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Lesson

Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care Using the Jigsaw Approach

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Abstract

Animal behaviour courses integrate concepts across biological disciplines and are particularly well suited for collaborative, student-focused teaching strategies. Case Studies can positively impact students by placing their learning in context while providing an opportunity to do quick research and have rich discussions with both their peers and instructional team. Case Studies can also enrich the learning environment and help to produce a safe, collaborative space for asking questions and developing critical thinking skills. Here we describe three Case Study lesson plans using the Jigsaw approach that allows students to explore animal communication, migration, and parental care. Each Case Study includes 16 primary literature summaries on four different animal groups. In the Jigsaw approach, students are first sorted into four "expert groups" where they receive primary literature summaries exploring proximate and ultimate approaches to a specific animal's behaviour (e.g., neurobiology, physiology, genetics, and evolution). One student from each "expert group" (e.g., ants, birds, etc.) then joins and shares their group's knowledge in a "jigsaw group." By the end of each lesson, students will have read one primary literature article summary, prepared and delivered an oral brief, and summarized and then presented their expert group's findings to the new Jigsaw group members. Through this collaborative peer-to-peer learning activity, students gain skills in interpreting, analyzing and synthesizing scientific literature. They also have the opportunity to practice communicating scientific findings effectively and concisely, sharing how animal behaviour is studied, and explaining how behaviour is influenced by both proximate and ultimate factors

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Supporting Materials: Supporting Files S1. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Communication Case Study Readings; S2. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Migration Case Study Readings; S3. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Parental Care Case Study Readings; S4. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care -Communication Case Study Worksheet; S5. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Migration Case Study Worksheet; and S6. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Parental Care Case Study Worksheet.

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Learning Goals

Following these lessons, students will:

- Recognize the diversity of communication, migration, and parental care behaviours across animal taxa.
- Understand the different communication, migration, and parental care signals and cues used by animals.
- Understand the proximate mechanisms and ultimate evolutionary explanations that contribute to an animal's communication, migration, or parental care behaviour.

Learning Objectives

In completing these Case Study lessons, students will be able to:

- Explain and discuss the different ways animals communicate, migrate, or engage in parental care.
- Interpret, analyze, and synthesize information from the primary literature to explain how researchers study animal behaviour.
- Concisely communicate scientific findings by identifying and summarizing driving questions, key methods, and results in a scientific article.

INTRODUCTION

Animal behaviour is a field of study that can allow students to integrate knowledge across biological sub-disciplines (molecular genetics, neuroscience, ecology, and evolution). Animal behaviour courses are therefore well suited to meet calls for increased active learning activities that target higher-order synthesis and application skills in undergraduate biology (e.g., critical thinking, reading and interpreting the primary literature, science communication) (1, 2). Laboratory activities allow students to observe animals, collect and analyze their own data, and analyze video, audio, and behavioural data available online (e.g., (3, 4)). The availability of course-based research experiences (e.g., Squirrel-Net; see (5)), and community science platforms (e.g., i-Naturalist) also allow students to engage deeply in the process of science and contribute valuable research data through animal behaviour courses. Incorporating discussion of animal behaviour research into lectures can also allow rich discussion of both scientific concepts and practices. As a result, individual Case Studies are commonly used in animal behaviour, and span topics including mating and parental care (6–9), communication (10, 11), physiology and social behaviour (12, 13), and conservation (14). Due to the diversity of animal behaviour observed across taxa, as well as the influences of neuroscience, genetics, development, and evolutionary history, topics within animal behaviour such as animal communication, migration, and parental care, are ideal candidates for learning through Case Studies.

Case Studies can be designed as an active-learning pedagogical technique that provide an alternative to lecture-based learning to promote student-student peer interactions and active group-learning. Case studies using the Jigsaw approach encourage consistent student engagement in small and large group discussions, which creates a highly structured and student-centric active learning environment (15, 16). There are many examples of Jigsaw Case Studies available, covering a wide range of topics in biology (17–19). 'Jig-saw' can also be searched as a Type/Method in Case Study libraries. Student-centric teaching has been shown to enhance student engagement as well as positively affect academic performance, which are attributes particularly valuable to struggling students and promoting inclusion within science majors (20, 21). For example, Jigsaw Case Studies and other student-focused teaching strategies have been proposed to promote inclusion of cognitive-diversity among students in group-learning settings (22, 23). Active participation and discussion activities that promote participation and cooperative learning, such as Case Study teaching and Think-Pair-Share, have become widespread in biology teaching (23, 24).

These three Case Study lessons are separated into three animal behaviours – communication, migration, and parental care – and enable students to analyze how these behaviours are studied from a variety of biological subfields (molecular genetics, neuroscience, and ecology/evolution) by using summaries of primary literature. Each lesson investigates four animals, each with four primary literature article summaries designed as a one-page handout. Communication studies include ants (25–28), bees (29–32), birds (33–36), and monkeys (37–40); migration studies focus on monarch butterflies (41–44), whales (45–48), zooplankton (49–52), and birds (53–56); and parental care studies involve penguins (57–60), voles (61–64), spiders (65–68), and fish (69–72). These animals were chosen based on their diversity and behaviour display. Each one-page summary handout includes the study source, background, objectives, methods, a figure with legend, results/discussion and defined terms to familiarize students with the structure of the primary article and introduce students to scientific writing in an approachable manner.

Each case study lesson uses a Jigsaw approach, where students first review their primary article summary and make notes and annotations. During this step, students gain skills in interpreting, synthesizing, and communicating relevant information from scientific investigations. The use of primary literature in undergraduate courses enhances students' confidence, improves scientific research presentation skills, and aids in the transition to future academic studies (73). Individual students share their synthesis of their research article summary and learn about the other research studies for their animal within their "expert" group. One student from each "expert group" then joins and shares their group's knowledge in a "jigsaw group." This "jigsaw group" identifies commonalities and differences for both the behaviour and study designs for different animals. The lesson ends with a whole class discussion that emphasizes the research process and uses a comparative approach to understanding animal behaviour. This Jigsaw method allows students to combine the perspectives and expertise of their peers to create a comprehensive understanding of each animal behaviour and how it is studied.

Intended Audience

These lessons are intended for upper-level undergraduate biology, ecology or zoology courses. They were given to students in a fourth-year animal behaviour zoology course for majors at the University of Calgary (n=96). Pre-requisites for the course were Principles of Ecology and at least one additional Zoology or Ecology course. In this course, students complete individual literature reviews on a behavioural topic of their interest throughout the term.

Required Learning Time

These lessons were designed for a 50-minute class period. However, they can be modified to fit a longer class by expanding the time allotted to each step in the lesson.

Prerequisite Student Knowledge

These lesson plans were designed for an advanced biology class, therefore a strong background in biology and previous experience with typical scientific figure format was assumed. Prior to each lesson, students were introduced to the topic of animal behaviour being studied, either communication, migration, or parental care through an active learning lecture with think-pair-share "clicker" questions and group discussion. These lectures focused on the context for each behaviour, types of behavioural signals (including multimodal signals), and environmental influences on each behaviour type.

Prerequisite Instructor Knowledge

We recommend that instructors are familiar with fundamental concepts in animal behaviour, ecology, and evolution and how scientists study animal communication, migration and parental care. Instructors can also review each of the readings that are summarized for students prior to the lesson, communication case study (25-40), migration case study (41-56), and parental

care case study (57-72). Reviewing the article summaries will most likely be sufficient, as instructors are intended to fill a facilitator role.

SCIENTIFIC TEACHING THEMES

Active Learning

Case Studies using the Jigsaw method incorporate a variety of student-centered active learning strategies (74). Student are given an opportunity to read, think, and write on their own before disseminating their learning through oral discussions with two different groups of students. The timed group discussion ensures that each student participates in all of the discussions, and while their group member is conversing, students are actively taking notes and preparing summaries of their learning on the worksheet provided.

Assessment

Completed worksheets were treated as an opportunity for students to develop skills they would use for their term literature review project. Students were expected to complete an individual worksheet by the end of each lesson. These worksheets were graded as complete or incomplete based on participation.

Inclusive Teaching

Case Studies using the Jigsaw method rely on the creation of an environment in which students are comfortable learning and thinking on their own and as part of a group. Case Studies create this type of environment by allowing time for individual learning and structured small-group discussion. In both cases, students are aware that there is not a single correct answer. During the individual learning stages, students are presented with information through both text and visualizations, and can take notes by writing, drawing, or preparing an oral summary. Students are also given the option to share their learning in a way that they are most comfortable with, as long as it is within the time-limit. Many students used both a prepared oral summary with their drawings to communicate with other students. This promotes individual ownerships of the learning materials and comfort in sharing ideas before groupwork.

Student groups for the discussion were formed randomly and then 'shuffled', allowing communication among students who may not interact on a day-to-day basis. This has the effect of increasing within-group cognitive, cultural, gender and personal identity (or hidden identities) diversity. Increasing diversity in groupwork can improve group-level problem-solving and individual learning (75–77). Within each group, students were given specific times to share their knowledge and take notes on others' contributions. Ensuring that time was equally distributed among group members provides an opportunity for different ideas to emerge and for ensuring contributions from all students. Inclusive group work has been shown to have positive effects on individual- and group-level learning (78, 79). This type of active learning is student-centered, a strategy believed to improve student learning as well as student attitudes and experiences regarding biology (74).

LESSON PLAN

Each case study lesson set is designed for a 50-minute class period and is intended to introduce students to the skills involved in the interpretation, analysis and synthesis of primary literature on animal behaviours including communication, migration, and parental care. Table 1 provides the progression through the Case Study lessons with approximate timings. We ran each of the three Case Study sets at the end of a unit on the behaviour topic.

Progressing through the lesson

1. Individual students review one Article Summary in "expert group." Worksheet Activity 1 (~15 min)

You will start the lesson by organizing groups of 16 students into four groups of four individuals (Figure 1). In our course we had 96 students and a Teaching Assistant or instructor filled in for any odd-number groups or missing students. Each four-person group becomes an "expert group" and will receive one case study that includes four unique readings which focus on a particular animal in the context of the behaviour being studied (e.g., ants in communication). Each student in the group will receive an article summary (Supporting Files S1-S3. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care – Communication Case Study Readings, - Migration Case Study Readings, - Parental Care Case Study Readings) and a worksheet (Supporting Files S4-S6. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care – Communication Case Study Worksheet, - Migration Case Study Worksheet, - Parental Care Case Study Worksheet) (Article summaries are colour-coded for each animal "expert group"). To complete Worksheet Activity 1, students will read, annotate, and summarize their article summary individually. Each article summary is a one-page handout and includes the reference, background information, study objectives, methods, a figure with figure legend, and results. Many articles also include underlined scientific terminology, with definitions found at the bottom of the page. Once the student has finished reading their summary, they will prepare to give a 1-minute oral summary of their article to the other members of their "expert group." Our students spent approximately ten minutes reading and annotating each article, and five minutes preparing their summary.

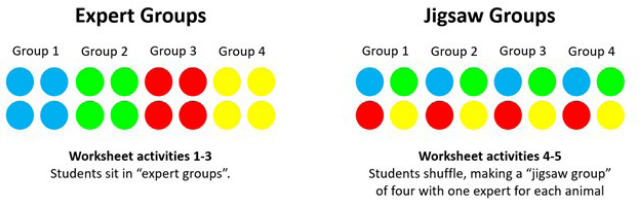

Figure 1. Organization of "expert" and "Jigsaw" groups. Students are first divided into four "expert groups," each consisting of four students. For each case study there are four sets of articles focused on four different animals. Every student in the group is given a unique article summary relating to that group's specific animal as well as a worksheet. Students remain in their expert group for worksheet activities 1-3. Students then shuffle to form new "Jigsaw" groups consisting of four unique animal experts. Worksheet activities 4-5 are completed in these new "Jigsaw groups".

2. Students share their Article Summary with other students in "expert group." Worksheet Activity 2 (4 min)

To complete Worksheet Activity 2, students will take turns presenting their one-minute oral summary while non-presenting students take notes in the provided space in the worksheet. Before students begin, you can ask students to choose a time-keeper to ensure that each presenter stays within the one-minute time limit and each individual is given equal time to talk. You should also remind students that during this step they should only be listening and taking notes, as they will get the opportunity to ask questions and discuss during the next activity.

3. "Expert group" Case Study Summary of their animal's behaviour and how it is studied. Worksheet Activity 3 (5 min)

After listening to all students present, students will summarize their group's animal behaviour by incorporating all four studies and answering the question prompts in the worksheet space provided. Each individual student will then prepare a 2-minute presentation summarizing their animal's behaviour and how it is studied to share with their next group, the "Jigsaw group".

Shuffle (1 min)

Remaining in their 16-person cohort, students shuffle to form "Jigsaw groups". Each "Jigsaw group" will have one member of each "expert group" (Figure 1). Students will remain in their "Jigsaw group" for worksheet activities 4-5.

4. Students share Case Study Summary to "Jigsaw groups." Worksheet Activity 4 (8 min)

Once in their "Jigsaw group," each animal expert gives the two-minute presentation that they prepared with their "expert group" to share the behaviour of their specific animal and how that behaviour is studied. Other students will listen and take notes in the worksheet space provided. Before students begin, you can ask students to choose a time-keeper to ensure that each presenter stays within the two-minute time limit and each individual is given equal time to talk. As in Activity 2, you should also remind students that they should only be listening and taking notes, as they will have the opportunity to ask questions and discuss during the next activity.

5. "Jigsaw group" summary on Four Case Studies. Worksheet Activity 5 (10 min)

Finally, as a "Jigsaw group", students answer prompts in the worksheet space provided and synthesize and discuss all four of the behaviours of the animals examined. While students discuss, you can ask follow-up questions to students following the prompts provided on the worksheet for each case study, such as What similarities did they notice between each animals' behaviour and how they were studied? What differences? What considerations were taken by the researchers to study the different types of animals? How were proximate and ultimate questions studied? What research methodologies were most interesting or new to them? What did you find effective about the presentation of data or results? Which animal behaviour would they be most interested in studying? What questions do they have now that they have been introduced to this area of research? Through the discussion, the Jigsaw group will identify 3-5 take-aways or key points from the set of four case studies. Students can then share their take-aways with the class. We found it helpful to ask students to choose one of their group-members to report these take-aways to the entire class. We also asked students to call on each other to encourage them to lead the dialogue and follow-up on each other's thinking.

TEACHING DISCUSSION

Facilitating in Different Sized Classrooms

We ran these case studies in our class of 96 students, making 6 groups of 16 students for each case study. However, on days where students were missing, we had a Teaching Assistant or instructor fill-in. To accommodate different class sizes, readings or animal groups can be removed from the case studies.

Options for Online Facilitation

Case Studies have been shown to enhance collaboration among students in online learning environments (80). Specifically, Jigsaw is a commonly used Case Study format for distance learning and builds a "learning community," increasing student success (81). Students may be divided into "expert groups" and "Jigsaw groups" through email or the course management system. Students can use an online discussion board or chatroom such as Zoom breakout rooms to share with their group. Class discussion, synthesis, and take-aways may also use online discussion boards or chatrooms.

Additional Suggestions to Enhance Student Learning While Using This Lesson

1. Provide more time for in-depth discussions.

Our goals were to help students gain skills in quickly synthesizing material, but this could easily be a longer activity. While students performed well within the 50 to 55 minute timeframe, some expressed a desire for more time for the activity. In an anonymous midterm survey, students discussed anxiety related to being able to finish the activity and an interest in going into more details. This lesson can easily be extended to fit in a 1h30 time period by simply extending the time allotted for each worksheet step. In a shorter time period, time management becomes more important, especially during group switches. Students mentioned that without proper organization, getting into "Jigsaw groups" can be "a little bit chaotic". Therefore, it is important to have defined groups (both "expert" and "Jigsaw") prior to starting the case study.

2. Create opportunities to engage before class.

The in-class portion of this activity could be enhanced by assigning a preparatory worksheet for students to complete using freely accessible online video material, readings and lecture materials. This activity could cover all animal models and multiple aspects of each behaviour to facilitate group discussions before and after shuffling. This kind of preparation prior to the Case Study could improve students' perception of their own knowledge and their comfort in sharing ideas with other students (74). Students could also be given access to the article summaries prior to class.

3. Design a synthesis activity for all three case studies.

In our course, after completing all three case studies, students brainstormed a list of questions. Students used these questions to design a research study based on the methods they learn as

part of the case studies. They then presented the research plan as an elevator pitch to the rest of the class. A similar activity, such as a summary report, or individual or group reflective exercises could further allow students to synthesize their learning.

Feedback, Reflection, and Conclusion

These Case Study lessons were successfully used in an upper-level animal behaviour course with the goal of establishing subject relevance and examining real-life scenarios. From the perspective of the Teaching Assistants and Instructor, watching students collaborate and act as their animal's "expert" was a rewarding experience. During the lesson, students gained confidence and became familiar with quick summarizations of difficult concepts by effectively digesting their article summaries and synthesizing the information via presentations to their peers. Student feedback regarding the Case Study gathered though an anonymous midterm survey was overall positive, and students commented that the Case Studies provide a unique and reasonable level of challenge while also allowing for application of scientific concepts to authentic scientific articles. In addition, use of Case Studies made students more confident when presenting scientific material to classmates and while solving problems as a team. Students also commented that through presenting the material to others, concepts were reinforced and better understood. Finally, through the use of the Case Studies, the learning goals and objectives to analyze primary literature, communicate concisely, and explain different forms of animal behaviour were achieved.

SUPPORTING MATERIALS

- S1. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Communication Case Study Readings. Readings distributed to students during the communication case study lesson.
- S2. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Migration Case Study Readings. Readings distributed to students during the migration case study lesson.
- S3. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Parental Care Case Study Readings. Readings distributed to students during the parental care case study lesson.
- S4. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Communication Case Study Worksheet. Worksheet to be completed by the students during the communication case study lesson.
- S5. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Migration Case Study Worksheet. Worksheet to be completed by the students during the migration case study lesson.
- S6. Animal Behaviour Case Study Lessons in Communication, Migration, and Parental Care - Parental Care Case Study Worksheet. Worksheet to be completed by the students during the parental care case study lesson.

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Table 1. Progressing through the lesson. Detailed account of each worksheet activity and group.

Activity	Description	Time
Class Session - Progressing Through the Activity		
1. Individual students review one Article Summary in "expert group." Worksheet Activity 1	1. Organize groups of 16 students into four groups of four individuals. Each four-person group is called an "expert group." 2. Each four-person group receives one case study. Each case study focuses on one particular animal (e.g., bees, penguins, ants) and includes four Case Study Worksheets and four unique Article Summaries. 3. Students individually read, annotate, and summarize one Article Summary. Each student then prepares a 1-minute oral synopsis of their Article Summary to present to their "expert group" in the next activity.	~15 minutes
2. Students share their Article Summary with other students in "expert group." Worksheet Activity 2	1. A time-keeper is chosen by the group to ensure that each person presents for one minute. 2. Students present their 1-minute oral summary to other students in their "expert group." 3. Non-presenting students take notes in the worksheet space provided.	4 min
3. "Expert group" Case Study Summary of their animal's behaviour and how it is studied. Worksheet Activity 3	1. Students answer prompts to discuss and incorporate findings from all four Article Summaries into one main summary of their given animal's behaviour and how that behaviour is studied. 2. Each student prepares a 2-minute oral presentation of their animal's behaviour to share with their "Jigsaw group" in the next activity.	5 min
Shuffle	1. Students shuffle to form a "Jigsaw group" of four individuals, with one person from each "expert group." See Figure 1.	1 min
4. Students share Case Study Summary to "Jigsaw groups." Worksheet Activity 4	1. A time-keeper is chosen by the group to ensure that each person presents for two minutes. 2. Each animal expert shares a two-minute presentation on the behaviour of their animal and how the behaviour is studied to their "Jigsaw group." 3. Non-presenting students take notes in the worksheet space provided.	8 min
5. "Jigsaw group" summary on Four Case Studies. Worksheet Activity 5	1. Students answer prompts to discuss and incorporate findings from all four Case Studies into one summary discussing the behaviour's variation and the diversity of ways that it can be studied. 2. Students from each group take turns sharing with the class their take-aways from the four case-studies.	~10 min