

INFLUENCE OF GROUP INQUIRY-BASED LEARNING EXPERIMENTATION ON STUDENT INTEREST, EXPERIENCE, AND MOTIVATION IN AN INTRODUCTORY ANIMAL AGRICULTURE COURSE



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Abstract

Inquiry-based learning (IBL) is an active learning strategy which poses questions to students and supplies them with materials and resources to solve it at their own learning pace. This creates a self-driven atmosphere which promotes collaboration, creativity, cognitive processing, and a curiosity to learn. Three levels of IBL were implemented in an introductory animal science laboratory course across four periods during the Fall of 2022. Students (n=176) were enrolled in one of five laboratory sessions and then randomly placed into one of six groups. In each session, students engaged in a 45-minute collaborative and authentic IBL case scenario which was created to mimic one of the three levels of IBL or a control. The control simulated a teacher-centered lecture. After each period, half of the students self-reported their situational interest and half reported their perception of active learning. Students in the control group reported less orientation to learn, readiness to learn, cognitive processing, and motivational orientation than in any level of IBL. Students reported different challenges, novelty, and attention demand in certain levels of IBL when compared to traditional lectures. In conclusion, IBL levels offer numerous benefits to students' experiences such as increased creativity, motivation, interest, and autonomy.

Keywords: active learning, animal science, inquiry-based learning, motivation, situational interest

First year students enter college with diverse backgrounds and range of academic preparedness. Diverse experiences can create uncertainty among students and result in feelings of apprehension related to their skill levels and academic capabilities (Brabec et al., 2018). These negative affective states are important to examine as up to 50% of attrition will occur following the first year of college (Delen, 2011). The high attrition rate within the first year demonstrates the necessity to generate student interest, involvement, and motivation in course materials. Students must be engaged early in their undergraduate program and be exposed to pedagogies that create curiosity and excitement in their academic area.

Students often decide to study animal science based on five key themed areas: 1) impact on society; 2) potential job exposure; 3) locational opportunities; 4) ability to work outdoors; and 5) love for working with animals (Winkel et al., 2019). With these key reasons, it is crucial to evaluate how to meet students' expectations for curriculum structure and prepare them for their future careers. One way to meet this challenge is to utilize active learning pedagogies in courses to make content relevant and engaging. For example, students enrolled in an introduction to animal science course engaged more deeply and experienced the greatest interest with hands-on, problem-based laboratory stations compared with video lectures (Erickson et al., 2020). Team-based learning, another form of active learning, promoted engagement and discussion in a large first-year animal science undergraduate course (Hazel et al., 2013). One form of active learning, inquiry-

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based learning (IBL), creates environments that promote an increase in academic challenge, support, and engagement (Brabec et al., 2018). Additionally, IBL approaches increased interest, motivation, and engagement in an undergraduate animal science course (Ragland & Karcher, 2022).

Active learning pedagogies, such as IBL, challenge instructors to reconsider the traditional instructor-centered approach to teaching. This traditional approach, where students are characterized as passive learners, often results in less effective long-term retention of materials (Kooloos et al., 2019). By restructuring traditional classroom roles, IBL transitions instructors to become facilitators of the learning process. In this active learning process, students learn, practice, and understand the content material through problem solving and collaboration with their fellow peers (Khalaf & Mohammad, 2018). By prompting learners to work through the problem solving, and not providing immediate answers, IBL prompts students to think critically, which promotes development of intellectual and academic skills (Justice et al., 2009). Additional benefits of IBL methodologies in the classroom include: increased effectiveness for teaching learning outcomes, processing and analytic abilities, creativity, and achievement in comparison to traditional instruction and higher learning gains, increased enjoyment, and improved attitudes (Prince & Felder, 2006; Beck et al., 2014).

IBL includes various levels that can be utilized in instruction to create a more student-centered autonomous classroom. There is limited research comparing student responses between IBL levels and exploring the impact of the transition to passive learning to IBL on the learner (Bunterm et al., 2014). There are four IBL levels that begin with traditional learning and then progress through structured, guided, and open learning (Spronken-Smith, 2010). As progression is made between levels, the instructor's role shifts to facilitator and students take on more responsibility for their learning. When IBL levels are properly aligned with course learning outcomes, students have positive experiences with IBL and prefer IBL levels that include more autonomy and self-facilitation (Spronken-Smith, 2010).

Llewellyn (2002) explained that IBL leads to lifelong learners and freedom among learners within each of these steps. Traditional learning is when students are presented with a problem, given a procedure, and provided an expected result and conclusion for why it happened. Structured inquiry is when teachers provide a problem and an outline for students to follow to reach an expected answer (Staver & Bay, 1987; Spronken-Smith, 2010). Guided inquiry occurs when teachers provide an inquiry activity, but students self-direct how they answer or address the issue. Finally, open inquiry is where students create or formulate a question or issue and work through an inquiry cycle to answer it (Staver & Bay, 1987; Spronken-Smith, 2010). When polled, students rated the open level of IBL their favorite, followed by guided and structured (Spronken-Smith, 2010). The various levels of IBL are important to examine because of their impact on student experience. Additional research is needed on the different IBL levels to create recommendations for instructors on how to incorporate the levels of IBL into their classroom to best enhance the student experience.

When implementing IBL into a classroom, it is important

to monitor its impact on students. Situational interest and motivational frameworks provide perspectives on how to implement IBL in a meaningful way. Situational interest refers to a psychological reactionary state caused by the environment and/or person-activity interaction. Instructional strategies, such as IBL can impact students' situational interest (Sun et al., 2008). When students engage in hands-on activities, the course material may seem more appealing than the material would be if delivered as a traditional lecture. Over time, this interest can lead to a more sustained individual interest (Harackiewicz et al., 2016). Development of individual interest is related to intrinsic motivation, where students complete tasks based on their own interest and enjoyment in the activity (Ryan & Deci, 2000). Increase in individual interest and autonomy are also important because these are characteristics that often result in better academic performance (Deci et al., 1991).

Based on the potential benefits of IBL methodologies, the objective of this study is to evaluate the impact of IBL on student interest, active learning experience, and the three basic motivational needs (autonomy, relatedness, and competence). Additionally, we wanted to examine the impact of scaffolding on these three variables. Our study was guided by the following research questions.

1. Does students' self-reported situational interest or active learning experience differ between levels of IBL?
2. Does students' self-reported interest or active learning experience differ between traditional lecture and IBL?
3. Does scaffolding between the three upper levels of IBL impact students' interest or active learning experience?
4. Does the IBL level or traditional lecture impact the fulfillment of students' basic motivation needs?

Materials and Methods

Participants and Context

This study was conducted during the laboratory portion of an introductory animal science course. The 16-week course structure consisted of two fifty-minute lectures and one, one hour and fifty-minute lab each week. There were 176 students enrolled in the course, and students were enrolled across five laboratory sections. The class consisted primarily of first-year students 73.17% ($n=128$). Most students were majoring in animal sciences (83.54%; $n=147$) and had a concentration in pre-veterinary medicine (62.20%; $n=109$). Students in the course came from a wide range of previous experiences with food producing animals. For example, several had experience caring for food producing animals (37.20%; $n=65$), but 38.41% reported minimum exposure to livestock.

Study Design

All procedures used during this study were approved by the university's institutional review board #2021-1428. The study examined instruction styles including three upper

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levels of IBL: structured, guided, and open, as well as a traditional, teacher-centered lecture style which was referred to as the control. Appendix 1 describes characteristics of the IBL levels implemented in this study. Our study was guided by an information-oriented frame, meaning students should already have been exposed to possible answers and the activity was to build on their previous body of knowledge (Spronken-Smith, 2010; Levy, 2009).

The experimental periods occurred during weeks two, five, eight, and 11 of the 16-week semester. The topics for each experimental period were reproductive anatomy and physiology, aquaculture, animal health, and laboratory animals, respectively. Each week, content and learning outcomes were standardized across the different IBL levels. Students were randomly assigned into six groups within each laboratory section, for a total of 30 groups. Each group ranged between 5-7 students and students remained in the same groups throughout the study.

One laboratory section served as the control throughout all four study periods (Table 1). Additionally, period 1 served as the control for all students enrolled in the study. Three of the laboratory sections were assigned one of the following levels for periods 2, 3, and 4 (open, guided, or structured). The remaining laboratory section received all three IBLs levels, but the levels were scaffolded beginning with control, then structured, guided, and open.

A control group was included in this study to provide a baseline for each laboratory time and period. There is a lack of data comparing traditional and inquiry-based teaching styles, with a control group (Beck et al., 2014). The control data were gathered before any of the students experienced the IBL treatments to provide a baseline. A control group was maintained through the various periods to account for any interest, engagement, or motivation changes dependent on the species or topic. During the first and second period, students gave consent to their data being included in the study (94.3% response rate: $n=166$).

The levels are outlined in Figure 1, and the facilitation and student roles are described. The instruction style was applied to each of the laboratory period's topics.

During each IBL laboratory, students engaged in a scientific process to answer a research question. Students

worked collaboratively with groups and resources were provided. Students had worksheets, as well as materials for testing hypotheses and gathering data. In each period, students, based on their laboratory time, were assigned to an IBL level, and had 45-50 minutes to work in their team. Following completion of IBL activity, students were given a few minutes to synthesize their scientific findings with their group. Students were then asked to present their group findings to the whole class. This aligns with the communication and justification of proposed explanations portion of "Inquiry and the National Science Education Standards" (NRC, 2000). During period 1 and for the remaining periods for the control lab group, a traditional lecture (PowerPoint presentation) was provided to students that ranged from 20-30 minutes.

Instrumentation

A mixed methods approach was implemented to best understand students' experience and outcomes from engaging in IBL. Demographic and prior experience questionnaires were administered to all students. These instruments gathered self-reported data from the students regarding their hometown, prior experience with animal agriculture, prior agricultural education (formal or informal educational programming), year within the University, and concentration (if enrolled in animal sciences major).

Situational interest was measured across the timepoints through the Situational Interest Scale (SIS) which was developed and validated by Chen et al. (1999). The instrument consists of 20 statements, which students responded to using a Likert scale from 1-5 with response choices ranging from strongly disagree (1) to strongly agree (5). The SIS evaluates the following subscales: challenge, attention demand, exploration intention, instant enjoyment, and novelty. Challenge and novelty impact the perception of interest. The challenge subscale measures the difficulty of the activity and its impact on student engagement. Novelty describes the difference in new and prior knowledge, meaning what new information is being presented. This gap in knowledge elicits exploratory behavior, which can be challenging depending on the student's ability. Attention

Table 1

IBL Level Treatment Arrangement

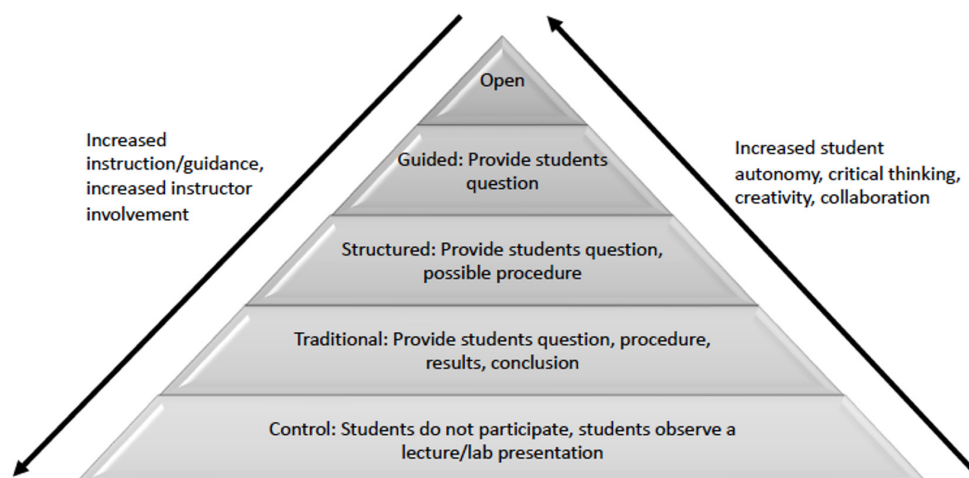
Lab Time	Treatment	Period 1 Reproductive Anatomy	Period 2 Aquaculture	Period 3 Animal Health	Period 4 Companion & Laboratory Animals
7:30	A	Control	Structured	Guided	Open
9:30	B	Control	Open	Open	Open
11:30	C	Control	Guided	Guided	Guided
1:30	D	Control	Structured	Structured	Structured
3:30	E	Control	Control	Control	Control

Note. The treatment arrangement for inquiry-based learning levels across four periods in an introductory animal science course.

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Figure 1

Description of inquiry-based learning levels implemented in the laboratory portion of an introductory animal science course.



demand refers to the cognitive and mental energy that is required during the learning process. Exploration intention describes the stimulation of curiosity and desire to invest in the learning process to the activity. Instant enjoyment describes the instant gratification of the activity, for instance the student's satisfaction with the learning experience (Chen et al., 1999; Roure & Pasco, 2018).

The active learning experience questionnaire, which was developed by Shroff et al. (2021), was also administered to students following their IBL experience. The instrument consisted of 20 prompts, which students responded to using a Likert-Type scale of 1-7 with responses ranging from strongly disagree (1) to strongly agree (7). This instrument included the following subscales: engagement, cognitive processing, orientation to learning, readiness to learn, and motivational orientation. Cognitive processing refers to students working through the scientific process for instance, to identify or create a question and work to create procedures or solutions. Motivational orientation explains if students feel flexible in how they are learning and/or their preferences in learning. Readiness to learn describes a favorable disposition towards the learning activity, meaning the feeling of wanting to contribute and be an active member of the experience. Orientation to learning describes the value dedicated towards the learning experience or process and having a context of the learning material (Shroff et al., 2021).

Additionally, students answered three short qualitative response questions. Each question was guided using one of the three basic needs of student motivation: competence, relatedness, and autonomy (Ryan & Deci, 2000). The three questions prompted students to reflect upon how feedback provided throughout the experience impacted their confidence (competence), instruction and guidance impacted their creativity and feeling of choice (autonomy), and peers and instructors impacted their experience (relatedness).

Distribution of Instrumentation

Following the completion of the scientific process and presentation of results, students were provided a QR link

to a Qualtrics survey (Qualtrics, Inc. Provo, UT). Within each laboratory time, students were assigned into one of six groups. The student groups were divided among the two questionnaires as follows: half of the groups (1, 2, and 3) completed the active learning questionnaire while the other half (groups 4, 5, and 6) completed SIS. These groups and the assigned questionnaire remained consistent across all periods. Surveys were divided and administered to separate groups to minimize survey fatigue across the four timepoints. From a preliminary study examining the impact of IBL levels, it was hypothesized that students experienced survey fatigue when asked to complete multiple instruments over several timepoints (Ragland & Karcher, 2022)

The survey was completed via students using their mobile devices in class. It was anticipated to take between five to ten minutes to complete the survey and students usually completed it within seven minutes. There was a 94.32% response rate for students participating in at least one period and providing consent to use their data. For the active learning experience instrument, the response rates for each of the four periods ranged from 72.22 to 86.67%. The situational interest response rates ranged from 81.40 to 86.05% across the four periods.

Statistical Analysis

In statistical processing for quantitative data, students were deidentified and analyzed as subgroups of a group analyzation which was a subgroup within each lab time. Using SAS (SAS Institute Inc., 2013) programming, treatment mean responses within each subscale were analyzed using estimation and statistical inference in a generalized linear mixed model. Treatments were compared with periods and lab times as covariates, using least square means and pairwise comparisons with Tukey-Kramer P values.

Qualitative data was collected from students' responses to three short answer questions embedded in the Qualtrics survey (Qualtrics, Inc. Provo, UT).

1. How did your peers and instructors impact your experience? (relatedness)
2. How did the instruction and guidance impact your

creativity and feeling of choice? (autonomy)

- How did the feedback provided throughout the activity impact your confidence in solving the case scenario? (competence)

Qualitative questions were designed surrounding the students' three basic motivational needs. Students' responses were analyzed using thematic analysis. When analyzing qualitative data, students were deidentified and analyzed within their IBL treatment (structured, guided, or open). Students' responses were grouped by IBL level and analyzed to identify patterns and themes. Open codes were created and modified while analyzing the data (Maguire & Delahunt, 2017). An inductive coding scheme was used, meaning each students' response was grouped into a theme.

Results

Situational Interest

While there was no effect of lab time on any of the SIS subscales, there was a period effect within all subscales. This effect may be due to different topics that were taught during each period as highlighted in Table 1. The least square means for each of the SIS subscales is shown in Table 2.

The structured and open treatment groups reported greater challenge compared with the control treatment ($P \leq 0.05$). The guided and open treatments reported greater novelty than the control treatment ($P \leq 0.05$). Students in the guided group responded with greater attention demand compared with students in the control treatment ($P = 0.05$).

Active Learning

Like the SIS results, lab time did not have an impact on students' self-reported active learning experience. Period had a significant impact across all subscales. The least square means for students' self-reported active learning experience are provided in Table 3.

In the context of IBL, engagement describes students

actively interacting with their peers, instructors, and course content to learn new material and/or skills (Shroff et al., 2021). There were no significant differences noted between engagement among the different treatments and the control group. This was the only subscale that had no significant differences between treatments or the control. However, all IBL treatments were greater compared with the control for the cognitive processing, orientation to learning, readiness to learn, and motivation orientation subscales ($P \leq 0.05$). There was no difference between the three IBL treatments.

Qualitative Data

Qualitative data were collected from students to better understand three basic needs (autonomy, competence, and relatedness) necessary to support student's motivation. The emerging theme for each basic need is described in Table 4.

For the competence need, students in treatment groups responded expressing they had increased confidence or experienced a greater assurance from instructor feedback. For instance, students in the open and structured group responded with the following:

"The help of the instructors allowed for me to feel confident about the paths I took, but also helped me to understand when I needed to switch paths." (open)

"There was little feedback throughout the activity, however, I don't think much was necessary." (structured)

Students in different treatment levels were provided differing instructions from the beginning in terms of what direction to take their scientific inquiry and how to find answers. More information was provided to the structured group, which may have increased their confidence in following the described procedure. Their responses demonstrated that students took responsibility and an active role in their learning, but there were differing amounts of feedback and support necessary in addition to the provided directions.

For the autonomy needs, there was an overall theme of students experiencing increased freedom and creativity. For instance, one student in the structured treatment provided

Table 2.

Least Square Means (LSM) and Standard Error (SE) for Situational Interest Scale (SIS) during Each Treatment

	Control		Structured		Guided		Open	
	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Exploration Intention	4.13	0.16	3.93	0.18	4.15	0.17	4.18	0.17
Challenge	1.97 ^a	0.18	3.08 ^b	0.20	2.67 ^{ab}	0.19	3.16 ^b	0.19
Attention Demand	3.65 ^a	0.18	3.92 ^{ab}	0.20	4.43 ^b	0.19	4.20 ^{ab}	0.19
Novelty	3.36 ^a	0.17	4.07 ^{ab}	0.20	4.27 ^b	0.19	4.17 ^b	0.18
Instant Enjoyment	3.69	0.19	3.73	0.22	4.18	0.21	4.09	0.20

Note. Least square means for students ($n=176$) within an introductory animal science course across the different treatment groups. The SIS uses a Likert scale of 1 to 5, with 1 corresponding to strongly disagree and 5 corresponding to strongly agree. Differences in superscripts within a row indicate $P \leq 0.05$.

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Table 3.

Least Square Means (LSM) and Standard Errors (SE) for Active Learning Experience Subscales

	Control		Structured		Guided		Open	
	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Engagement	4.28	0.25	6.52	0.26	6.13	0.27	6.65	0.26
Cognitive Processing	4.30 ^a	0.25	5.94 ^b	0.26	5.63 ^b	0.27	6.44 ^b	0.26
Orientation to Learn	4.44 ^a	0.23	6.16 ^b	0.24	5.69 ^b	0.25	6.23 ^b	0.24
Readiness to Learn	4.43 ^a	0.23	6.01 ^b	0.24	5.73 ^b	0.25	6.22 ^b	0.24
Motivational Orientation	4.48 ^a	0.25	6.13 ^b	0.26	6.08 ^b	0.27	6.61 ^b	0.26

Note. Least square means for students ($n=176$) within an introductory animal agriculture course across the different treatments. The Active Learning Experience instrument uses a Likert-Type scale of 1 to 7, with 1 corresponding to strongly disagree and 7 corresponding to strongly agree. Superscripts represent significant differences as denoted within the table. Differences in superscripts within a row indicate $P \leq 0.05$.

Table 4.

Emerging Themes in Qualitative Data

Prompt	Emerging Theme	Level Breakdown
How did the instruction and guidance impact your creativity and feeling of choice?	Freedom & Increased Creativity	Structured: 21.35% Guided: 30.33% Open: 39.36%
How did feedback provided throughout the activity impact your confidence in solving the case scenario?	Assurance & Boosted Confidence	Structured: 31.11% Guided: 40.45% Open: 32.98%
How did your peers and instructors impact your experience?	Positive Collaborative Experience	Structured: 55.56% Guided: 39.33% Open: 37.23%

Note. Emergent themes from students' responses to qualitative questions across the 2nd, 3rd, and 4th period in the 9:30, 11:30, and 1:30 labs.

the following response,

"I initially wished for more direction in the beginning as there were no prefaces on how to operate the equipment. However, I found that the problem solving proved to have a greater impact on learning."

While students in the structured treatment received more guidance, they still needed to use their problem-solving skills to complete the activity. In alignment with the students' responses, additional students reported a degree of confusion, or uncertainty due to the lack of instruction provided within their treatment (24.72%, 15.73%, and 6.38% for structured, guided, and open respectively). Students in the open group responded with the following.

"It allowed me the freedom to discover my own, unique method of solving the problem."

"I was confused on what to do. If I had a little more

structure or less choices, I would have felt better prepared."

These two responses demonstrate a trend of students discovering their own knowledge with little guidance. This aligns with previous literature that reports that the IBL open level has a powerful link to preparing students for undergraduate research experiences, however, it is not suited for all students and can have negative effects such as diminished confidence, feeling a lack of support, and an increased confusion (NRC, 2000; Sadeh & Zion, 2012).

Finally, when examining how peers impacted students' performance, an emerging theme of positive collaboration was discovered. For instance, students in the IBL groups responded with:

"There was minimal instruction so we had to really utilize each other to be creative and figure out what we were supposed to be doing." (structured)

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“My peers made this experience a lot more enjoyable and helped further my understanding over the topics at hand.” (open)

“They gave us the opportunity to do this experiment and allow us to make decisions on our own which boosted our confidence and independence.” (structured)

These quotes represent that collaboration allowed students to complete the activity with little to no instruction or facilitation, which demonstrates their self-direction and responsibility for their learning.

Discussion

The results from this study align with previous research that found with proper guidance, expository instructional approaches, such as IBL, are more effective than traditional lectures (Lazonder & Harmsen, 2016). Additionally, previous researchers have reported that traditional classrooms can create disengaged learning cultures that have lower achievement of student learning outcomes, student perceptions, and decreased critical thinking and creativity (Friesen & Scott, 2013; Kreifels et al., 2021; Spronken-Smith et al., 2010).

Importance of Scaffolding to Prepare Students for IBL Activities

Not all students are prepared to engage in the critical thinking process and problem solving that higher levels of IBL require (Cox et al., 2008). To best prepare students for activities that require higher-order thinking and greater responsibility, guidance and implementation is key. Scaffolding helps students to cope when classrooms are changing (Lin et al., 2012). This is done by providing incremental goals and creating a nurturing space with self-reflection, so students are pushed at appropriate levels to successfully complete tasks beyond their initial capacity. While this study did not find differences in the scaffolding treatment when compared with IBL levels, we hypothesized two possibilities for why this was observed. There is a possibility that previous coursework prepared our students for IBL-like activities. Another possibility is that the instruments utilized in this study did not capture the adjustment period when students became more accustomed to limited direction and greater responsibility. There were two-week intervals between every IBL period. To further examine the scaffolding effects, this two-week interval or the frequency (more repetitions) could be changed to note any differences. The specific frequency in this study was selected to reduce survey fatigue among students. Future studies should examine this scaffolding in a randomized period design to capture any differences among the scaffolded treatments, as scaffolding prepares and eases students into active learning spaces (Lin et al., 2012)

Guidance is an integral pillar of classrooms, and it is crucial to understand how guidance shapes students' experiences in learning activities, performance success, and learning outcomes (Lazonder & Harmsen, 2016). Overall, student in this study experienced positive peer collaborations,

increased confidence, and increased creativity. Based on our results, we hypothesize that students in the structured group felt frustrated by the perceived lack of direction and feelings of not following procedures correctly. Interestingly, students in the open group expressed an ability to freely explore with less emphasis placed on correct results.

Generating Student Interest with IBL Methodologies

Situational interest is powerful because it can be impacted by the instructional methods selected by educators (Rotgans & Schmidt, 2010). One way in which academic situational interest is generated is through well-structured active learning experiences. Continued exposure to a topic has the potential to develop a student' long-term stable interest in the topic. Our students who experienced higher levels of IBL reported greater novelty, attention demand, and challenge when compared to the students in the control. Students in the treatment groups reported being more attentive to the material, found it new and exciting, and were intellectually stimulated by the material. These student qualities are important for programs or instructors aiming to foster sustained interest in the material.

Providing challenges to students can alleviate boredom and encourage growth. In our study, students in the structured and open IBL groups reported feeling more challenged compared with students in the control group. The decreased challenge in the control group is most likely a result of the increased guidance provided by a traditional classroom presentation. Although there are advantages to external guidance, these advantages diminish when students have prior knowledge to serve as an internal guidance (Kirschner et al., 2006). However, when students don't have this prior knowledge, minimally guided instruction can be less effective and efficient (Kirschner et al., 2006). When students are properly prepared, higher levels of IBL, such as open or guided, encourage critical thinking and can generate greater interest.

Attention demand was greater for guided in comparison to the control level. However, open was not different. This could suggest that the open level struggles to hold students' attention. Student may have needed more guidance to help them stay focused and on task. Tasks that require high attention demand require more sustained concentration and effort by the student. Additionally, novelty was greater in the guided and open treatment when compared to the control group. Students in animal science programs often experience traditional lectures that have the potential to provide greater support. However, students in the higher IBL groups in our study were provided greater autonomy and space for creativity. This may have allowed for the perception of novelty since the experience was designed differently from what students were most familiar with in their program.

When comparing treatment effects, there was no difference between IBL levels or the control passive lecture for students' self-reported exploration intention or instant enjoyment. The lack of significance with exploration intention could be because students felt exposed to new

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material relative to course content, regardless of their treatment. Additionally, majority of the students were in the animal science major and previously interested in the course content. Student reported instant enjoyment may not have differed between groups because students in all groups may have been experiencing satisfaction from the activity.

Motivation and Active Learning

Active learning pedagogies, such as IBL, foster more autonomous experience with higher levels of self-determination and intrinsic motivation (Jeno, 2015). While active learning research is growing within animal science contexts, it remains limited (Ragland et al., 2023). Students engaged with IBL in our study reported higher order thinking, greater complex cognitive processing, and increased engagement. This aligns with research that has found students discover new relationships and understandings while engaging in IBL (Staver & Bay, 1987; Tafoya et al., 1980).

While self-reported student engagement was not significantly different between control and IBL treatment, the IBL treatments had high self-reported engagement. Additional studies examining engagement in first-year science courses in undergraduate education found that IBL activities have high student satisfaction, learning outcomes, and increase student engagement as the activities foster independent learning (Smallhorn et al., 2015). The remainder of the subscales within the active learning instrument found significant differences between students in any level of IBL compared with the students in the control group. For instance, students had greater cognitive processing, orientation to learn, motivation to learn, and motivational orientation. Students approached their IBL treatment experiences excited to learn with an understanding of their perspective and the context of the activity. Additionally, students reported positive collaborative (relatedness), choice and creativity (autonomy), and confidence in their learning (competence). Thus, their three basic needs were met for them to have positive affective motivational experiences.

Conclusion & Limitations

This study demonstrates advantages to utilizing IBL methodologies within courses to increase student interest and experience. Overall, during laboratory sessions students generally had greater interest and an improved active learning experience when participating in an IBL activity, rather than participating in a traditional lecture. Despite no differences among IBL treatments, some levels may better meet students' needs and generate engagement. IBL levels should be implemented in laboratory courses to increase students' interest, improve their active learning experience, and prepare them for future careers. Sample size and topic variation may have served as limitations in this study. To further investigate scaffolded treatments, there needs to be a larger sample size and randomized period topic. This was a limitation of the study because each period

represented one topic and topics were different between periods. Students inherently had more or less interest or predisposed expectations depending on the topic. Future researchers should consider different instruments and measurements to find key differences between IBL levels. Additionally, future studies should examine how challenge and attention demand are related in creating IBL based scientific process activities to maximize student outcomes related to academic achievement, interest, and motivation.

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Description of the control, structured, guided, and open groups with example assignments

Control: students take notes on the worksheet provided while an instructor stands in front of the class. The instructor teaches using a PowerPoint and demonstrates the tests live for the students.

Structured: students are given the steps and are supposed to follow the steps and find their own results (Koksal & Berberoglu, 2014). Students are given a problem or question and do not know the results. They are given possible tests to run and the provided materials (Staver & Bay, 1987).

Procedures are outlined and this enables students to discover relationships and understandings from data collected (Tafoya et al., 1980). Students investigate a question through a prescribed procedure (Sadeh & Zion, 2012).

Guided: teacher serves as a guide and poses meaningful questions. Students are not given steps but rather clues (Koksal & Berberoglu, 2014). Students are only given a problem to be investigated, design procedure and methods, and analyze data for conclusions (Staver & Bay, 1987). During discussion, students are given the correct direction (Koksal & Berberoglu, 2014). Students receive a problem to investigate and create their own procedures and methods for learning and understanding the data (Tafoya et al., 1980).

Open: students are free to state the problem and conduct scientific inquiry (Koksal & Berberoglu, 2014). Students create the problem and procedure, solve, interpret, and report the results (Staver & Bay, 1987). The instructor establishes the framework to work within, but students can investigate a wide variety of questions through self-designed questions and procedures (Sadeh & Zion 2012).

INQUIRY-BASED LEARNING EXPERIMENTATION

Station 1: Water Quality (Controlled)

Today, your team is working as consultants for RDM Shrimp Company (located in Fowler, Indiana). Recently, they are having issues with increased shrimp mortality in Tank B due to tank conditions. Meanwhile, shrimp in Tank A have a very low mortality rate and no current health issues. They provided you with water samples from both tanks and are seeking your expertise in solving their issue.

Research Question:

What water quality parameters are not currently suitable for shrimp within Tank B?

What adjustments can be made to decrease shrimp mortality in Tank B?

Hypothesis:

Methods/ Materials:

	Tank A	Tank B	Tank B Adjusted	Tank B Adjusted
Dissolved Oxygen				
Temperature				
Salinity				
pH				
Alkalinity				
Nitrite				
Ammonia				
Nitrates				

Results/ Discussion: On the back of this page, please list your results and give future considerations for RDM.

INQUIRY-BASED LEARNING EXPERIMENTATION

Station 1: Water Quality (Structured)

Today, your team is working as consultants for RDM Shrimp Company (located in Fowler, Indiana). Recently, they are having issues with increased shrimp mortality in Tank B due to tank conditions. Meanwhile, shrimp in Tank A have a very low mortality rate and no current health issues. They provided you with water samples from both tanks and are seeking your expertise in solving their issue.

Research Question:

What water quality parameters are not currently suitable for shrimp within Tank B?
What adjustments can be made to decrease shrimp mortality in Tank B?

Hypothesis:

Methods/ Materials: Use the table below to take notes during experimentation. Conduct each of the diagnostic tests. Then using information in your lab packet, make adjustments so that Tank A and Tank B will have similar living conditions.

	Tank A	Tank B	Tank B Adjusted	Tank B Adjusted
Dissolved Oxygen				
Temperature				
Salinity				
pH				
Alkalinity				
Nitrite				
Ammonia				
Nitrates				

Results/ Discussion: On the back of this page, please list your results and give future considerations for RDM.

INQUIRY-BASED LEARNING EXPERIMENTATION

Station 1: Water Quality (Guided)

Today, your team is working as consultants for RDM Shrimp Company (located in Fowler, Indiana). Recently, they are having issues with increased shrimp mortality in Tank B due to tank conditions. Meanwhile, shrimp in Tank A have a very low mortality rate and no current health issues. They provided you with water samples from both tanks and are seeking your expertise in solving their issue.

Research Question:

What water quality parameters are not currently suitable for shrimp within Tank B?
What adjustments can be made to decrease shrimp mortality in Tank B?

Hypothesis:

Methods/ Materials: Use the space provided below to outline your chosen procedure to answer the research question.

Results/ Discussion: Please list your results and give future considerations for RDM.

INQUIRY-BASED LEARNING EXPERIMENTATION

Station 1: Water Quality (Open)

Today, your team is working as consultants for RDM Shrimp Company (located in Fowler, Indiana). Recently, they are having issues with increased shrimp mortality in Tank B due to tank conditions. Meanwhile, shrimp in Tank A have a very low mortality rate and no current health issues. They provided you with water samples from both tanks and are seeking your expertise in solving their issue.

Research Question: Design a research question to answer during the time provided.

Hypothesis:

Methods/ Materials: Use the space provided below to outline your chosen procedure to answer the research question.

Results/ Discussion: Please list your results and give future considerations for RDM.