ClueConnect: a word array game to promote student comprehension of key terminology in an introductory anatomy and physiology course

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Burleson KM, Olimpo JT. ClueConnect: a word array game to promote student comprehension of key terminology in an introductory anatomy and physiology course. Adv Physiol Educ 40: 223–228, 2016; doi:10.1152/advan.00106.2015.—The sheer amount of terminology and conceptual knowledge required for anatomy and physiology can be overwhelming for students. Educational games are one approach to reinforce such knowledge. In this activity, students worked collaboratively to review anatomy and physiology concepts by creating arrays of descriptive tiles to define a term. Once guessed, students located the structure or process within diagrams of the body. The game challenged students to think about course vocabulary in novel ways and to use their collective knowledge to get their classmates to guess the terms. Comparison of pretest/posttest/delayed posttest data revealed that students achieved statistically significant learning gains for each unit after playing the game, and a survey of student perceptions demonstrated that the game was helpful for learning vocabulary as well as fun to play. The game is easily adaptable for a variety of lower- and upper-division courses.

how we teach: classroom and laboratory research projects

METHODS

Participant recruitment procedures. Participants (n = 36) represented a convenience sample consisting of all students enrolled in one section of Human Anatomy and Physiology 1 (A&P1) in the fall 2015 semester at a small, liberal arts college in the Midwest. Participants did not receive course credit or compensation for their enrollment in the research, and the research was classified as exempt after an internal Institutional Review Board protocol review.

Activity description. In this activity, the game Funglish (Hasbro, Pawtucket, RI) was adapted to the 3000-level A&P course. Funglish consists of a game board with sections labeled “definitely,” “kind of,” and “not,” color-coded descriptive tiles containing adjectives (for example, “flexible,” “small,” or “historic”), and cards containing a list of nouns (“light bulb,” “apple,” or “Dead Sea”). One team member is selected to guess the terms on a noun card; the remaining teammates have 3 min to use the descriptive tiles to create an array on the game board to help their teammate guess each noun.

In our adapted game, the descriptive tiles were replaced with clue cards containing adjectives and verbs relevant to anatomy and physiology. Categories included anatomic directions (e.g., “superior” or “distal”), tissue types (e.g., “epithelial” or “secretory”), qualities (e.g., “stretchy” or “hollow”), and actions (e.g., “communicates” or “articulates”). Throughout the semester, students created new clue cards as concept mapping, role plays, and simulations (2, 5, 12). One approach to encourage active processing of information is through the use of educational games. Games can be an ideal supplement to traditional teaching approaches because they often adopt a variety of novel and engaging methods to reinforce and review concepts, resulting in improvements in student learning and interest as it pertains to topics addressed through gameplay (4, 10). To date, a number of games have been successfully used to help students in introductory biology and physiology classes, including those that model television game shows, crosswords and word scrambles, word games, and trivia-based board games (1, 8, 15, 16, 17). While these games are useful for teaching students about singular concepts (gastrointestinal physiology, scientific inquiry, or genetic pathways), they often do not allow students to practice and review the course vocabulary that is necessary to master the concepts.

In an attempt to reinforce course concepts and make learning more engaging in an anatomy and physiology class, we developed and evaluated a game focused on improving student mastery of course terminology. The modified Funglish game described here can easily be adapted for any classroom. Importantly, the game goes beyond memorization by requiring students to work as a team to recall what they know about a body part or process, describe it using an array of descriptive tiles, and then locate it on a diagram. This allows students to process and organize what they have learned and to be creative in conveying information to one another.
they played the game, writing additional words on blank slips to add to the deck. A total of 124 clue cards were generated over 2 semesters.

For each unit of the course, which included the integumentary, skeletal, muscular, and nervous systems, eight four-word term cards were created (Fig. 1). Term cards consisted of vocabulary from A&P1, featuring structures and processes described throughout the semester (see the Supplemental Material for the term cards, clue cards, and game board). To be able to locate each structure or process within the body, a page of diagrams accompanied the term cards for each unit. For example, the skeletal system unit featured unlabeled diagrams of the skeleton, a long bone, and an osteon.

**Playing the game.** After completing a pretest (methods described below), students self-assembled into groups of three to four to play the ClueConnect game (Table 1). Clue cards were spread across the table top so that those students giving the clues could see all of their options. One team member was selected for each round to guess all four words on a term card. The remaining team members provided the clues.

At the start of the game, the clue givers drew one term card and had 2 min to create an array for each of the four words listed on the card. Clue givers were allowed to use their notebooks, textbooks, or computers if they needed to look up the definition of a word. Without speaking or gesturing, the team then assembled clue cards on the game board to create an array of descriptors for the term being guessed (Fig. 2). Throughout this process, the player attempting to identify the term could continue to call out guesses until they provided a correct response or their time ran out.

Once the clue receiver successfully guessed the term, they used the provided diagrams to locate the structure or process within the body. After all four terms were identified and located, a new team member would become the guesser, and the next round would begin. This pattern continued until all members of the group had a turn guessing two term cards each. Depending on how quickly students guessed the terms, teams were able to get through all eight term cards within 60–90 min. On average, rounds lasted ~10 min.

**Measures of students’ conceptual understanding.** To determine the impact of the ClueConnect game on students’ comprehension of core anatomy and physiology terminology as well as their short-term retention of that knowledge, a pretest/posttest/delayed posttest study design was used. Pre- and posttests were administered immediately before and after each unit’s game, respectively, and consisted of 10 short-answer questions requiring students to identify various structures associated with the body system being investigated. Questions on the pre- and posttests differed so as to reduce potential confounding due to item recall; expert evaluation of these items indicated that they were of equal and appropriate difficulty for the course. Items on the delayed posttest reflected a randomized compilation of questions found on the pre- and posttests and were administered as part of the in-class unit exams.

**Student perceptions of ClueConnect.** To examine the degree to which students perceived the ClueConnect game to be engaging and beneficial to their learning, a brief survey was administered as part of each unit exam. These surveys were identical across units and consisted of three Likert-item questions designed to assess if the game helped students learn the terminology, prepared students for the exam, and was fun to play. One additional open-ended item was presented where students could provide general feedback on game structure and gameplay. On the final course exam, the following two open-ended items were presented to provide an overall evaluation of the game: “Are there certain units or topics for which the game works better?” and “Would you recommend continued use of the game in future semesters?” Students were furthermore asked to rank the overall helpfulness of ClueConnect in enhancing their understanding of anatomy and physiology content relative to other course learning activities using both a Likert-item scale and open-ended response format.

<table>
<thead>
<tr>
<th>Card 2</th>
<th>Card 14</th>
<th>Card 17</th>
<th>Card 28</th>
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<td>limbic system</td>
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**Table 1. ClueConnect rules**

1. Array the clue cards face up on the table in front of your team.
2. Select one team member to guess the terms and place the game board in front of them.
3. The remaining team members will give the clues. The clue givers draw one term card and familiarize themselves with the terms before starting the timer. Do not show the term card to the person guessing the terms.
4. For each term, start the timer and select clue cards to place onto the game board. All clue givers may add cards to the board but should not talk or gesture.
5. If clue givers find their choices for a term are lacking, they may write a new clue on the blank slips provided.
6. The team member guessing the terms may call out guesses until they correctly guess the term or their 2 min run out.
7. Once the term has been identified/revealed, the player guessing the term must locate it anatomically on the diagram sheet provided.
8. The game board should be cleared and clue givers can move on to the next clue on the card, continuing steps 4–6 until all four terms have been guessed.
9. After all four terms on the card have been guessed, a new team member is assigned to guess the terms from a newly drawn term card. This should repeat until everyone has had a turn to guess the terms.

1 Supplemental Material for this article is available at the Advances in Physiology Education website.
Results indicated statistically significant pretest/posttest learning gains for each unit as well as significant posttest/delayed posttest gains for units related to the skeletal and muscular systems. Student scores on the postgame tests increased by an average of three points immediately after gameplay, with an average posttest increase of 3.20 points for the skeletal system unit and 3.08 points for the muscular system (Fig. 3). Cohen’s $d$ values for pretest/posttest comparisons across units ranged from 1.35 to 1.82, indicating large effect sizes (paired $t$-test; data not shown). Overall, student performance on the unit posttests demonstrated that playing the game improved their immediate knowledge and recall of terms.

To further assess if playing the game increased students’ short-term retention of knowledge, a delayed posttest was embedded in each unit’s exam. Results of the delayed posttests revealed an average increase of 3.80 points compared with the pretests, with students scoring, for instance, an average of 4.41 points higher in the skeletal system unit and 5.10 points higher in the muscular system unit. Students gained an additional point, on average, between the posttest and delayed posttest (Fig. 3). These data suggest that the game helped students both retain information and better prepare for the exam.

Student perceptions of the game. In addition to assessing the impact of the ClueConnect exercises on students’ comprehension of course terminology, student perceptions about the game were collected for each unit to determine if students perceived the activity as fun and beneficial to their learning. Median scores on Likert-item questions suggested that students found ClueConnect to be moderately helpful in learning terminology and preparing for unit exams as well as moderately enjoyable (Table 2).

For instance, students rated the prompt “Did the game help you learn the course terminology?” with median scores ranging from 3.00 to 4.00 (out of 5.00) across the four units. The integumentary system received the highest score, with a median of 4.00 (Table 2). Students commented, specifically, that the game facilitated their acquisition and understanding of course vocabulary, with statements such as: “Yes, it works well for both the clue givers and the guesser to assess their knowledge of the vocabulary” and “The game generally helps review vocab words, so it is especially beneficial when a chapter has a lot of new vocabulary.”

When asked if ClueConnect helped them prepare for exams, students rated the game a median score of 3.00 (out of 5.00) overall (Table 2). Interestingly, not all students recognized the game as a learning tool: “The game is fun and temporarily helps with explaining concepts and structures. I wouldn’t use it as a way to study, the exams are far more in depth understanding than what the game covers.” Others felt the game revealed gaps in knowledge: “It helped me realize what I needed to go back and study based on my lack of knowledge on some of the subjects during the game.” Yet another felt that the game “helped with terminology and figuring out and connecting words and ideas together. Playing that game allows me to then learn and study what I couldn’t guess, and helped me with the concept map and quiz games in class later on in the week.”

In determining if ClueConnect was fun to play, students rated both the integumentary system and skeletal system units the highest, with a median score of 4.00 (out of 5.00) for each unit (Table 2). One student remarked “I thought the game was fun and helped me learn what I needed to.” Others commented on how it made reviewing the material more enjoyable: “Keep doing it. Games like that make studying fun” and “It is a fun way to know which vocabulary words you should know and learn them!”

A Kruskal-Wallis test was subsequently used to examine between-unit differences in student responses. The results indicated a statistically significant difference in students’ perceptions of the utility of each unit’s game in regard to its helpfulness in mastering terminology [$\chi^2 (3) = 9.48, P =$]
0.024] and preparing for the unit exam \( \chi^2 (3) = 10.99, P = 0.012 \) as well as the degree to which each unit’s game was fun to play relative to one another \( \chi^2 (3) = 14.71, P = 0.002 \). Planned Mann-Whitney U-comparisons with Bonferroni correction revealed that the ClueConnect game was perceived to be more beneficial for the integumentary system unit than any of the other units (Table 3). No statistically significant differences between unit 2, 3, and 4 exercises was observed (\( P \geq 0.103 \) for all comparisons).

Students expressed that the game might be more suitable for some units than for others when presented with the following prompt: “Think about the game overall across the semester. Are there certain units or topics for which the game works better?” Many students (\( n = 15 \)) indicated that they did not find the exercise helpful or enjoyable for unit four (the nervous system), although they found it beneficial for previous units. This perception, as one student stated, was likely due to the fact that “it works better for smaller units; for the nervous system, we had so much thrown at us, it was impossible to remember” and that “With the nervous system, there were so many more terms to know but the terms also related to so many different things it was hard to keep track of them all.” Importantly, however, analysis of qualitative data collected at the end of the semester largely revealed that ClueConnect was perceived as beneficial across most units of the course.

When asked if ClueConnect should be continued in future semesters of the course, student responses indicated a continued need for the game. Students’ overall assessment of the ClueConnect game was positive. More than 86% of participants (\( n = 31 \)) indicated that the game should be used in future semesters, citing, for example, that “it keeps us aware of what we need to know and don’t know, and that can help us determine what we need to work on in the future.” Another student stated that “it helps me understand concepts better and it helps me know if I understand it myself. If I can’t explain it, I don’t know it.” This theme was evident throughout numerous responses, suggesting an integral role of the ClueConnect game in enhancing students’ ability to recognize key terminology throughout the duration of the course. Students likewise emphasized the value of the ClueConnect exercises as a study mechanism to prepare for course exams. For instance, one student asserted “I recommend the game because it’s a kind of secret study component in which groups are having fun while learning. [I] learn more because [I am] enjoying knowledge rather than avoiding the drag of repetition and regurgitation to remember vocabulary.”

Finally, compared with other course learning activities (lecture, animations, concept mapping, Venn diagrams, Jeopardy, laboratories, and process-oriented guided-inquiry learning exercises), students ranked ClueConnect identically in its effectiveness at promoting understanding of course content, including course terminology, with a median score of 4.00 of 5.00 for all activities (data not shown). One student commented that “the game’s greatest value is the discussion and peer interaction.”

![Fig. 3. Average student performance on the pretest/posttest and delayed posttest assessments stratified by unit. *\( P < 0.001 \).](image-url)
Table 3. Planned Mann-Whitney U-comparisons for ClueConnect Likert-item questions

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Learning Terminology</th>
<th>Prepares for the Unit Exam</th>
<th>Fun to Play</th>
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<td>354.00*</td>
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<tr>
<td>Unit 3-unit 4</td>
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</tbody>
</table>

Results are reported as U-values. *P < 0.008; †P = 0.001.

it starts.” Another felt that all active learning exercises in the course aided their learning, indicating that it was important to “keep doing it all.”

DISCUSSION

The ClueConnect game provides a versatile and fun way for students to review and reinforce their knowledge of anatomy and physiology terminology. Furthermore, the results demonstrated statistically significant improvement in students’ knowledge of course vocabulary after gameplay, with learning gains apparent both immediately after each game as well as 1 wk later.

Student perceptions regarding the usefulness of the game for learning course terminology and preparing them for exams varied across each unit, with the majority of students rating the game as most helpful for the integumentary system and as least helpful for the nervous system. Critical analysis of the collected survey data coupled with informal classroom observations suggest that median scores on Likert-item questions may have been moderate because not all students were cognizant of their own learning. For instance, when students struggled with the terminology during gameplay, they often spent time looking up the information in their textbooks or notes and discussing the concepts with one another. Despite this informal study time, students often considered the game unsuccessful if their peers could not guess the terms. Importantly, while students did not always recognize this process as a significant part of their learning, their performance on subsequent posttests argued otherwise, with students scoring an average of three points higher after the game. Thus, ClueConnect worked successfully as a review tool even if the students themselves did not perceive that they were learning as a result of engaging in the game.

Furthermore, students’ written feedback at the end of the semester indicated that the game was considered valuable for reinforcing course terminology and encouraging them to study, with 86% of students recommending the game for future semesters of A&P1.

While students’ learning cannot be definitively attributed to the game itself rather than simply time spent with the material, it is clear that the game is an effective learning strategy to master course content. The game carries additional benefits to students over studying on their own as it allows students to consider the perspectives of their peers and reinforces teamwork skills. To make their review sessions more fruitful, some students admitted to modifying the game throughout the semester, adding their own verbal clues along with the clue cards or creating stories to link the terms together as they played. Others would use the provided diagrams to help their peer guess the terms. Their adaptation of the game allowed students to review course terminology, determine which concepts they did not fully grasp, and then discuss it with their peers, yielding marked and statistically significant improvement on postgame assessments. At the same time, the game provides faculty members who teach in flipped or active learning classrooms a novel method for students to review material. Indeed, in written feedback, several students commented that the novelty of the ClueConnect game aided in their learning. Current research in science, technology, engineering, and mathematics education shows improved outcomes for students in classes that incorporate active learning. Adding activities like ClueConnect allows students to practice and apply their knowledge, which increases their success. ClueConnect is an effective supplement to existing instructor resources to enhance students’ learning (6, 7).

There are a few limitations to the game in its current format. For instance, when students were allowed to form their own groups, they tended to gravitate towards peers who performed at a similar level, and this made the game problematic if no one in the group was prepared. In some cases, students had not studied before the game, so it was difficult for them to recall terms, and this led to frustration for some of the groups. Possible solutions to these issues include mixing up the groups or assigning students randomly so that groups are composed of individuals with a range of abilities and preparation levels.

Providing a list of vocabulary terms at the start of the unit and allowing students to refer to the sheet during the game may also make the game more effective by narrowing their choices. This approach also allows the students to review the unit’s terms before playing the game, which may make the activity more enjoyable.

Several students commented that they felt concepts from the game were not covered on the unit exams or that they wanted to have their pre- and posttests back so that they could see what they were getting wrong. After this feedback, the instructor made it a practice to briefly review concepts that consistently were wrong on the posttests and to circle the embedded posttest questions when scoring the unit exams to allow the students to track their performance. This practice appeared to motivate students in subsequent iterations of the game to work to learn the terms, as they knew they would appear on the exams.

The majority of students felt positive about the game, and several had suggestions for improving ClueConnect in future semesters. These suggestions include allowing the use of verbal clues/discussion in addition to game tiles, the addition of topic headers to narrow the focus for each round of the game, using pictures as clues in addition to words, and writing the definition of the terms on the back of the cards to aid clue givers and to allow them to verify they are giving valid clues. Additional ideas for gameplay include having student groups compete with one another to see who can guess or locate a term first. Game kits can be loaned out to those students who want to play on their own to review before exams. Finally, the game presented here was printed on cardstock. Modifications to make the game more durable include using laminated pieces or printing on magnetic sheets or using a whiteboard to write clues to reduce preparation time and printing costs.

In conclusion, the ClueConnect game is a low-cost, fun, and effective way for students to review anatomy and physiology...
vocabulary and is easily adaptable to a variety of courses at both the introductory and advanced level.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS


REFERENCES