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Analyzing student engagement: a case study of active learning in two biology courses from a three-point perspective

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ABSTRACT

Active learning is being encouraged in higher education as alternatives to a lecture-based approach. This study investigates the impact of active learning on student engagement across the three-dimensional construct (emotional, behavioral, cognitive). A mixed-methods design was employed with data drawn from four cohorts of undergraduate biology students ($n = 131$) from two biology courses at a French university that use active learning as an instructional approach. Engagement was analyzed through a three-point perspective: non-participant observation (timeline analysis), teacher interviews, and student questionnaires including open-ended questions. Results showed that students reported higher motivation and collaboration; the teachers expressed satisfaction with the instructional approach and the level of interaction during the sessions; and the timeline analysis revealed sustained engagement throughout class sessions. Findings indicated that triangulating these perspectives provided valuable insights into how active learning fosters student engagement. Future research should investigate the use of different measuring tools when it comes to active learning approaches to teaching at the university level.

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Introduction

Over the years, there has been an apparent shift from lecture-based learning environments to student-centered learning environments in higher education (Levesque-Bristol, 2021; Baeten & Simons, 2022). There remains a gap in the research regarding the instructional approaches teachers use and the extent to which students are engaged during these lessons. Both the teacher and the students play essential roles in building the relationship required for an environment conducive to learning (Gehlbach et al., 2023). We will explore this relationship by examining how students engage with the course, interact with the teacher, and participate in classroom activities. There has been a push towards alternative teaching methods in which students are actively engaged in the classroom, active learning being a prominent example. Active learning is generally understood as an overarching instructional approach that engages students in the learning process through structured activities fostering higher-order thinking, student participation, and interaction rather than passive reception (Doolittle et al., 2023). In this study, we will focus on two Biology courses that use active learning as an instructional approach, specifically employing presentation-based learning activities chosen based on the teachers' instructional preferences, to examine its impact on student engagement.

Active learning as an instructional approach

Active learning is grounded in constructivist learning philosophies, which positions students to take responsibility for their own learning and to engage in peer sharing assessment; recent work shows that such constructivist peer assessment interventions significantly enhance critical thinking, creative self-efficacy, and learning outcomes in higher education settings (Xu et al., 2024). Teachers are switching

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their courses from lecturing on information, to students taking the role as teacher, where they present their knowledge and understanding to their peers. Teachers use this method as a way of putting the responsibility of learning onto the students. This overarching approach can take many forms, including student-led presentations, peer teaching, group problem-solving, collaborative discussions and any other interactive methods that shift the focus from teacher-centered delivery to student-centered engagement. Active learning creates an environment where students construct knowledge through interaction with their peers and teacher (Chi & Wylie, 2014; Grijpma et al., 2022). 'Being the teacher' allows them to adopt the role of an 'expert' when they talk about their subject, so that they can address relevant questions or comments, which further promotes critical thinking by encouraging them to analyze, apply, and communicate what they have learned in meaningful ways (Kusumoto, 2018). Research has shown that increasing active learning in the classroom enhances student learning (Freeman et al., 2014). Providing students with an active-learning environment could give them a sense of purpose, which could lead to students' learning (Godsk & Møller, 2025).

Sugeng and Suryani (2018) reported that presentation-based learning activities, where students prepare and conduct presentations, 'actively engage students in the learning process' (p. 178). However, while presentations involve student participation, they are sometimes considered a relatively passive form of active learning compared with more interactive strategies, such as group problem-solving or debates. Still, when students present to their classmates instead of the teacher, they are a part of the active learning process, one in which learning occurs starting from the preparation phase up to the presentation itself. In the preparation phase, students explore all of the information and material that they find by using the internet, books, discussion with teachers and peers, and so forth, so that they can create an interesting and well-structured presentation. Students are often forced to gain skills that help them do research and then organize the information they have acquired, develop further understanding of what they have to present, and encourage interaction with their peers (Almulla, 2023). In addition, one way for students to achieve self-confidence is by having the teacher encourage students to devote more time co-constructing knowledge with their classmates (Chi & Wylie, 2014) and work in groups (Brannen et al., 2021). However, students presenting have also been identified as a least favorite way of learning, as it can negatively impact their perceived learning due to the challenges of group work, preparation, and presenting, as well as the lack of guidance throughout the learning process (Remsberg & Hagar, 2019).

Considering all of these possibilities, it is beneficial to use the active learning approach. Presentation-based learning activities allow students to be actively engaged by processing the information they receive and discussing it with their classmates, thereby demonstrating student engagement.

Student engagement

Active learning approaches have a positive impact on learning as this approach drives students to be engaged in the learning process. Student engagement can be viewed as a direct pathway for student learning (Bronfenbrenner & Morris, 1998; Carini et al., 2006; Xu, 2023). Creating instructional approaches which reinforce student engagement will have an impact on students within their own learning (Koubek & Rodriguez, 2023). In addition to the instructional approach, having the necessary tools and practices is also important to ensure that students have a positive learning experience (Li & Xue, 2023). Student engagement has been defined in many ways, but all definitions refer to the idea that it is related to high-quality learning leading to positive student outcomes that include critical thinking and cognitive development (Zepke, 2015).

For 30-plus years, there have been different variations in what student engagement means (e.g. Finn, 1989; Lin et al., 2023); however, it can now be agreed upon that student engagement is a multidimensional construct (Fredricks et al., 2016). In this study, we define engagement as a three-dimensional construct: emotional, behavioral, and cognitive engagement (Fredricks et al., 2004) - as further supported by recent empirical studies (Xu, 2023).

Emotional engagement focuses on interest, positive emotions, enjoyment, and enthusiasm in class. Behavioral engagement is shown in observable behaviors, such as when students are paying attention, participating in class (discussion, raising their hands, etc.), following directions and any other noticeable

physical or verbal action from students. Cognitive engagement is more difficult to identify, because it refers to students' mental effort (learning process, strategy, focus, and metacognition; Fredricks et al., 2016).

These three dimensions of student engagement have been used in education for decades, with different measures (Wong & Liem, 2022). Some common data collection methods used include student self-reports, experience sampling, interviews, and observations. While student self-report is the most typically used because it is uniquely positioned to collect students' subjective perceptions on their engagement (Fredricks, 2022a), research indicates that relying on any singular method cannot reliably capture the entire, multidimensional construct. Therefore, to provide a comprehensive and reliable evaluation of the full construct, there is a critical need for multiple methods that work together to collect and triangulate the data. Specifically, to address the core difficulty of identifying and measuring the mental effort of cognitive engagement, our study utilized the ICAP framework (Chi & Wylie, 2014) to systematically categorize observable student actions and behaviors.

A framework for understanding interactive approaches in relations to student engagement

The Interactive-Constructive-Active-Passive (ICAP) framework was selected to show how instructional approaches relate to student engagement. This ICAP framework (proposed by Chi & Wylie, 2014) analyzes the link between instructional approaches and how the students are cognitively engaged. In the literature, it has been used to guide experiments by testing different forms of peer instruction (Henderson, 2019) and to investigate student engagement in non-face-to-face activities (video lectures, discussion forums, readings, tutorial materials; Lee et al., 2020). This framework focuses on the different levels of cognitive engagement required by classroom student activities. In doing so, it fills the gap that research has shown regarding the direct link between instructional approaches and students' cognitive engagement (Pintrich et al., 2000).

The ICAP is not only a relevant framework for measuring cognitive engagement, it is also an adaptable framework that can be used when evaluating any kind of instructional approach. In order to understand how a student is cognitively engaged during an activity, we employed systematic classroom observations and used the ICAP Framework as a behavioral coding system. This allowed us to translate a student's overt action into one of the four measurable modes: passive, active, constructive, or interactive. These four modes are used as different levels of cognitive engagement, interactive being the highest and passive being the lowest ($I > C > A > P$). Interactive engagement has to meet two criteria: the people involved must construct knowledge that comes from the individual or socially, they must have an adequate amount of time taking turns to talk and some form of social action. Constructive engagement is defined as occurring when learners actively build their own understanding (Fredricks, 2022b). There is a fine line between the active and passive mode of engagement. In active engagement, 'some sort of overt motoric action or physical manipulation is undertaken' and in passive engagement, no overt behavior besides listening and paying attention is shown (Chi & Wylie, 2014, p. 221), examples shown in Table 1. These examples illustrate how students' engagement would be classified based on the behaviors shown during certain classroom activities, and can be modified to fit any learning activity.

Our aim for this study was to explore active learning approaches and their impact on student engagement. The analysis of student engagement was performed from a triangulated three-point perspective, gathering data from three distinct sources: students (questionnaire and open-ended questions), teachers (interviews), and a non-participant observer (classroom observations and a framework).

Method

This study employed a mixed-methods design to examine active learning's impact on student engagement in undergraduate Biology courses. Qualitative data (ethnographic observations and teacher interviews) and quantitative data (student self-report questionnaires) were collected to provide a comprehensive understanding of engagement from multiple perspectives. Data were gathered from two courses across multiple academic years, enabling comparisons across cohorts and instructional contexts. The analysis was guided by the three-dimensional construct of engagement (emotional, behavioral,

Table 1. Examples of learning activities by mode of engagement.

	Passive *receiving*	Active *manipulating*	Constructive *generating*	Interactive *dialoguing*
Listening to a lecture	Listening without doing anything else but oriented toward instruction	Repeating or rehearsing; Copying solution steps; Taking verbatim notes	Reflecting out-loud; Drawing concept maps; Asking questions	Defending and arguing a position in dyads or some groups
Reading a text	Reading entire text passages silently/aloud without doing anything else	Underlining or highlighting; Summarizing by copy-and-delete	Self-explaining; Integrating across texts; Taking notes in one's own words	Asking and answering comprehension question with a partner
Observing a video	Watching the video without doing anything else	Manipulating the tape by pausing, playing, fast-forward, rewind	Explaining concepts in the video; Comparing and contrasting to prior knowledge or other materials	Debating with a peer about the justifications; Discussing similarities and differences

Note: From Chi and Wylie (2014, 221).

cognitive; Fredricks et al., 2011) and the ICAP framework (Chi & Wylie, 2014) to systematically assess observable student behaviors and cognitive engagement.

Participants

Data were collected from two undergraduate Biology courses (Cellular and Molecular) at a French university, involving a total of 131 final-year students across four cohorts. Participants were selected based on their enrollment in the targeted courses and their willingness to participate, constituting a convenience sample. The Cellular Biology course included two cohorts (academic years: 2016–2017: $n = 19$; 2017–2018: $n = 12$) taught by two teachers, while the Molecular Biology course included two cohorts (academic years: 2015–2016: $n = 67$; 2017–2018: $n = 33$) taught by one teacher. Before observing and giving out the questionnaires, the observer explained her PhD research project to the students. She verbally asked them if they would consent to being a part of her study anonymously, to which all of the students agreed. Participants was contingent upon the receipt of informed consent. All participants were anonymous. The observer didn't take any pictures and was never given a list of names of the students.

Data collection and analysis: the 3-point perspective

Observer's perspective: observing student engagement by using an ethnographic method and analyzing the data by using the ICAP framework

The observations focused on student engagement during the two courses and were conducted by a single trained observer using an ethnographic method. The instrument used for observation was an ethnographic method of observation. The collected observation data were then analyzed using Chi and Wylie (2014) ICAP framework. The students were aware of the observer's presence as she informed them of her work and also because she observed the same cohorts in both Biology courses.

The choice of using an ethnographic method was done to provide an in-depth description when trying to understand human behavior at the time when it is happening. The observer wrote down everything that happened in chronological order, including student activities (presenting and/or listening, talking with group members, taking notes, working on their computers) and the teachers (answering questions, asking questions, moving from group to group). Each observation lasted the full length of the session (2–3 hours), allowing the observer to capture all relevant behavior as they occurred. Using this narrative as a form of observation, after each session, the observer was able to create a timeline of what students were doing.

The ICAP framework was used as a tool to analyze the observations noted when using the ethnographic method. This ethnographic method of observation was used because it gave a clear indication of what exactly the students were doing during class. The framework served as a guide and an overview for understanding levels of cognitive engagement based on the observations done in class. Some examples from the ICAP framework of cognitive engagement in an interactive mode were debating, constant back-and-forth by asking and answering questions, discussing an issue by making constant

contributions, and so forth (Chi & Wylie, 2014). Those examples could be seen in the observer's ethnographic notes.

Students' perspective: evaluating student engagement by using the CEI and open-ended questions about the instructional approach

Students' self-reported engagement in class was measured using the Classroom Engagement Inventory (CEI, Wang et al.'s, 2014). It assesses student engagement across three dimensions**:** emotional engagement, which refers to students' affective reactions in the classroom, such as interest, enjoyment, and sense of belonging; behavioral engagement, which includes participation in learning activities, effort, and persistence; and cognitive engagement, which involves the investment in learning, use of learning strategies, and self-regulation (Fredricks et al., 2011; Xu, 2023). The students were asked to fill in the CEI and open-ended questions anonymously.

Student engagement was measured using the French-translated Classroom Engagement Inventory (CEI, Wang et al., 2014). The CEI is a 24-question 5-point Likert scale inventory (from 4 = always to 0 = never). The inventory was translated into French using the forward-backward translation method (Mimura & Griffiths, 2008). The French-translated version of the CEI was validated on a sample of 407[1] participants, students from the same university. Overall, this test has a Cronbach's alpha of 0.73 for all three factors. In Wang et al.'s (2014) original study, the CEI reliabilities ranged from 0.82 to 0.92 over all engagement factors. Table 2 shows Cronbach's alpha for both the original CEI and for the French-translated version, for each dimension of engagement. This comparison confirms the psychometric soundness of the French-translated CEI, validating its reliability for measuring student engagement within the context of the present study.

On the paper version of the French-translated CEI, participants were presented with three open-ended questions asking about their opinions about the active learning approach. These questions were: What aspects of the teaching method did you appreciate and why? What particular aspects of the teaching method did you appreciate the least and why? And what other suggestions would you give to better the teaching method (activity, environment, content, etc.)? These open-ended questions were used as a supplement to the questionnaire itself. Having students' spontaneous comments about the teaching method allowed us to see if the questionnaire was reliable, as well as if the comments were consistent based on the observations from the outsider's perspective and from the students' point of view. To analyze the students' responses, the researcher identified themes that emerged and counted the number of times the students responded concerning those themes.

Teachers' perspective: explanations of active learning approach

To understand the process teachers go through when choosing an instructional approach and how they believe that approach helps students engagement during the course, semi-structured interviews were conducted with the teachers. Cellular Biology was held twice, once for each cohort, and Molecular Biology was held once, for the first cohort. Interview questions were: why did you decide to change from a lecture-based classroom to a student-centered classroom? How long have you been teaching this approach? And, how did you learn about this type of student engaged learning? What were the adjustments you have made since you started using this approach? And did it make a difference with student outcomes? The interviews were conducted informally to understand teachers' motivations, perceptions of students, and reasoning behind adopting the active learning approach. The teacher interviews were conducted in English, the shared language between the researcher and the teachers. Given the teachers' high English proficiency, this approach ensured clear communication and bypassed the need for post-interview translation, thereby protecting data integrity.

Table 2. Validity (cronbach's alpha) for the three dimensions of engagement from the original CEI and the French-translated version.

	Wang et al. (2014)	Sample of 407 participants
Emotional engagement	0.90	0.73
Behavioral engagement	0.82	0.59
Cognitive engagement	0.88	0.75

Research procedure

This study will follow two Biology courses that use active learning as a way to engage students.

Course 1: Cellular biology. There was a total of 18 hours in the course, per cohort, that focused on three parts, and for each part, there was a grade attributed. These three parts were: (1) working in the laboratory (6 hours in 2 sessions), where students conducted experiments on plants and animals; (2) working in groups of 2 to 3 students on assigned topics (6 hours in 2 sessions) to prepare their presentations and the reading material (a maximum of two pages) for the other students; and (3) interactive student-led presentations (6 hours in 2 sessions), which lasted about 30 minutes per group. The total grade consisted of analysing results in the laboratory (20%), working in groups to provide reading material based on the subjects in their presentations to their classmates (20% participation and 20% reading material), the presentations (20%), and the final exam, which was based on the subjects of the presentations (20%).

Course 2: Molecular biology. For this course, there are 24 hours of classroom time for each cohort, which is then divided into 12 sessions of 2 hours. There are three parts to this course: (1) creation of the chapters (8 sessions of 2 hours), where working groups of 5 to 6 students in each group write a 'chapter' based on an assigned topic for the reading material for their classmates; (2) rotating Tables (8 sessions of 2 hours), which involve groups of students working together to solve problems by way of drawings and then sharing their answers with the rest of the class; and (3) creation of the exam (8 sessions of 2 hours), where the students generate a range of exam questions (both easy and difficult). The two assessments given to the students are a midterm exam (30%), which consists of points that the teacher gives to each student based on their individual and group work effort, and a final exam (70%), which is based on the content produced during the three different parts of the course.

The data collected for the two courses included teacher interviews, observations, and a questionnaire. Interviews were analyzed thematically, observations were coded using the ICAP framework (Chi & Wylie, 2014), and questionnaire responses were analyzed quantitatively and qualitatively to assess emotional, behavioral, and cognitive engagement. The Cellular Biology teacher was interviewed just before the start of both school years (January 2017 and January 2018), while the Molecular Biology teacher was interviewed before the start of cohort 1 (January 2016). The ethnographic method was employed twice for the Cellular Biology course (during the last session of both cohorts) and 18 times for the Molecular Biology course (11 sessions with cohort 1 and 7 sessions with cohort 2). The observer was not able to attend all the course sessions and participated based on availability. The CEI was administered to all cohorts during the final 15 minutes of the last session of the course.

Results

We present the results of student engagement during active learning approaches in the classroom from the perspectives of the observer, the students, and the teacher.

Observer's perspective: observing student engagement by using an ethnographic method to produce a timeline analysis and the ICAP framework

We provide the two timelines for the Cellular Biology course and a selection of four representative timelines from the 18 collected for the Molecular Biology course.

The timeline analysis: cellular biology

Looking at the ethnographic timeline analysis of active learning sessions shown in Figure 1 and 2, overall, students were more 'engaged' during the lesson than 'disengaged'. Figure 1 shows three times when students were disengaged (i.e. on their phone, talking when not appropriate, and one student left).

Figure 2 shows the same kind of timeline analysis for the ethnographic observation for cohort 2. Twelve incidents were reported in which students were disengaged over a period of 3 hours. Out of the

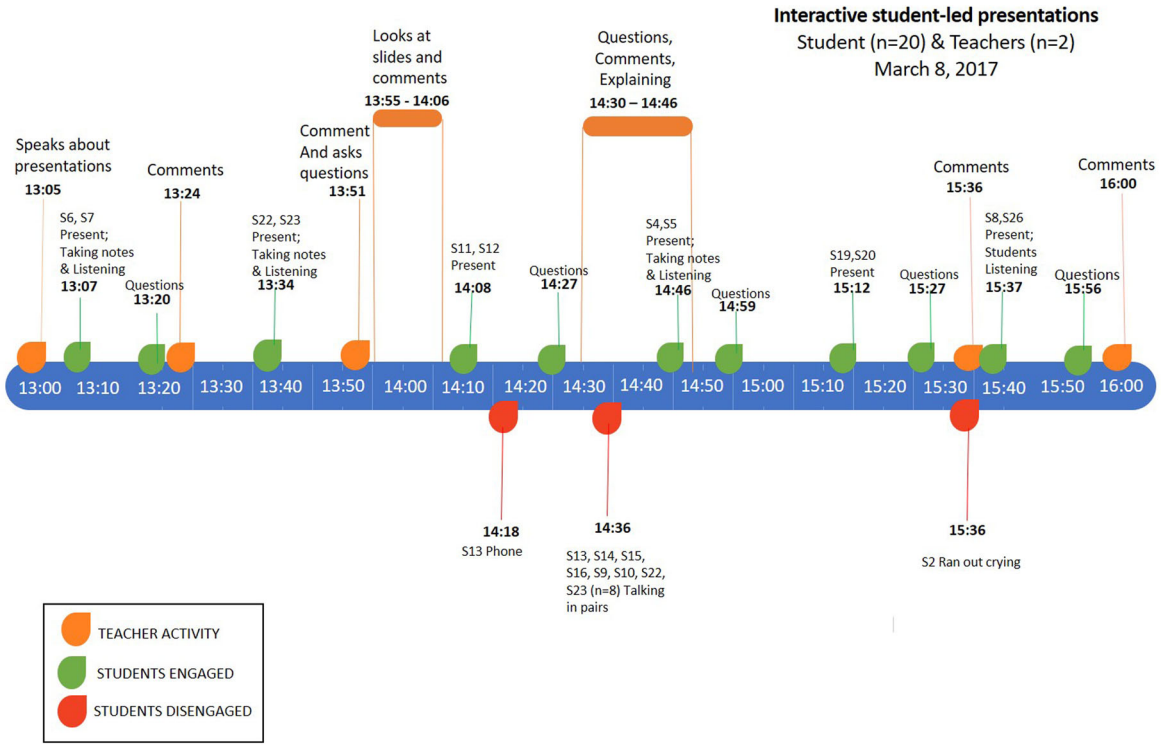

Figure 1. Cellular Biology - Cohort 1: Timeline analysis of an observation of an active learning session (8 March 2017).

12 incidents of disengagement, a few students repeatedly disengaged themselves by talking to others ($n = 3$), or interacting on their phones ($n = 3$), while other students talked once ($n = 4$) or used their phones once ($n = 1$).

The timeline analysis: molecular biology

The timeline analysis for the Molecular Biology course are shown in Figures 3 and 4. Figure 3 represents cohort 1. Both timelines show that the students are very active during the two sessions. The total number of students disengaged are 10 students. Student 9 (S9) was continually unfocused (using a phone, head on the desk) during the 27 January session. In the 22 March session, six students were disengaged because they were on their phones (less than two minute).

Figure 4 presents two timeline analysis of cohort 2. With a total of 33 students, 18 students were disengaged on 16 January and 8 students were disengaged on 14 March. During the 16 January session, all of the students that were disengaged were on the phone or on social media, where they were on for less than a minute long. Some students of those students were disengaged two to three times throughout the session. During the 14 March session, there were 8 students that were on their phone or on social media. Some of the students were on their phones (less than a minute) more than once: S1 ($n = 3$), S25 ($n = 4$) and S2 ($n = 2$).

Modes of engagement: the ICAP framework

The ICAP framework was used as a reference for understanding if students' engagement was passive, active, constructive or interactive. Based on the observations from both the Cellular and Molecular Biology courses and guided by the ICAP framework, we constructed a table illustrating the different modes of engagement during various active learning approaches in class. Table 3 presents five active learning examples derived from our observation data, with some moments illustrated through the ethnographic observations conducted in this study, along with the different modes of student engagement during these activities.

Table 3 outlines five main activities: creation of chapters, rotating tables, creation of the exam, students presenting and students listening. Some activities apply to both the Cellular and Molecular Biology courses, while others are more specific to one. The Molecular Biology course includes all five

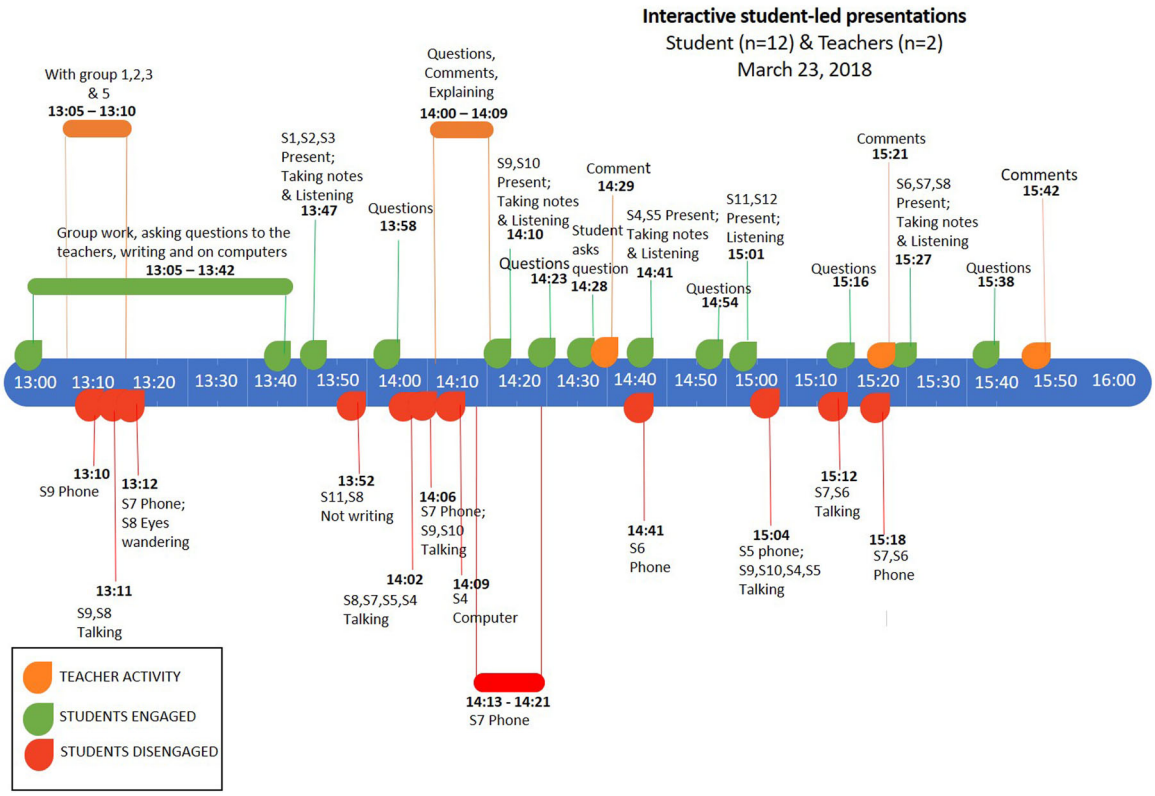

Figure 2. Cellular Biology - Cohort 2: Timeline analysis of an active learning session (23 March 2018).

activities, while the Cellular Biology course uses only creation of the chapter, students presenting and students listening. For example, during chapter creation in both courses, students demonstrated constructive engagement by reflecting, monitoring, and explaining their understanding of the material, while also being interactive by asking questions to promote discussion. Similarly, in both courses, students presenting were in a constructive mode because self-explaining was necessary to understand what they had learned and convey that knowledge to their peers (Chi & Wylie, 2014; Kusumoto, 2018). They explained the material in their own words (constructive) rather than simply relying on the teacher's notes (passive).

In the Cellular and Molecular Biology courses, students listening to presentations shifted between active and interactive modes. While taking notes, some students engaged actively by copying what they heard, while others demonstrated constructive engagement by reformulating the information in their own words. Presenters often incorporated interactive activities, such as asking questions to test their audience's comprehension. This encouraged interactive engagement for the presenters, who deepened their understanding through peer interaction, and constructive engagement for the audience, who generated and answered questions based on what they heard.

The ICAP framework's flexibility enables students to shift between different modes or remain in one mode during a session. For instance, students can be passive, simply listening, or become constructive by reflecting, self-explaining, and asking 'why'. Interactive engagement combines constructive behaviors with dialogue, such as promoting discussions, expressing new ideas, or collaborating within groups.

Students' perspective: evaluating student engagement using the CEI and open-ended questions on the instructional approach

The results for the three-dimensional construct of student engagement were measured quantitatively using the CEI, and qualitatively using responses to an open-ended questionnaire about the teaching approach.

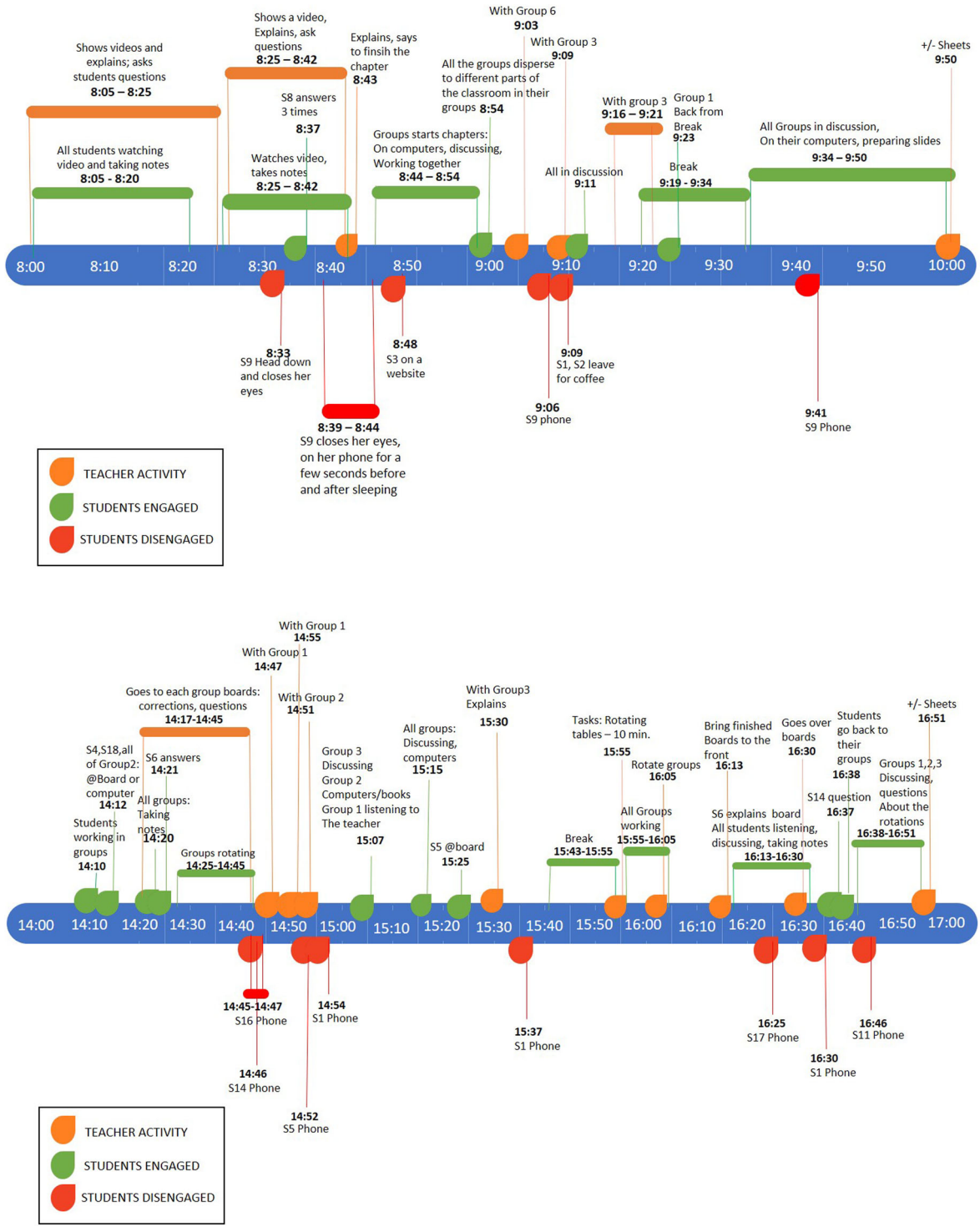

Figure 3. Molecular Biology - Cohort 1: Timeline analysis of an observation of an active learning session (27 January 2016 & 22 March 2016).

Quality of the engagement: emotional, behavioral and cognitive from the CEI

Using the CEI in the Cellular and Molecular Biology courses, the students ($N = 131$) were engaged in their course. The results presented in Table 4 show that students were emotionally (*Mean* = 2.72 out of 4; $SD = 0.56$), behaviorally (*Mean* = 2.72 out of 4; $SD = 0.48$) and cognitively (*Mean* = 2.78 out of 4; $SD = 0.47$) engaged in their course. On the scale used, 0 was the lowest possible value and 4 the highest. There were statistically significant positive relationships between behavioral and emotional engagement, $r = 0.43$, $p = 0.000$ and behavioral and cognitive engagement, $r = 0.54$, $p = .000$. The relationship

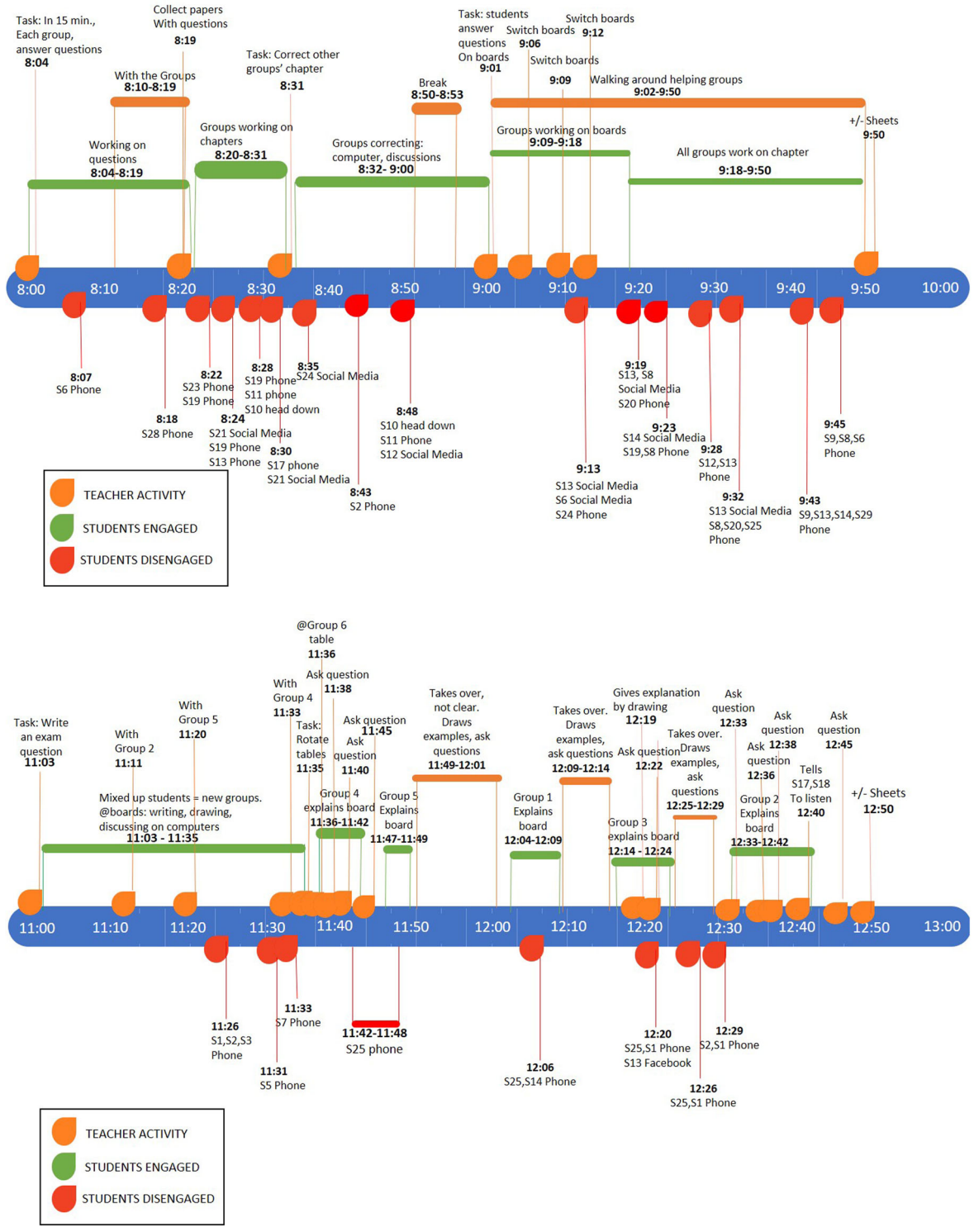

Figure 4. Molecular Biology - Cohort 2: Timeline analysis of an observation of an active learning session (26 January 2018 & 14 March 2018).

between emotional and cognitive engagement was significantly positive, $r = 0.28$, $p = 0.008$, but the strength is relatively weak. The highest average was for cognitive engagement, showing that the students were engaged in learning during the active learning approaches.

Table 4 also shows the averages for both courses separately, based on the average score for all items addressing each dimension, which shows that the participants in each course were

Table 3. ICAP mode of engagement—active learning.

	Passive	Active	Constructive	Interactive
Creation of the chapters	Copy-paste information found, watch videos	Write information in their own words, ask for more clarification, verify if information is correct	Reflect, monitor and explain one's understanding of the subject, ask questions to compare and contrast information, generalizing the information obtained	Help group members, promote discussion with group members and teacher, create organizational tools to explain information
Rotating tables	Listen to what others are saying, closely observe what is written, watch videos, take notes	Write on boards, ask for clarification, take notes in their own words, read what is written on the boards and question it without saying it out loud	Explain why their response is correct, expressing concerns based on others' responses, write on board to promote discussion, comparing and contrasting what is written on the boards	Promote discussion with others and teacher (verbally), help peers in understanding the subject, expressing new ideas that emerged from the discussions, incorporate feedback and responses from the group
Creation of the exam	Listen to group, write a question (copy-paste), take notes	Write a question in their own words, take notes in their own words, ask question for clarification	Explain why their question should be used, connecting, comparing and contrasting which is a good question,	Ask questions to promote discussion for their question, incorporate feedback and responses to create a new question, encourage others to write new questions
Student presenting	Using notes that the teacher gave them	Copy-and-paste from teacher notes or information is correct	*Self-explaining* and reiterating to their peers	Creating questions/ discussion for their peers
Student Listening	Sitting and not taking notes	Copy-and-paste the notes	Writing notes in their own words/way; *self-explaining* the presentation	*Collaborative* note-taking in innovative ways

Note: This table demonstrates the use of the ICAP framework to categorize students' learning activities.

engaged. These results reinforce the appropriateness of the use of active learning as a way to engage students, with mean scores on all three engagement components on the positive end of the scale (above 2.5).

In addition to the questionnaire, the students also responded to 3 open-ended questions. The analysis of their responses highlighted the students' views about active learning and its links to engagement. Figure 5 shows that the students in both courses found it interesting to exchange ideas and learn from their classmates in an interactive way (47 mentions). Students were also interested in this particular approach because they were able to see the outcome from what they produced and their peers' products (11 mentions) and the teaching method itself (25 mentions). For both courses, they also found it difficult to learn (18 mentions) and work with students who were not as motivated as they were in their groups (35 mentions). In both cohorts, as far as suggestions regarding the teaching approach, students felt that they would like more feedback from their teachers (19 mentions) and also have the choice to choose their group members (13 mentions).

Three obvious differences seen between the two courses were that the students in Molecular Biology wanted more feedback from the teacher (21 mentions) and suggested that there needed to be improvement in the instructional approach (15 mentions) and to have more structure when creating the chapters (11 mentions).

Teachers' perspective: active learning

Cellular Biology

The important information from the semi-structured interview with one of the team of teachers was the fact that the teacher wanted to change her approach to teaching. Giving a lecture was not enriching and her students responded negatively to her old approach. For the first interview, in 2017, when asked

Table 4. Classroom engagement Inventory scores (CEI): the means and standard deviations for cellular and molecular biology and overall.

	Cellular biology Cohort 1 & 2 ($n = 31$)		Molecular biology Cohort 1 & 2 ($n = 100$)		Total ($N = 131$)	
	Mean	SD	Mean	SD	Mean	SD
Emotional engagement	2.76	0.58	2.70	0.56	2.72	0.56
Behavioral engagement	2.69	0.48	2.74	0.49	2.72	0.48
Cognitive engagement	2.94	0.38	2.70	0.49	2.78	0.47
Total					2.69	0.40

Note: The scores on the CEI mean range from 0 = lowest to 4 = highest.

Cellular Biology
School years: 2016-2017 & 2017-2018
($n = 31$)

1. **What aspects in particular of this method of learning did you most appreciate? And why?**
   (20) Group work/exchange with others
   (11) The outcome
   (6) Develop new skills
2. **What aspects in particular of this method of learning did you least appreciate? And why?**
   (11) Difficult to learn
   (7) Group work: don't always agree/investment/different work effort
   (3) Stress
   (1) Difficult presentation theme
   (1) A lot of work done outside of class
3. **What suggestions would you have to better this method of learning? (Content, classroom, activities, environment, etc.)**
   (5) More feedback
   (4) Room not adapted
   (2) Different levels of group knowledge

Molecular Biology
School years: 2016-2017 & 2017-2018
($n = 100$)

1. **What aspects in particular of this method of learning did you most appreciate? And why?**
   (45) Group work/exchange with others
   (25) The teaching methods
   (9) Interesting
   (2) Real life experience
2. **What aspects in particular of this method of learning did you least appreciate? And why?**
   (28) Group work: don't always agree/investment/different work effort
   (21) Need feedback/verification from teacher
   (7) Difficult to learn
   (7) Issues with the approaches
   (4) Redundant explanations
3. **What suggestions would you have to better this method of learning? (Content, classroom, activities, environment, etc.)**
   (15) Improvement to the approaches (Have moments of real lectures, alternate chapters to learn different things, more diversity)
   (14) More feedback
   (12) Group members: More practice together, choose groups, change groups after each session
   (11) Need more structure and limits for chapters, have a summary sheet, use suitable diagrams
   (2) A more adapted room
   (1) Have a set time frame

Figure 5. Student responses to the open-ended questions from both cohorts (Cellular, $n = 31$, Molecular Biology, $n = 100$) concerning student engagement and active learning.
Note: Numbers shown in the figure indicate how many times students mentioned the given topic.

what her objective was after changing her lecture-based approach to a new approach, she said that she wanted the students to have 'the ability to understand the texts that they read and to be able to extract main concepts in the text'. The teacher had been going back and forth about changing the layout of the course since 2013, but had not fully committed to the change. Having taught this course for many years, she was able to sit back and analyze what was needed to fulfill the goals and expectations of the

course. After understanding what was required, the teacher started the 'design' process. She decided that four sessions (two sessions for group work and two sessions for students' presentations) was the amount of time needed.

She also agreed that having students interact while giving their presentation was important for engagement. She did not want the audience to sit and listen passively. For the past few years, she had tried out different approaches. She tried having students present different topics to the rest of the class and found that a lot of the students only focused on their own presentations and not so much on those of their classmates. Since 2016, the two teachers had found that an interactive student-led presentation approach was a good fit for both the teachers and students.

What did an interactive student-led presentation mean for them? It meant that a group of students (usually 2–3) would present their work to the other students as if they were the teacher(s) of the class. The criterion making it interactive and engaging that the students presenting must have audience participation. They usually did that by leading with discussion questions, having a question-and-answer session at the end or asking the students in the audience to give examples or reiterate what was presented. Many of the students' responses to the open-ended questions were positive and addressed the concerns the teachers had.

Molecular biology

The semi-structured interview, conducted in January 2016, sought to understand why the teacher wanted to change their course from a lecture-based format to an active learning approach. The teacher decided to make this change in 2012, influenced by the Codesign methodology (Binder et al., 2008), which brings groups of people together to co-create ideas and concepts while working toward a common goal. This concept became the basis for his new course. He wanted students to actively participate during class and transition from the role of student to teacher. Having students take on the role of teacher gives them greater responsibility for their own learning.

It wasn't until 2014, when the teacher finalized his course to what it is today. He decided that he wanted his students to work on three important tasks that the teacher would typically handle and have the students take charge instead. That is when he created three active tasks: students creating chapters for the class to use as a study guide, students teaching other students what they know about certain topics, and students creating the exam questions for the final exam. These tasks allow the students to be interactive in class and engaged in the learning process. The teacher believes that, in order to learn, one must teach.

Discussion

This study found that active learning was associated with students' behavioral and cognitive engagement by use of the three-point perspective. Although university courses can be taught in lecture-based environments in order to present content to a large number of students, lectures promote mostly passive and surface learning (Deslauriers et al., 2019; Freeman et al., 2017). Unfortunately, students who sit inactive listening to lectures have difficulty paying attention. In this study, the data collected suggest that students were engaged when active learning was being used in two Biology courses. These results also support the idea that using multiple instruments (qualitative and quantitative) capturing different points of view (the three-point perspective) and an analytical tool (the ICAP framework) all together as a whole, helped researchers see the impact active learning has on student engagement. For this reason, the researchers forward the following two emerging discussion points:

Using the 3-point perspective for data collection and analysis

The findings in the present study suggest that the three-point perspective is useful in measuring how the active learning engaged students in two Biology courses. The students, teacher and observer had positive common perspectives on both the instructional approach and the learning experience in the classroom. According to Arthurs and Kreager (2017), an active learning environment contributes to a more positive learning environment. Likewise, teacher interviews and classroom observations supported

what the students had written in the open-ended questions, which confirmed that the students were engaged and that using this type of observational analysis is beneficial (Hendry et al., 2014). These results support the initial hypothesis that when students are engaged in the instruction, they are motivated to learn (Deslauriers et al., 2019). Overall, the results from this study suggest that using three different perspectives as a triangulation method works when intertwined together to form one conceptual analysis, because there was mutual reinforcement of everything the students, teacher and observer said about what they observed. These results can therefore help other teachers who want to change their approach to teaching, so that they can be confident in moving to a more active learning environment (Baeten & Simons, 2022).

Previous research has used active learning as a teaching and learning approach, but there has not been a direct link with the three-dimensional construct of student engagement (Aguilera et al., 2017). For that reason, using more than one instrument helped create better support both quantitatively and qualitatively when analyzing student engagement. By observing what happens in the classroom, the observer can understand and measure how active learning has overall value for the students' engagement. Based on developments in measurement of teaching, having more than one type of measurement when evaluating teaching can be valuable (DeMonbrun et al., 2017). So, having used several instruments in this study to capture three different points of view reinforced and created a stronger measurement apparatus as a whole. In addition, using a qualitative (ethnographic) method for observations had added value for the analysis of student behavior.

Analyzing cognitive engagement through the ICAP framework

The aim of using Chi and Wylie (2014) ICAP framework was twofold: observing behavior that indicates cognitive engagement and extending the research of Chi and Wylie. A number of strengths of this framework can be identified. First, the ICAP framework gives examples of what different levels of cognitive engagement look like based on observing behavioral engagement. Since research suggests that cognitive engagement is often difficult to assess (Fredricks et al., 2016; Xu, 2023), it was important to be able to use other instruments that could help measure cognitive engagement. Second, the ICAP framework shows that there is an apparent relationship between behavior and cognition (Wiggins et al., 2017). The ICAP framework has added value as an analytical tool when using the three-point perspective. The ethnographic method showed that the students mostly used constructive and interactive modes of engagement. Visually observing students while they are cognitively engaged is a more concrete way of understanding their willingness to exert effort and master the necessary skills than by using other forms of assessment (Huang et al., 2019). Third, this project redefined what the ICAP had to offer, in that the original examples indirectly led us to come up with new examples. Above all, we observed that students were constructive and interactively engaged in the learning process. These findings show that active learning promotes higher-order cognitive engagement and that combining multiple perspectives and instruments provides a more complete understanding of student engagement. This study contributes empirical evidence that triangulating observation, teacher input, and student self-reports can better capture the impact of active learning in higher education.

Limitations

Although the data coming from the multiple instruments showed that the students in both courses were behaviorally and cognitively engaged, some limitations should be addressed. First, the years in which the data was collected were before the COVID-19 pandemic. The timeframe of these courses, whether before or after the pandemic, is not a significant variable because many factors remained unchanged, including the student profile, course content, instructors, assessments, and active learning approaches. Secondly, the observer did not attend all the sessions of both Biology courses. Attending more sessions might have had more weight on what was observed, and could have showed possible similarities and/or differences within each course. Finally, there were four questions on the CEI that caused the validity of the questionnaire to be low compared to the original, due to two factors (grade level and translation). The original CEI was given to American high school students, while in this project

the respondents were third year French university students. Because of that, one question was, 'I think deeply when I take quizzes in this class' (cognitive engagement), which doesn't work with these university students since they did not take any quizzes during the course. When the questionnaire was given to the students, they had not taken any quizzes or tests. Their marks were based on the presentation, reading material, laboratory analysis, participation and the final exam, and were received after the courses was over. Although the translation process was done using the back-translation method, three questions were lost in translation. In French, 'I feel interested' (emotional) is not something students would say about a course. Students would more likely say what they felt they were interested in specifically. 'I do not stop working at the end of class' (behavioral) and 'I go back over the things I don't understand' (cognitive) were translated in a negative rather than a positive sense. The first sounded as if students were so interested in the lesson that they lost track of time and the second sounded as if looking back over their work was something that should not be done, as if they were doing something bad.

Conclusion and implications

Recent research on active learning has provided understanding of the benefits of instructional approaches in higher education. This paper's findings suggest that the approach drives a new and interesting learning experience for students and the application of the three-point perspective confirms that using more instruments helps us to understand the three dimensions of engagement, with a focus on how to observe cognitive engagement. The contribution of this study lies in showing that combining the three-point perspective with the ICAP framework provides a practical and reliable way to capture student engagement in real classroom contexts. We can further this project in future studies by adding another supporting instrument to further analyze emotional engagement. From an applied perspective, the results have implications for instructors in higher education who are seeking ways to strengthen student participation and learning outcomes by implementing active learning approaches. Finally, the evidence found in this study indicates that investigations of active learning approaches that use multiple ways, the three-point perspective, to evaluate student engagement will help further research when it comes to analyzing approaches to engaging students.

Note

1. The participants were part of a larger study that investigated the impact of pedagogical approaches on student engagement.

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Author contributions

JS (Conceptualization, Original Drafting, Writing of the manuscript, Methodology, Formal Analysis, Editing, Review, Corresponding Author, Approval of manuscript and Agreement), MF (Supervision, Methodology, Editing, Reviewing, Approval of manuscript and Agreement), HM (Supervision, Editing, Reviewing, Approval of manuscript and Agreement).

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Data availability statement

The data of the study will be made available on reasonable request.

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