71	65	18	21
iliopsoas	40	34	34	43
ipsilateral	43	33	42	44
latissimus	71	65	7	16
meninx	79	44	13	4
pallidus	39	38	43	35
pellucidum	36	31	37	30
semitendinosus	33	22	28	34
sternocleidomastoid	74	57	17	26
styloglossus	71	67	21	21
substantia nigra	50	34	26	53
zygomaticus	91	78	3	13
MEAN $\pm$ SEM	55.7 $\pm$ 4.1*	46.8 $\pm$ 3.8*	29.2 $\pm$ 3.3**	35.2 $\pm$ 3.8**

* $p < 0.001$; ** $p = 0.004$

Table 7. Word-specific comparison of outcomes (spelled perfectly versus wrong word or no answer) on midterm 2 for Group 1 and Group 2 students, depending on whether each word appeared in one of their CWPs. (n=226 for Group 1 and n=270 for Group 2). To correct for different Group sizes, data are expressed as the percent (%) of students with each spelling outcome.

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This investigation was extended to assess the influence of CWP on the percent of *minor* spelling errors for those students who demonstrated that they knew which term was the answer to the question (Table 8). Students who knew the term but did not have that term in either of their CWPs (CWP 3 or 4) had a higher incidence ($t(22) = 3.314, p = 0.003$) of minor spelling errors ($22.7 \pm 2.7\%$) compared to students who knew the term and had also had the term in their assigned CWP ($18.1 \pm 2.6\%$).

WORD	MINOR SPELLING ERRORS (%)	
	In CWP	Not In CWP
amygdala	11%	16%
arachnoid	13%	9%
brachioradialis	13%	23%
buccinator	7%	3%
calcaneal	13%	17%
cerebral aqueduct	6%	16%
coccygeus	13%	22%
decussation	14%	13%
fibularis	7%	8%
flocculonodular	46%	44%
gastrocnemius	27%	33%
hypoglossal	12%	21%
iliopsoas	36%	31%
ipsilateral	18%	26%
latissimus	20%	25%
meninx	9%	35%
pallidus	24%	28%
pellucidum	31%	32%
semitendinosus	52%	60%
sternocleidomastoid	15%	18%
styloglossus	10%	11%
substantia nigra	14%	20%
zygomaticus	4%	10%
MEAN $\pm$ SEM	18.1 $\pm$ 2.6*	22.7 $\pm$ 2.7*

* $p = 0.003$

Table 8. Word-specific comparison of minor spelling errors on midterm 2 for Group 1 and Group 2 students, depending on whether each word appeared in one of their CWPs. ($n=226$ for Group 1 and $n=270$ for Group 2). Data are expressed as the percent (%) of students with each spelling outcome.

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Discussion

This study was designed so that possible benefits associated with practicing new vocabulary using crossword puzzles could be evaluated while each of the two student groups were still provided with opportunities to benefit from any learning advantages associated with these applied exercises. The results demonstrated a positive effect of CWP on student success when learning new anatomical terminology, both in terms of knowledge retention (being aware of what term was requested with an exam question) and an ability to spell new terminology words correctly.

Using course content to develop the CWP clues provided students with opportunities to link new terminology with a deeper understanding of the structure and/or function of that body component, be it a bone or bone marking, a type of skin cell, or a muscle spanning a joint (Mintzes et al., 1997; Qutieshat et al., 2022). In this era of rapidly emerging online learning tools, CWPs might be viewed as an old-fashioned type of puzzle. However, these puzzles can be valuable learning and self-testing tools. As has been reported by others, the ability to interact with each part of the CWP online and to keep trying until the correct word has been inserted and spelled correctly challenges students to continue to interact with course content outside the classroom, promoting increased retention of A&P factual information (Moore & Dettlaff, 2005; Nirmal et al., 2020; Saxena et al., 2009).

The high level of student engagement in these CWP assignments suggests that students were motivated to participate. Motivation is an important driving force to prompt successful learning and it can be subdivided into two types: intrinsic and extrinsic (Lapum & St-Amant, 2016; McDaniel & Tornwall, 2016; Mennenga et al., 2016; Paas et al., 2003). Both types of motivating forces were incorporated into the CWP assignments. The extrinsic motivation (an external reward) for these puzzles was small at 0.75% of one mark for each puzzle completed successfully and submitted on time. The intrinsic motivation was the internal reward that came from putting effort into these homework assignments that were designed to provide opportunities to become more familiar with course content as students worked through the clues to solve each puzzle. When assigning the puzzles, it was explained to students that the clues came directly from course content for which they were responsible and that the more important goal of the crosswords, over and above the 0.75% earned for completing the puzzle accurately and on time, was that the assignments were designed to help them better prepare for exam questions. While intrinsic versus extrinsic motivation for each student was not measured in this study, the high level of participation (90-97%) in each CWP assignment did lead to more successful outcomes on those parts of their midterm exams that asked them to supply words from their CWPs in response to a question or a diagram.

In these days of spell-check and other forms of artificial intelligence, the ability to spell correctly may seem to be not as important as it used to be. Many students studying A&P are in professional programs such as nursing, physiotherapy, or paramedicine. The importance of being comfortable with new terminology associated with a student's sphere of postsecondary education cannot be overestimated and the ability to spell correctly is just as valuable post graduation as it is during undergraduate and graduate studies (Morrison, 2017). Correct spelling fosters better and more accurate communication and demonstrates professionalism and an appropriate level of knowledge; it can even improve an applicant's chances of being hired (Babcock, 2024; Morrison, 2017).

There were some limitations to this study. In the creation of the word banks for Groups 1 and 2 students, effort was made to have both banks have words of similar levels of difficulty. However, some words may have been more familiar to students because that term was encountered more frequently in class or was simply a term that was of particular interest to a student and so remembered better. When evaluating spelling on the exams, themselves, we were dealing with student handwriting that often is quite legible but sometimes can be very difficult to decipher. Finally, the puzzles were online, out-of-class assignments. This meant that students were free to do the crossword puzzles on their own or to work together in groups or to even share answers with one another. It was not possible to control for the amount of individual effort that each student devoted to each CWP.

In conclusion, students embraced the CWP assignments and completed them with close to 100% participation. Having access to terms in their CWPs resulted in students having a higher level of recall as well as increased familiarity with and improved spelling of the new words. An important consideration is always the time required to create interactive assignments for students. With the CWP creation software, puzzle creation was fast and easy. It was simply a matter of selecting about 25 new terms and creating clues based on course content. Within seconds, the software worked with the words to fit them into a puzzle of specified dimensions that could be uploaded for students. A&P courses are content-dense courses with a whole new set of terminology that needs to be mastered. Practicing with CWPs can help students meet that challenge.

Acknowledgments

I am grateful to the Undergraduate Research Opportunity Program of the University of Ottawa for providing funding for two students to assist with this project. I would also like to thank Sam Touma and Armin Farhoudi for their hard work in helping to prepare the crossword puzzles and to evaluate student outcomes for midterm 1.

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Game Night! Assessment of Playability and Learning Effectiveness of Active Learning Games by Anatomy and Physiology Students

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Abstract

Human Anatomy and Physiology (A&P) courses are a requirement for many students pursuing a healthcare career. These courses tend to have lower success rates than other entry-level courses because students are not adequately prepared for the dedication, self-discipline, and studying required for success. This problem is exacerbated for students as these A&P courses may predict their success in their future education. A&P professors are continually working to develop effective techniques to engage students while learning and to raise their chances for success. Many educators have turned to using game-based learning in their courses to promote an enjoyable and motivational environment for their students. However, questions have arisen about whether these games are beneficial or simply entertaining for the students. Our goal for this study was to test the learning effectiveness of several A&P games and identify variables that were most effective in raising students' exam scores. We assessed the enjoyment, playability, competitiveness, and effectiveness of these A&P games by surveying students before and after playing each game as well as at the beginning and end of the course. Survey responses, including predicted exam performance, were linked to exam scores to assess game success. Positive correlations between game and exam performance were topic-dependent (e.g., muscular system) with no clear, one-size-fits-all game format. From students' qualitative responses, the best learning games were like games they had played in the past, were about a moderately difficult topic, involved collaboration, and did not include instructions more complex (e.g., action potential) than the course topic itself. <https://doi.org/10.21692/haps.2025.019>

Key words: anatomy, physiology, education, survey, game-based learning

Introduction

Human anatomy and physiology (A&P) courses pose many challenges for professors and students alike with game-based learning emerging as a potential solution to some of the challenges. Professors are responsible for teaching large volumes of information to large numbers of students in a short amount of time. Demand for as well as student enrollment in these courses has risen significantly, as they are required for many professional schools in healthcare (Kuyatt & Baker, 2014; Pollock, 2022). Because of these challenges, professors may struggle to convey the material to every student efficiently, keep students engaged during the class period, and relay the material in a way that students will enjoy learning it.

Students, particularly those in pre-health areas of study, need A&P courses for graduate school and may view the class as a burden instead of a learning opportunity (Brown et al.,

2017). Also, success in these courses may determine how well these students do in later years of education (Brown et al., 2017; Friedel & Treagust, 2005; McVicar & Clancy, 2001). Finally, some students may not be academically prepared for these courses because they rarely require upper-level STEM prerequisites, and many students going into programs where A&P is required have not taken a STEM course at the college level (Gultice et al., 2015). With the lack of an upper-level science background, these students may not have developed the advanced study methods needed for this class. A&P courses require students to retain a large amount of complicated material in a short amount of time, and if these students have not been exposed to a course of this rigor before, they may not have the endurance to be successful (Gultice et al., 2015; Meguid et al. 2019; Whitehead & Britson, 2022). Another obstacle that students must overcome is that they are learning differently compared to other science

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courses. A&P courses connect the functions of the body and the structures of the body parts performing these functions. Retaining context and perspective can be challenging for some students as some find the material too abstract to comprehend (Luchi et al., 2019; Sturges & Maurer, 2013).

Students going into A&P courses may approach them with a feeling of dread because of a predetermined mindset that they will be unsuccessful based on hearing from their peers about how challenging these courses are. Published reports do show low success rates, and many students either drop or fail the course (Britson, 2022; Maurer et al., 2013; Whitehead & Britson, 2022). This pattern poses multiple problems for students and their professional career prospects. They risk jeopardizing their GPA, lowering their chances of getting into graduate school, and potentially delaying progress in their career paths by needing to repeat the course for a better grade (Gultice et al., 2015). With these emotions and responsibilities, it can be challenging for a student to go back into a course they did not complete successfully in the past. Some students with this challenge may even resort to changing their major or dropping out (Maurer et al., 2013); they may give up on their planned career paths because they failed one course.

Professors have been consistently researching and experimenting with different resources and techniques to convey A&P material to their students effectively. Many professors offer their students supplemental instruction (SI) sessions (Britson, 2022). These sessions are free learning opportunities offered to students and are led by other student(s) who has(ve) previously excelled in the course. Although professors may encourage their students to attend these sessions outside of the classroom, many students do not want to commit to additional sessions, making class time the only time some students will work with the information, not including the time they spend studying on their own (Britson, 2022).

Some professors have turned to using active learning opportunities in their classes to encourage their students to build their knowledge as they learn the material. Also, active learning provides mitigations to some of the problems that students may face in a traditional learning/classroom setting by providing “interactivity, collaboration, peer learning, and active learning” (Lean et al., 2006; Ruben, 1999). Active learning can also be complex for professors as they locate or develop the activities and the course time to use them (Roberts et al, 2024). Active learning within the classroom can also expose (to others) a student’s weakness in the course that was previously unknown to them, leading to negative reviews from the student (Carew, 2018).

Many studies have shown that games can support student learning and engagement. Educational games are growing in popularity and effectiveness in supporting learning in

higher-level education (Bai et al., 2020; Roberts et al, 2024). The number of peer-reviewed journal articles indexed on the Education Resources Information Center (ERIC) database on game-based learning has been increasing markedly; 456 articles were published between 2006 and 2015, 886 between 2016 and 2020, 1341 between 2021 and 2024, and 130 articles were published in the first 5.5 months of 2025 (search conducted 20 June 2025). Introducing educational games in the classroom can create an enjoyable and enriching environment for the students, which is beneficial for the students retaking the course or for those who have a predetermined mindset that they will fail. However, some questions remain. Some past studies (e.g., Mistry et al., 2023) have explored the question of whether a game is successful because it is simply entertaining or because it actually leads to student success in understanding the material.

Collaborative games have been shown to be effective for students as they engage with their peers and learn material while working with others (Roberts et al., 2024). Carew (2018) introduced a game to encourage students to work in groups and participate in active learning by performing a word game to test their physiology comprehension. Most student responses were positive, and one student said that the style differed from what they had experienced in the past but liked how “it puts you on the spot” (Carew, 2018). By incorporating pressure into the game, students are required to answer the question given to them with little time to think, which can be an excellent tool to practice before facing the pressure of an upcoming exam.

Competition is another aspect of game-based learning that has been tested. Mistry et al. (2023) tested a “physiology quiz competition” with students competing in four different rounds of questions, and the group with the most points at the end winning the game. They conducted this experiment with the idea that “physiology quiz competitions held in the past have shown that they enhance student’s interest in effectively learning the subject” (Mistry et al., 2023). When given a motive for participating in educational games (in this case, the chance to win), students are more likely to want to play and, therefore, are more likely to engage with the material.

Another aspect that makes a game successful is how clear its instructions are and how playable it is. To be an effective learning tool a game should be easily understood by the students, making it easier to enjoy and play.

The goals of this study were to (1) identify what factors make a learning game successful in an A&P I course by inviting students to play several different learning games associated with course content, and, (2) identify whether participation in the learning game translated to improved student performance in the course.

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Methods

Students enrolled in Human A&P I during the fall semester of 2023 (351 total) were invited to participate in this project via announcements in the laboratory and on the learning management system. This course is the first of a two-semester course sequence focusing on the structure and function of cells, tissues, and the integumentary, skeletal, muscular, and nervous systems within the human body (Human Anatomy and Physiology Society Learning Outcome Modules A through H; HAPS, 2019). Additional information about the course, including design, assessments, and performance data can be found in Britson (2022).

In the first lab session students received and completed, if agreeing to participate, a consent form to use their performance scores for the course as part of this project. This protocol was approved as Exempt under 45 CFR 46.101(b) (#2) by the University of Mississippi Institutional Review Board (Protocol #23x-272). Also in the first lab session, participating students were given a short survey asking for their background information (e.g., year in college, major, career goal, etc.), general preparation for the course, study habits, and knowledge of learning games. Students were also asked if they were willing to participate in outside-of-class, game-based learning activities. These activities took place

within the laboratory at 4pm on Monday afternoons and did not conflict with other course activities. Students were given a small amount of extra credit at the end of the course for participating in any portion of the project. Students who did not want to participate but wanted to earn the extra credit were given an alternate activity (e.g., a short writing assignment of 400-500 words).

There was at least one game session with a topic linked to a major topic for each lecture exam (Table 1). For example, the first lecture exam assessed knowledge of body terminology, chemistry review, and cell structure, and the first game was designed to develop proficiency in body terminology. Wherever possible, previously published A&P learning games were used, or we used variations of culturally popular games such as Jeopardy!® (Newcomb, 2004). At the beginning of each session, students were told the general premise of the game and written instructions were provided when needed. After students understood the instructions, game play began. Every game involved students working in groups or pairs to encourage collaboration. When students completed the game, they were asked to complete a post-game rubric (Table 2). Questions for each survey and post-game rubric are presented within the Results section.

Content	Exam	Game(s)	Source
Body Terminology, Chemistry Review, Cell Structure	1	Body Region Cornhole	Modified historical lawn game [Jensen-Brown (2016)]
Tissues, Integumentary System, Bone Tissue	2	Tissue Jeopardy	Modified from Jeopardy! (created by M. Griffin [Newcomb (2004)])
Axial Skeleton, Appendicular Skeleton, Joints	3	Axial Skeleton Jeopardy, Appendicular Skeleton Bone Buzzer	Modified from Jeopardy! (created by M. Griffin [Newcomb (2004)]), Develop by first author (H.M. Brady)
Muscle Tissue, Muscular System, Nervous Tissue	4	Muscle Contraction Puzzle, Muscular System Board Game	Modified from Machado et al., (2017), Luchi et al., (2019)
Central, Peripheral, and Autonomic Nervous Systems	5	Membrane Potential Puzzle	Machado et al., (2017)

Table 1. A&P I learning games tested for playability, competitiveness, enjoyment, and effectiveness (as correlated to lecture exam score) during the fall semester of 2023 at the University of Mississippi.

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Question	Response
Rate the playability for this game.	Ranked
Rate the level of competition felt while playing this game amongst your opponents.	Ranked
How much fun was this game?	Ranked
How well did you understand the material BEFORE playing this game?	Ranked
How well did you understand the material AFTER playing the game?	Ranked
How likely are you to play this game again when studying this topic?	Ranked
How likely are you to recommend this game to other A&P students?	Ranked
After completing this game, predict how well you think you will do on exam questions relating to this topic.	0 to 100

Table 2. Assessment questions for the post-game rubric completed by participating students in A&P I. Students were asked to rank their response [1 (low) to 5 (high)] for the first seven questions. For the last question, students were asked to predict their score on the upcoming lecture exam.

In the first game, Body Region Cornhole, participating students were divided into groups of 3-4 students each. One student in each group served as the model body that was traced onto a roll of blank paper. The outline would remain on the floor and serve as the game board. No additional markings were made to the body outline. Body regions from the course need-to-know list were written on separate index cards. Teams of players would draw a region card, and points would be earned by hitting the specific region with a bean bag. There were multiple ways to earn points that did not depend solely on physical skill. Specifically, points were earned if the bag landed on the correct region without consulting the textbook (4 points), the bag landed on the correct region but the textbook was consulted prior to the throw (3 points), the bag landed on a different region but that region could be named without consulting the textbook (2 points), or the bag landed on a different region and that region could be named only after consulting the textbook (1 point). Each team was responsible for keeping track of their score. Once all region cards had been played, the team with the most points at the end won the game.

The second and third games played were variations on the Jeopardy!® game show (Newcomb, 2004). Free templates available online (Johnson, 2020) were used to create "Tissue Jeopardy" and "Axial Skeleton Jeopardy". In "Tissue

Jeopardy" the categories were "Visual Epithelial", "Visual Connective", "Visual Muscle and Nervous", "Written Epithelial", "Written Connective", and "Written Muscle and Nervous." In "Axial Skeleton Jeopardy" the categories were "Overall Axial Skeleton", "Cranial Bones", "Facial Bones", "Bones of the Ears and Neck", "The Vertebral Column", and "The Ribcage and Sternum". Students played in teams of 3-4 as they arrived and followed the game show rules. The game concluded once all categories were selected with the team earning the most "money" declared the winner.

The fourth game, Appendicular Skeleton "Bone Buzzer", was created by the first author (Brady) and designed to test students on their ability to identify the bones of the appendicular skeleton. Specifically, the femur, humerus, tibia, fibula, ulna, radius, coxal bone, sacrum, clavicle, patella, and scapula were collected from the set of loose bones in the lab. As the students arrived, they were instructed to split into two groups and download a buzzer app on their smartphone (e.g., The Ultimate Buzzer, Makens Apps, LLC). After the instructions were explained, one student from each group came forward and faced each other while a bone was placed in between them. After the moderator (Brady) revealed the bone, whichever student pressed their buzzer first, had the chance to guess the bone. If the first person guessed the

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bone correctly, they got a point and were asked a question about the bone. If they answered the question correctly, they got an additional two points. If they were unable to identify the bone and/or answer the question correctly, the other team got the chance to steal. After all the bones were presented, the team that received the most points was announced as the winner.

For the fifth session, the Membrane Potential Puzzle (Machado et al., 2017) was modified to test students' knowledge of the steps of muscle contraction and called the "Muscle Contraction Puzzle." Puzzle categories included Molecules Used; Cell Structure (Location); Position of Actin and Myosin; Length of H, A, and I Bands; and ATP Needed? for the six stages of the process of muscle contraction: excitation, excitation-contraction coupling, excitation of the myosin head, the power stroke, detachment of the myosin head from actin, and relaxation. Instructions, puzzle game board, and game cards were provided for groups of 3-4 students. It was explained that the goal of this game was not to win or lose, but to see how many times it took for each group to correctly complete the puzzle. Groups attempted to place all game cards in the correct location and once each group believed they placed all of the cards correctly, the session leader (Brady) determined correctness. Student groups were allowed as many attempts as needed to complete the puzzle correctly. The group with the lowest number of attempts was determined the winner.

The sixth game used was the muscular system board game published by Luchi et al. (2019) with questions specific to the course need-to-know list selected for use. The game board, question cards, packet of correct answers, and instructions were printed from supplemental files provided by Luchi et al. (2019). When the game session began, students separated into groups of 4-6 students, and each group received these materials as well as dice and game tokens. After explaining the premise of the game, play began and continued until one student from each group reached the end of the board first and was declared the winner.

For the seventh and final gaming session, the Membrane Potential Puzzle (Machado et al., 2018) was used without modification. Students played in groups of 3-4 students, and the game continued the same way as the Muscle Contraction Puzzle; the winning group had the lowest number of attempts needed to correctly complete the game.

In the final laboratory session, a survey was given to all students, with specific questions for those who participated in gaming sessions and those who did not. This survey asked participating students to collectively rate all games played, and non-gaming students if they thought participating would have led to higher exam scores. Lastly, statistical analyses [e.g., descriptive statistics, analysis of variance (ANOVA), correlation analyses, etc.] were completed using SPSS V27 statistical software licensed to the University of

Mississippi with the level of significance set at 0.05. Specific details linking statistical test with data analyzed are found in the Results section.

Results

Demographic Background

A total of 344 students participated in at least one portion of the study. The majority were in their sophomore year (60.8%), with smaller numbers for juniors (27.0%), seniors (9.9%), and first year students (2.4%). More than two-thirds of respondents (71.0%) to the first, in-lab survey had taken a biology course at the post-secondary level with 44.6% of these students reporting earning a letter grade of B or better. When asked to estimate how prepared they felt for this A&P I course, 9.7% of students said they were 100% prepared, 43.9% said 75% prepared, 32.4% said 50% prepared, 9.4% said 25% prepared, and 4.4% said 0% prepared. Most students typically studied a little each night before a test (57.0%), compared to 12.2% who studied by just reading their notes the night before the test or 30.8% who studied a week or two in advance of exams. Students could select more than one answer when asked about the physical resources or study outlets they used when studying, with flashcards and their laptop being the most frequent response (Figure 1). Studying by themselves was the preferred method of studying (62.2%), followed by studying with others (30.1%), and either by themselves or with others (7.8%). While most students indicated that they had never formulated or used a study game for themselves (68.9%), 31.1% did report prior use of study "games" (Figure 2).

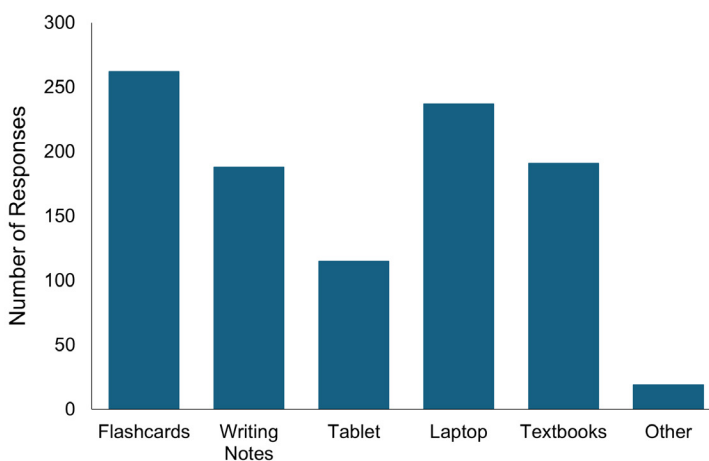


Figure 1. Study resources typically used when studying for an exam by students enrolled in A&P I (students could select more than one answer). For "other" responses, students reported using diagrams, teaching others, going to supplemental instruction sessions, and watching videos. Software applications such as Quizlet, GoodNotes, Notability, or Evernote, and PowerPoint were listed.

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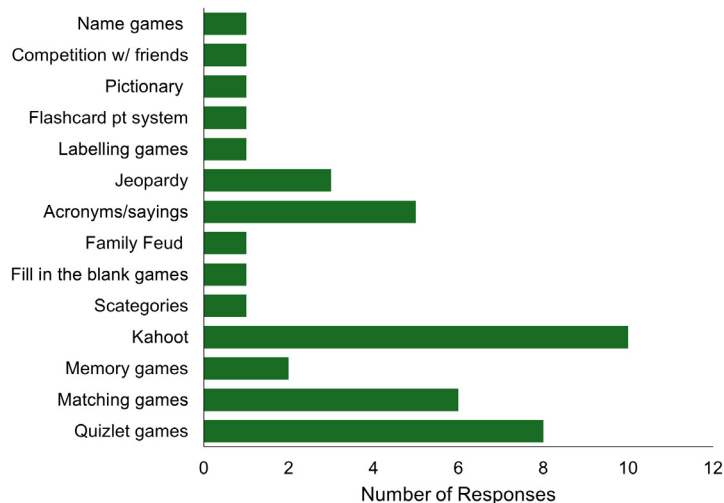


Figure 2. Self-study games that students have formulated or used in the past to help them learn scientific material as reported by students enrolled in A&P I.

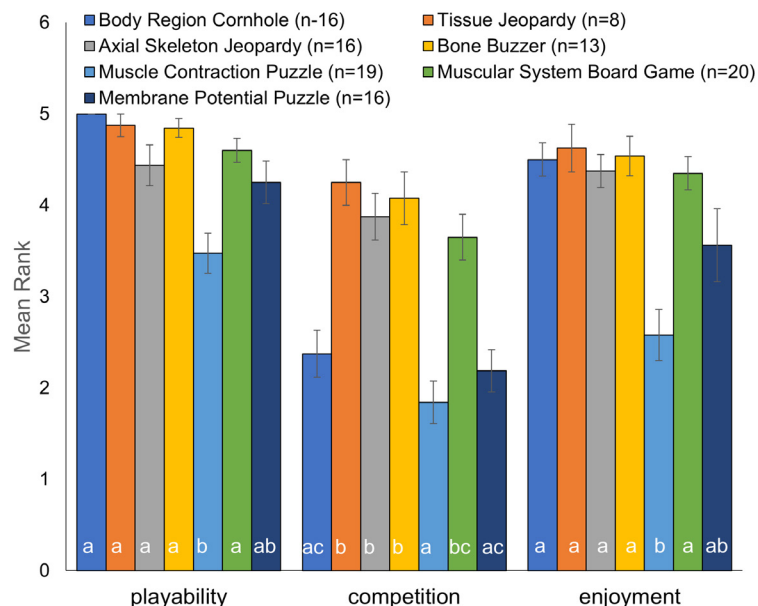


Figure 3. Mean ($\pm$ SE) ranked response (1 = low, 5 = high) on post-game assessment rubrics completed by students in A&P I for the following questions: rate the playability for this game, rate the level of competition felt while playing this game amongst your opponents, and how much fun was this game? For each rubric variable, means with the same letter are not significantly different.

Gaming Sessions

Out of the 166 students who said “Yes” to wanting to attend gaming sessions, only 37 students attended all seven of them. Attendance varied for each game with 46 students participating in at least one gaming session. A Kruskal-Wallis H-test for independent samples was used to compare ranked responses on the post-game assessment rubric completed at the end of each game, and a Mann-Whitney U-test with Bonferroni correction was used for post-hoc pairwise comparisons. The ranked level of playability was significantly different across the 7 games [$H_{(6)}=39.652$, $p<0.001$] with the muscle contraction puzzle and membrane potential puzzle games receiving the lowest playability ranks (Figure 3). The ranked level of competitiveness was significantly different across the 7 games [$H_{(6)}=47.537$, $p<0.001$] with the body region cornhole, muscle contraction puzzle, and membrane potential puzzle games receiving the lowest competitiveness ranks (Figure 3). The ranked level of enjoyment was significantly different across the 7 games [$H_{(6)}=30.901$, $p<0.001$] with the muscle contraction puzzle and membrane potential puzzle games receiving the lowest enjoyment ranks (Figure 3).

The self-assessed rank of A&P topic understanding before playing the game was subtracted from the ranked level of understanding after playing the game to estimate the level of learning that took place during game play. There was no significant difference in the level of learning across the 7 games [$H_{(6)}=6.534$, $p=0.366$; Figure 4]. There were significant differences in the ranked likelihood that students would play the games again for self-study [$H_{(6)}=14.348$, $p=0.026$] with the muscle contraction puzzle and membrane potential puzzle games receiving the lowest ranks (Figure 5). Similarly, there were significant differences in the ranked likelihood that students would recommend the games to a friend [$H_{(6)}=21.144$, $p=0.002$] with the muscle contraction puzzle and membrane potential puzzle games, again, receiving the lowest ranks (Figure 5).

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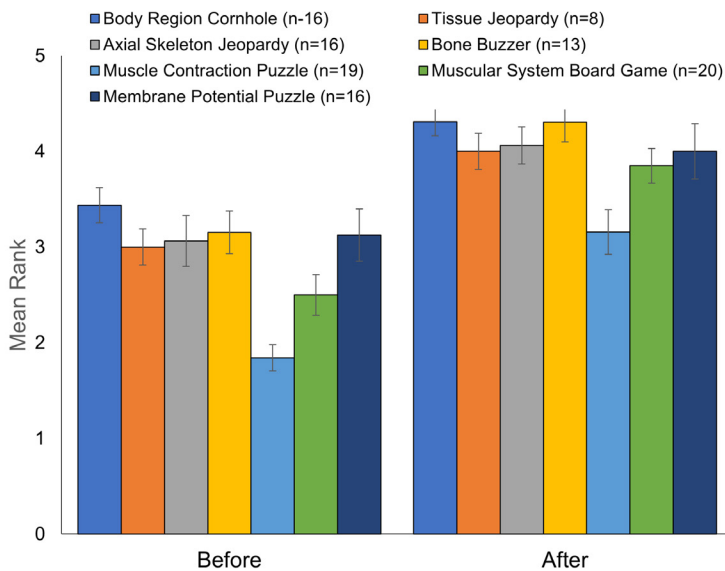


Figure 4. Mean ($\pm$ SE) ranked response (1 = low, 5 = high) on post-game assessment rubrics completed by students in A&P I for the following questions: how well did you understand the material BEFORE playing this game, and how well did you understand the material AFTER playing this game?

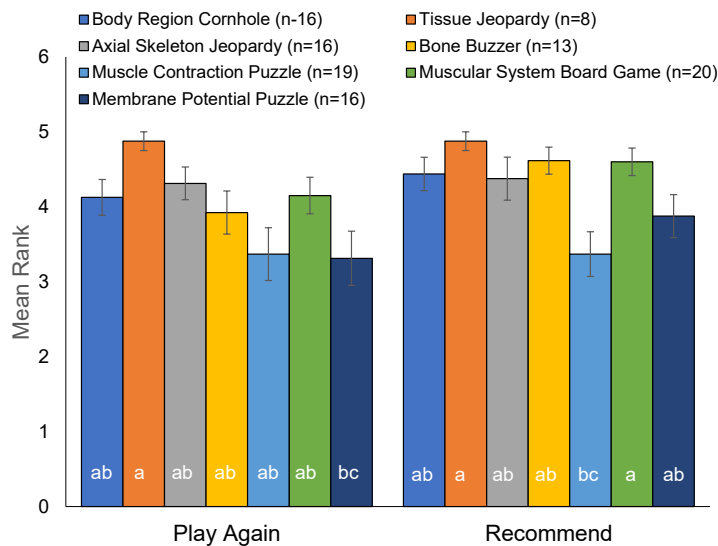


Figure 5. Mean ($\pm$ SE) ranked response (1 = low, 5 = high) on post-game assessment rubrics completed by students in A&P I for the following questions: how likely are you to play this game again when studying this topic, and how likely are you to recommend this game to other A&P students? For each rubric variable, means with the same letter are not significantly different.

Student Feedback and Performance

For students who participated in gaming sessions, a one-way ANOVA with a Tukey post-hoc test was used to analyze their predicted exam scores from the post-game assessment rubric. There were significant differences in predicted exam scores [$F_{(1,6)}=2.747$, $p=0.017$; Figure 6] with post-hoc analyses showing that only the predicted score for exam 1 (taken after the body region cornhole game) from the predicted exam 4 score taken after the muscle contraction puzzle game ($p=0.037$) and muscular system board game ($p=0.029$) from each other. Only the predicted score after playing the muscle contraction puzzle was significantly, and positively, correlated with their actual exam 4 score ($r^2=0.726$, $p=0.002$; Figure 7). No other predicted scores were significantly correlated, either positively or negatively, with actual exam scores.

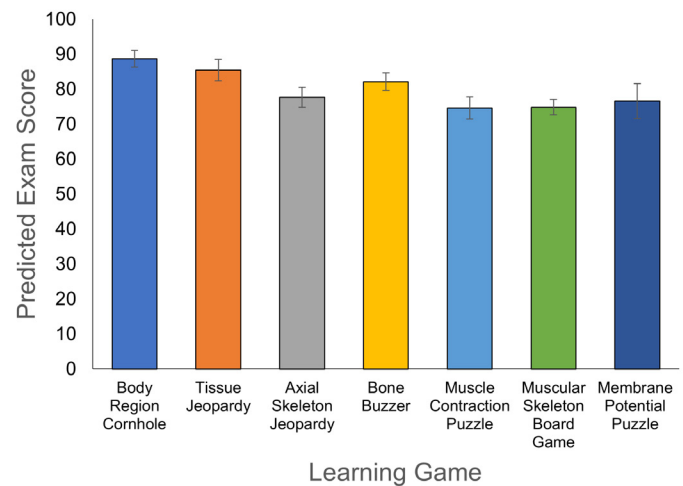


Figure 6. Predicted exam scores (mean $\pm$ SE) on post-game assessment rubrics completed by students in A&P I.

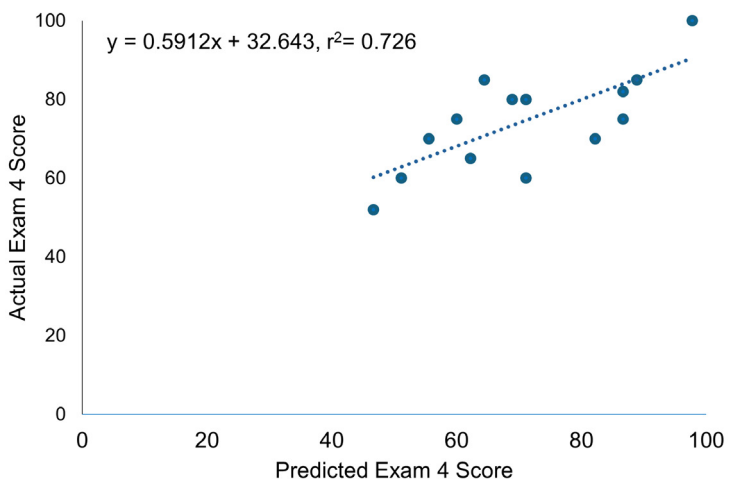


Figure 7. Significant correlation between predicted exam 4 scores after playing the Muscle Contraction Puzzle learning game with actual exam 4 scores by students in A&P I [$F_{(1,15)} = 0/726$, $p=0.002$].

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A Chi-square analysis was used to compare responses to the Likert questions on the final survey given to students who participated in one or more gaming sessions (Table 3). When asked to evaluate all games completed, most participants agreed (56.7%) or strongly agreed (21.1%) that 'The games I played helped me understand the information better.' However, 45.9% were neutral in response to 'Playing the games resulted in me performing better on the exams' and 59.4% were also neutral in response to 'I performed worse on tests when I did not attend game sessions'. Additionally, 48.3% agreed that 'I believe that I would have done better in this course if I had participated in playing more games' and 52.8% agreed that 'I would recommend one or more of the games I played to future students taking this course'.

Free response questions asking students to provide positive comments about games they liked the most (Table 4) contrasted with the negative comments about games they liked the least (Table 5). There were also significant differences in responses given by students who did not participate in any game session (Table 3) with most students neutral (40.3%) to the statement 'After talking with other students who participated, I believe I would have done better in this course had I played the games'.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	X ² result
1. The games I played helped me understand the information better.	8 (21.6)	21 (56.7)	6 (16.2)	1 (2.7)	1 (2.7)	X ² =36.378, df=4, p<0.001
2. Playing the games resulted in me performing better on the exams.	5 (13.5)	8 (21.6)	17 (45.9)	4 (10.8)	3 (8.1)	X ² =17.459, df=4, p=0.002
3. I performed worse on tests when I did not attend the game sessions.	2 (6.3)	8 (25)	19 (59.4)	1 (3.1)	2 (6.3)	X ² =35.813, df=4, p<0.001
4. I believe that I would have done better in this course if I had participated in playing more games.	2 (6.9)	14 (48.3)	9 (31)	1 (3.4)	3 (10.3)	X ² =21.172, df=4, p<0.001
5. I would recommend one or more of the games I played to future students taking this course.	10 (27.8)	19 (52.8)	7 (19.4)	0 (0)	0 (0)	X ² =6.5, df=2, p=0.039
6. After talking with other students who participated, I believe I would have done better in this course had I played the games.	14 (8.2)	42 (24.6)	69 (40.3)	29 (17)	17 (9.9)	X ² =58.561, df=4, p<0.001

Table 3. Likert response scale with X² results from students who participated in multiple game sessions (statements 1 through 5) or did not participate in a gaming session (statement 6) on the final survey in A&P I. Number of respondents (percentages in parentheses) are provided for each response category.

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Game	Positive Comments
Tissue and Axial Skeletal Jeopardy	'It was the most engaging and competitive.' 'You were able to compare the different types.' '[It] was the most helpful because of the variety of questions.' '[It] helped to clear the concept with other students.' 'It was the easiest to play, and I am an auditory learner.'
Muscular System Board Game	'It was more of a competition and our group helped explain why answers were wrong/right.' 'More similar to games I've played and enjoyed in the past. I liked playing it so I feel like I learned a little better this way.' 'Forced you to keep going over the content you missed.' '[It] helped to clear the concept with other students.' 'I feel as though getting quizzed in that way was the most effective with me studying'
Body Region Cornhole	'It helped me to talk it out with other students and to hear tricks they had to remember different regions' 'I see what/which region I was trying for and relate it to the material' 'This was the first new information for me in this class. I found this game extremely helpful because it is a concept held constant throughout the class. This game also helped with everything else we learned' 'You really had to know exactly where and what each region was along with peer's opinions.'
Muscle Contraction and Membrane Potential Puzzle	'It made more sense after about the process which can be confusing.' '[It] helped me to understand the content because everything had to be perfectly ordered to complete the game.' 'Helped me visualize contractions in different ways.' 'It helped to think through the stages with others.'

Table 4. Representative positive comments about games which helped them understand content the most as given by students on the final survey in A&P and participating in multiple game sessions.

Game	Negative Comments
Muscle Contraction/ Membrane Potential Puzzle	'[It] was the least helpful because it had too many pieces and did not help my test score.' 'This game was hard to understand and play. I was already confused on the concept and felt this did not help much.' 'It was consuming to play and didn't help to learn it.'
Bone Buzzer	'Hearing the follow up questions was helpful but didn't help me learn it as well because it was only through listening rather than seeing something.' 'You don't have time to think about the questions.' '[I] felt like I knew most of the bones already.' 'Most of them were long bones that we identified but did not discuss much further.'
Tissue and Axial Skeletal Jeopardy	'You don't have time to think about the questions.' 'After an answer was said, I would not remember it.'
Body Region Cornhole	'There would have been more effective ways to learn it besides cornhole.'

Table 5. Representative negative comments about games which helped them understand content the least as given by students on the final survey in A&P I and participating in multiple game sessions.

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Discussion

Assessment of a single learning game's success, as measured by playability, competitiveness, enjoyment, self-reported changes in understanding, and likelihood of using again, cannot be determined in isolation. A comprehensive evaluation of multiple games over time as well as relationship of game assessment variables with course performance is also critical. The games chosen for this project were either modified from other well-known games (Jensen-Brown, 2016; Newcomb, 2004), constructed for the purposes of this study, or published A&P games that have been used elsewhere (Luchi et al, 2019; Machado et al., 2017). A goal was to use games that related to content assessed on exams given in the course, 5 in total (Britson, 2022).

Most students (60.8%) taking this course were sophomores, and 71.0% of respondents had taken a lower-level biology course in college and passed with grades in the A to B range. The University of Mississippi, like most colleges (Gultice et al., 2015), does not require upper-level STEM classes before taking A&P, so the biology courses taken by participants were either introductory level survey courses or non-major courses (e.g., microbiology for allied health students). Most students (46.2%) also reported feeling 75% to 100% prepared for this course. This position may be an example of how the Dunning-Kruger effect (Kruger & Dunning, 1999) can convince students that they believe they know more information on a topic than they do. Schlosser et al., (2013) wrote that, according to the effect, not everyone overrates his or her ability and performance. Rather it is individuals with low levels of knowledge who are responsible for much of the overestimation. In our study, we expected more students to state a lower level of preparation for this course considering that there are no prerequisites. Students may, however, have been estimating future course performance as based on past performance in other college courses.

The post-game assessment and final survey results are a study of contrasts. The Tissue Jeopardy game consistently ranked high, or the highest, for playability, competitiveness, enjoyment, potential repeat used, and likelihood to recommend to a classmate. Yet, in the free-response section of the final survey, some students said it helped them the least and indicated: **'You don't have time to think about the questions'** or **'After an answer was said, I would not remember it.'** Similarly, the Axial Skeleton Jeopardy and Appendicular Skeleton "Bone Buzzer" ranked high on the post-game rubric, but students left the following representative, negative comments in the final survey: **'Hearing the follow up questions was helpful but didn't help me learn it as well because it was only through listening rather than seeing something,'** **'[I] felt like I knew most of the bones already,'** **'Most of them were long bones that we identified but did not discuss much further,'** and **'You don't have time to think about the questions.'** Body

Region Cornhole did not rank high in competitiveness and although it ranked high in the other variables, the following negative comment was given: **'There would have been more effective ways to learn it besides cornhole.'** The only game that did not receive negative comments was the Muscular System Board Game.

The Muscle Contraction Puzzle and Membrane Potential Puzzle games ranked the lowest for playability, competitiveness, enjoyment, potential repeat used, and likelihood to recommend to a classmate. Negative comments on the final survey were numerous (e.g., **'[It] was the least helpful because it had too many pieces and did not help my test score,'** **'This game was hard to understand and play. I was already confused on the concept and felt this did not help much,'** **'It was consuming to play and didn't help me to learn it.'** While there were no differences in self-reported learning as a result of playing a game, only the predicted exam 4 score (as given after playing the Muscle Contraction Puzzle or Muscular System Board Games) was significantly and positively correlated with the actual exam 4 score. Other than the predicted exam 1 score being higher than other predicted scores and likely related to positive expectations going into the first exam, there were no other differences in post-game, predicted exam scores or actual scores.

While engaging, competitive, and easy to play were frequently mentioned, and all games received some positive comments, the theme of working with others was mentioned for multiple games. **'[It] helped to clear the concept with other students,'** **'our group helped explain why answers were wrong/right,'** **'It helped me to talk it out with other students and to hear tricks they had to remember different regions,'** and **'It helped to think through the stages with others'** were common positive statements. Games that promote collaboration with their peers is an attribute that many researchers in the past have reported to be beneficial for students learning A&P material (Abdulmajed et al., 2015; Luchi et al., 2019; Roberts et al, 2024; Surapaneni, 2024).

Collaboration was built into the Muscular System Board Game and if a student answered incorrectly, others could explain to them why that answer was incorrect and why the right answer was the appropriate one. This game may have been popular because it allowed students to feel challenged, without the anxiety of competition, when being quizzed by their peers. At the onset of this study, we predicted that implementing competition into the games would work in the students' favor and make them enjoy the game more. However, the results of competitiveness and enjoyment were not in parallel with each other. Some students feed off competition and it motivates them, whereas others view competition as a setback and freeze when facing it. This idea is one of the problems seen in educational games, where students become unmotivated while playing because

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they realize how little they know about the topic (Carew, 2018). Instead of promoting competition between peers, collaboration is a more favorable attribute of a successful learning game.

The two least popular games, according to playability and future use, were the Muscle Contraction Puzzle and the Membrane Potential Puzzle. The combination of difficult to understand instructions and difficult to understand topics contributed to their low ranking. While the developers of the game (Machado et al., 2018), found the game to be successful in their classroom, cognitive overload may result when the instructions detract from the actual A&P topic. Educational games with instructions based on those of other well-known games can enable students to focus more on learning the A&P content instead of trying to learn the game's rules. One study by Herkes et al. (2021) tested the effectiveness of a card game in learning human systems physiology. These and additional authors stated that the positive impact of card games as learning tools is partly due to students' familiarity with these types of games and the inherent logic of card games (Herkes et al., 2021; Kordaki & Gousiou, 2016).

In this study the Muscular System Board Game had the most successful combination for a successful learning game. For example, the material students are being tested on should be moderately challenging to the point that the students learn something, but the instructions for the game should be fairly easy so the students can focus on what matters. Indeed, one of the students reported the Muscular System Board Game as being **'more similar to games I've played and enjoyed in the past'**. Additionally, educational games that encourage collaboration over competition, have easy and familiar instructions, and challenge students just enough make for a motivational learning environment for the students (Marcondes et al., 2023).

Limitations

The games played all connected to a topic in the A&P I course. There are other games connecting to A&P II topics [e.g., endocrine physiology (Afonso et al., 2024), the immune system (Taylor & Jackson, 1996; Work et al., 2023), digestive physiology (de Campos et al., 2020; Odenweller et al., 1998), nutrition (Dias Inamori & Lellis-Santos, 2024), and acid-base balance (Surapaneni 2024)] that could be tested. Educators should be mindful, however, that once a collaborative, educational game with easy-to-understand instructions has been identified and selected for use, that use, alone, is unlikely to increase students' exam scores.

Acknowledgments

We thank Sally McDonnell Barksdale Honors College and the Department of Biology at the University of Mississippi for their support of this project. Dr. Carla Carr and Dr. Ann Monroe provided comments on earlier versions of the manuscript. Lastly, we thank the students who volunteered to participate in the gaming sessions.

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Student-Led Study Sessions and Gamification for Anatomy and Physiology Increases ATI Scores

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Abstract

Anatomy and physiology (A&P) often present significant challenges to nursing students, contributing to early academic attrition. To address this, a series of voluntary study sessions was implemented at a nursing-focused institution, combining student-led discussions with Kahoot!®-based gamified review. Over a four-year period, students who attended these sessions demonstrated improved retention of A&P content, with up to a 20% increase in their scores on a standardized comprehensive exam. This practice-based intervention suggests that integrating low-stakes gamification with student-centered dialogue can foster engagement, clarify complex concepts, and promote academic persistence in foundational science courses. <https://doi.org/10.21692/haps.2025.020>

Key words: anatomy and physiology, gamification, student retention, nursing education, collaborative learning

Introduction

A firm understanding of anatomy and physiology (A&P) is critical for students who aspire to become nurses. This foundational course introduces the structure and function of all human organ systems and supports students in developing the biomedical knowledge required for effective clinical reasoning and decision-making. Despite this importance, many nursing students perform poorly in A&P, even when they express genuine interest in the subject. Prior research has linked this poor retention to increased academic attrition, often occurring before students even enter the core nursing curriculum (Mayner et al., 2013; Smith-Wacholz et al., 2019).

One of the most pressing concerns for nursing programs is student attrition. Williams (2010) conducted a longitudinal study of nursing students in the Midwest, identifying four major themes that distinguished students who persisted in their programs: “keeping up” with course material, “not giving up” during periods of difficulty, “just doing it” in terms of effort and discipline, and critically, “connecting” with institutional resources. This last theme of “connecting” echoes throughout the nursing education literature and is central to student retention models such as the one developed by Shelton (2012), which emphasizes the interaction of background characteristics, internal psychological processes,

and external support systems in shaping academic persistence and performance.

While educators cannot modify a student’s background or internal mindset, they can provide meaningful, accessible external support. Faculty-driven support systems, when perceived as available and reliable, increase the likelihood that students will persist in their academic programs and reduce the risk of failure due to academic disengagement (Shelton, 2013). In contrast, when such support is absent, students may not seek assistance or may interpret their struggles as signs of personal inadequacy rather than as part of the learning process (O’Reilly-Knapp, 1994).

This understanding aligns with the emerging framework of the Social Determinants of Learning (SDOL), which asserts that academic outcomes are influenced by systemic factors such as economic stability, social support networks, institutional climate, and time flexibility (Levinson & Cohen, 2023). For students balancing work, caregiving, financial hardship, and/or psychosocial stress, A&P courses, which are often designed without such contextualization, can become insurmountable. Institutions that intentionally structure academic support to acknowledge and mitigate these determinants are more likely to foster equitable learning outcomes.

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With the rapid advancement of digital tools and the shifting profile of student needs, instructors must continue evolving in their approach to support. Gamified learning platforms have gained traction in higher education for their ability to create engaging, low-stakes environments that encourage repeated exposure and motivate performance (Pront et al., 2018; Zourmpakis et al., 2023). *Kahoot!*, a quiz-based, game-like platform, provides a mechanism for instructors to reinforce key material through music, timers, and competitive interaction. These features foster classroom energy, invite student participation, and offer real-time formative feedback. The platform has been shown to increase knowledge retention, motivation, and learner satisfaction in health sciences education (Arruzza & Chau, 2023; Elkhamisy & Wassef, 2021; Ismail et al., 2019; Plump & LaRosa, 2017; Wang & Tahir, 2020).

The aim of this study was to evaluate whether a structured study session model, combining student-led discussion and game-based review using *Kahoot!*, could improve academic performance and content retention among undergraduate nursing students enrolled in A&P courses. Grounded in the SDOL framework, this research investigated whether intentional academic support offered outside of regular class time could promote persistence and success, particularly in a course with historically high attrition rates. Rather than assessing performance on the gamified elements themselves, the study focused on the overall impact of this blended support model on students' summative assessment outcomes.

The study sessions described in this manuscript combined two strategies rooted in the principles of engagement, equity, and evidence-based practice: student-led discussion and gamified formative assessment. Sessions were offered in both in-person and virtual formats to maximize accessibility and participation. During the first hour of each session, students identified challenging topics, engaged in collaborative problem-solving, and clarified difficult content in a psychologically safe environment. The second hour transitioned to *Kahoot!*-based quizzes that reinforced concepts, promoted retrieval practice, and helped students track their own understanding.

This study did not evaluate quiz performance per se, but rather examined whether this structured, supportive, and interactive format improved summative academic outcomes. As Lucardie (2014) argued, adult learners are more likely to remain motivated and perform well when learning environments are enjoyable and responsive to their needs. By aligning academic support with principles of adult learning and the SDOL framework, this study explored a promising approach for improving student outcomes and reducing attrition in anatomy and physiology.

Methods

Setting and Participants

This study was conducted at the Chicago campus of Chamberlain University, a nursing-focused institution serving a diverse undergraduate population. Students enrolled at this campus represent a wide range of socioeconomic backgrounds, with many balancing employment, caregiving responsibilities, and family obligations alongside their coursework. These contextual factors often shape students' available study time and access to academic support, making external resources particularly valuable.

Over the course of four academic years (2019 - 2022), voluntary study sessions were offered to students enrolled in BIOS251 (A&P I), BIOS252 (A&P II), BIOS255 (A&P III), and BIOS256 (A&P IV), courses comprising the full anatomy and physiology sequence required prior to beginning upper-level nursing coursework. It is imperative to note that Chamberlain University's curriculum is designed to be at an accelerated pace, and the classes are subdivided into four courses as opposed to the standard two (A&P I & II) seen at other institutions. This condensed pace increases the cognitive and time demands on students and underscores the importance of targeted, accessible academic support.

At the end of the A&P series, all students completed a standardized comprehensive exam using the Assessment Technologies Institute (ATI) platform. This exam was used to evaluate long-term retention of core anatomy and physiology concepts and served as a readiness measure for entering courses such as pathophysiology. Because it is administered to all students regardless of study session attendance, the ATI exam provides a consistent and objective measure for comparing academic outcomes across participant groups.

All students enrolled in the A&P sequence were eligible to attend the study sessions, which were promoted as voluntary, non-credit-bearing, and supplemental. To ensure alignment with course content, separate study sessions were scheduled for each course in the sequence. Participation data were collected from session sign-in sheets, and ATI performance was used as the primary measure for academic success.

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Study Session Design

Each session lasted two hours and was offered as often as twice per week. The sessions were divided into two key components to promote both content clarity and engagement:

1. Student-Led Discussion (Hour 1)

The first half of the session centered around a student-led discussion facilitated by a faculty member. Students identified topics they found most challenging, and the group collaboratively explored these areas through explanation, questioning, and peer feedback. Topics varied by course level:

- *BIOS251 (Introductory A&P)*: Students often brought forward questions about terminology, cell transport mechanisms, or the structural differences among tissue types. For example, one discussion revolved around distinguishing epithelial tissue layers, where students sketched diagrams on the virtual whiteboard to clarify stratified vs. simple arrangements.
- *BIOS252 (Regulation)*: Sessions frequently tackled the complexity of muscle contraction or neural pathway integration. In one meeting, students debated the sequence of electrical events during an action potential, while the facilitator ensured scientific accuracy and prompted connections to endocrine regulation near the end of the course.
- *BIOS255 (Flow Systems)*: Cardiovascular physiology was a recurring challenge. Students worked through the cardiac cycle using peer explanations, with one group modeling the opening and closing of valves using hand gestures and sound effects. The facilitator intervened only to refine misconceptions and encourage precision.
- *BIOS256 (Application)*: Discussions emphasized systems integration, such as how acid–base balance interacts with renal physiology. Students posed case-based scenarios (e.g., metabolic acidosis in diabetic ketoacidosis) and reasoned through compensatory mechanisms collaboratively.

The instructor guided the discussion without dominating it, helping ensure accuracy while promoting student agency, clarifying points of confusion, posing probing questions, and keeping the focus on student voices. As noted by Jones (2007), small-group discussion fosters active participation, conceptual analysis, and reflection, crucial skills for success in content-heavy science courses.

2. Gamified Review with Kahoot!® (Hour 2)

Following a short break, students participated in a review activity using Kahoot!, a game-based learning platform. Each quiz included 10–20 multiple-choice questions aligned with current course content and learning objectives. For example:

- In BIOS251, *Kahoot!* items might ask students to identify the organelle responsible for ATP production or match medical terms with their definitions.
- In BIOS252, questions often integrated diagrams of sarcomere contraction or endocrine feedback loops.
- In BIOS255, items covered tracing blood flow through the heart or interpreting a simple spirometry curve.
- In BIOS256, application-based questions asked students to predict the physiological outcome of altered digestive enzyme secretion or to match urinary pH changes with underlying pathologies.

Kahoot!'s use of music, countdown timers, and competitive scoring introduced an element of fun and urgency, while also encouraging retrieval practice and immediate feedback. This approach provided students with insight into their understanding of material in a low stakes and engaging format that reinforced learning without punitive grading.

The goal of the sessions was not to measure quiz performance itself, but rather to determine whether participation in this combined support model enhanced long-term retention and summative academic performance.

By design, the structure of these sessions reflected the SDOL framework. Many nursing students balance employment, family responsibilities, and financial constraints that can limit opportunities for extended study. Offering the sessions in both on-campus and virtual formats increased accessibility, while the voluntary and non-credit-bearing nature reduced pressure and allowed students to engage without fear of penalty. The student-led format promoted peer connection and social support, helping mitigate isolation, while the gamified review provided an enjoyable and time-efficient strategy for reinforcing content mastery. Together, these features aligned the intervention with SDOL principles by addressing institutional climate, time flexibility, and social support, factors shown to significantly influence persistence and success in academically demanding courses.

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Data Collection

Student participation in the study sessions was tracked using sign-in sheets maintained in the instructor's office. These records included the number of sessions each student attended throughout the term.

Summative academic performance was assessed via the ATI comprehensive anatomy and physiology exam, administered at the end of the A&P course sequence. This exam evaluates long-term retention of foundational science concepts and serves as a readiness indicator for entry into courses such as pathophysiology. The ATI platform is widely used in nursing education and has been shown to provide accurate predictors of NCLEX-RN success (Jenkins, 2016), further supporting its use as a reliable benchmark for evaluating academic outcomes in this study.

This project was approved by the Institutional Effectiveness, Accreditation, and Research (IEAR) board of Chamberlain University, and informed consent was obtained from all participants.

Data Analysis

Quantitative data were analyzed using IBM SPSS Version 28.0. Descriptive statistics were used to summarize the distribution of study session attendance and ATI exam scores (Table 1). Prior to inferential testing, assumptions for normality and linearity were examined using Shapiro–Wilk tests and visual inspection of histograms and scatterplots. Because the outcome variable (ATI exam score) was continuous and approximately normally distributed, Pearson's product–moment correlation was selected as the primary test to evaluate the association between number of sessions attended and exam performance.

An independent samples t-test was conducted as a complementary analysis to compare the mean ATI scores of students who attended at least one study session with those who did not attend.

Non-parametric correlations (Spearman's rho and Kendall's tau) were initially explored to assess robustness in case of deviations from normality; however, because assumptions were sufficiently met and results were consistent, only Pearson's correlation is emphasized in the final interpretation.

Results

Across the four-year period of implementation, a total of 212 students attended at least one study session, with varying levels of participation. Attendance per session averaged 9 students (SD = 7.18), with a range of 2 to 28 students. Participation across students ranged from 1 to over 30 sessions, and ATI exam performance was tracked for all enrolled students, regardless of their participation in the sessions. Students who did not attend any sessions served as the control group (Table 1).

Number of Study Sessions	Number of Students	Relative Frequency
0	65	23.5%
1-5	96	34.7%
6-10	63	22.7%
11-20	35	12.6%
21-30	12	4.3%
< 30	6	2.2%

Table 1. Help Session Attendance Distribution

Analysis revealed a statistically significant positive association ($p < 0.001$) between study session attendance and academic performance on the ATI comprehensive anatomy and physiology exam. Students who attended as few as five sessions demonstrated a measurable improvement in retention and assessment performance. Those who attended more than 20 sessions showed the most pronounced gains, with a 20% increase in average ATI scores compared to students who did not attend any sessions.

The independent samples test confirmed a significant difference in performance, with students who attended sessions scoring higher, on average, than those who did not ($p < 0.001$). Pearson's correlation coefficient indicated a moderate positive correlation between number of sessions attended and ATI exam score ($r = 0.427$, $p < 0.001$). Figure 1 illustrates the relationship between session attendance and average ATI score.

EFFECTS OF STUDY SESSIONS ON AVERAGE COMPREHENSIVE EXAM SCORES

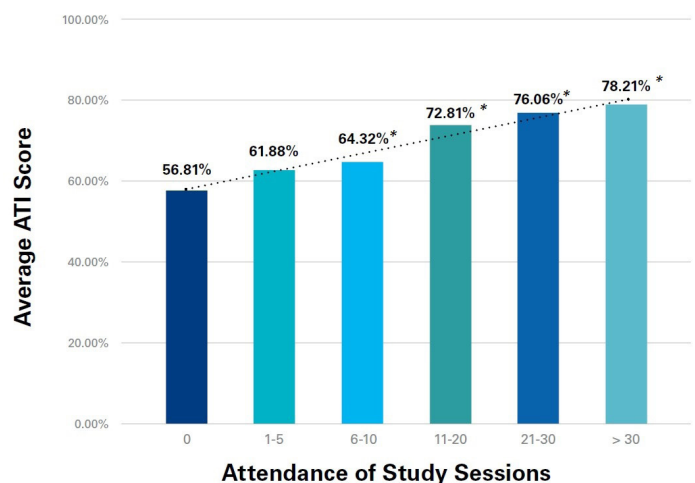


Figure 1. Comparison of average ATI scores for students that did not attend study sessions and those that did attend. (*) represents $p < 0.05$.

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These findings suggest that the study sessions, particularly when attended consistently, had a meaningful impact on students' ability to retain and apply A&P content.

Discussion and Implications

The findings from this multi-year study suggest that structured, voluntary study sessions incorporating student-led discussion and gamified review can significantly enhance academic performance in undergraduate A&P courses. Students who attended these sessions, particularly those with consistent participation, demonstrated measurable gains in retention, as evidenced by higher scores on the ATI comprehensive exam. These outcomes align with existing literature emphasizing the importance of engagement, repetition, and feedback in promoting meaningful learning in the health sciences (Wang & Tahir, 2020; Zourmpakis et al., 2023).

Importantly, the intervention addressed several challenges commonly encountered in gateway STEM courses. First, the integration of student-led discussion provided opportunities for collaborative learning, peer teaching, and clarification of difficult content. As Jones (2007) and Shelton (2012) have suggested, such forms of academic support are essential for fostering persistence in students who may otherwise feel overwhelmed or isolated in high-content courses. The findings of this study further affirm the role of faculty-facilitated but student-centered spaces in promoting engagement and metacognitive reflection.

The magnitude of the observed effects is noteworthy in the context of nursing education. A correlation of $r = 0.427$ represents a moderate association between study session attendance and exam performance, indicating that increased participation was consistently linked with higher levels of long-term content retention. Practically, this translated into an approximate 20% gain in ATI scores for students with the highest levels of participation compared to non-attendees. In high-stakes, prerequisite courses such as A&P, even modest improvements in performance can determine whether a student persists to enter upper-level nursing coursework or is lost to early attrition. Thus, the statistical significance of these findings is reinforced by their educational significance; consistent engagement in structured study sessions meaningfully improved students' academic trajectories.

Second, the use of *Kahoot!* introduced a gamified, low-stakes method for review that was both motivational and diagnostically useful. Gamification has increasingly been shown to improve student motivation and satisfaction in higher education science contexts (Arruzza & Chau, 2023; Elkhamsy & Wassef, 2021). In this study, the game-based quizzes not only reinforced weekly content but also helped students identify areas of weakness in a psychologically safe and enjoyable manner.

Furthermore, the study's design intentionally aligned with the SDOL framework, which recognizes that student achievement is influenced by factors such as socioeconomic status, time flexibility, and access to academic support (Levinson & Cohen, 2023). By offering sessions in both in-person and virtual formats, and by creating an inclusive, non-evaluative learning environment, the intervention helped mitigate some of the structural barriers that disproportionately affect historically marginalized student groups.

From a curricular standpoint, the success of this initiative demonstrates that relatively low-cost, faculty-led interventions can yield significant academic benefits. The results suggest that incorporating structured, interactive support mechanisms outside of standard instructional hours can strengthen content retention and potentially improve long-term academic persistence, particularly in prerequisite science courses foundational to nursing education.

These findings have practical implications for A&P educators. Institutions may consider adopting similar support models that leverage collaborative discussion, gamification, and flexible delivery formats. Additionally, feedback from participants suggests that offering additional asynchronous resources such as self-paced practice quizzes or instructor-created review recordings could further enhance the reach and impact of such interventions while avoiding potential concerns associated with the Family Educational Rights and Privacy Act (FERPA) when live-recorded, student-led sessions are used.

Limitations and Future Directions

While this study provides encouraging evidence for the effectiveness of structured study sessions incorporating student-led discussion and gamification, several limitations warrant consideration.

First, the voluntary nature of session participation introduces potential self-selection bias. Students who elected to attend may have been more motivated, better prepared, or more academically proactive than their peers. Although these findings suggest a positive relationship between attendance and performance, causality cannot be definitively established.

Second, the study did not control for extraneous variables such as prior academic background, concurrent use of outside tutoring resources, differences in lecture instruction across sections, or variation in test-taking skills. These uncontrolled factors may have influenced ATI scores independently of the study session intervention.

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Third, while the ATI comprehensive anatomy and physiology exam provided a standardized measure of content retention and has been shown to predict NCLEX-RN success (Jenkins, 2016), it may not fully capture the breadth of learning relevant to long-term clinical reasoning and application. Moreover, Chamberlain University is currently in the process of developing a new institutional comprehensive exam that reflects the evolving landscape of healthcare education, evidence-based practice, and curricular outcomes. This forthcoming exam may offer an even more accurate and tailored measure of student success for future program evaluations and intervention studies.

Fourth, qualitative comments were originally gathered through a survey, but due to an issue with the survey tool, these responses could not be analyzed reliably. While this limits the ability to capture students' subjective experiences, future research will integrate qualitative data to provide a richer understanding of how learners perceive and engage with the study sessions.

Future research should also explore quasi-experimental or mixed methods designs that can better isolate the effects of specific intervention components and integrate both cognitive and affective outcomes. Expanding the study across multiple campuses or student populations would improve generalizability, while incorporating longitudinal tracking could help assess whether study sessions and gamification translate into stronger performance in subsequent nursing coursework, such as pathophysiology or pharmacology.

Finally, as the educational landscape continues to shift toward digital and hybrid modalities, future studies might examine the integration of asynchronous gamified tools, mobile-based review platforms, or adaptive learning systems to meet the needs of diverse and time-constrained learners.

Conclusion

As anatomy and physiology remain foundational yet challenging courses within nursing education, innovative approaches to academic support are essential for promoting student retention, equity, and long-term success. This study demonstrates that a structured, voluntary intervention combining student-led discussion with gamified review can positively impact academic performance and content retention, as measured by ATI, a standardized comprehensive exam.

The consistent, moderate positive correlation between session attendance and exam scores suggests that even limited participation in these study sessions may yield meaningful benefits. These findings support the growing body of literature advocating for learner-centered, engaging strategies, particularly those grounded in the SDOL framework.

Importantly, this intervention can be implemented with

minimal cost and high flexibility, making it a scalable model for other institutions seeking to improve student outcomes in high-stakes, content-dense courses. As healthcare education continues to evolve, the integration of inclusive academic support rooted in engagement and accessibility will remain critical in shaping the success of future healthcare professionals.

About the Author

Leslie Worrell, DrPHc, TEFL, is an Associate Professor of Anatomy and Physiology at Chamberlain University's Chicago Campus. With over a decade of experience in science education, she specializes in inclusive curriculum development and student success strategies in the health sciences. Her work integrates gamification, collaborative learning, and the SDOL to support equity in nursing education. Leslie is an active member of the Human Anatomy and Physiology Society and presents nationally on gender-inclusive teaching practices. She is currently completing a Doctor of Public Health (DrPH), with a research focus on transgender health and academic persistence.

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“Unique and Interesting”: Games Promote Office Hour Participation by Undergraduate Students

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Abstract

Office hours are a widely used, optional form of academic support that allow students to meet with their instructors outside of class time. Despite evidence that students benefit from student-faculty interactions, instructors broadly report that office hour attendance is poor. This article describes the implementation of a weekly “Alternative Office Hour” designed to encourage students in developmental neurobiology and human physiology classes during the 2023-24 academic year to attend office hours. Instructor observations, attendance rates, and anonymous survey feedback from enrolled students are presented that reveal the use of games during the Alternative Office Hour promoted office hour participation by undergraduate students. <https://doi.org/10.21692/haps.2025.015>

Key words: office hours; student-faculty interaction; student-student interaction; student engagement, games

Introduction

Office hours are a form of academic support that consist of regularly scheduled times during which students can meet with instructors to discuss course organization, clarify content, or get to know their instructors through personal, one-on-one interactions (Mineo, 2017; Supiano, 2023). Traditionally, office hours have involved students visiting an instructor’s campus office in-person. Some faculty, however, reported meeting students at alternative locations such as a pool hall (Soares, 2012) or café (Glynn-Adey, 2020) because of their space, accessibility, and appeal (Derry et al 2020). Based on a qualitative study of 23 student experiences with online office hours during the COVID19 pandemic, Luxmoore and Fairless (2022) recommended offering online office hour options to increase accessibility for students with employment, long commutes, or family care responsibilities that might prevent office hour attendance or for those who are uncomfortable visiting an instructor’s office. In addition, a survey of life-sciences undergraduate students at Chapman University indicated that 63.9% of 531 respondents perceived online office hours as more convenient than in-person office hours. Yet, 30.3% of these respondents identified more challenges to connecting and engaging with instructors in the online format (Hsu et al., 2022). Thus, instructors may strike a balance of accessibility and providing opportunities for meaningful, personal engagement with students by

offering both in-person and online forms of office hours (Johnson, 2018; Mowreader, 2023).

Students benefit from student-faculty interactions outside the classroom (Griffin et al., 2014; Lundberg and Schreiner, 2004) and from office hour participation (Guerrero and Rod, 2013). Guerrero & Rod (2013) have reported a positive correlation between office hour attendance and academic performance. Yet, many instructors report poor student office hour attendance (Griffin et al, 2014; Joyce, 2017; Li & Pitts, 2009). For example, Griffin and colleagues (2014) conducted a survey of undergraduate students at a large, mid-Atlantic public research university that revealed that 66% of 625 respondents never attended office hours.

Differences in how students and faculty view the purpose and potential benefits of office hours may impact office hour attendance (Hsu et al, 2022; Smith et al, 2017). For example, a survey by Hsu et al. (2022) showed that students and faculty agreed that a primary purpose of office hours is content clarification. However, only faculty acknowledged the importance of using office hours to discuss study methods, metacognition, career development, and research opportunities. To promote office hour turnout, some faculty used student-centered language such as “happy hours,” “visiting hours,” or “student drop-in hours” to describe office

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hours in their syllabi (Benaduce & Brinn, 2024; Mowreader, 2023), while others invited their students for a walk outside to avoid the formal setting of the physical office (Rawle, 2017; Steinhuis, 1999).

Use of group activities to encourage office hour attendance

Since 2015, I have held one office hour a week in addition to my traditional in-person and online office hours where I participate in a group activity with my students that I call the Alternative Office Hour. Past Alternative Office Hour activities have included going for group runs on campus (Cafferty, 2018, 2021a), coloring physiological illustrations (Cafferty, 2021b, 2021c), and drawing cellular and anatomical structures on campus walkways using sidewalk chalk (Cafferty, 2022). Most recently, I drew inspiration from a workshop on educational gamification held at the 37th annual HAPS conference that outlined the potential benefits of and strategies for the employment of games in the classroom (Neumeier, 2023). During this workshop, I learned that educational gamification involves the use of game elements, for example earning points or badges and reaching increasing levels of achievement through activity engagement, in an educational context to motivate student participation (Domínguez et al, 2013; Manzano-León et al, 2021).

Classroom examples of educational gamification include: (1) the use of a computer game to create custom contests enabling students from middle school to graduate school to solve molecular puzzles (Cooper et al, 2010; Dsilva, 2019), (2) a role-playing game involving assignment of readings and roles based on major historical events to students who must communicate, collaborate, and compete to achieve game objectives (Doerer, 2019), and, (3) online software that allows student polling by instructors using a classroom response system incorporating game-like features (Adkins-Jablonsky et al, 2021). The gamification workshop inspired a question regarding the feasibility of using pre-existing games to attract students to office hours. To explore this question, students in the 2023-24 academic year were invited to attend office hours and play games with their instructor.

Methods and Results

Promotion of and types of games played during the Alternative Office Hour

Throughout the 2023-24 academic year, I held one weekly Alternative Office Hour in addition to my three-weekly traditional in-person and online office hours. I promoted my office hours to students in my course syllabi, on the front page of class websites on our learning management system, and during weekly announcements in class. Alternative Office Hours were held on Fridays at noon hour as most undergraduate classes are held on Monday/Wednesday and Tuesday/Thursday schedules at my institution, allowing a Friday time slot to conflict with fewer courses. For the

Alternative Office Hour, I invited students to come to the lobby area of my department where there is one long table plus several smaller tables that can be moved together to seat another large group of people.

During the first three weeks of the fall 2023 semester, I brought card games from home for the Alternative Office Hour to both gauge student interest and determine what games might work best for my program. Subsequently, I obtained used games at community yard sales and local thrift stores, and I successfully applied for an institutional "Pedagogy Mini-Grant" to purchase new games.

Games that work well for the Alternative Office Hour have short game booklets of only 1 or 2 pages, have simple instructions that are easy to explain, can be set up quickly, have colorful art, allow for 6 or more players, and take no more than 30 minutes to play. Games that can be quickly explained to newcomers or have simple rules that can be easily read by students in a few minutes promote inclusion of anyone who would like to join as their schedules allow. By contrast, highly complex games with many rules, game booklets that are several pages long, or have numerous cards or game pieces for players to keep track of, can be exclusionary because they are overly difficult to explain to students who come and go from the Alternative Office Hour at any time. In addition, games that allow players to pair up easily can accommodate more people and allow students who arrive mid-round to participate right way and learn the rules of that game from others on-the-fly. Examples of the most popular games amongst students for the Alternative Office Hour include course content-related games such as OrganATTACK[®] and Anatomy Fluxx[®] and non-content related games including Exploding Kittens[®] and Unstable Unicorns[®].

Alternative Office Hour attendance and participation

The Alternative Office Hour was well attended and developed a following of students who participated most weeks of the semester. In fact, during the first and last weeks of the spring semester, before laboratory classes began and after classes ended, I ran out of seats during the Alternative Office Hour, and I scrambled to find more chairs in a nearby conference room to include more people. Typical mid-semester Alternative Office Hour attendance was 12-14 students per week compared to 20-25 students who participated during the first and final weeks of the semester when students had fewer competing obligations.

The Alternative Office Hours were distinguished from traditional office hours by several features including the topics of conversation, activity duration, and the attendants. Occasionally, students would ask questions related to course content during the Alternative Office Hour. Most often, the relaxed nature of the Alternative Office Hour promoted discussion of college life including challenges experienced in other classes and in research laboratories, work accomplished during ongoing independent projects, and progress made toward applications for summer employment

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and graduate and professional programs. Conversely, most conversations that took place during my traditional office hours centered on course structure or content, with students leaving shortly after their questions were answered.

While the Alternative Office Hour was scheduled for 60 minutes, on most weeks the event lasted 90 minutes as students wished to finish their games, play another round of games, or continue with their conversations. Students brought friends, visiting family members, and occasionally their pets with them to Alternative Office Hours, suggesting that students enjoyed and were comfortable during this program. In addition, not only did my 8-year-old daughter attend the Alternative Office Hour whenever she was off school, but the children of many faculty and staff members also participated during their spring break

week. Participation by the children of campus members contributed to a greater sense of community that extended beyond my classes.

Alternative Office Hour assessment

Students were invited to voluntarily complete anonymous, online surveys outside of class time at the end of the fall 2023 and spring 2024 semesters. These surveys were composed of questions related to office hour participation (Table 1) and survey respondent demographics (Table 2). The survey response rate dropped from 100% during the fall semester to 70% during the spring semester due, in part, to the disruption of classes and the unexpected early departure of students from Atlanta as a result of violence during campus protests (Gluckman, 2024; Pratt, 2024).

Please answer the following questions about your participation in office hours during our class.	
1.	Have you attended at least one <i>Regular Office Hour</i> ? (Tuesdays and Thursdays in office, and Wednesdays online, from 1:30-2:30pm) A. Yes B. No
2.	If you have not attended a <i>Regular Office Hour</i> , why not? Select all that apply. A. I have a schedule conflict. B. I forget when they are. C. I don't feel the need for help. D. I am hesitant to seek out help. E. I do not know what office hours are for. F. I do not know how to capitalize on office hours. G. I made an appointment at an alternative time. H. Other (Please elaborate here)
3.	Have you attended at least one <i>Alternative Office Hour</i> ? (Games held on Fridays at 11:30am)
4.	If you have attended an <i>Alternative Office Hour</i> , why did you attend?
5.	If you have attended an <i>Alternative Office Hour</i> , would you recommend it to others? A. Yes B. No
6.	If you have not attended an <i>Alternative Office Hour</i> , why not? A. I do not like playing games. B. I do not want to spend more time on this class. C. Conflict with another class. D. Conflict with another activity. E. Other (Please elaborate here)
7.	What games do you recommend we play during <i>Alternative Office Hour</i> next semester?
8.	Is there anything else you would like to say about your office hour experience in our class?

Table 1: Office hour participation survey administered to students at the end of the fall 2023 and spring 2024 semesters.

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Question	Options	Fall 2023 (%)	Spring 2024 (%)
With what gender do you identify?	Nonbinary/third gender	0	1
	Female	89	56
	Male	11	43
What is your race/ethnicity? Choose as many as apply.	Asian	55	59
	Black/African American	5	7
	Hispanic/Latino/Latina/Latinx	10	12
	White/Caucasian	30	32
	Prefer to self-describe	0	1
	Prefer not to disclose	0	1
What is your class year?	First year	0	1
	Sophomore	0	34
	Junior	16	55
	Senior	84	9
	Graduate studies	0	1
What is your major/program? Choose as many as apply.	Anthropology and Human Biology	0	6
	Biology	37	31
	Chemistry	0	12
	Human Health	0	4
	Math and Computer Science	0	1
	Neuroscience and Behavioral Biology	68	32
	Psychology	0	7
	Other	10	10

Table 2: Demographic information of survey respondents ($n = 26$, fall 2023 – developmental neurobiology; $n = 71$, spring 2024 – human physiology). Only options selected by survey respondents are included.

As shown in Table 3, more students reported having attended at least one Alternative Office Hour than a traditional in-person or online office hour during the 2023-24 academic year, despite traditional office hours being offered three times more often than Alternative Office Hours. In addition, during the fall and spring semesters, 44% and 41% of students, respectively, reported attending at least one Alternative Office Hour to play games. In contrast, during past offerings of Alternative Office Hours using different

formats, only 10% of students reported attending at least one group run during a semester (Cafferty, 2021a) and 26% of students stated they attended at least one office hour during the semester to color physiology illustrations (Cafferty, 2021c). Together, these observations suggest use of games may be a more inviting and inclusive way to encourage office hour attendance compared to past Alternative Office Hour formats.

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Semester	Fall 2023	Spring 2024
Course taught	Developmental Neurobiology	Human Physiology
Course level	400-level	300-level
Scheduled traditional office hours/week (hours)	3	3
Scheduled Alternative Office Hours/week (hours)	1	1
Number of survey respondents (n)	26	69
Number of enrolled students	26	99
Survey response rate (%)	100	70
Attended at least one traditional office hour (in-person or online) (% of survey respondents)	28	25
Attended at least one Alternative Office Hour (% of survey respondents)	44	41

Table 3: Office hour attendance reported by students at the end of the fall 2023 and spring 2024 semesters.

Anonymous survey results revealed that Alternative Office Hour participants enjoyed the experience, with selected student comments shown in Table 4. For example, during the fall and spring semesters, 92% and 93% of students who attended the Alternative Office Hour, respectively, reported that they would recommend the experience to their peers.

Two themes emerged when students commented upon their motivation for attending the Alternative Office Hour. The first theme included students who reported attending the Alternative Office Hour to have fun, with some students

stating it was "unique and interesting." The second theme involved students who cited attending the Alternative Office Hour to interact with others. As such, one student explained, "I like being able to bond with classmates that I see but never meet in the classroom." Further examples of student comments on the themes of participating in the Alternative Office Hour to have fun and to interact with their peers and instructor are shown in Table 4. The quotes in Table 4 are representative of other student comments received on anonymous surveys.

Course	If you have attended an Alternative Office Hour, why did you attend?
Developmental Neurobiology	I personally love board games but realized that I did not get to play as much in college and I also wanted to be able to spend time with other peers outside of the course!
	I felt that Alternative Office Hour was a good way to interact with other students and the instructor.
	I attended the Alternative Office Hour because I thought it would be a nice break in my day to play a game.
	I wanted to build relationships with the professor and classmates.
	Desire to build relationship beyond class with professor.
	It was such a nice de-stresser on Fridays in between my classes.
Human Physiology	Thank you for providing Alternative Office Hours, I find regular office hours to sometimes be intimidating and this was the first time I was able to have an office hours experience like this.
	I really enjoyed the Alternative Office Hours because I felt like it showed students that the professor is a real person too who likes to have fun just like us.
	I have loved going to Alternative Office Hours! It is such a fun time to get to know other students in the class and it allowed me to get to know Dr. Cafferty better.
	Because it was a nice break from my week. Gave me a chance to get to meet more people.
	I loved being able to do something fun with students and Dr. Cafferty outside of the class. I wanted to build a community with the other students in the class.
	It seemed fun (and it subsequently was! :))

Table 4: Survey responses reveal students attended the Alternative Office Hour to have fun and to interact with others.

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Consistent with recent results reported by Hsu et al (2022), the most common reason students did not attend office hours was conflict with another class or activity. During the fall and spring semesters, 92% and 93% of students, respectively, reported not attending office hours due to a time conflict. However, some students who did not attend the Alternative Office Hour did view the program positively. For example, one student declared, "I couldn't go but all the games looked so perfect!"

Discussion

During the 2023-24 academic year, the use of games during the Alternative Office Hour was enthusiastically received by my students and led to an improvement in office hour attendance. In fact, Alternative Office Hour attendance surpassed my expectations, occasionally leading me to scramble to find additional seating and set up multiple games for students sitting at different tables. Students were comfortable enough to invite their friends and family members to participate in the Alternative Office Hour and, on different occasions, bring their pets. While traditional office hour attendance increased from 1 or 2 students on a typical week of class to as many as 6 students during the weeks of midterm or final exams, consistently, traditional office hour attendance was far less than that of the Alternative Office Hour.

In a survey published by Hsu et al (2022), faculty noted that one benefit of office hour attendance is the opportunity for students to meet and form study groups. However, surveyed students in that same study did not identify study group formation as a potential benefit (Hsu et al., 2022). During the first weeks of the spring 2024 Alternative Office Hour, many human physiology students exchanged cell phone numbers explicitly to form study groups. Thus, the game-playing format of the Alternative Office Hour led to student community building behavior that is broadly desired by faculty.

Increased Alternative Office Hour attendance may have resulted from inviting students to participate in a shared group activity in an informal venue. Past work has revealed that, compared to faculty, students have a narrower view of the benefits of office hour attendance that focus on the clarification of course content and organization (Hsu et al, 2022; Smith et al, 2017). Similarly, my students have reported in past course surveys that they do not attend traditional office hours when they do not have a question (unpublished data). Engagement in the shared group activity of playing card games might remove the barrier of a perceived need for a question to attend office hours. Consistent with this idea, students who attended the Alternative Office Hour rarely asked content-related questions and, instead, commonly reported their motivation for participation was to better get to know their peers and instructor and to have fun (Table 4).

In addition, holding the Alternative Office Hour in a departmental lobby might serve to remove another barrier to office hour attendance: the formal atmosphere of an instructor's office. Indeed, to improve attendance and make office hours more welcoming, many instructors hold their office hours in less formal locations such as library spaces (Nadworny, 2019), common areas (Eidinger, 2020), or even outdoors (Steinhaus, 1999; Rawle, 2017). Thus, instructors who wish to promote office hour attendance might try holding different group activities in alternative locations that work best for their students.

A relationship between Alternative Office Hour attendance and student learning was not examined in this work. However, the use of games during the Alternative Office Hour promoted student office hour attendance and thus increased student-faculty interaction during the 2023-24 academic year. Extensive work by Carini et al. (2006), Kuh et al. (2008), and McClenney et al. (2012) has revealed that student-faculty interaction, an important component of student engagement, is positively correlated with student learning and academic achievement. Further work is needed to determine whether programs similar to the Alternative Office Hour can directly or indirectly promote student learning and thus impact course retention or student grades.

While the game-playing Alternative Office Hour format was inspired by educational gamification, I did not directly introduce elements of gaming into the structure of the office hour itself. Might the introduction of badges awarded for overall attendance, consistent participation, winning multiple rounds of games, or for attempting new games during the Alternative Office Hour further promote attendance? What are the personality traits of students for whom office hour participation might be positively impacted by the gamification of office hours (Smiderle et al, 2020)? These are just some of the exciting questions I hope to explore in future semesters.

Acknowledgments

The author would like to thank his students, and in particular his learning assistants Amanda Kim and Hollis Zeng, for playing games with him during office hours throughout the year, and the Center for Faculty Development and Excellence (CFDE) at Emory University for supporting this work with a Pedagogy Mini-Grant used to purchase games.

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Leveling Up the A&P Classroom: Gamification Strategies for Increasing Engagement and Belonging in Anatomy and Physiology

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Abstract

This paper explores the implementation of gamification in higher education, specifically within the anatomy and physiology classroom. By leveraging desirable game elements, such as rapid feedback, a low-stakes environment, and collaborative learning, educators may enhance student engagement, persistence, and overall learning experiences. I will discuss key components for successful gamification, including clarity, accessibility, and atmosphere creation, while also addressing potential barriers such as student preferences and perceptions of acceptable methods. Five innovative gamification strategies—Jenga, Headbands, Acid-Base Race, Team (Bone) Building, and a Physiology Space Race—are presented as practical applications to build an interactive and enjoyable learning environment. Additionally, we emphasize the need for further research to evaluate the effectiveness of gamification in promoting student retention and a sense of belonging in STEM fields. Ultimately, gamification can serve as a valuable instructional strategy in anatomy and physiology, transforming the classroom into a more dynamic, positive and inclusive space. <https://doi.org/10.21692/haps.2025.016>

Key words: gamification, higher education, anatomy, physiology, belonging

Introduction

Gamification in the Higher Education Classroom: Key Components and Strategies

There are many similarities between the worlds of gaming and learning. Both settings experience time limits, learning from failures, social collaboration, feedback and exploration of unknown topics or areas (Wang, 2021). However, there are key differences in which gaming can highlight the negatives of learning. Gaming is generally low risk with freedom to fail, allowing for rapid feedback, in a playful and rewarding setting. Learning environments in opposition can be considered high risk, with little room to fail, collaborate, receive quick feedback, or engage in fun. By using the positive aspects of gaming and embedding those within the learning environment, we may see better success with engagement, persistence and content mastery.

Gamification in education refers to the introduction of game design elements and gameful experiences in the design of learning processes (Dichey and Dicheva, 2017). The literature currently has no official guidelines for gamification in higher education settings; however, some have identified key

components for successful gamification in the classroom (Stott and Neustaedter, 2013). Perhaps the most important is rapid feedback. Rapid feedback is essential, as it allows students to reflect on their performance immediately and make necessary modifications, which can foster a growth mindset (Stott and Neustaedter, 2013). Equally important is the freedom to fail; because games in the classroom are usually low stakes, this encourages students to take risks without the fear of negative impacts on grades (Lee and Hammer, 2011). In addition, games in the classroom should be accessible. Games should strive to accommodate diverse learning styles and abilities (Wang, 2023). This can be done through providing objectives for the game, being transparent as to why they are playing a game and giving them clearly defined rules. As abilities can vary among students, knowledge of student accommodations would be important during the planning and implementation of any such activities. Lastly, atmosphere creation or “storytelling” is vital (Stott and Neustaedter, 2013). From my perspective, this entails setting a stage for the game. For example, if you are

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playing Jeopardy game in class, consider showing a screen with the real images from the game, playing the theme song on your computer, and using your best “gameshow” voice. This will increase buy-in from the students and enhance motivation, contributing to the success of the gamification activity as well as the learning beyond that. In addition, this faculty passion and the creation of an exciting atmosphere can set the tone for a positive and collaborative environment, reducing the impact for negative outcomes.

Student Preference

Student preference may play a major role in student engagement and learning (Ellis, 2015). Students may gravitate toward gamification in the classroom because it fosters a sense of belonging through collaboration and friendly competition. Belonging in higher education, specifically STEM fields, can be a significant barrier to retention and persistence (Binning et al., 2020). Thus, gamification could be an instructional innovation to assist in this aspect. Frequent gamification can create a dynamic learning environment where students can connect with their peers, forming bonds as they work together to tackle shared challenges. This collaborative spirit may cultivate a positive attitude toward learning and studying, transforming what can often feel like a daunting task into an exciting adventure.

Furthermore, educational gamification can tap into intrinsic motivation by introducing competitive elements. Competing against themselves may in fact be the most important element of all. Another reason students may prefer gamification is instantaneous feedback. While papers and exams may take days to weeks to receive feedback, gamification can quickly assess their performance and help to adjust their strategies immediately. In addition, the instructor can offer clarity on content in real-time as well. Another reason students may prefer gamification is that it provides a safe space for experimentation and failure. Because gamification usually has a light spirit and low stakes associated with it, students may feel more at ease to try, even if wrong, because there is a minimal impact to their grades. Overall, gamification may not only enhance engagement but may also enrich the educational experience by making learning more interactive and enjoyable.

In this paper, I will explore easy to implement games for the anatomy and physiology classroom that will help engage students, enhance learning, and spark creativity and joy for students and instructors alike. Of note, these games were played in classrooms of 15-30 undergraduate students but could be adapted with modifications to larger classrooms.

Gamification Ideas for Anatomy and Physiology

While there are games or game-like activities that many of us commonly use in the classroom (Jeopardy, polling, Pictionary, bingo, etc.), I will now explore five, hopefully unique to you, strategies you can implement and fit to your own classroom needs.

JENGA - SKELETAL SHOWDOWN

Game Basis: Jenga consists of a tower of 54 wooden blocks, each rectangular and identical in size, orientated in opposing layers. Players take turns removing one block from the tower, using only one hand, and then placing it on top of the structure without causing it to collapse. As the game progresses, the tower becomes increasingly unstable, adding tension and excitement (and thus engagement!) to each turn. Jenga is typically played until the tower falls, at which point the last player to successfully place a block without toppling the tower is declared the winner.

The A&P Element: Instead of blank wooden blocks, each block will have a bone marking(term) written on it. The bone marking will be labeled on the part of the block which is hidden while secure in the tower. As the students pull out a block, they will read the skeletal marking, and then be required to find the marking on the skeleton model and show it to the team. If they are correct, the game moves the next player. If they are not correct, they must draw again.

Pitfalls, Extensions, and other Considerations: One potential pitfall is that one student may not be strong in the content area and thus must keep drawing over and over again. To avoid this, you can have students’ team up or allow them to have a “phone-a-friend” or “sneak-a-peek” at their notes option to utilize if needed. Pairing students can also make this game lower risk. This can also assist in accommodation issues if dexterity or mobility is an issue. An extension of this game would be to switch out bone markings for other content areas. Histology or anatomical terms would pair well with this activity due to the volume of terms.

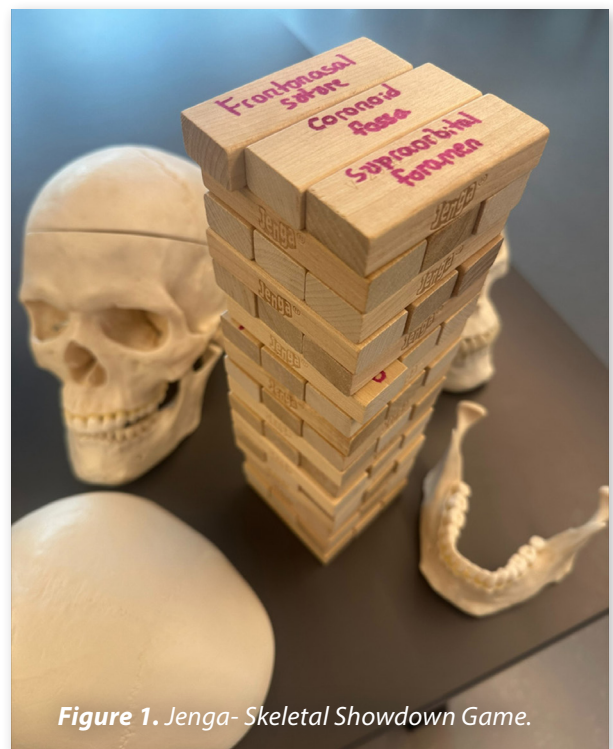


Figure 1. Jenga- Skeletal Showdown Game.

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HEADBANDS

Game Basis: Headbands is a fun guessing game for 3 or more players where each person wears a headband holding a card that they can't see but others can (card faces anterior). On their turn, players ask yes-or-no questions to figure out what's on their card. The objective is to be the first to guess their card image or word correctly. The goal is to guess the word or image correctly before others do. Players can play multiple rounds, and the one who guesses the most cards correctly wins.

The A&P Element: Instead of animals or characters on the cards, I put tissue types on each card (stratified squamous epithelium, cardiac muscle, etc.). Students can then ask yes or no questions about their cards (Am I an epithelial tissue? Am I stratified? Am I used for protection? etc.).

Pitfalls, Extensions, and other Considerations: Again, for students who may struggle with this topic area, you can allow them to use their notes. They will still have to figure out the tissue type, but they will have their notes to help respond to the yes/no questions. For those who may have visual impairments, you can always have a student from another group read the other player headbands to them. To extend the game's utility, you can use different units or subject areas. Because these are just written on index cards and slipped in the headband, it is easy to reuse this game over and over. Other units which work well are digestive system components as they widely vary in form and function, anatomical terms, bones, hormones/endocrine glands, muscles, and articulations.

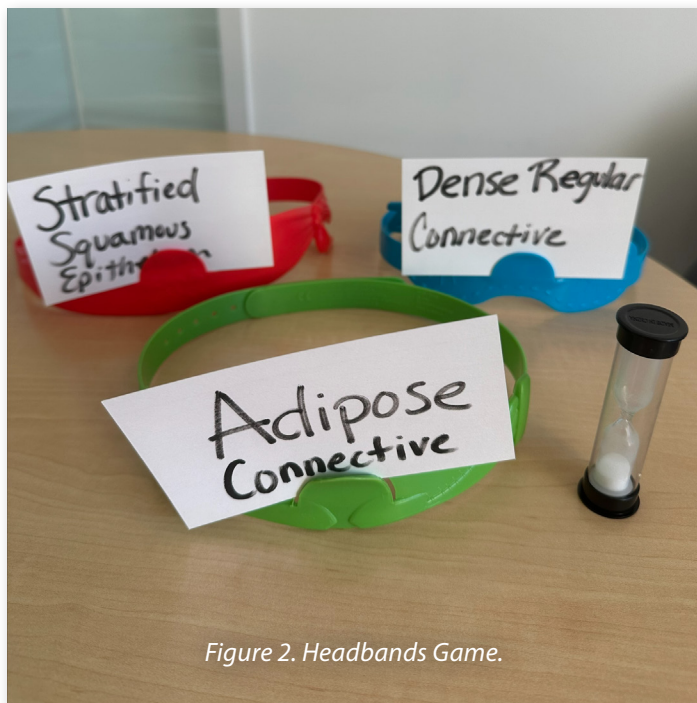


Figure 2. Headbands Game.

ACID BASE RACE

Game Basis: In this race-against-the-clock activity, groups of participants compete to arrange a set of items in the correct order as quickly as possible. Each team is given a collection of terms, and they must work together to figure out the proper arrangement. As the clock ticks, teamwork and communication become crucial. The excitement builds as teams frantically rearrange their items and run to the instructor to check for accuracy. The first team with the correct ordering of terms wins. This engaging challenge not only fosters collaboration but also sharpens problem-solving skills in a fun, competitive environment.

The A&P Element: For this type of game, I give 8-10 scenarios up on the board labeled A-J and then give the teams those letters on sticky notes along with a large Post-it with a pH scale. The scenarios can either lead to acidosis or alkalosis. Once the time starts, I reveal the scenarios on the board and students race to place A-J either on the alkaline or acidic side of their pH scale. Once they feel they are complete, they run up to the front for me to check. The first team to finish correctly wins! However, I continue until all teams finish.

Pitfalls, Extensions, and other Considerations: This game moves very quickly and gives instantaneous feedback. As an extension, you can then have groups work together to answer WHY the specific scenario leads to an outcome (metabolic vs respiratory, etc.). You can have students come up with how the body would compensate or how the issue could be resolved. One pitfall is that you might have very competitive students who take over an entire group or work so quickly that others do not have the chance to learn. I recommend groups no larger than 2 or 3 so each student gets an opportunity to contribute to the task. In addition, you can make each student responsible for physically placing a specified number of scenarios on the scale so that one student cannot complete them all.

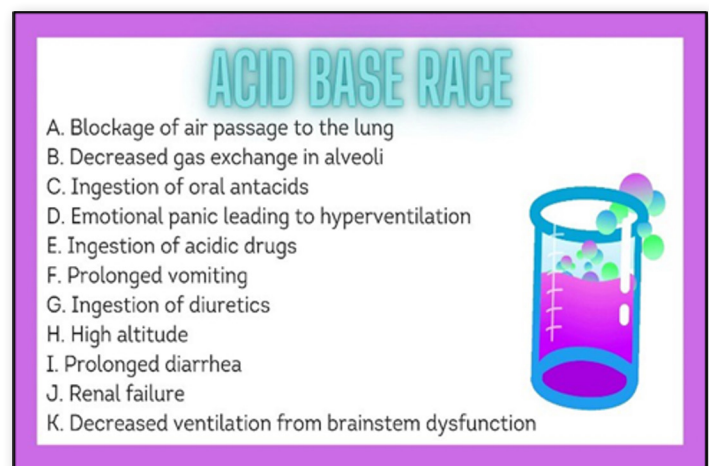


Figure 3. Acid-Base Race Game.

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TEAM (BONE) BUILDING

Game Basis: This activity is designed to improve communication and collaboration among students. Students will work together to master academic material while strengthening relationships. The goal is to enhance classroom dynamics and foster a positive classroom environment.

The A&P Element: In this game, you will provide each group with a container filled with disarticulated skeleton parts. Once the timer starts, teams will race to retrieve their container and empty it onto a clear surface. Students must collaborate to accurately assemble the skeleton, paying close attention to left and right orientations. The first team to successfully complete the assembly wins!

Pitfalls, Extensions, and other Considerations: To evaluate progress, you could have students articulate the skeleton before and after the lab session, encouraging them to beat their own previous times. An extension could involve placing bones in an opaque/nontransparent container, challenging students to identify each bone based solely on its markings and shapes before seeing it. In addition, you could add organs to this activity, or you could include notecards with articulation terms such as “diarthrosis, amphiarthrosis, and synarthrosis” and have them place those correctly. One pitfall is that you may have one student who is overly competitive and completes it quickly without team input. To avoid this, require each student to physically place a certain number of bones.



Figure 4. Bone (Team) Building Game

ANATOMY & PHYSIOLOGY SPACE RACE

Game Basis: This game can be played using a free application called Socrative (<https://www.socrative.com>). There is also a desktop version for those students without smartphones or who prefer using laptops or tablets. The Space Race is an interactive game-based learning activity which engages students in a competitive way while assessing their understanding of the material. The teacher creates a quiz or set of questions and the students join the classroom by using a unique code. The teacher can display the leaderboard on the classroom screen. Students are divided into teams via the app and as they start to answer questions, they earn points for their team (and their team spaceship/marker will move). Correct answers contribute to the progress of their spaceship on a visual leaderboard. Incorrect answers by a team member will slow the movement of the team spaceship. The race continues until all questions are answered or a set time limit is reached. The goal is to be the first team to reach the finish line, fostering collaboration and healthy competition.

The A&P Element: You can create these questions exclusively with anatomy and physiology content. Once you have a “quiz” saved, you can use it year after year making for easy implementation. To host a larger review for an exam or assessment, simply play rounds of space races with saved quizzes from multiple content areas/units.

Pitfalls, extensions, and other Considerations: This application can also be used individually instead of as a team, if you prefer students to race against one another or their own previous time. The quiz can be administered as a space race or a traditional quiz within this application. One potential pitfall is that a student’s smartphone or computer may not work properly or have connectivity issues. I always have a classroom digital notebook or my phone available to lend to students quickly on these days.

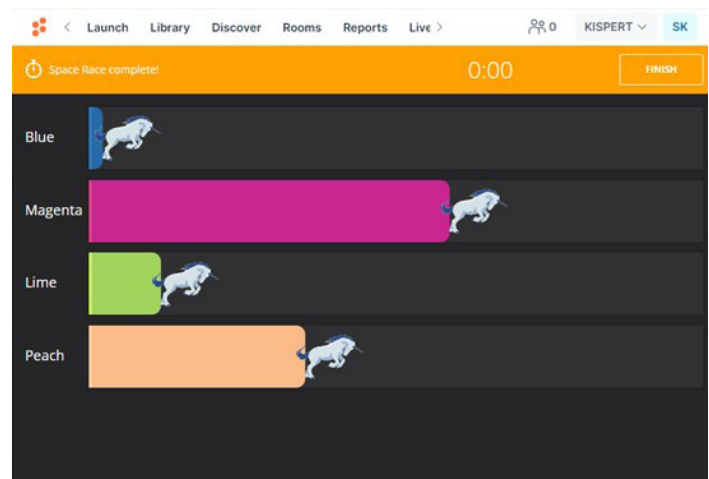


Figure 5. Physiology Space Race.

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Discussion

Gamification is an effective tool for enhancing student engagement; however, like any innovative strategy, it comes with its own set of challenges. Research indicates that several barriers impede students' engagement with new instructional methods, including student preferences, perceptions of acceptable teaching methods, autonomy, effects on grades, peer influence, clarity, and time constraints (Ellis, 2015). This discussion will focus on the barriers most relevant to the five innovations described, particularly within the context of anatomy and physiology education.

A lack of engagement can significantly hinder the successful implementation of gamification. To mitigate this, storytelling and creating an engaging environment are crucial. Energizing the classroom and generating excitement before gameplay can be achieved through simple statements or incentives, such as offering bonus points. In addition, for students to be engaged, they must feel included. To promote inclusivity in these games, I recommend that the instructor creates the teams, preferably mixed-ability teams. In addition, the instructor can assign tasks (reporter, timer, etc.) to keep students engaged and included. The instructor can also verbally praise team-collaboration during the game as well as verbally celebrate all contributions at the end of the game, not just the winning teams.

Clarity and transparency are essential factors in fostering engagement (Winkelmes, 2023). For students to fully invest in the gamified experience, they need to understand what is expected of them and the rationale behind the activity. Transparency regarding the rules, as well as providing an opportunity for students to ask questions, is vital and an important aspect of classroom management. Before starting a game, I recommend presenting the rules and expectations on a PowerPoint or writing them on the classroom board to ensure clarity. I emphasize that, even if the game offers bonus points, everyone benefits from the review and learning that takes place, regardless of whether they need the points. Additionally, I remind students that our classroom environment should be supportive and inclusive, so the language used—even in the spirit of competition—must remain respectful. Thus, they recognize that the purpose of the game is to aid in their review or mastery of anatomy and physiology content and this understanding can help clarify the use of class time for “games.”

One notable challenge unique to gamification, compared to other instructional strategies, is the perception of acceptable methods. While gamification may be more prevalent in K-12 education, it has a valid place in higher education as well. To shift students' outlook on gamification, transparency is once again essential. It is important to communicate that the game is a means of acquiring or mastering new content through enhanced engagement and positive associations.

Additionally, students may gravitate toward traditional lectures over novel instructional methods due to discomfort with the unfamiliar. Providing insight into the “why” behind our teaching methods is crucial for fostering their buy-in.

Finally, further research is needed to evaluate the efficacy of gamification specifically in anatomy and physiology classrooms. While anecdotal evidence suggests that gamification can lead to improved quiz and test scores, as well as enhanced content knowledge, a quantitative assessment of these methods is necessary. Moreover, given the challenges of belonging and persistence in STEM fields, it is important to investigate whether gamification can positively impact students' feelings of inclusion and their persistence and retention. If gamification can foster a greater sense of belonging, it could emerge as a significant instructional strategy in higher education.

Conclusion

In conclusion, gamification presents a promising avenue for enhancing student engagement and content mastery in anatomy and physiology. By integrating game elements into the classroom, we can harness the positive aspects of gaming—such as rapid feedback, a low-stakes environment, and collaborative learning—to create a more dynamic educational experience. The strategies discussed, including Jenga, Headbands, Acid Base Race, Team (Bone) Building, and Physiology Space Race, offer innovative ways to facilitate learning while increasing belonging and a sense of classroom community.

However, successful implementation of gamification requires careful consideration of potential barriers, such as student preferences and their perceptions of acceptable methods. Transparency and clarity are crucial in helping students understand the purpose and benefits of these activities, ultimately fostering their buy-in and participation. As we navigate the challenges of modern education, ongoing research is essential to quantify the efficacy of gamification in higher education, particularly in anatomy and physiology. By focusing on fostering a sense of belonging and enhancing retention, gamification could not only transform individual learning experiences but also contribute to a more inclusive and collaborative academic environment.

As we continue to explore and fine-tune gamification strategies, we hold the potential to transform the way students engage with complex subjects such as anatomy and physiology, making learning not only more successful but also more enjoyable.

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About the Author

Dr. Shannon Kispert is faculty in the Department of Natural Sciences and Mathematics at Webster University. Her passion is teaching anatomy and physiology, connecting with students, and making science accessible and fun. She is the recipient of the 2022 Human Anatomy and Physiology Society Teaching and Mentoring Award. Her research explores the impact of cigarette use on breast and bladder cancer development, with a focus on phospholipase-A₂ pathways. Dr. Kispert is also dedicated to the scholarship of teaching and learning, particularly student engagement and belonging in STEM. She is the current Faculty Fellow for Teaching and Learning Innovation at Webster University and advises all pre-health students.

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Introducing “Homeostasis: The Game” – A Game-Based Activity for Teaching Homeostasis and the Endocrine System

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Abstract

Understanding homeostasis is foundational to biology; yet students often hold persistent misconceptions about its mechanisms and complexity. To address these challenges, we developed a collaborative, card-based board game in which players act as components of the endocrine and physiological systems to help a character named Bill enact homeostasis after disruptive events of his own making. The game design specifically targets six common misconceptions regarding homeostatic and endocrine systems. Gameplay involves strategic use of hormone and physiological response cards to return the central character to homeostasis. The game was implemented in introductory biology courses across multiple institutions, and student feedback was collected through pre- and post-game surveys. Results showed high enjoyment (mean rating of 8.2/10) and a significant increase in students' confidence in their understanding of hormonal regulation and homeostasis. These findings suggest that the game is an effective and engaging tool for improving conceptual understanding in undergraduate biology education. <https://doi.org/10.21692/haps.2025.017>

Key words: homeostasis, game, endocrine, hormone, teaching

Introduction

Homeostasis is a core concept for physiology courses. However, despite its central position in the curriculum, homeostasis is a concept that students often struggle to understand. There are many reasons underlying this difficulty, including the systems-level thinking needed to understand homeostasis, the many variables involved in homeostasis, the wide variety of terms involved, and the difficulty of generalization (Beckett et al., 2023; Kiesewetter & Schmiemann, 2022; McFarland et al., 2016; Modell et al., 2015). Furthermore, our teaching of homeostasis occurs when teaching about the endocrine system, a system that relies on homeostatic feedback to properly function. This endocrine system context amplifies the barriers to understanding homeostasis by introducing more language and more complexities, such as various means of interaction between various systems and indirect impacts of involved chemicals (Colthorpe et al., 2018; Modell et al., 2015; Zukswert et al., 2019). Because homeostasis is so central to our understanding of health, and because of the number of ailments that arise from endocrine dysregulation, we need to overcome these issues.

While inquiry-driven laboratory exercises can teach students about the endocrine system (Kalman & Grahn, 2004; Moats, 2009), there are challenges to directly addressing the concept of homeostasis in a wet lab. The time scales of endocrine system functioning can exceed the 2–3-hour period typical of a laboratory experience. In addition, it can be challenging to monitor or perturb the different parts of an endocrine feedback loop in a traditional laboratory setting, and materials and equipment can be prohibitively expensive. As a result, instructors may turn to hands-on activities or simulations as a way to teach concepts (including but not limited to homeostasis) that are not easily taught in a typical laboratory setting (Abraham et al., 2009; Christ & Thews, 2016; Meir, 2022; Meir et al., 2005; Vagula & Liu, 2018; Zangerolamo et al., 2020; Zhang et al., 2021).

Games are a promising format for simulation-based laboratory exercises. During game-based learning, students are actively engaged in learning or practicing concepts through gameplay. Serious games are designed to achieve a goal beyond entertainment (Edwards et al., 2023).

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A growing body of literature has shown that serious games are effective in teaching concepts in physiology topics such as acid-base regulation (Surapaneni, 2024), signal transduction (de Oliveira et al., 2024), neurophysiology (Machado et al., 2018; Montrezor, 2016), nursing education (Kuruca Ozdemir & Dinc, 2022), and more. Similarly, game-based learning has been reported to positively impact student engagement and confidence in physiological topics (de Oliveira et al., 2024; Kaur, 2021; Neems-Baran, 2024).

Collaborative games, in which all players are invested in achieving a common outcome (Zagal, 2020; Zagal et al., 2006), hold particular promise to help students develop collaborative skills while reinforcing content knowledge (Sulbaran Reyes et al., 2024; Surapaneni, 2024). As more graduate biomedical programs in the health sciences move to team-based learning (Burgess & Matar, 2023; Sterpu et al., 2024) and employers desire teamwork skills (National Association of Colleges and Employers, 2025), games can help students practice group problem-solving skills in a low-stakes environment.

Here we describe The Homeostasis Game, a collaborative game in which students play as the endocrine system to enact the process of homeostasis in response to physiological challenges.

Game Overview

The game centers around its main character, Bill, a young man who makes some questionable decisions. At the start of each round, a "Bill card" is flipped, revealing something Bill has done to challenge his physiology. The players then play collaboratively to coordinate Bill's nervous and endocrine systems to enact the process of homeostasis, returning Bill's monitored values to a more balanced range. The players win if Bill survives the game and lose if he dies. The game takes approximately 30-40 minutes to play, and students played three times prior to completing an end-of game survey.

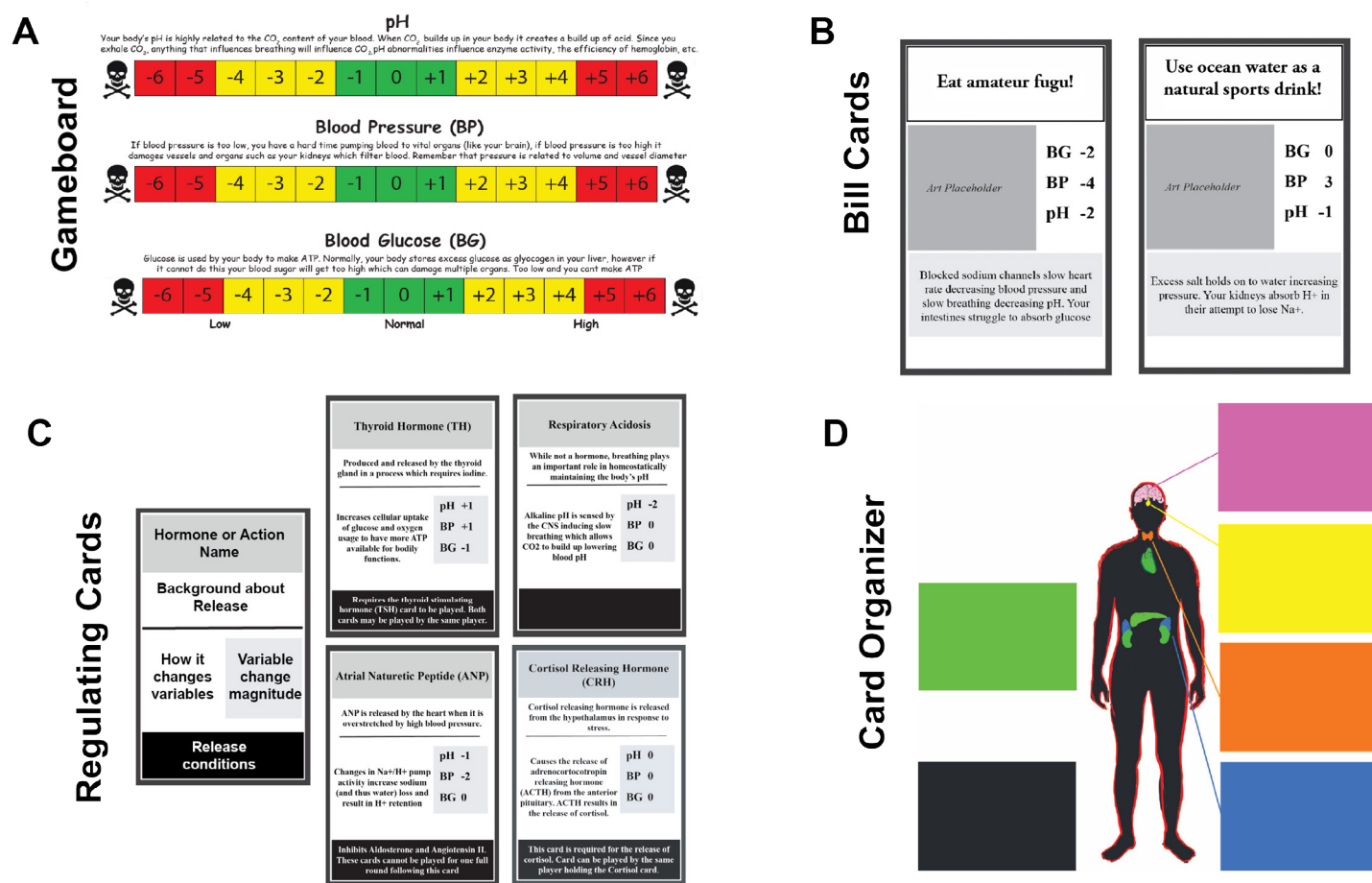


Figure 1. Anatomy of the Board Game. **A.** Gameboard: tokens are placed to indicate the level of homeostasis for each variable (pH, Blood Pressure, and Blood Glucose). **B.** Bill Cards: a card is flipped to present a homeostatic challenge. **C.** Regulating Cards: players play cards that represent actions that the body uses to return to homeostasis. **D.** Card Organizer: regulating cards are organized by their origin, including aspects of the nervous and endocrine systems. After using regulating cards, the player repopulates their hand and can do so strategically by grabbing from specific piles on the organizer.

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How is the Game Played?

Bill’s internal state is represented by the gameboard, which is divided into spaces for three physiological variables – pH, blood glucose, and blood pressure. Each of the variables is represented by a range of values, which are color-coded into zones. The center is the green (or normal) zone, and to either side of the normal zone, we have yellow and red areas indicating dysregulation. At the start of the game, the game markers are all placed in the middle of the green zone, indicating that Bill’s physiology is well-regulated.

At this time, a “Bill card” is flipped to reveal a scenario that presents Bill’s system with a homeostatic challenge and indicates the amount of perturbation occurring to each of his physiological variables. While many of the situations are unusual, they are, as much as possible, grounded in reality. For example, when Bill irritates some pirates and finds himself marooned on an island, the lack of food results in a decrease in blood sugar, and dehydration results in decreased blood pressure. The markers on the board are moved accordingly to represent Bill’s new internal state.

After the “Bill card” is flipped, the players (3-6 individuals) work collaboratively as the nervous system by identifying perturbations and determining means to address them via

playing their playing cards, which represent hormones and other regulatory physiological functions. The majority of these cards impact more than one variable. As changes are made, the markers are moved accordingly to reflect Bill’s new internal state. Each player is allowed to play only one card, so cooperation and discussion are key to the proper outcome, especially since each player’s actions may impact the activity of another. For example, if the team wants to increase Bill’s blood glucose levels, one player would need to play growth hormone-releasing hormone (GHRH) so that another player can play growth hormone, resulting in an increase in blood glucose.

Gameplay, like homeostasis, involves constant monitoring of the relevant variables. Players do not have to play a card if they cannot improve Bill’s situation. The starting player rotates each round and generally leads the round’s discussion of which actions to take. Once the team has exhausted their turn or is happy with Bill’s state, they flip the next Bill card. If Bill’s variables move too far away from the acceptable ranges, he dies, and the team loses. If they make it through the entire stack of Bill cards alive, they win.

Learning Outcome	Related HAPS Physiology Learning Outcomes (Silverthorn, et al. 2023 and Tomicek, et al. 2024)	Homeostasis Conceptual Framework outcomes (McFarland et al. 2016)	Misconception Addressed	Relevant Game Design Feature
Recognize that homeostasis is a range, not a single set point.	C.1.16 , C.1.18, CC.2.3, CC.2.5	H1.7 , H1.1, H1.2, H1.3, H1.4, H4.4	1, 3	The gameboard indicates a range of functional values.
Explain how hormones help accomplish homeostatic processes.	CC.6.6 , C.1.1, C.1.17, CC.2.1, CC.6.3,	H5.3 , H4.1	2	Hormones, when played, alter physiological variables.
Explain the role of negative feedback in homeostatic processes.	C.1.18 , C.1.11, CC.2.3, CC.2.4, CC.2.5, CC.2.9	H2.1 , H1.8	2, 4	Moving the tokens back to the green zone indicates negative feedback.
Express that hormones can be released from different places.	CC.6.3 , C.1.3, CC.6.2,	H5 , H2.4	6	Hormones are placed in piles based on the location of release.
Identify the effects of hormones on target physiological variables.	C.1.17 , C.1.9, C.2.3, C.2.4, C.3.9, C.4.4, C.6.8	H5.2 , H5.1, H5.3, H5.4	3, 5	When played, hormones will alter physiological variables.
Describe how one hormone can act on multiple variables.	CC.5.1 , C.1.9, CC.1.7	H1.4	5	Most of the hormones change 2 or more of the physiological variables.
Describe the inhibitory or antagonistic effects of hormones.	C.1.8 , C.1.12, C.2.6		5	Some of the hormones inhibit others. (ex. Glucagon inhibits insulin)
Explain the role of releasing hormones in controlling endocrine processes.	C.1.19 , C. 2.6, CC.2.10, C.3.6		5	Some hormone cards can only be played after the releasing hormone is played.
Express the role of the brain in hormonal release and coordination.	C.2 , C.2.3, C2.4, C.2.5, C.2.8		6	The brain is one of the locations of hormone release and is the origin of several releasing hormones.

Table 1. Alignment between Game Learning Outcomes and the HAPS Physiology Learning Outcomes. Outcomes in bold are the most relevant.

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The learning outcomes features of Homeostasis: The Game align with several of the HAPS Physiology Learning Outcomes Related to Homeostasis and the Endocrine System (for more information see Silverthorn, et al. 2023 and Tomicek, et al. 2024). Furthermore, the design choices in the game represent these outcomes and concepts (Table 1). Additionally, we aimed to combat common student misconceptions about homeostasis through design choices within the physical game, which we will describe here.

Gameboard

1) **Misconception #1: Homeostasis is a single set point**

The game board design helps students see homeostasis as a range through multiple values that fall within the green or normal zone. The board design reinforces that there is a range of values that can still fall within the norm.

2) **Misconception #2: Negative feedback decreases a variable's value and positive feedback increases it.**

Many students simply view decreasing a variable's value as "negative feedback" and increasing the value as "positive feedback". However, positive feedback is a self-reinforcing process, while negative feedback is a self-regulating process that counteracts the perturbation of a variable by either increasing or decreasing its value. Since values that are too high or too low are both out of the green range, we were able to reinforce the idea of negative feedback returning balance regardless of the direction of change of the variable. This allowed students to realize that homeostatic processes return a variable to its central norm. It should be noted that the range for the variables is not physiologically based (ex. 30 to 300 mg/dL for blood glucose) but rather is a generic 12-point scale to enable students to focus on the negative feedback loop process and direction of change without being distracted by the meaning of the values.

3) **Misconception #3: Homeostasis only involves a single variable**

As examples of homeostasis used in classrooms often include single variables, students often think that homeostasis is a process only related to that variable, such as temperature. Since the game board monitors multiple variables, the game reinforces the multivariable nature of homeostasis. Furthermore, the text on the playing cards often links variable changes to their underlying mechanism. For example, salt retention increases fluid volume, increasing blood pressure.

Game cards

4) **Misconception #4: Homeostasis is solely maintained by hormones.**

In the game, a scenario occurs that changes homeostatic variables. The players must react to this by playing different cards to restore these variables within their homeostatic ranges. While many of the cards describe specific hormones and how they affect the system, the cards also describe specific conditions. However, the nervous system can sense perturbations and can trigger several different means of addressing them. For example, the respiratory acidosis card may be used to decrease blood pH, and potentially move overly alkaline blood pH closer to physiological norms. Since students are effectively playing as the nervous system they are sensing the perturbations and determining a means of addressing them. Additionally, the card organizer (Figure 1) communicates the origin of the response (e.g. endocrine organ or brain region of release).

5) **Misconception #5: Each hormone only has one function**

Students often think that each hormone controls one variable, such as insulin's control over blood glucose. However, hormones may directly or indirectly impact multiple variables within the system. As such, most of the playing cards influence more than one of the homeostatic values the team is monitoring. All of this influence is based on primary literature, such as the impact of cortisol on blood glucose and pH or the impact of growth hormone on blood pressure (Devesa et al., 2016; Ennis, 2018). The game also includes releasing hormones, which directly influence whether or not a hormone is released, and hormones that promote or inhibit the release of other hormones more indirectly.

Game set up

6) **Misconception #6: The hypothalamus is the sole controller of homeostasis.**

We found that many students assumed that all things homeostatic originated at the hypothalamus. To correct this misunderstanding, cards are played by the organ or gland that releases them (for primary endocrine organs) or into secondary endocrine organs. This creates a space that includes the various endocrine organs in the conversation of homeostasis, and helps students associate specific hormones with their origin.

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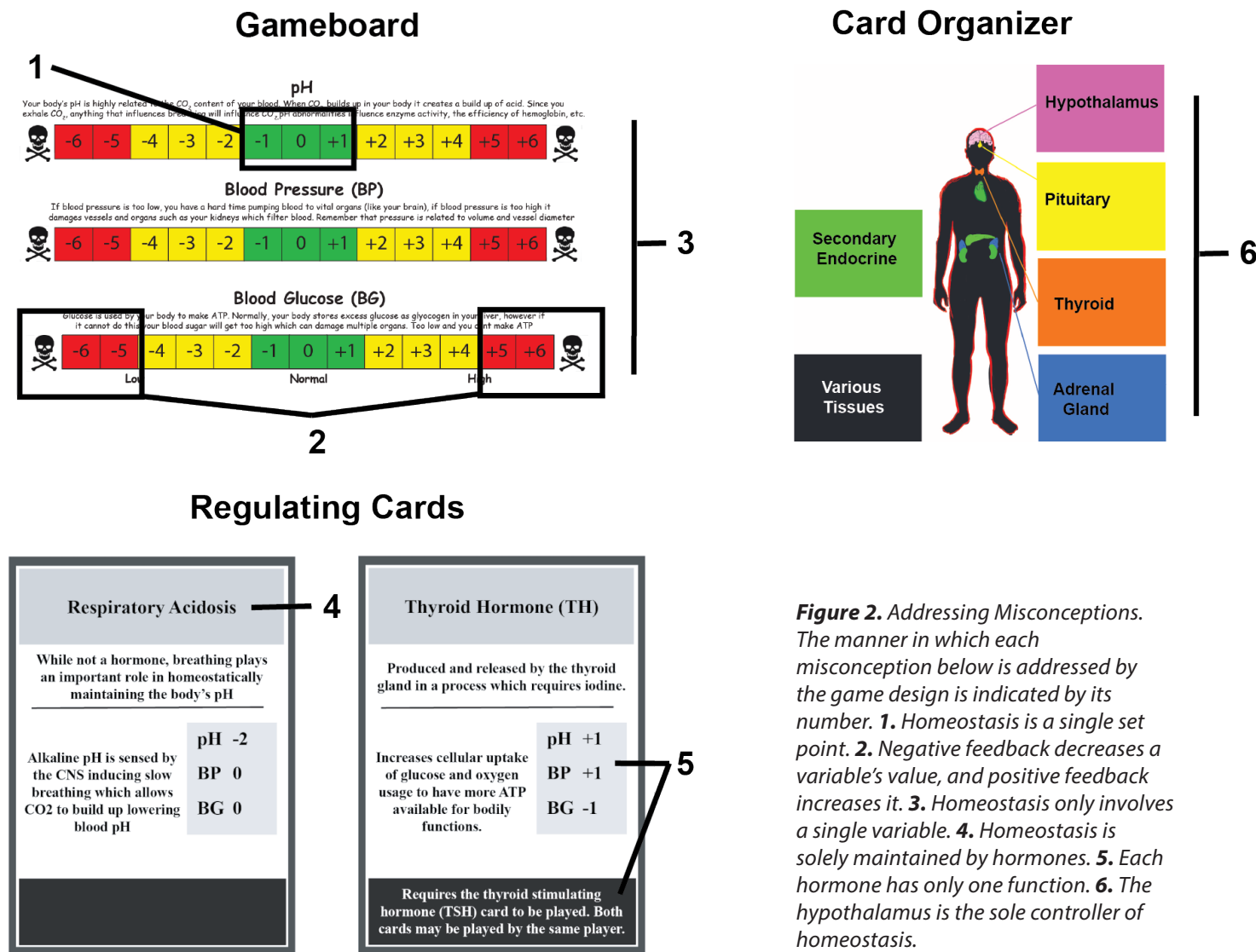


Figure 2. Addressing Misconceptions. The manner in which each misconception below is addressed by the game design is indicated by its number. **1.** Homeostasis is a single set point. **2.** Negative feedback decreases a variable's value, and positive feedback increases it. **3.** Homeostasis only involves a single variable. **4.** Homeostasis is solely maintained by hormones. **5.** Each hormone has only one function. **6.** The hypothalamus is the sole controller of homeostasis.

How was it Received?

Currently, analysis of learning gains is underway. In this paper, we focus on our analysis of student attitudes and perspectives about the game, which speaks to the engagement aspect of the activity. Prior to data collection, this project was approved by the Human Subjects Review Board at Metropolitan State University (1214177-1). We collected anonymized data in two introductory settings at two public colleges: an introductory biology course at a small public liberal arts college (2 sections: 28 and 15 students) and an introductory human anatomy and physiology course at a small state university (5 sections: 22, 13, 13, 18, 18 students). After completing a pre-survey related to homeostasis, students played three rounds of the game (each taking about

30-40 minutes) and then completed a post-game survey which included the same questions related to homeostasis as well as questions exploring their attitudes about the game experience.

Surveys given to students asked, "On a scale of 1 to 10 (1 is horrible and 10 is amazing), how much did you like the game?" (Figure 3A). Examining results across our seven sections at two institutions involving a total of 125 students, we found that the mean indicated enjoyment was 8.2. Mean values varied between 7.85 and 8.8 among the classes at the two institutions, indicating consistently a relatively high level of enjoyment of this activity.

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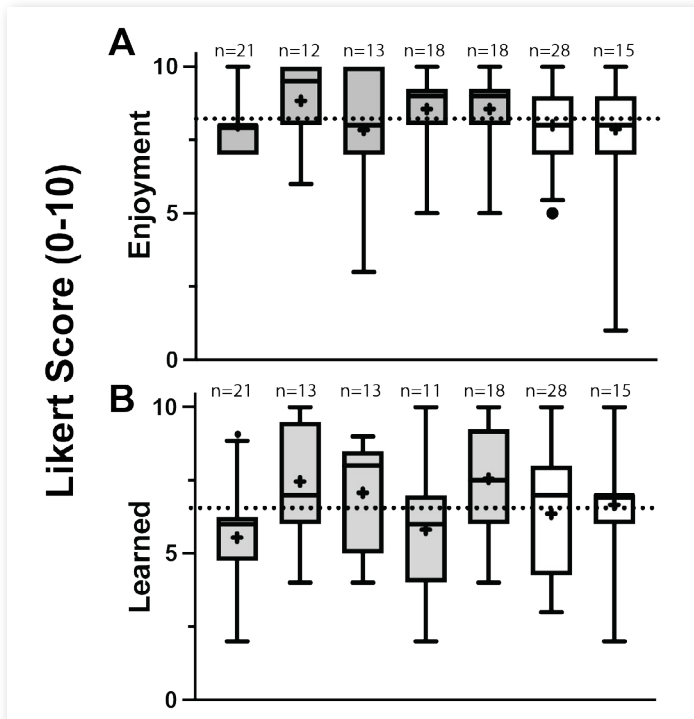


Figure 3. Students indicated a high level of enjoyment and learning from the game. Students from 7 different groups (at two different universities indicated by box shading or absence of shading) were asked to indicate how much they enjoyed the game and how much they learned on a 1-10 scale. The box extends from the 25-75th percentiles, the line is the median, the mean is indicated by +. Whiskers extend from the 5th to 95th percentiles. Outliers are represented by a dot. The dotted line represents the mean across groups.

We then asked the students one of two questions to assess how much they felt that they learned from playing the game. These were: "On a scale from 1 to 10 (1 is nothing and 10 is a lot), rate how much you learned playing this game" (3B, gray) or "On a scale from 1 to 10 (1 is nothing and 10 is a lot) how much do you feel the game helped your understanding of the role of hormones in homeostasis" (3B, white). Group averages ranged from 5.5 to 7.5, with the average response at 6.6 across our seven groups from the two institutions. This suggests that our 120 students who responded to these questions felt that there was an overall positive impact of gameplay on their understanding of the material. It is worth noting here that often student perceptions of learning are lower for active learning exercises such as games than they are for traditional lecture, despite the fact that it has been shown that they learn and retain more using active methodologies (Deslauriers et al., 2019; Georgiou & Sharma, 2015).

Students in two of our groups (of 11 and 28 students) were also asked, "On a scale from 1-10 (10 being very confident and 1 being a feeling of a complete lack of understanding of hormones and homeostasis), how confident are you in your knowledge of how hormones affect homeostasis?" This question was asked in both the pre- and post-game surveys. We found that students indicated a significant increase in their confidence in their knowledge of homeostasis after playing the game (Wilcoxon matched-pairs signed rank test, $p < 0.001$ group A and $p < 0.0001$ group B). In group A, the confidence level increased from 4.6 to 6.7 and in group B from 3.9 to 6.5. With the exception of 6 of the 39 students who indicated no change in confidence level, the rest all indicated an increase in confidence.

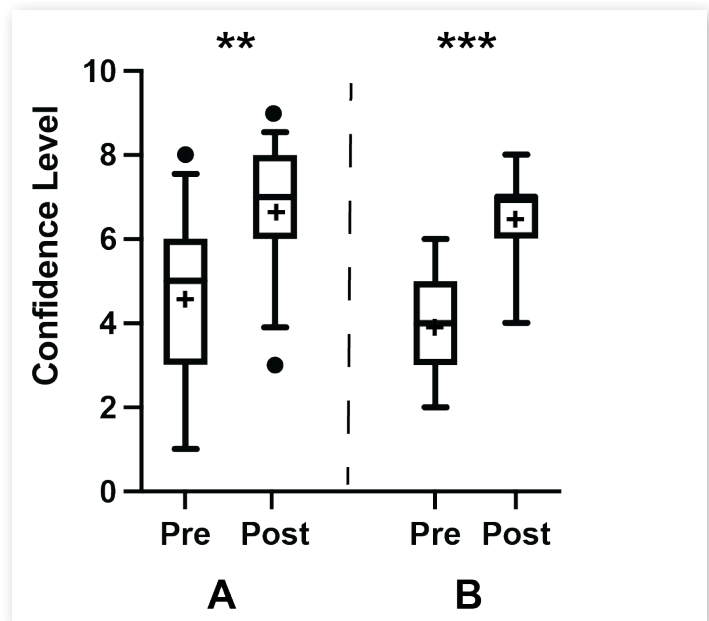


Figure 4. Students' confidence in their knowledge was increased by playing the game. Two groups of students (A, $n = 28$; and B, $n = 11$) were asked to answer the following: On a scale from 1-10 (10 being very confident and 1 being a feeling of a complete lack of understanding of hormones and homeostasis), how confident are you in your knowledge of how hormones affect homeostasis. The box represents the 25th to 75th percentile, with the line being the median. The mean is represented by a +. Whiskers extend from the 5th to the 95th percentile. Outliers are represented by dots. A Wilcoxon matched-pairs signed rank test indicated that the increase in confidence was significant at $p < 0.001$ for group A and $p < 0.0001$ for group B.

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While this study is focused on the attitude and enjoyment of learning about homeostasis, which is important to learning, we also need to assess content knowledge. We are currently analyzing our data with regard to content knowledge, which includes a survey inspired by the homeostasis concept inventory (McFarland, et. al. 2017).

Instructors wanting to assess student understanding in their courses could craft a diversity of questions depending on their assessment goals. For example, instructors could craft multiple-choice or true-false exam questions that probe misconceptions about homeostasis, or semantic knowledge about hormones, tissues, and variables involved in homeostatic processes (relating to HAPs Physiology Learning Outcome CC.2.4, see Silverthorn et al, 2023 and Tomicek et al. 2024). Alternatively, instructors could ask students to describe a homeostatic process that they learned during gameplay, and explain how it matches the basic framework of a homeostatic process (relating to HAPs Physiology Learning Outcome CC.2.3) or negative feedback loop (relating to HAPs CC.2.9).

Conclusions

Through the design and implementation of this homeostasis-themed game, we aimed to engage students with homeostasis core concepts and correct several persistent misconceptions that students hold about physiological regulation. By engaging students in active, collaborative gameplay where they assume the roles of Bill's internal regulatory systems, we created an immersive learning experience that reinforces complex biological concepts in a memorable and meaningful way. The game's structure—ranging from its multivariable gameboard to its organ-specific card organization—intentionally challenges oversimplified views of homeostasis and highlights the dynamic, interconnected nature of physiological processes.

Student feedback suggests that the game was not only enjoyable but also effective in enhancing their understanding and confidence regarding the role of hormones and other mechanisms in maintaining homeostasis. The significant gains in self-reported confidence, coupled with high enjoyment ratings, support the value of this game as a pedagogical tool. While student perceptions of learning may not always align with actual learning gains, the positive reception and increased confidence levels indicate that this game holds promise as an easy-to-implement exercise for teaching about the endocrine system.

About the Authors

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Designing Narrative Role-Playing Activities in Anatomy and Forensic Science Education

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Abstract

Narrative-based roleplaying is a mode of active learning that can be integrated into a wide array of educational settings. This paper offers guidelines to create narrative-based role-playing activities to improve learner engagement and educational outcomes. Stories offer unique learning opportunities as they encourage learner participation through the demonstration of knowledge and skills. While developing narrative role-playing activities is a demanding endeavor, basic guidelines for creating interactive learning experiences can make the process less daunting. The following guide provides insights on how to write a compelling hook to draw learners into a story, develop interesting characters with whom learners can play and interact, and create encounters that reinforce learning while contributing to an overall narrative. By designing activities with these elements in mind, educators can create interesting, fun, and unique experiences that enhance learning and reinforce practical skills. <https://doi.org/10.21692/haps.2025.021>

Key words: role-playing, narrative, active learning, challenge-based learning, simulation

Introduction

Narrative-based role-playing (RP) has emerged as a significant pedagogical strategy in current educational settings. Functioning as a mode of challenge-based learning (CBL), a type of active learning, RP engages learners in simulated scenarios in which course-related knowledge is not only acquired but meaningfully applied. By following a narrative that requires cooperation, inquiry, and problem solving, learners are invited to integrate content in a manner that mirrors real-world application. CBL is an instructional approach that encourages learners to confront complex problems using tools, methods, and knowledge reflective of those employed in professional practice (Bracewell & Jones, 2022; Leijon et al., 2022; Nichols et al., 2016). In this context, RP serves as both an instructional mechanism and epistemological practice, fostering engagement and demonstration of learning through participatory storytelling. Although the benefits of RP are evident in previous research (Cheville, 2016; Craciun, 2010; L. Miller, 2015; Winardy & Septiana, 2023), incorporating RP into courses and other learning environments may pose challenges regarding

investments from facilitators and learner perceptions of performance (Bracewell & Jones, 2022; Deslauriers et al., 2019; Eraña-Rojas et al., 2019; McDaniel, 2023)2022; Deslauriers et al., 2019; Eraña-Rojas et al., 2019; McDaniel, 2023. This paper, developed from a workshop at the 2025 Human Anatomy and Physiology Society (HAPS) conference in Pittsburgh, PA (Neidich et al., 2025), aims to address those challenges by proposing a basic guide for developing narrative-based RP activities.

Active learning

Active learning is any teaching approach that engages learners in activities beyond listening to lectures and taking notes and includes typical laboratory activities. Active learning improves learning outcomes and engagement in science, technology, engineering, and mathematics (STEM) disciplines. Learners achieve better outcomes in courses that incorporate active learning strategies, compared to those that rely solely on traditional lecture-based instruction (Freeman et al., 2014). These findings are observed across

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STEM curricula and at all stages of learning (Bracewell & Jones, 2022; Craciun, 2010; Leijon et al., 2022; Menchaca-Torre et al., 2024; Miller & Krajcik, 2019; Reiser et al., 2021). Incorporating active learning into educational environments has become more critical as learners increasingly struggle with traditional lecture-based learning (Freeman et al., 2014; Hassan & McKee, 2021; Zendejas et al., 2013). Encouraging learners to invest in their own education, especially after large disruptions (e.g., COVID-19 pandemic) and uncertain futures can feel like a daunting task. Incorporating an element of “play,” such as RP, as a means of active learning can increase learner engagement (Berdida et al., 2023; Hassan & McKee, 2021; Tidy & Fournet, 2022).

Active learning is common practice in anatomy and physiology and forensic sciences. Classes with laboratory components engage learners with hands-on experience to guide learning. Laboratory activities frequently employ role-playing to teach complex anatomical and physiological concepts. However, not all role-playing is narrative-based. In these non-narrative role-playing activities learners were asked to embody DNA, organelles, cells, and organs within biological processes, such as protein synthesis (Sturges et al., 2009), meiosis and mitosis (Chinnici et al., 2004; Wyn & Stegink, 2000), and glycolysis and the Krebs Cycle (Ross et al., 2008). Although these activities can be effectively leveraged to explore and understand complex concepts and physiology by choreographing biological processes, they differ from narrative-based role-playing, where learners are making decisions and solving problems using their knowledge to construct a story. Narrative and non-narrative role playing activities are useful in anatomy, physiology, and forensic science education. They are both active learning techniques that can be used to meet learning objectives and student goals. The distinction is that narrative role-play is challenge-based learning (CBL).

The role of narratives in active learning

Narratives are ancient forms of communication with familiar structures and elements that allow for outside contributions; this allows facilitators and learners to construct an interesting and meaningful story (Al Ghazi et al., 2025; Cheville, 2016; Hassan & McKee, 2021; Thompson, 2020). These conventions can be used to provide context to course content allowing learners to make sense of phenomena and fostering engagement (Marginean, 2025; McDaniel, 2023; E. C. Miller & Krajcik, 2019; Reiser et al., 2021). Learners report a preference for hands-on activities like those they encounter in anatomy labs. However, it is easy for them to go onto autopilot, aiming to get a result without much consideration of what it is they are doing or how it is relevant to practice. Following a narrative requires situational awareness. Application of course material to the narrative requires that learners understand how their knowledge influences their decisions and actions (Freeman et al., 2014).

Many forms of narratives, from “choose your own adventure” style narrative-building computer programs (Thompson,

2020) and creative writing projects (Marginean, 2025), have been employed to teach principles of forensic science by having learners use course material to design their own stories. In these examples, giving learners agency over narratives empowered them to explore topics of interest. However, the openness of this type of assignment can leave learners feeling directionless due to the lack of specific guidelines or the existence of “one true answer.” Participatory narratives, where instructors and learners both play roles that contribute to a story, foster learner agency while providing a specific challenge within strict narrative parameters. For example, McDaniel (2016) used the narrative of an art theft to teach learners about the integumentary system. Evidence presented in the story required learners to assess variations in microscopic anatomy and human phenotypes such as melanin production, tattoo ink, epidermal ridges, and variations in hair structure, texture, and color to identify the thief. In this use of narrative, learners had little agency to build the narrative, but the story line invested those learners in a goal-oriented task that required more than traditional laboratory activities by giving them the purpose to “solve the crime.”

Although RP provides a fun framework for participants to learn, practice, and demonstrate skills and knowledge, their development poses some significant challenges. The creation and implementation of RP scenarios result in substantial workload for facilitators. Furthermore, while the efficacy of active learning has repeatedly been demonstrated, student feedback has been variable. While learners report enjoying activities in active classrooms (Eraña-Rojas et al., 2019; Marginean, 2025; McDaniel, 2023), they frequently report feeling as though they learned less than they would have in a more traditional classroom setting despite better performance on course assessments (Craciun, 2010; Deslauriers et al., 2019; Thompson, 2020). This incongruity likely comes from different cognitive efforts, like problem solving and self-directed study, which are required during active learning.

Despite the challenges associated with developing RP learning activities, the innate aspects of these activities can be used to educators’ advantages. Challenge-based learning is customizable and scalable at its core, making it an ideal tool for instructors looking to engage learners in fun and new ways. They can take place over the course of a single outreach event (Boone et al., 2020; Nesbitt et al., 2025), a class period or two (Bracewell & Jones, 2022), a week (Eraña-Rojas et al., 2019), or even a full semester (Marginean, 2025). These activities can often be replicated or easily reimagined for multiple uses (Bracewell and Jones 2022).

Bracewell and Jones (2022) describe incorporating a simulated crime scene into their forensic science undergraduate courses. This is an activity that has been used for multiple years by the authors to reinforce principles learned in anthropology and criminal justice classrooms. Bracewell and Jones designed their crime scenes as

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interdisciplinary simulations where students taking classes from the anthropology and criminal justice departments worked collaboratively, using skills learned in their respective classes, for a common goal. New simulated crime scene scenarios or plots are developed every year to coincide with desired learning outcomes. When designing their scenario, the authors developed six modules that aligned with course learning objectives, and each learning objective was broken down to one to six desired learning outcomes. For example, one desired learning outcome for the learning objective “understand basic methods used in recording data from skeletal remains” was to have students “apply methods to inventory skeletal remains,” where students were expected to properly fill out skeletal inventory forms for selected replicas of human skeletal remains. This is an activity that can remain the same from year-to-year, but the facilitators’ selection of available skeletal materials can change to fit new scenarios. Additionally, the number of learning objectives required to complete a simulation can change based on the needs of the instructor. A longer, more intensive simulation, like that used by Bracewell and Jones, has many activities contributing to a storyline, while a shorter simulation has fewer.

Narrative role-playing activities are especially appropriate in STEM curricula because they reflect the applications of principles being taught in the classroom. Aspects of CBL and RP are already well integrated in STEM education. Simulated patients, crime scenes, and scenarios are used to teach learners in medicine, forensics, and other STEM fields how to act and interact with people and scenarios that they may encounter during their careers and practice skills they will need to be successful (Al Ghazi et al., 2025; Berdida et al., 2023; Bracewell & Jones, 2022; Chiniara & Crelinsten, 2019; Drake & Adams, 2015; Menchaca-Torre et al., 2024; Zendejas et al., 2013). Narrative based role-playing adds a fun element

to CBL because it permits instructors and learners to be creative while exploring learning goals (Nichols et al., 2016).

Proposed guidelines for developing narrative-based role-playing activities

The following guidelines and suggestions provide insight into the creation of narrative RP scenarios for anatomy and physiology and forensic science education. Role-play facilitators will assume multiple parts critical to the success of a narrative role-play activity. As narrative architects, facilitators will design a world and storyline that aligns with learning objectives, guiding learners through active engagement. As storytellers, facilitators will help learners visualize unfolding events, adapting as needed to maintain the flow of the narrative. As actors, facilitators will portray supporting characters, enriching the narrative with diverse perspectives and information to challenge and guide learners. And as educators, facilitators will ensure that learners apply learned content effectively to solve the narrative’s challenges, integrating knowledge with problem solving. Balancing these roles will be key to creating an immersive educational experience.

Designing a narrative RP activity

The process of designing an RP activity should begin with the learning objectives. Consider the knowledge and skills learners must acquire and practice during the activity. Next, consider constraints like the duration of the learning experience, learner-to-instructor ratio, learners’ previous knowledge, and the type(s) of physical space available for these activities. Finally, appraise available instructor resources including preparation time, space, supplies (e.g., pre-existing laboratory activities, models, images, etc.), budget, and personnel (Bracewell & Jones, 2022; Eraña-Rojas et al., 2019; McDaniel, 2023)2022; Eraña-Rojas et al., 2019; McDaniel, 2023. Each RP experience will have unique needs and resources, so there is no universal standard for designing a narrative RP activity (Figure 1). In general, with increased resources there is a higher capacity for complexity in an RP activity. Furthermore, these needs are likely to differ depending on the context of an RP activity. In a classroom, the role-playing scenario can be the culmination of a semester’s worth of learning, while a single public outreach event will have to introduce learners to concepts and techniques while they are already immersed in a scenario. There is ample opportunity for creativity and complexity, as various narrative elements can be integrated into many CBL activities.

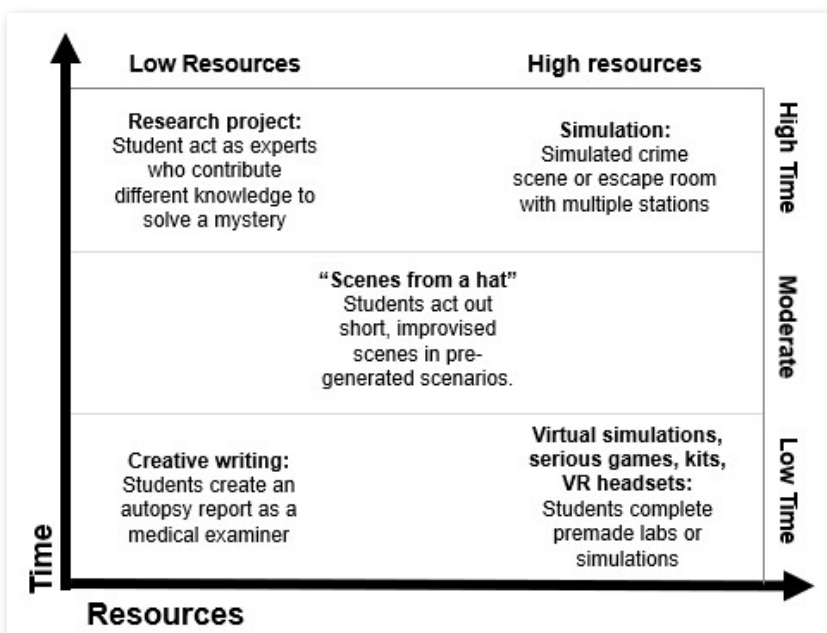


Figure 1. Matrix suggesting role-playing and narrative activities to use with learners based on different time and resource constraints.

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Narrative-based RP is a familiar concept to many people; tabletop, computer, and console-based role-playing games (RPGs) immerse players as characters within fictional worlds. The use and purpose of narrative RP in education is different than the types of RP people engage with outside of the classroom (Winardy & Septiana, 2023). However, elements can be borrowed from video, computer, and tabletop games to inspire immersive narrative role-playing activities for educational purposes. When building an RP activity, many elements shared in other role-playing media will be present, these include the development of a narrative (story), characters for people to play and interact with, a hook to draw people in, and encounters for learners to engage with (Figure 2).

The story

The narrative is the story line that runs throughout an RP activity. The story may be simple or complex, but it must function as a framework for learners to demonstrate skills and knowledge. It is not necessary to create an original narrative. Plots from the news, books, television, and movies can all serve as inspiration for the story created with learners. Consider how learning goals can be incorporated into the story in a meaningful way where learning activities are relevant and important to the progression of the story.

Player Characters

Participatory narratives foster learner agency through the development of a personal and professional identity by encouraging learners to connect academic experiences to simulated real-world experiences through role-playing (Cheville, 2016; L. Miller, 2015). Role-playing allows learners to explore alternate roles and envision different personal outcomes by embodying characters who are tasked to respond purposefully to a scenario. It also fosters the development of skills such as cooperation, communication, conflict resolution, and empathy (Cheville, 2016; Craciun, 2010; Gade & Chari, 2013; L. Miller, 2015). By inviting learners to create a new reality within the bounds of a story, RP activities can invest learners not only in classroom information, but also in the emotional, social, and even political stakes or consequences of real-world decision making (Craciun, 2010; Eraña-Rojas et al., 2019; Freeman et al., 2014; Menchaca-Torre et al., 2024). Additionally, by simulating authentic experiences, learners are better able to conceptualize how and when certain course materials are relevant to their own futures, which may subsequently influence learning outcomes and performance on assessments. Therefore, it is important to establish what roles each learner will adopt during the exercise. These can be thought of as player characters. These roles may be simple assigned roles such as “a forensic pathologist,” or more complex roles, for which learners invent new names, background and personalities to embody throughout the narrative (Table 1).

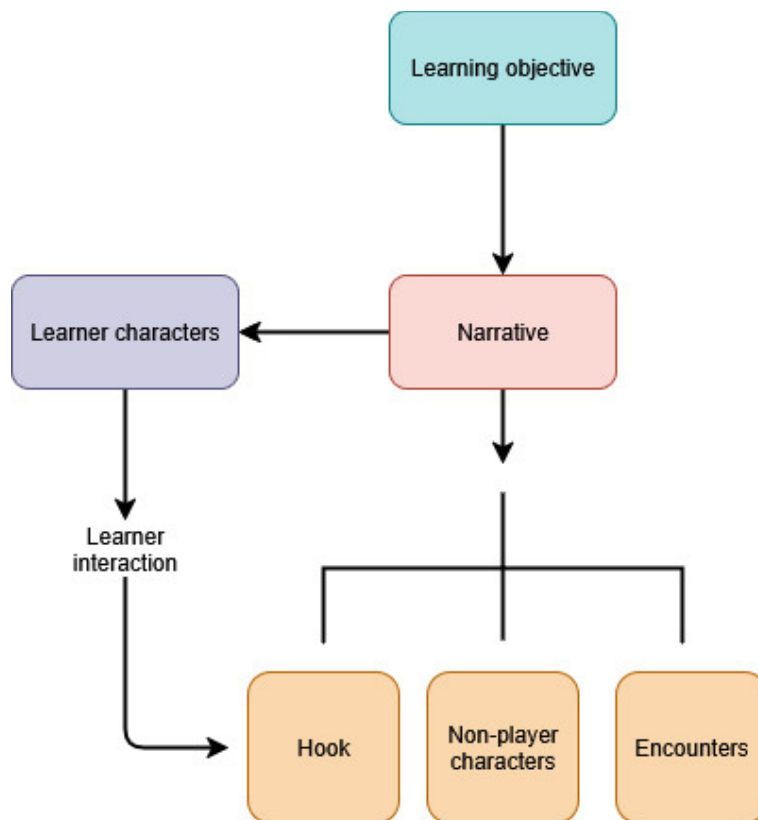


Figure 2. Flowchart for developing role-playing activities

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Time and effort invested in character creation	Time estimates	
Low	0-5 minutes	Learners are prompted to imagine themselves in a new/ different role
Medium	5-10 minutes	Learners are encouraged to create a fictional character with a new name and persona to embody
High	20+ minutes	Learners create a fictional character with a new name and persona to embody who also has degrees of specialization or knowledge unique to that character which may require additional student-driven research

Table 1. Variations of character creation complexity

The characters that the players adopt will influence how they approach a scenario, the identity they assume will shape their decision making and engagement with the activity. The personality or interests of a player character may be different than those of a learner and may therefore impact how that learner interacts with a narrative. For example, a typically quiet learner may ask more questions or be more vociferous if they are playing a gruff, hard-boiled detective. Even when character creation is relatively simple, giving learners freedom to make a new character provides them with agency and engagement with the narrative. Learners are more likely to take the activity seriously when they feel personally connected to the characters that they portray (Cheville, 2016; Cover, 2014). Increasing complexity of player character backgrounds can be used to broaden the educational scope of a narrative. For example, if learners pick a field specialty for their character, they should research career requirements and specialized knowledge or necessary skills for their character's occupation. By having learners research real-life education and career training opportunities in a character's field or requiring them to make a realistic resume or curriculum vitae for their character, they gain a deeper grasp on professional development in a field by having them consider career training, trajectory, and opportunities associated with that specialty. Character creation and interactions between characters provide opportunities for learners to practice professional development and how to create a positive collaborative learning and working environment.

Learners should be given instruction and guidance during character creation. Facilitators are encouraged to create specific guidelines for how characters are made, these instructions should include required elements for character creation (e.g., name, occupation or specialty, personality, backstory, etc.). During character creation, learners should be told that the use of stereotypes and caricatures in RP is unacceptable. RP exercises are meant to be part of an intellectual challenge, where exaggerated accents, behaviors, mannerisms, phrases, and costumes have no place. It is

recommended that facilitators discuss with learners how to avoid stereotypes before character creation begins to prevent unintentional or inappropriate stereotyping (Gajda et al., 2022; Garg, 2024; *Overcoming Obstacles*, n.d.; Platts & Hoosier, 2020). For this reason, character creation may require oversight from a facilitator, so learners can get feedback on the appropriateness of their character.

Character creation, regardless of complexity, is an essential component of narrative design. These characters do not exist in isolation, but as part of the larger narrative world. The roles that learners adopt should be aligned with the narrative setting in a way that mimics real life experience and is relevant to success in the exercise (e.g., a football player is not a relevant character for a medical narrative). The creation of roles and storyline can be a learning exercise for a facilitator as well. A lack of experience or knowledge about a role or scenario allows for interdisciplinary collaboration with clinicians, professionals, and experts to guide the activity. Then the characters replicate a particular social context that reflects certain professional expectations of the roles that learners assume. This is necessary to simulate realistic scenarios where the actions, responsibilities, and challenges associated with these roles appear within the context of the narrative created together (Biddle, 1986; L. Miller, 2015; Winardy & Septiana, 2023). In terms of successfully accomplishing the narrative goal, consider the skills each character needs to develop to do their job and how application of those skills contributes to the narrative. The process of skill development may vary depending on the timeframe and might include warm-up guided activities for a single day event or multiple sessions of self-guided pre-work for semester-long activities. Consider relevant methodological skills as well as cooperation, communication, conflict resolution, and empathy.

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The Hook and Non-Player Characters (NPCs)

To engage learners effectively, it is crucial to first introduce them to the activity through a compelling story hook. Regardless of narrative setting, the hook sets the stage for the story, drawing learners' characters into unfolding events. For example, in a simulated crime scene, the hook may involve presenting the initial discovery of a murder victim, or in a simulated medical scenario, it could introduce a patient and their presenting symptoms.

The hook plays a pivotal role in guiding the player's engagement with the scenario. It should be designed not only to capture attention but also to offer a clear introduction to the central narrative (Table 2). The hook provides essential context, to the scenario including events pertinent to the narrative, the setting, and key characters. Most importantly, the hook must introduce the central problem or conflict that the player characters will need to address. Thus, establishing a setting and a problem using a hook is essential for immersing learners in the narrative and creating a sense of urgency that compels them to action.

In addition to setting the stage, hooks also serve as an opportunity to introduce key non-player characters (NPCs) whose roles are critical to the progression of the story and are not controlled by a learner. NPCs can include victim(s), suspects, witnesses, patients, colleagues, medical personnel, specialists, etc. who are integral to the narrative and provide the player characters with information necessary for addressing the challenge presented by the hook. The facilitator is responsible for embodying these NPCs. This can be accomplished through acting (higher complexity and resource demand), providing props (e.g., laboratory reports, pre-recorded messages, etc.) or simple narration (relatively lower resource demand). The addition of NPCs helps construct an immersive experience, while providing learners with built-in people to interact with. NPCs also provide facilitators with an avenue for controlling the direction of the narrative.

When designing NPCs, be sure that they are relevant to the narrative. Too many characters make stories difficult to follow, especially if they do not contribute to helping learners solve the challenge at hand. To ensure a diverse and interesting group of NPCs, online random name generators can be used for the new cast of characters. As with player characters, it is important that when portraying NPCs, avoid stereotyping them. Do not use accents and be careful when using costume elements. Wearing a lab coat and stethoscope or a fake police badge is enough to signal to learners that someone is playing a character. AI image generators may also be used to make customizable images to match the narrative and avoid using images of real people or scenes.

The use of generative AI in educational materials is controversial and creates ambiguity on ethical use because AI programs frequently infringe on copyright and intellectual property, have human biases (sexism, racism, ageism, etc.) built into algorithms, generate inaccurate or inconsistent content, and consume a significant amount of energy among a myriad other concerns (Amanbay, 2023; Catellano et al., 2023; Lazarus et al., 2022; Nesbitt et al., 2025; Noel, 2023; Selwyn, 2022; Wiese et al., 2025). Use AI with discretion following institutional guidelines. As of now, HAPS does not have an official policy on implementing generative AI in the development of educational materials. There are benefits and pitfalls to using AI-generated images and ideas, and they require a human to evaluate generated materials. General recommendations when using generative AI in classrooms include being transparent with learners when and how AI is used, using generative AI critically with an eye for promoting diversity and accuracy in generated materials, acknowledging uncertainty, variation, or inconsistencies in generated materials (Lazarus et al., 2022). Discussions surrounding the use of AI in anatomy and forensic science education are ongoing and no consensus has been reached on best practices for its implementation in the creation of educational materials (Lazarus et al., 2022, Noel et al., 2023; Selwyn 2022).

Example story hooks
Player characters are given a crime scene or cold case report
Player characters are wrapped up in or flown out to help with a mass disaster recovery
Player characters are presented with a patient with mysterious symptoms
Player characters hear a rumor about strange or changing ecology
Player characters receive a summons from a wealthy benefactor to investigate a crime
As part of their research, player characters notice the rapid spread of symptoms among a particular population

Table 2. Example story hooks

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Hooks and NPCs are critical elements in introducing a narrative as it engages learners and sets the tone for the activity. By effectively crafting a compelling hook, and peopling the world with interesting characters, facilitators lay a framework on which to build narrative events through which learning occurs. There are many existing forms of media to inspire hooks and NPCs. Procedural crime and medical television dramas or true crime shows and podcasts often have compelling stories that can serve as inspiration for a narrative or characters. These will have built in twists, and suggested methods, based on the plot or storyline of the show that can be adapted into encounters for learners.

Encounters

In RPGs, encounters are typically interactions that players have with their world that in some way enhance or advance the plot of the narrative. Similarly, in an educational RP exercise, encounters will be the activities learners will do to demonstrate knowledge, practice skills, and solve problems. These encounters can be multiple stations for learners to visit at a single event, or as incremental (daily or weekly) activities that each reveal something about the narrative to practice knowledge that advances the plot of the story. In a simulated crime scene, different encounters might mimic scene recovery, autopsy, radiography, histology, and/or toxicology. A simulated medical case might employ patient interviews, pathology, medical history, and report reading. HAPS learning outcomes for anatomy and/or physiology may serve as a starting point for designing encounters that fit within a curriculum. It is important to remember that encounters are the mechanism for meeting learning objectives and can easily be adapted from traditional laboratory activities (McDaniel, 2023).

Encounters are the fun part of any RP experience, but they are resource heavy. Not only do they help immerse learners in scenes, but they are also where the majority of the learning and/or application of knowledge happens. Encounters should answer questions, encourage identifications, and support the learning objectives. When assessing how to allot available resources, encounters should take precedence. If laboratory resources like printed materials, models, slides, simulated lab samples, etc., are available, these are worth incorporating into encounters. Ideally, encounters can be adapted from laboratory materials previously used or available. For example, a typical lab activity requiring learners to identify features on a CT scan can become a low-resource RP investigation for pathology, where they are presented with a small patient description in addition to the CT and asked to look for disease or trauma in each of the organs. Complexity can be increased by requiring learners to make a differential diagnosis or determine future tests to be undertaken. The results of the requested test can be provided in a subsequent encounter to support additional learning objectives.

It is important to clearly communicate the limitations of the materials to learners and where they will have to use their imaginations, especially if using a forensic storyline. Learners may assess materials literally and with great attention to detail. Typos, errors in dates, numbers, or times will be seen as a conspiracy or hidden clue. For instance, learners may ask if the lack of legs on an anatomical model of a torso or accession numbers written on samples are relevant to the case. Be prepared to remind learners that there are natural limitations to available resources and be sure to let them know that it is okay to ask questions about learning material.

Using props and hands-on activities adds to the immersive aspect of RP. However, the resources available will be unique for each facilitator. Many materials, like histology images, printable anatomical models, and medical imaging can be found online using a basic web search and can easily be printed for free as a low-cost and portable resource for encounter building. Many websites, including radiopaedia.org and University of Michigan's Histology Laboratory and Virtual Microscopy Resources website (Hortsch, 2023), have classroom-quality materials freely available to the public. Other materials, like anatomical models, microscopes, and slides will be more expensive and may require a budget to acquire or advanced planning to be borrowed. Encounters and props may be adapted to fit any budget, and learners are willing to suspend an element of belief as long as they have a stake in the narrative (Cheville, 2016; Cover, 2014).

The flexibility of narrative-based RP activities means that they can be adapted to suit multiple needs. These activities can be used in a flipped classroom or lab to reinforce information learners have received. They can be implemented on a learning management system as a text-based adventure, or as a series of rotating stations where learners take on new roles at each stop. Regardless of delivery mechanism, it must connect in a meaningful way. Sequencing encounters in a specific way may not be necessary, as long as the information from each encounter contributes information to help learners confront the challenge presented by the narrative. For example, a public outreach activity by Nesbitt and colleagues (2025) used multiple encounter stations to teach learners methods used in investigating a simulated murder. Six separate encounters were created to replicate an aspect of the investigation (evidence and investigation, mapping, fingerprint analysis, DNA, autopsy, and toxicology). The order in which learners visited stations did not matter, as each encounter provided unique information pertinent to the case. If learners participated in all six encounters, they were able to solve the mystery and develop a hypothesis about what happened.

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Reflection and documentation of learning

Each encounter should be structured in a manner that not only requires learners to demonstrate knowledge and skill but should also have a means for learners to document their assessments and reasoning. It is often a difficult task for learners to reflect on educational activities because accomplishing certain tasks seems “obvious”; but having them document their character’s reasoning may be easier for learners to have this self-reflection because they are no longer required to speak about their own experiences, but those of a fictional character (Cheville, 2016). This reflective process enables learners to analyze the evolving relationships between course content and underlying concepts, thereby fostering a deeper understanding of the subject matter by using RP in documentation and decision making within the narrative framework (Cheville, 2016; Eraña-Rojas et al., 2019; Marginean, 2025; McDaniel, 2023).

Documentation and learner reflections can take multiple forms. Learners may be asked to turn in handouts and worksheets throughout the course of the narrative, they may be asked to write summary reports, act as expert witnesses, make presentations, and/or record videos regarding their solutions (Eraña-Rojas et al., 2019; Marginean, 2025; McDaniel, 2023). Documentation creates avenues to assess the impact of each activity as learners should be required to demonstrate their approaches to a solution and their justification for that approach. Certain forms of reflection may also serve as opportunities for peer-teaching about different roles, which can underscore learning objectives in situations where learners enact only one specialty or occupation. Other methods of assessment, like pre-and post-activity testing may also be used to evaluate learning (Hull, 2016).

Random Outcomes

A common element to RP activities is the use of random number generators, like dice or computer driven generators, to create random variability in the course of events. Random number generators are often a tempting addition to an RP

scenario due to the added element of excitement generated by the randomness of a roll, but they should be used in an educational setting with caution. In traditional role-playing games, rolling well or poorly on dice can determine whether there is a good or bad outcome for a decision made by a player character. For example: rolling a high number may allow a character to understand a report they receive from a DNA lab while rolling a low number would make the report indecipherable to the character. Random number generators should never be used if there is a risk of failure for a learner. Rolling poorly on a die (singular of dice) should not determine if a player is able to access pertinent information from the narrative, especially if it is a skill or method being practiced as part of the activity. Participation in educational RP is meant to demonstrate content-relevant knowledge, and a poor die roll on a skill or knowledge set that a learner has can be disheartening. This highlights one of the key differences between role-playing games and narrative role-playing in education. In an RPG, players can fail; in an educational RP activity, learners should not fail if they demonstrate necessary knowledge and skill. Randomness, if employed without thorough consideration, can also significantly increase complexity by fracturing an otherwise controlled learning narrative.

This does not mean that there is no place for randomness within an RP activity. Random number generators can be used for in-the-moment encounters and scenes through the use of roll tables. Roll tables are a list of items or characteristics that can be randomly selected using a single die roll. Using roll tables is a great way to give learners/ learner groups unique experiences during their RP. An example roll table for a forensics scenario could include a list of things that may affect taphonomy and decomposition of a body (Table 3). Random rolls for each possible scenario will require learners to understand how remains are preserved in different environmental conditions and what techniques or tools they would need to use in that generated environment.

Die roll	Environmental conditions impacting taphonomy & decomposition
1	Outdoors under a bush, naked
2	Outdoors in a lake, clothed
3	On top of a snow-covered mountain, clothed
4	Indoors on the floor, clothed
5	Inside of a sealed container, naked
6	Outdoors in a field, clothed

Table 3. Example roll table, illustrating environmental conditions that have different impacts on taphonomy and decomposition. Meant to be used with a 6-sided die (d6).

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Conclusion

As a facilitator creating an educational narrative RP experience, it is important to consider the different elements that make this type of activity impactful. It is key that learning goals remain the focus of each experience. Only then can immersive stories be constructed around those goals. Two factors must be considered when developing this type of activity: available resources, and the elements of the narrative (hook, characters, and encounters). Complexity can be increased or decreased in any of these narrative categories depending on available resources.

Narrative RP activities are not limited to in-person learning. All elements of RP can be emulated online. Interactions with NPCs, props, handouts, and encounters can all be replicated using classroom management software or even email. Educators have also developed role-playing serious games (computer-based learning games) (Al Ghazi et al., 2025; Anders et al., 2023) and simulation software (Berdida et al., 2023; Consorti et al., 2012; Drake & Adams, 2015) to give learners online RP experiences to incorporate with in-person and remote learning.

One future direction for the growth of narrative-based RP activities in anatomy, physiology, and forensic education includes the development of a sourcebook which outlines formalized rules and guidelines for running a narrative-based RP activity for learners. Additionally, the sourcebook will contain prewritten modules with hooks and encounters designed for specific learning objectives. Each module will also have non-player characters, roll tables, documents and images (e.g., crime scenes, character portraits, diagrams, lab reports, etc.), and suggested resource lists to ease some of the workload that comes with running a narrative role-playing activity. This sourcebook would be developed with large numbers of learners in mind. Most RP experiences, like interacting with simulated patients, are developed for one-on-one or small group learning, so a resource that emulates interactions with unreliable patients or scenarios with partial information designed for large-enrollment classes is needed.

Additionally, further development of serious games, simulations, and hybrid activities with narrative arcs is needed as these would serve a wide audience of in-person, remote, and hybrid (blended) learners. Online or computer-based narrative software has the advantage of being used in asynchronous learning environments while still providing a story driven experience.

Active learning experiences are an important part of education as these activities allow learners to experience a scenario while demonstrating knowledge and problem-solving skills. While RP activities are fun for participants, their development poses some significant challenges. The hooks and character development guidelines detailed here aim to foster learner acceptance, support, and participation in

RP Activities. Reflection suggestions provide opportunities for learners to map learning outcomes to RP activities as a means of emphasizing how much they are retaining. These guidelines address the significant workload of RP activity development by providing options based on various levels of material resources and time investment. Role-playing activities can provide both rewarding experiences for learners and be a manageable endeavor for educators.

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This committee consists of all committee chairs. It coordinates activities among committees and represents the collective committee activity to the HAPS BOD.

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This committee is responsible for publishing spring, summer and winter editions of the HAPS Educator, the journal of the Human Anatomy and Physiology Society. The committee works closely with the Steering Committee and the President of HAPS.

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