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Are My Students Engaged? Nonverbal Interactions as an Indicator of Engagement in a Stadium-Style Lecture Hall

Nicole E. States, Carina Bruno, Karsten Martin, and Renée S. Cole

Department of Chemistry, University of Iowa, Iowa City, Iowa, United States

ABSTRACT

Many large introductory classes are taught in stadium-style classrooms, which makes group work more difficult due to the room layout and immobile seating. These classrooms may create challenges for an instructor who wants to monitor student engagement because the layouts make it difficult to interact with the students as they work. Student nonverbal actions, such as eyes on the paper or an unsettled gaze, can be used to determine when students are actively engaged during group work. While other methods have been implemented to determine student actions during a class period, in larger settings these protocols require time-consuming data collection and cannot give in-the-moment feedback. In this study, student verbal and nonverbal interactions were analyzed and compared to determine the types of nonverbal interactions students take when collaboratively engaging in group work during lectures. It was found that a larger variety of nonverbal interactions, such as gesturing and leaning, were used when students were collaboratively working within their groups. Instructors of large enrollment classrooms can use the results of this work to aid in their facilitation of group work within stadium-style classrooms.

KEYWORDS

Classroom management; Instructional strategies; Teaching strategies; Cooperative groups

Introduction

Reformed Learning Environments Foster Student-Centered Instruction

Encouraging students to interact in class can be described as a type of active-engagement instruction and is the first step in student-centered teaching. Research has shown evidence that active-engagement instruction positively affects student achievement outcomes and success in undergraduate science, technology, engineering, and mathematics (STEM) courses (Deslauriers et al., 2019; Freeman et al., 2014; Haak et al., 2011; Theobald et al., 2020). While reformed learning environments promote active engagement in a classroom, not every course can be taught in a smaller size or in redesigned active learning classrooms with tables. It is important to investigate how we can work within the systems already established at many universities to provide students with positive learning experiences in their introductory courses.

Many factors influence the way a student can learn, including seating arrangement and instructor facilitation style (Brooks, 2011; Cotner et al., 2013; Henshaw et al., 2011; Kranzfelder et al., 2019; León & García-Martínez, 2021; Shekhar & Borrego, 2018). The way an instructor facilitates the classroom environment can be crucial in terms of strengthening a student's ability to learn and engage with the classroom material (Cooper et al., 2021; León & García-Martínez, 2021; Neill et al., 2019; Osborne et al., 2019; Ralph & Lewis, 2020; Scott et al., 2006; Stains & Vickrey, 2017). Research has shown that reformed learning environments can guide student learning. One study done by Kranzfelder et al. (2019) investigated thirteen STEM faculty teaching in a reformed learning environment. This study found that in a reformed learning environment where students were able to sit at group tables, instructors guided student learning by having student work on problems three times more than they listened to information in a didactic style (Kranzfelder et al., 2019).

Room Layout Affects How Instructors Can Manage Engagement

An instructor's facilitation methods impact student learning through the way they choose to present material and encourage students to interact during class

CONTACT Renée S. Cole renee-cole@uiowa.edu Department of Chemistry, University of Iowa, Iowa City, Iowa, United States.

(Brazeal et al., 2021; Cooper et al., 2021; Dietrich et al., 2021; León & García-Martínez, 2021; Nadile et al., 2021; Ralph & Lewis, 2020; Scott et al., 2006; Stains & Vickrey, 2017). A study done on two large engineering classes found that the use of different student response systems in combination with cluster-style seating arrangements can increase student engagement in large classrooms (Shekhar & Borrego, 2018). However many instructors indicate the traditional lecture hall environment inhibits the way they can engage students in active learning (Henderson & Dancy, 2007; Shadle et al., 2017). This would indicate that seating arrangements can also play a role in a student's ability to learn successfully. If students are seated close to each other, they may be more likely to engage with people around them to work through the assigned problems. If students are more isolated throughout the classroom, they may be less inclined to work with other people in the area, making it important for instructors to know how to engage students in traditional learning environments.

Nonverbal Interactions as an Indicator of Engagement

Because there are a variety of factors that can affect the way students learn and interact in a classroom or lecture hall, having a reliable way to monitor engagement through nonverbal interactions can be beneficial for instructors to know if their facilitation is engaging students. Nonverbal communication makes up about 50% of communication and can be an important factor in learning environments (Mehrabian, 2017). Student nonverbal actions can be used to determine when students are actively engaged during group work (Bremme & Erickson, 1977; McCarthy et al., 2006; Scherr & Hammer, 2009; Tucker et al., 2016).

Tucker et al. completed a study that (2016) showed that visual data alone was as reliable as audio or audio/visual to measure student engagement. This study found that nonverbal data allowed a coder to observe in-the-moment behavioral responses to the classroom environment. However, this study was completed in a small, reformed learning environment and captured nonverbal interactions such as bodies leaned 30 degrees to the vertical, neutral faces, and unsettled gazes that are not easily captured in a larger stadium-style lecture hall with immobile seating. Other methods such as the Classroom Observation Protocol for Undergraduate STEM (COPUS) have been implemented to determine student actions during a class period in larger settings, (Kranzfelder et al., 2019; Smith et al., 2013) but this protocol is not designed for in the moment feedback. This highlights the need for more research investigating the types of nonverbal interactions that take place in these large classrooms so that instructors can monitor in-the-moment levels of engagement. Our study aims to investigate the role of nonverbal interactions in student engagement by answering the following question: What nonverbal interactions are observed when students are engaged in group work in a large enrollment stadium-style lecture hall?

Methods

Setting

The study took place at a large research-intensive university in the United States in a large enrollment, introductory chemistry course. Students in this course attended three lectures, one discussion, and one laboratory/case study session a week. The lecture portion of this course was analyzed in this study and is described in detail below. The lecture section met three times a week for 50 minutes in a traditional, stadium-style lecture hall with 390 seat capacity and approximately 250 students enrolled. The course was team-taught by three instructors who rotated into the classroom for different topics across the semester. All three instructors implemented student response system questions during their lectures. At any given time during the semester, there was one faculty instructor and three graduate teaching assistants (GTAs) in the room. The instructors (indicated using colors for pseudonyms) taught at varying intervals across the semester; the schedule of their instruction during the observation period can be found in Table 1.

During lecture, each instructor spoke from the front of the room using PowerPoint slides and periodically delivered questions designed to be answered using a student response system, typically referred to as clicker questions. Each instructor asked at least one question a day, with a maximum of nine questions in one day. The questions were shown on both a PowerPoint slide and on the response system screen and consisted of multiple selection (22%), multiple choice (33%), matching, (15%), free response (24%), ranking (3%), and drawing (3%) questions. Variable amounts of time were allotted for each question, ranging from 45 seconds to 7 minutes. Students were expected to work in groups on the questions but had

Table 1. Number of lectures and order of instructors across the semester.

Instructor	Orange	Pink	Purple	Pink	Orange	Purple
Number of Lectures	4	4	4	7	5	5

to submit answers to questions individually due to the constraints of the student response system. Bonus points for participation were awarded if students answered a majority of questions throughout the semester. While students were working on questions, GTAs would stand in the aisles and watch for student questions. All instructors would circulate the room, asking about and observing student progress while answering questions.

Participants

Students in this classroom were not required to sit in groups to work on the clicker questions, so target groups were chosen based on the observational data of students who interacted and sat together consistently before the first exam when Instructor Purple was teaching. Four student groups comprised of 2-4 students were selected, and IRB-approved informed consent was obtained for every member. The groups were located on the right, middle top, middle bottom, and left sections of the lecture hall, as shown in Figure 1, and remained the same throughout the semester.

Data Collection

Data collection for this study involved video recordings of the classroom using video cameras placed at the front of the classroom facing the students. The locations of the video cameras may be seen in Figure 1. Observational field notes were taken by the researcher to collect information about classroom norms. Each group had their audio and written work recorded using an audio recorder and a whiteboard app on an iPad during the lecture periods. The scope of this paper will discuss the observational videos and audio collected of student interactions during clicker question periods.

Data Analysis

Visual Analysis

Video data were trimmed so that only portions of the video when students were working on the clicker questions were analyzed. Questions were split into thirty-second blocks, unless the time allotted was less than one minute, where the question was coded as a singular block. An open coding method to develop code categories as described in Merriam and Tisdell was used to code the video data (Merriam, 2016). The resulting nonverbal interactions coding scheme can be found in Table 2. After developing the coding scheme, the first and second authors coded the rest of the data set. Twenty percent of the data was coded by both researchers to establish reliability for the coding. Gwet's AC1-statistics (Gwet, 2002) were found to be between 0.78-1.00, showing moderate to almost perfect agreement for all codes (McHugh, 2012).

Audio Analysis

Audio analysis was not started until after the visual analysis was completed to avoid biasing the visual analysis coding. The codes used in this study were

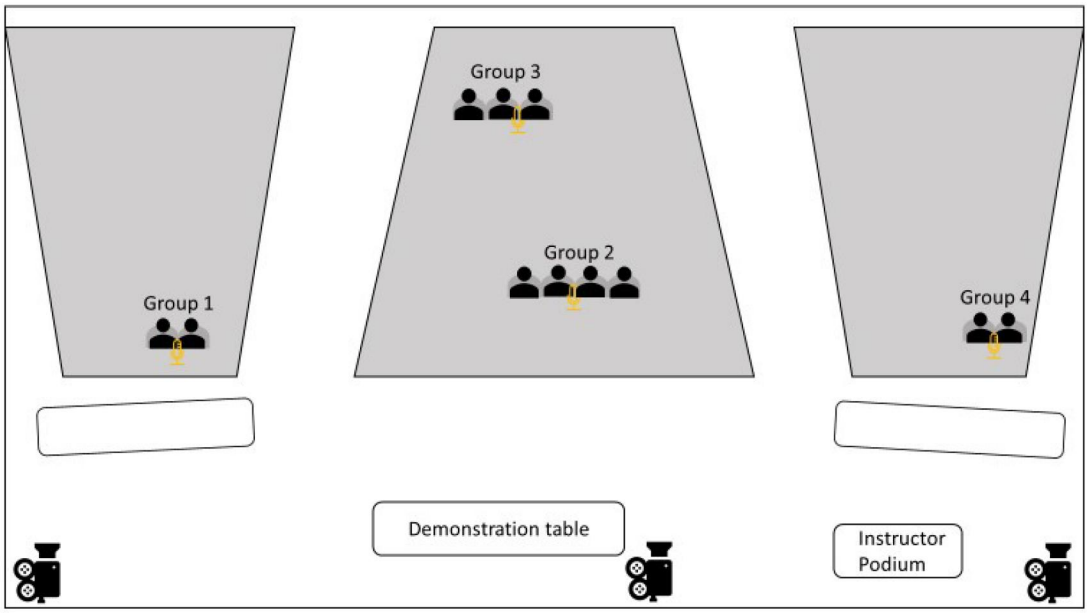

Figure 1. The layout of the stadium-style lecture hall for the study. The students all were seated in unmovable chairs facing the front of the classroom. Approximate student group locations can be seen with their labels. The location of the video cameras may also be seen facing each seating section.

Table 2. Code definitions for visual engagement coding scheme.

Code	Definition
Look	Movement of a head/neck to look in the direction of another person in their group
Lean	Movement of the shoulders/chest to look in the direction of another person in their group
Turn	Movement of the hips/lower body to look in the direction of another person in their group
Gesture	Movement of the arms/hands
Nod	Movement of the head to indicate yes or no
Laugh	Opening and closing of the mouth with body or head movement
Get Attention	Action that draws someone's attention to look/lean or turn to the person
Outside Interaction	Engaging in one of the other codes with a person that was not in the group when the consent form was filled out
Other	Anything that does not fit into the described categories

Table 3. Code definitions for social processing and knowledge dynamic.

Social Processing	Definitions
Collaborative	Students are co-constructing ideas and generating products together
Confusion	Students are too confused to generate the expected product or make confident progress for a question
Domination	One student constructs the response for the group while not considering, ignoring, or rejecting input given by others
Leader	One student primarily constructs the response due to a lack of contribution from others
Tutoring	One or more students ask questions that another student, "tutor", responds to. This is either done by the tutor guiding the students, "tutees", through the problem asking for their ideas, or just by the tutor explaining their reasoning without asking input from the tutees who asked the question.
Individualistic	Students are working independently and are not having conversations about the question products
Non-interactive	Students are not having any conversations, but there is no proof of individualistic work
Knowledge Dynamic	**Definition**
Not Applicable	No knowledge dynamic is seen due to a lack of student interaction with knowledge. Inclusive of when students just check in with only the final answer.
Knowledge Sharing	The focus of the group interactions is based on sharing information to answer the task without questioning the why/how of the utterances presented
Knowledge Application	The focus of the group interactions is based on applying a formula/method/concept and relating that to an understanding of how it relates to the explanation of solving the problem
Knowledge Construction	The focus of group interactions is based on sharing information and building upon the ideas of others by questioning or critiquing the why/how of the ideas presented

developed in previous work (Reid et al., 2022). Because this study is investigating what nonverbal actions can be used to determine if students are actively engaged in answering clicker questions, only the social processing and knowledge dynamic categories of the protocol were used. Social processing describes how student groups are interacting with each other during a question-answering period. Knowledge dynamic describes the way that students are interacting with content knowledge to answer the question. Social processing and knowledge dynamic codes with their definitions can be found in Table 3. These two categories were chosen for analysis because comparing visual action patterns with audio evidence of student engagement provides insights into what nonverbal actions indicate active engagement in group work while completing clicker questions. Researchers one and three coded all the audio data. Twenty percent of the data was coded by both researchers to assure the reliability of the applied scheme and Cohen's kappa values were found to be 0.69 for social processing and 0.81 for knowledge dynamics.

Results and Discussion

The goal of this project was to characterize the types of nonverbal interactions in student groups during in class clicker questions delivered across a semester. This was accomplished by observing their temporal nonverbal interactions and comparing them with their social processing and knowledge dynamics. Data showed that nonverbal interactions can be used as an indicator of social interactions, but do not indicate how students are engaging with content knowledge.

Specific Nonverbal Interactions Cannot Be Associated with Engagement Types

Throughout the semester, students were asked clicker questions intermittently during the classroom lectures, where they were expected to work with their neighbors and submit answers individually. A total of 121 questions were delivered during the study, potentially generating 484 episodes for analysis across the four groups. However, due to occasional group absences, 449 responses were coded for both their verbal and nonverbal interaction. Temporal Activity Plots were created for each day to show the presence of each nonverbal interaction that took place within a group. Each plot shows the timeline of one class period, broken into sections when clicker questions were asked in class. An example of a Temporal Activity Plot can be seen in Figure 2.

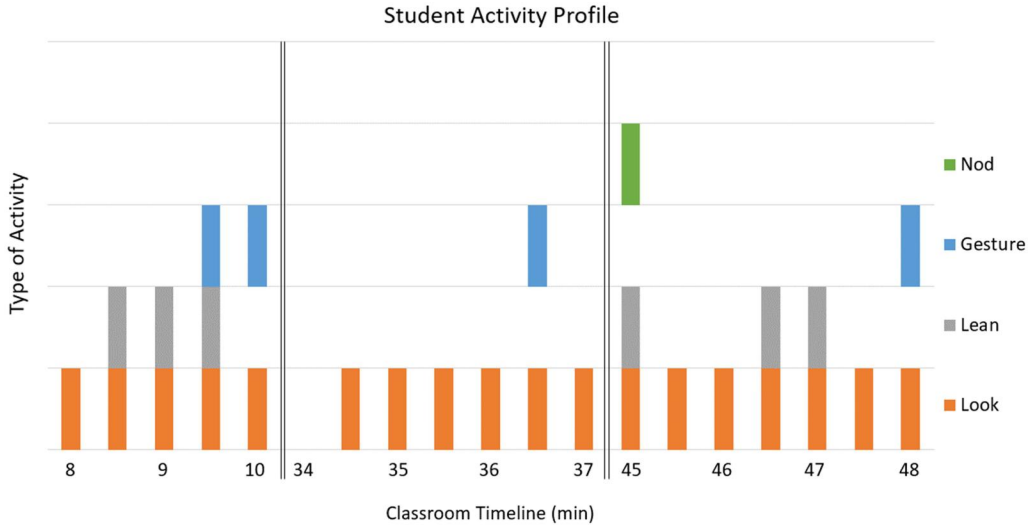

Figure 2. Temporal Activity Plot example showing three questions that were asked in one day. The horizontal lines indicate when there is a gap in time and a new question is asked.

Table 4. Percentages of appearance of nonverbal interactions in collaborative and noncollaborative interactions questions.

Nonverbal Movement	Collaborative Interactions (n = 205)	Noncollaborative Interactions (n = 244)
Look	99	100
Lean	28	21
Turn	1	0
Gesture	72	39
Nod	22	25
Laugh	2	3
Get Attention	2	2
Outside Interaction	16	16
Other	2	2

There was a classroom expectation for students to work together in groups, but given the constraints of the classroom, that was not easily enforced. Student groups engaged in a variety of social processing types across questions throughout the semester. To compare trends between different social processing categories, the categories were separated by those that were collaborative and those that were noncollaborative. Collaborative social processing categories (collaborative, tutoring, and confusion) represented interactive modes where students were sharing ideas and working together to generate answers. Noncollaborative social processing categories (noninteractive, leader, domination, and individualistic) occurred when student groups were either working alone or only one person was working to get the answer. Similar nonverbal actions were observed across group sizes and instructors; the percentage of each nonverbal interaction as they appeared in all the collaborative and noncollaborative interactions can be found in Table 4.

Most of the nonverbal interactions are seen in equal amounts for both the collaborative and noncollaborative interactions across the semester. In particular, look interactions were observed across most of the collaborative and noncollaborative interactions, so it is not a good discriminatory move to determine whether or not a student group was collaboratively engaged. Gesturing was the only nonverbal interaction where a significant difference in its appearance was seen between collaborative and noncollaborative interactions. Because no other nonverbal interaction appeared more frequently between the modes of interaction, the researchers wanted to examine the trends of nonverbal interactions that occurred when students were working either collaboratively or noncollaboratively across the semester.

Students Used More Nonverbal Interactions When Collaboratively Engaged

After analysis of all student group nonverbal interactions across the semester, it was observed that when student groups were collaborative, nonverbal interactions besides look and nod interactions can be seen. An example of a day when students worked collaboratively can be seen in Figure 3.

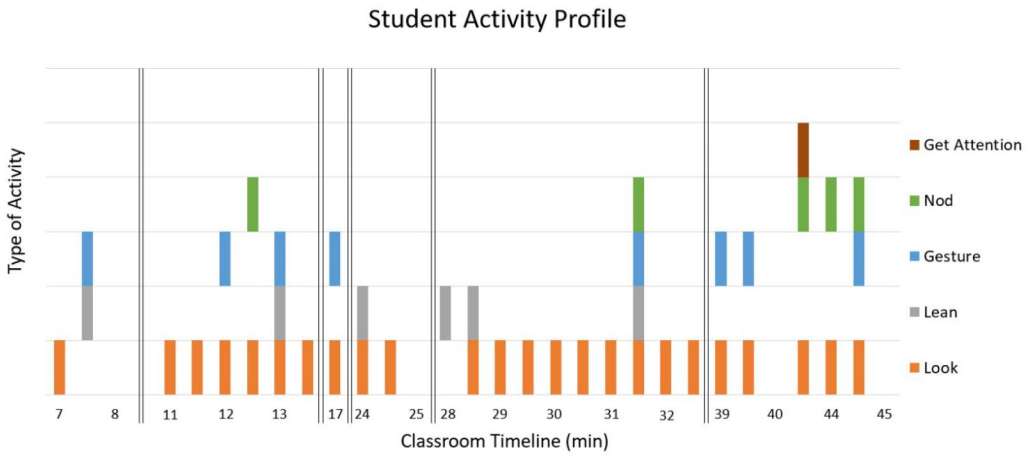

Figure 3. Example student activity profile where students were engaging in a large variety of nonverbal interactions while working collaboratively on each of the seven questions that were asked that day.

In this example, the students were asked seven questions related to the gas laws with a total of twelve minutes of potential group work time. For all questions, the groups were collaboratively working together to answer the problems and engaged in a variety of nonverbal interactions outside of looking and nodding as seen in Figure 3. This was even observed in question 3, with a duration of less than a minute. Across all these questions, students were either engaging in knowledge sharing or knowledge application. Gesturing was the most common nonverbal interaction other than look seen when students were collaboratively working together.

Next, we investigated whether this trend was observed across all student groups when they were interacting collaboratively over the semester. Looking across all the 449 data points we confirmed or rejected whether this hypothesis was observed. We analyzed this agreement across all instructors and the hypothesis was confirmed 76% of the time for group 1, 88% of the time for group 2, 85% of the time for group 3, and 69% of the time for group 4. There were some outlier data values with lower percent agreement such as with Group 4 with Instructor Purple at 42% and group 1 with Instructor Pink at 57%, but overall, across the 449 data points, the trend was consistent.

Students Used Few Nonverbal Interactions When Noncollaboratively Engaged

Contrasting these types of collaborative interactions, it was seen that when groups were working noncollaboratively, look and nod interactions were primarily observed, and all other interactions occurred sporadically. An example of a day when students were working noncollaboratively can be seen in Figure 4.

In this example, the students were asked two questions about equilibrium constants that gave a total of four minutes of potential group work time. During question one, students were looking and there was a nod interaction as well while students were noninteractive and there was no verbal indication of students working on the problems in the audio data. In the second question, there were only look interactions while students were working individually and sharing knowledge. In the same manner, as with collaborative interactions, we looked across all the 449 data points to confirm or reject whether this hypothesis was observed. We analyzed this agreement across all instructors and the hypothesis was confirmed 68% of the time for group 1, 81% of the time for group 2, 68% of the time for group 3, and 56% of the time for group 4.

The overall agreement is lower than the collaborative trend. However, within the noncollaborative social processing, leader and domination have one person explaining the answer to the others in the group. This means that they may often be engaged in a large variety of nonverbal interactions, even if the group was not. There were no instances of domination social processing, but if we remove the leader social processing from our percentages, the trend becomes more consistent being confirmed 76% of the time for group 1, 91% of the time for group 2, 79% of the time for group 3, and 70% of the time for group 4. By removing the leader social processing, the data agrees with the trend observed from collaborative interactions consistently across all student groups.

Nonverbal Interactions Cannot Predict Cognitive Engagement

The authors were also interested in examining whether cognitive engagement could be evaluated from nonverbal

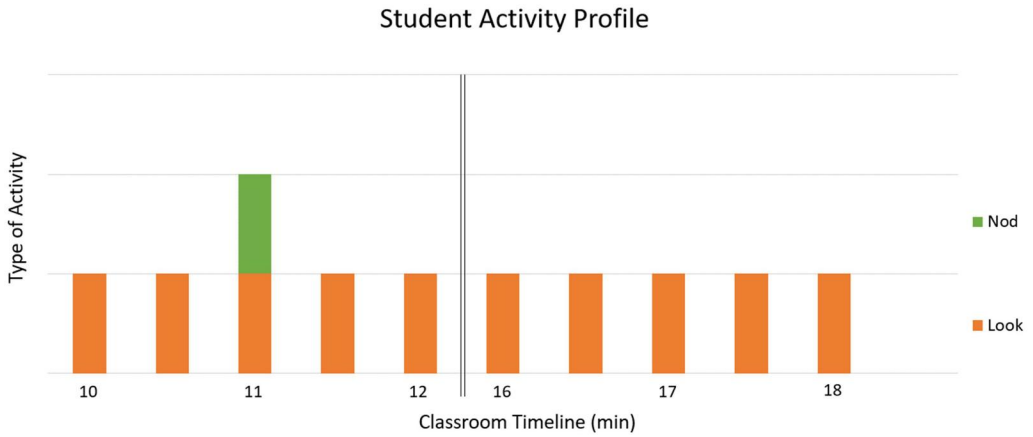

Figure 4. An example student activity profile where students were noninteractive for question one (ten to twelve minute segment). Students were working individualistically for question two (sixteen minutes to 19 minutes segment).

Table 5. Percentages of appearance of knowledge dynamics in collaborative and noncollaborative interactions questions.

Knowledge Dynamic	Collaborative Interactions (n = 205)	Noncollaborative Interactions (n = 244)
Not Observable	1	63
Knowledge Sharing	53	36
Knowledge Application	36	1
Knowledge Construction	10	0

interactions. This analysis focused on the presence of knowledge dynamics across both collaborative and noncollaborative interactions. In both cases, students ranged from not interacting with the knowledge, to constructing knowledge. The percentage of each knowledge dynamic as they appeared in all the collaborative and noncollaborative interactions can be found in Table 5.

When students are engaging noncollaboratively, with look and nod interactions only, they are more likely to be either not interacting with the knowledge or only sharing knowledge with their groups with 99% of noncollaborative interactions falling in these two dynamics. Any of the knowledge dynamics could be observed when students were interacting collaboratively. Even though one would be unable to predict the exact way students are engaging with knowledge, if students are engaging in nonverbal interactions outside of look and nod, they are likely to be engaging with knowledge in some form with only 1% of collaborative interactions seeing not observable knowledge dynamics. These results are not surprising because it would be hard to predict what students are discussing related to content knowledge only by looking at nonverbal interactions.

Limitations

The described study took place at a midwestern university in the United States. This study may not represent other classrooms that are not presented in a stadium-style lecture hall with all the students facing forward in immobile chairs. The authors would also like to acknowledge that demographic information was not collected for any participant but recognize that participants may not reflect a diverse set of backgrounds that may be seen in other classrooms. Lastly, this study was completed on student's interaction during clicker questions and if instructors use alternate forms of group activities, their nonverbal interactions may differ.

Implications

Our results indicate that nonverbal interactions that can be seen from the front of a large stadium-style seating classroom can be used as an indicator of student engagement. These results can be used by instructors who want to monitor engagement within large classrooms but are unable to circulate the whole room and interact with students during group work. Instructors can scan the classroom and look for nonverbal indicators of student engagement such as gesturing, leaning, and turning across all the student groups. If instructors are only seeing students look and nod, they will be able to intervene and facilitate students using their time more productively.

If most of the classroom groups are only engaging in look or nod interactions before time is up for the group work portion, the instructor can first check to see if most of the class has submitted answers either

in the response system or by verbally asking students if they are done with the question or need more time. If the majority have responded, an instructor can move on to the next portion of the class, allowing them to use the extra time on a topic students may need extra time with. If a majority of students have not answered, the instructor can give a reminder that students should be working in groups to answer this problem or check in to see if they need help. It is important to remember that they may not be working because they are confused and stuck on a topic and not because they are just ignoring the task. Related to this, if an instructor only sees pockets or certain groups not engaging nonverbally, this can be a good time to go check in with that group specifically to see if they are done with the problem or have gotten stuck and need help. The results presented allow instructors in large enrollment courses to not have to rely on stagnant timers to meet the needs of the specific classroom population and provide a more productive learning experience where time is not wasted when the class is ready to move on or needs support.

Conclusions

Four student groups were observed across a semester for both their nonverbal and verbal interactions. Analysis of student data revealed that when student groups were noncollaborative, they mostly engaged in look and nod interactions alone. However, when student groups were collaborating, a wider variety of nonverbal interactions, including gesturing, leaning, and turning, were observed. Instructors can use these results to know when to intervene in classroom discussions to promote more productive group work. This will allow facilitators in large enrollment classrooms to be able to broadly monitor student engagement in the moment even when they are not able to interact with all the student groups.

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Author Contributions

Conceptualization: NS and RC; methodology: NS and RC; data curation: NS; data analysis: NS, CB and KM; writing original draft: NS and CB; writing-review and editing, NS and RC; visualization, NS; supervision, RC; project administration, RC; funding acquisition: RC.

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