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Research paper

Using an extended ICAP-based coding guide as a framework for the analysis of classroom observations

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HIGHLIGHTS

- An ICAP-based coding guide was used to analyse lesson transcripts from classroom observations.
- Seventy percent of the observed lesson tasks were categorized as Passive and/or active.
- Only half of the 20 experienced teachers engaged students in Constructive and interactive tasks.
- For large numbers of students, classroom learning happens only at a superficial level.

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ABSTRACT

A coding guide based on the Interactive, Constructive, Active, Passive (ICAP) theory was developed and used to analyze the transcripts from filmed classroom observations. The analysis focused on the lesson tasks used by the 20 participating teachers to promote student cognitive engagement and the links between these tasks and student learning. The results showed that a) only 30% of the lesson tasks were assigned the Constructive and Interactive codes, and b) there were important teacher differences. About half of the teachers provided no or very few opportunities for Constructive or Interactive student cognitive engagement in their lessons.

We present a framework and a set of guidelines that can be used to analyze school classroom observations of instruction based on the Interactive, Constructive, Active, Passive (ICAP) theory of student cognitive engagement (Chi, 2009; Chi et al., 2018; Chi & Wylie, 2014). The ICAP theory has so far been applied to the analysis of ICAP-based interventions (Chi, 2021; Chi et al., 2018), but not to the analysis of classroom observations of teachers who have not previously undertaken professional learning related to ICAP. The research focuses on the examination of the lesson tasks that teachers use to promote student cognitive engagement and the links between these tasks and student learning. The term cognitive engagement is used as defined by Chi (2021), with reference to the underlying cognitive processes that take place during learning. In what follows, we review some of the frameworks for the analysis of classroom observations, describe the ICAP theory, and explain how we derived from it an ICAP coding guide to analyze the classroom observations used in the present research.

1. Frameworks for the analysis of classroom observations based on student cognitive activation

Criteria for the analysis of classroom observations are often derived from the results of longitudinal or meta-analytic studies that examine the quality of teaching. Such studies have highlighted factors such as classroom management and organization, student support, and cognitive activation (Hiebert et al., 2005; Klieme,

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Pauli, & Reusser, 2009; Pianta & Hamre, 2009; Pressley et al., 2001; Scheerens, Luyten, Steen, & de Thouars, 2007; Seidel & Shavelson, 2007). The present study focuses on the quality of instruction with respect to student *cognitive activation*: the teacher practices designed to encourage students "to engage in making sense of the materials" (Mayer, 2008, p. 17).

There is significant literature showing improvements in learning associated with instruction that gives students the opportunities to be active contributors in their learning as opposed to being passive receivers of information (e.g., Freeman et al., 2014). As Chi et al. (2018) argue, however, although "active learning" has been associated with improved learning outcomes, it is also a poorly defined construct, usually referring to practically everything that students might be doing except passively listening to lectures. Different learning activities have been described as active learning, ranging from simply "doing something" to activities that involve group work and peer collaboration. In addition to the lack of clear operational definitions, there is a lack of specification of the benefits of different activities for learning, making it difficult to determine which are better than others.

An important contribution of the ICAP theory to our understanding of student learning is that, in addition to distinguishing Active from Passive learning, it also differentiates the generic category of "active learning" into three hierarchical modes of student cognitive engagement—Active, Constructive, and Interactive (Chi et al., 2018; Chi & Wylie, 2014). Moreover, the theory offers concrete operational definitions of all four modes (Passive, Active, Constructive, and Interactive), making it possible to reliably measure them in the context of classroom observations. Finally, as we will discuss in greater detail later in this paper, it offers a hypothesis about how these four modes of student engagement are associated with different learning outcomes, a hypothesis supported by considerable empirical research. By doing so, the ICAP theory clearly specifies the criteria for a constructivist environment that encourages meaning making, consistent with Vygotskian approaches (Hatano, 1993; Moll, 2012; Vygotsky, 1935/1978).

Another perspective that focuses on students' learning actions and has been used to assess teachers' instructional practices is that of self-regulated learning (SRL). There are different theoretical approaches to SRL, but they all agree that student achievement is determined by the actions students take to manage their learning, and investigate what these actions are and how teachers can best promote them (Boekaerts & Corno, 2005; Pintrich, 2004; Usher & Schunk, 2018; Zimmerman & Kitsantas, 2007). The promotion of SRL in the classroom seems to be best achieved through the direct and explicit teaching of strategies that students can use to manage their learning (Dignath & Veenman, 2021; Pressley, Harris, & Marks, 1992; Schraw, 1998; Zimmerman & Cleary, 2006).

While both ICAP and SRL stress the importance of students' actions on their learning, there are important differences among them. SRL theories distinguish students' learning activities mainly with respect to the monitoring of learning. For example, in Zimmerman's influential model (Zimmerman & Campillo, 2003; Zimmerman & Kitsantas, 2007), students' learning actions are differentiated with respect to the phases of learning to which they are related—before learning starts (the Forethought phase), during learning (Performance Phase), or after learning (Self-Reflection phase)—as well as whether they are cognitive, metacognitive, or motivational. ICAP, on the other hand, focuses on modes of student cognitive engagement (Passive, Active, Constructive, Interactive) and their relationship to learning outcomes.

The present research, which applies the ICAP theory to evaluate the effects of instruction on student cognitive engagement, is not inconsistent with SRL. In a recent review of the literature on classroom observation studies, Dignath and Veenman (2021) argue that the indirect promotion of SRL is facilitated by constructivist learning environments, such as those encouraged by ICAP, that foster collaborative learning where learners "can actively take part in their learning process by constructing their knowledge" (p. 495). Drawing on prior research such as that of De Corte, Verschaffel, and Masui (2004), Baumert et al. (2010), and Vosniadou, Ioannides, Dimitrakopoulou, and Papademetriou (2001), Dignath and Veenman (2021) describe environments as constructivist when teachers prompt students to associate new information with prior knowledge, give complex and open problems that allow multiple solutions, and introduce new information in a meaningful context. Similarly, Perry (1998; Perry & VandeKamp, 2000) noticed that the use of complex tasks that focused on large chunks of meaning was one of the characteristics that differentiated high-from low-SRL classrooms.

In short, the ICAP theory can provide a framework for conceptualizing student cognitive engagement and a constructivist learning environment that encourages meaning making that has certain advantages over other, more qualitative approaches. More specifically, (1) it distinguishes four modes of cognitive engagement, namely, Passive, Active, Constructive, and Interactive; (2) it provides clear operational criteria for defining these different modes; and (3) it links the different modes of cognitive engagement to distinct learning outcomes.

2. Overview of the ICAP theory

As already mentioned, ICAP argues that students can engage with instructional materials in four cognitive engagement modes: Interactive, Constructive, Active, and Passive (Chi, 2021; Chi & Wylie, 2014), and provides clear operational criteria to define these modes. A Passive mode of engagement is one where learners are being oriented toward and receiving information from the instructional materials without overtly doing anything observable related to learning, such as listening to a lecture.

Active engagement requires behaviors that cause focused attention while manipulating lesson materials or input. Students engage in Active mode when they underline certain text sentences or write a summary of an essay.

Constructive engagement with instructional materials requires behavior that produces new ideas that go beyond the information given. For example, in a Constructive behavior such as self-explaining, learners are articulating what a text sentence means to them in their own words. They relate the information to their previous knowledge, generate inferences that are not explicitly stated in the text, or provide justifications that make the text or the problem solution more explicit (Chi, Bassok, Lewis, Reimann, & Glaser, 1989).

ICAP defines the Interactive mode of cognitive engagement as group activity that meets two criteria: (a) the partners' utterances must be primarily Constructive, and (b) the interaction must extend the generative nature of the prior contributions of the individual partners. Chi (2021) refers to this type of engagement as a "co-generative or co-constructive way of interacting" (p. 455). Interactive engagement subsumes Constructive engagement.

Another important aspect of ICAP is that it relates the four modes of cognitive engagement to different learning outcomes. It argues that Active engagement leads to better learning outcomes than Passive, that Constructive is better than Active, and that the Interactive mode of engagement leads to the best learning outcomes. The theoretical justification of the linking of modes of student engagement to learning outcomes is that they implicate different underlying knowledge change processes. Passive is the lowest mode of engagement in the hierarchy because learners do not engage in activities that facilitate the generation of knowledge change processes. The Active mode leads to better learning outcomes than the Passive mode because learners engage in activities like note taking that facilitate the generation of knowledge change processes such as activating prior knowledge, linking it to new information, and storing it in ways that make it easy to be retrieved and transferred. The Constructive mode is superior to the Active mode because it is related to activities such as providing explanations, raising critical questions, or creating concept maps that can give rise to elaborative cognitive processing (Greeno, 2015). Such activities have the potential to result in deep and meaningful learning. Finally, the Interactive mode leads to better learning outcomes than the Constructive mode because it is related to constructive activities that take place between two or more learners, such as critiquing each other's ideas, which can give rise to knowledge change processes that have the potential to create new knowledge that the partners could not have generated alone.

Chi (2009) and Chi and Wylie (2014) have provided persuasive empirical evidence in support of the ICAP hypothesis. The evidence comes from studies undertaken by Chi and her colleagues that compared all four modes (Menekse, Stump, Krause, & Chi, 2013), as well as other studies that compared three (e.g., Coleman, Brown, & Rivkin, 1997; Gobert & Clement, 1999) or two modes of engagement (Bauer & Koedinger, 2007; Kam et al., 2005; Peper & Mayer, 1986; Trafton & Trickett, 2001). This research includes classroom interventions that compared the same activity in different engagement modes, such as note taking from a partial, scaffolded outline of a lesson vs. a verbatim transcript (Russell, Caris, Harris, & Hendricson, 1983), or discussing cause-effect relations vs. observing a teacher identifying cause-effect relations (Hendricks, 2001). Chi, Kang, and Yaghmourian (2017) found that college students learned more when they watched tutorial dialogue-videos compared to monologue-videos. The results supported the ICAP hypothesis, showing that the mode in which a task is implemented influences learning outcomes in the predicted direction.

The ICAP theory provides specific guidelines for teacher practices associated with higher modes of student cognitive engagement, some of which have been explored by Chi and her colleagues (Chi, 2021; Chi et al., 2018; Menekse & Chi, 2018; Morris & Chi, 2020; Roscoe, Gutierrez, Wylie, & Chi, 2014; Stump et al., 2017). Morris and Chi (2020) investigated the effectiveness of the ICAP theory as a framework for improving middle school science teachers' questioning. The results showed a marked improvement in the number of questions that required students to think deeply about intervention. In another study, Stump et al. (2017) used video analysis to assess how teachers transferred their professional learning about the ICAP theory when implementing the lesson plans in their classrooms. The results showed that teachers were more successful at transferring lessons intended at the Active level (89%) compared to the Constructive (21%) and the Interactive (22%) levels.

3. The present study

In the present research, we drew on the ICAP theory to derive a framework for the analysis of classroom observations and developed an ICAP-based coding guide (hereafter, ICAP-CG) to code transcripts of these observations. The ICAP-CG focuses on the lesson tasks the teachers use to promote student learning.

The focus on lesson task design is of considerable theoretical and practical significance because tasks are pervasive features of lessons. In a well-known longitudinal study, Baumert et al. (2010) examined teachers' selection and implementation of tasks and activities as a defining aspect of their pedagogical knowledge. With a sample of 181 teachers and 4353 students, the study investigated the influence on student learning of teachers' content knowledge and pedagogical content knowledge in mathematics. The results showed that teachers' pedagogical content knowledge had the greatest predictive power for students' knowledge gains in mathematics, explaining 39% of the between-class variance in achievement at the end of Grade 10. The most crucial aspects of teachers' pedagogical content knowledge related to student *cognitive activation* and the provision of *individual learning* support. Cognitive activation was determined by looking at teachers' selection and implementation of tasks and activities. According to the authors: "Tasks and subsequent task activities create learning opportunities and determine the internal logic of instruction, the level of challenge, and the level of understanding that can be attained" (p. 142).

Within the ICAP perspective, it is important for teachers not only to employ appropriate tasks, but also to provide students with instructions that will facilitate Constructive and Interactive engagement with these tasks. Even when the task is listening to a lecture or reading, students can be engaged in the Passive, Active, Constructive, or Interactive modes, depending on what the teachers have instructed them to do. For example, while reading, students can be reading silently (Passive mode), reading and underlining (Active mode), reading and taking notes in their own words (Constructive mode), or reading and asking another student questions about the materials (Interactive mode). Similarly, while reading, students can engage in one of several types of activities that all fit into a single (e.g., Constructive) mode, such as self-explaining, creating concept maps, or comparing new information to prior knowledge or other materials.

The ICAP-CG was used to examine the transcripts of filmed lessons and identify the lesson tasks the teachers used to promote student learning. Teachers' instructions for each task, specifically the verbs used in whole class directions, were used to determine the mode of student cognitive engagement they promoted. Student actions, talk, and outputs were also examined to assess whether the actual mode of engagement that students displayed matched that described in the teachers' intentions for each task.

The ICAP-CG extended the ICAP theory by introducing additional criteria to examine whether teachers gave students some choices to determine their learning. This enriched coding system differentiated student self-determination related to practical aspects of learning, such as choices about where to sit or which activity to select from a list, from student self-determination related to task content-related aspects of learning, such as choices about which components of a topic to research or the nature of a report or a presentation.

Finally, the research investigated relationships between the participating teachers' lesson task design and their beliefs about learning as well as their self-efficacy as teachers. Prior research has shown that teachers' beliefs play an important role in teacher practices (Fives & Buehl, 2008; Lombaerts, Engels, & van Braak, 2009; Pajares, 1992; Richardson & Placier, 2001; Warfield, Wood, & Lehman, 2005). Beliefs about learning and teaching as well as high self-efficacy in teaching are important predictors of teachers' self-reported promotion of SRL in the classroom (Dignath-van Ewijk, 2016; Lombaerts, De Backer, Engels, Van Braak, & Athanasou, 2009; Spruce & Bol, 2015) and of pre-service teachers' self-reported use of study strategies and academic performance (Vosniadou et al., 2001, 2020).

Four research questions guided the project:

(1) What modes of cognitive engagement characterize the lesson tasks that teachers design for their students?
(2) Are these tasks implemented in ways that occupy the students at the intended mode of cognitive engagement?
(3) Do teachers give students some choices over aspects of their learning and if so what and how?

(4) Do teachers' beliefs about learning and teaching as well as about self-efficacy in teaching correlate with their design of lesson tasks?

4. Method

4.1. Participants

The participants were 20 teachers (11 female and nine male) from eight schools in the Greater Adelaide region of South Australia. All but one of the teachers taught in public schools, and all but one in secondary. The teachers were between 24 and 54 years of age ($M = 37.16$), with 13 of them having more than 5 years of teaching experience. All the teachers had Bachelor level degrees while four of them had a master's level degree. All teachers taught classes broadly classified as STEM subjects, which we distinguished in three categories: Mathematics, Hard Sciences (including Physics, Biology, and Aviation), and Soft Sciences (Psychology, Health, Product Innovation, Food Technology, Sustainable Futures, and Entrepreneurism). We also distinguished the participating schools into “More Advantaged” and “Less Advantaged”, judged by their scores on the Index of Educational Disadvantage (Department for Education). The More Advantaged Schools had a score of 7 (highest) to 5, and the Less Advantaged had a score of 4.

Approval for the research was granted by the university human research ethics committee. A letter was sent to the principals of schools near the research university explaining the purpose of the study and asking permission to recruit interested teachers. If the principal gave permission, the researchers sent a letter to all teachers of the school providing information about the study and asking them to participate. The teachers who expressed interest signed a consent letter, completed a survey, and arranged with the researchers to film one of their lessons. Four teachers did their own filming following the procedures used by the researchers. Student faces were not recorded or were blanked out if recorded inadvertently. All participants were assured of anonymity and informed that participation was entirely voluntary.

4.2. Procedure

The teachers wore a microphone during the recording so researchers could hear their voice during both whole-class instruction and students’ work time when the teachers circulated among students. The recordings also captured student conversation. During coding the researchers took notes to indicate when students were taking up a task differently than was described by the teacher. The filmed lessons were transcribed by the researchers, who included descriptions of teacher and student actions in the classroom in their notes when relevant. Because of differences in the length of the filmed lessons, only the first 30 min of each lesson were coded. The transcripts from each lesson were placed into a coding template on an Excel spreadsheet which the researchers used to complete the coding.

4.3. Materials

All teachers completed a Beliefs about Learning and Teaching (BALT) survey and a teacher Self-Efficacy survey prior to the filming of their lesson. The rationale of the BALT instrument was to measure the teachers’ beliefs about learning and teaching and about the self-regulation of learning. The test included 54 4-point-scale items, 31 investigating *beliefs about teaching and learning consistent with SRL* and 23 investigating *beliefs about teaching and learning inconsistent with SRL.* The first category included 13 items about *constructive learning (CONL),* such as “When students activate their existing knowledge about a topic, they learn more”; nine items about *constructive teaching (CONT),* such as “Teachers are most effective when they create an environment that encourages student inquiry”; and nine items testing the belief that *SRL is important for student achievement* (*SRL Ac*), such as “When students learn detailed strategies for learning they develop better understanding”. The second category included nine items testing beliefs that *learning is quick and natural* (*NATL*), such as “The ability to learn can hardly be influenced by practice”; nine items testing the belief that *SRL is not important for learning* (*SRL Inc*), such as “You do not need learning strategies to develop good understanding”; and five items testing the belief that *teaching involves mainly the provision of subject knowledge* (*TRANT*), such as “The most important task for teachers consists of teaching subject knowledge”. The factor structure of this instrument was validated and reported by Darmawan, Vosniadou, Lawson, Van Deur, and Wyra (2020).

The teacher Self-Efficacy instrument (SEEF) was an adaptation and translation into English of the Teacher Self-Efficacy Scale by Schmitz and Schwarzer (2000). This instrument included 10 4-point-scale items, the purpose of which was to measure teacher self-efficacy in four major areas of importance for successful teaching. These four areas included: a) job accomplishment, e.g., “I am convinced that I am able to teach all relevant subject content”, b) skill development on the job, e.g., “I am convinced that as time goes, I will continue to become more and more capable of helping to address my students’ needs”, c) social interaction with students, parents, and colleagues, e.g., “I know I can maintain a positive relationship with parents even when tensions arise”, and d) coping with job stress, e.g., “Even if I get disrupted while teaching, I am confident that I can maintain my composure and continue to teach well”.

4.4. Coding of the filmed lesson transcripts

The coding system focused on the analysis of lesson tasks, the actions and verbal instructions provided by the teacher for each task, and the actions and talk of the students while engaged in each task.

4.4.1. Determining the lesson tasks

A task was broadly defined as one activity or instance of instructional focus set by the teacher. The coders viewed the filmed lesson, read the lesson transcript, and then decided on the number of tasks in the lesson, marking the beginning of each task and its end. The following examples show some of the tasks and the phrases that were considered to cue them in one of the lesson excerpts.

- Task 1: (Overview of the lesson) “I'll just run through the overview […] what is entrepreneurship?”
- Task 2: (Watch a video) “What we are going to do now is watch a couple of videos on entrepreneurs.”
- Task 3: (Class discussion) “Okay, so after we've written about what we think entrepreneurs are, do you think some of these points meet some of the things that were shown in this video?”

4.4.2. Determining the task engagement code

Each task was broken down into 1-min units. During any given minute, all the verbs the teacher used to introduce or describe the task, when addressing the *whole class*, were used to determine which mode of engagement was most frequent for that minute. These verbs were identified in previous work by Chi (2021) and are listed in the Appendix. When an equal number of verbs from two different modes of engagement were used in 1 min, the code for the higher mode of engagement was assigned.

Teachers. When the teacher taught by lecturing and/or engaged in administrative work without giving students any instructions about how to act or process information or asked the students to act using verbs for *receiving* knowledge as described in the Appendix (e.g., listen, read, observe, etc.), the minutes were coded as **Passive**.

When the teachers instructed the students to engage in activities described with verbs for *manipulating* knowledge as described in the Appendix (e.g., describe, check, complete, measure, calculate), the minutes spent on the task described were coded as **Active**. A minute was also coded as Active when students were involved in a whole-class discussion in which they were recalling information or reporting back.

When the teacher instructed the students to do something that would generate new information using verbs for *generating* knowledge as described in the Appendix (e.g., ask questions, compare, explain, justify, summarize), the minutes spent on the task described were coded as **Constructive**. A minute was also coded as Constructive when the teacher led a whole-class discussion in which students were involved in generating new understanding.

When students were working together and had been instructed to do so with Constructive verbs and/or verbs for *dialoguing* about knowledge as described in the Appendix, the minutes spent on the task described were coded as **Interactive**. Sometimes the students were instructed to work together, however, the teacher did not use Constructive verbs to specify the interaction. In these cases, the minutes spent on the task described were coded as **Active/Collaborative**.

Students. In the case of students, ICAP codes were assigned to indicate the dominant mode of engagement *displayed* by most students for each minute. When the students' actions did not contradict this assumption, the students were assumed to engage in the tasks as described by the teachers' instructions. Thus, the verbs from those instructions were used to determine the mode of engagement that was most frequent for the students for each minute. If the transcript indicated a *discrepancy* between the teachers' instructions and the students' activity, the student code was based on the description of student activity displayed.

The **overall task engagement code** was determined by adding the codes assigned to each minute of a task and assigning the most frequent code to the overall task. For example, if a teacher task had 3 Passive minutes and 5 Active minutes, the overall task engagement code for the teacher would be Active. Two codes were assigned for each task, one for the teacher and one for the students. These two overall task engagement codes could differ if the students were observed displaying behavior that was different from that described in the teacher task instructions. For example, in the task mentioned above, if the students were assigned 5 Passive minutes and 3 Active minutes, the overall task engagement code for the students would be Passive. If there were an equal number of minutes from two different codes, the code representing the *higher* mode of engagement was assigned as the overall task code.

4.5. Student self-determination

The 20 lesson transcripts were checked to find examples of teachers giving students some choice over their learning. We distinguished three possible cases of student self-determination:

(1) *no* instance of student self-determination in the transcript,
(2) cases where the teachers gave students *minor* choice over their learning, but these choices were rather practical and had tenuous links to learning, and
(3) cases where the teachers gave students *major* choice over the task-related content in their learning.

4.6. Coding reliability

Three researchers coded six of the lesson transcripts, assigning ICAP modes of engagement for teachers and students for every minute. They discussed differences and refined the definitions in the ICAP-CG. Two researchers then completed independent coding of sample transcripts. Assessment of inter-rater reliability resulted in 93% level of agreement between researchers (Cohen's kappa of 0.86). Final coding was then undertaken by one researcher.

5. Results

5.1. Number of tasks and task engagement codes

The number of tasks the teachers used in the 30 min of observed lesson time ranged from one to seven as shown in Table 1. Half of the 20 teachers used between three to five tasks in their lessons.

The teachers were assigned Passive and/or Active codes in 56 of the total 76 tasks observed (75%). In only 19 of the 76 tasks (25%) were teachers assigned Constructive or Interactive codes (Table 2). One task was assigned the Active/Collaborative code. The results for students were very similar. In 57 of the 76 tasks (78%), the students were assigned Passive and/or Active engagement codes, and in only 17 tasks (22%) they were assigned Constructive or Interactive codes. There were two instances in which the task engagement code for students was Active/Collaborative. Overall, there was a high degree of correspondence in the task engagement codes of the students and the teachers (94%).

We also looked at the number of minutes of instruction time teachers and students spent on these tasks. It is important to note that while a task could be characterized as Constructive because most of the time spent in that task was coded Constructive, it could also contain several minutes during which the teacher and the students were assigned different engagement codes. For example, a

Table 1
Frequency and percent of tasks used by the participating teachers.

Number of tasks	Number of teachers	%
4	5	25
5	3	15
1	3	15
2	3	15
3	2	10
6	2	10
7	2	10

Table 2
Frequency and percent of the task engagement codes assigned to the participating teachers and students.

Mode of engagement	Teachers	Students
Passive	27 (35.5%)	30 (39.5%)
Active	29 (38.2%)	27 (35.5%)
Active/Collaborative	1 (1.3%)	2 (2.6%)
Constructive	10 (13.2%)	6 (7.9%)
Interactive	9 (11.8%)	11 (14.5%)
Total	76	76

Table 3
Frequency and percent of time (minutes) the teachers and students were assigned the five engagement codes.

ICAP code	Minutes	
	Teachers	Students
Passive	197 (32.85%)	211 (35.2%)
Active	215 (35.8%)	206 (34.3%)
Active/Collaborative	6 (1%)	10 (1.7%)
Constructive	96 (16%)	78 (13%)
Interactive	86 (14.3%)	95 (15.8%)
Total	600	600

Constructive task could consist of 7 min of constructive activity, but also 3 min of the teacher introducing this task at the passive mode of engagement. Furthermore, there were considerable differences in the duration of each task. In a lesson with a Passive task and an Interactive task, the duration of the Interactive task might be 5 min, while the duration of the Passive task might be 25 min. As can be seen in Table 3, the teachers and students spent approximately 70% of their time in the combined Passive and Active modes and only 30% of their time in the combined Constructive and Interactive modes.

In general, the profiles of cognitive engagement modes for the Overall Task (Table 2) and Task Minutes (Table 3) analyses were quite similar. The results from both analyses showed that around 70% of tasks/time involved actions coded as Passive or Active for both teachers and students. Across a significant proportion of the lesson time observed in this analysis, students were not stimulated to engage in the more powerful types of cognitive engagement.

5.2. Description of the tasks in the five engagement modes

5.2.1. Passive tasks

Of the total 27 Passive tasks observed, 13 involved classroom situations in which students were instructed to listen, watch, or follow along while the teacher lectured up at the board/screen, and there were two tasks in which the students were asked to watch a video. The remaining 12 cases were classroom situations in which the students were presented with administrative information, welcomes, general introductions, or brief recaps, and were not instructed to do anything at all.

5.2.2. Active tasks

Of the 29 Active tasks observed, 18 consisted of whole-class discussions in which students were expected to actively participate in recalling information or providing answers for questions they had finished working on. The remaining 11 Active tasks observed represented classroom situations where the students were asked to find answers, do calculations, fill in forms, or fold paper, or to take notes while reading, watching a video, studying for an exam, or listening to the teacher lecture.

5.2.3. Active/collaborative tasks

There was only one Active/Collaborative task, in a science class in which the students were given a worksheet with a list of genetic traits (e.g., fixed earlobes, dimples, cleft chin) and were asked to pair up, look at each other's genetic traits, and fill in a chart.

5.2.4. Constructive and Interactive tasks

There were 10 Constructive tasks and nine Interactive tasks. The Interactive tasks were very similar to the Constructive tasks with the exception that they involved higher-level interaction among students. These 19 tasks belonged to the following categories.

(1) **Problem-Solve/Discuss Solutions.** In eight examples, all observed in the mathematics classrooms, the students were asked to do the kind of complex problem solving that can be characterized as Constructive, working either individually or in small groups. In one task, the students were required to look for patterns in tables of x- and y-coordinates and come up with a rule to explain the algebraic relationship. Other tasks consisted of problems where the students were given blocks and tokens and were asked to use them to represent algebraic expressions displayed on the board, and then write and draw what they had done in their books.

(2) **Research/Find Out/Design Ideas/Conduct Experiment.** In seven examples, mostly observed in the hard and soft science classrooms, the students were asked to research a topic, to design ideas for a new product, or to find information about a new concept, either individually or in small groups. In some lessons with older students (Years 11 and 12), the students engaged with an independent research project where they were expected to consult multiple sources of information, gather data, analyze it, and report their results. In one example, the students worked in groups to conduct trials of an experiment and write up all the steps, from hypothesis to conclusion. The goal of this experiment was to measure the friction acting on an object.

(3) **Generate Ideas in Class Discussion/Discuss Ideas in Group.** There were four examples, one of which was a whole-class discussion, where the teacher invited the students to generate, share and explore their ideas. In the other three examples, the students were asked to form groups so they could discuss what they had learned, rate items in order of importance, or come up with research questions.

5.3. Differences among teachers in the engagement codes assigned to their lesson per task and per minute

As shown in Table 4, seven teachers' lessons used tasks for which the overall engagement code was only Passive, Active, and/or Active/Collaborative. Some of these lessons involved a combination of teacher lecturing (Passive) and class discussion (Active), or one big task (Active, mostly with Year 11 and 12 students). The remaining 13 teachers used a combination of Passive, Active, Constructive, and Interactive tasks in their lessons. These included teacher lecturing (Passive), student work time (Active, Constructive, and/or Interactive), and/or class discussion (mostly Active). Some consisted of one big task at the Constructive and/or Interactive engagement modes.

Fig. 1 shows the minutes the teachers spent in each ICAP mode. As can be seen, about half of the teachers devoted all or a very large proportion of their lesson to activities in the Passive, Active, or Active/Collaborative modes. The remaining teachers spent at least 10 min of instruction time engaging the students in activities in the Constructive or Interactive modes, with some of them allocating most, and one devoting all, of the lesson time to constructive activities.

To better understand the relations among teachers, tasks, and subjects taught, we separated the teachers into two groups. Group 1 (low-ICAP) included seven teachers with only Passive, Active, and Active/Collaborative task codes, and one teacher who designed an Interactive task that was, however, assigned a Passive code for the students due to off-task behavior (n = 8). Group 2 (high-ICAP) included all the other teachers who had tasks with Constructive

Table 4
Teacher ICAP codes assigned to each lesson per task and per minute.

Lesson	Task engagement code	Minutes assigned to each engagement code		
		Passive	Active and Active/Collaborative	Constructive and Interactive
1	Passive only	29	1	0
2	Active only	3	27	0
3	Active only	6	17	7
4	Passive and Active	14	16	0
5	Passive and Active	14	13	3
6	Passive and Active	9	17	4
7	Passive, Active, and Active/Collaborative	6	23	1
8	Passive, Active, and Constructive	16	9	5
9	Passive, Active, and Constructive	12	13	5
10	Passive, Active, and Interactive	11	13	6
11	Active and Constructive	9	11	10
12	Passive, Active, and Interactive	6	14	10
13	Active and Interactive	7	8	15
14	Passive, Active, Constructive, and Interactive	10	7	13
15	Passive, Active, and Constructive	14	5	11
16	Passive, Active, and Constructive	14	5	11
17	Passive and Interactive	9	4	17
18	Passive and Constructive	8	2	20
19	Passive and Interactive	8	0	22
20	Constructive only	0	0	30

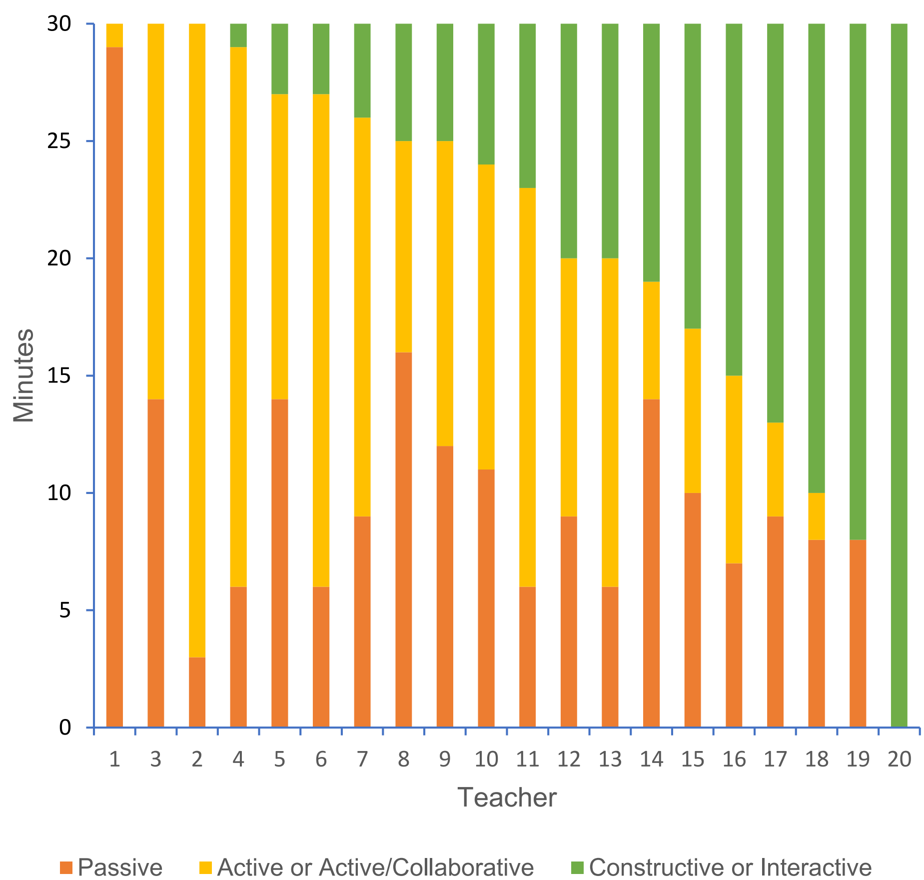

Fig. 1. Minutes assigned to the passive, active or active/collaborative, and constructive or interactive codes for each participating teacher.

and Interactive codes ($n = 12$). The results showed that amongst the high-ICAP teachers taught mostly Mathematics or Soft Science courses and came exclusively from the More Advantaged schools. The low-ICAP teachers taught mostly Hard Science courses and were evenly split between the More and Less Advantaged schools. As shown in Table 5, all the 12 high ICAP teachers came from More Advantaged schools and only 2 taught Hard Science courses. On the contrary, among the 8 low ICAP teachers, 6 taught Hard Science courses and 5 of them in the Less Advantaged Schools.

Table 5
Low and High ICAP teachers with information about Subject, Course and School (More Advantaged vs. Less Advantaged).

Teacher	Subject	Level	School
Low-ICAP Teachers			
1	Hard Science	SACE*	More Advantaged
2	Mathematics	Middle	More Advantaged
3	Hard Science	SACE	Less Advantaged
4	Hard Science	Middle	Less Advantaged
5	Hard Science	Primary	Less Advantaged
6	Hard Science	SACE	More Advantaged
7	Hard Science	Middle	Less Advantaged
16 (only included due to students' off-task behavior)	Soft Science	Middle	More Advantaged
Teacher	Subject	Level	School
High-ICAP Teachers			
8	Soft Science	SACE	More Advantaged
9	Soft Science	Middle	More Advantaged
10	Mathematics	Middle	More Advantaged
11	Soft Science	Middle	More Advantaged
12	Hard Science	SACE	More Advantaged
13	Mathematics	Middle	More Advantaged
14	Soft Science	SACE	More Advantaged
15	Hard Science	Middle	More Advantaged
17	Soft Science	SACE	More Advantaged
18	Soft Science	Middle	More Advantaged
19	Mathematics	Middle	More Advantaged
20	Mathematics	Middle	More Advantaged

SACE stands for South Australia Certification Examination

Table 6
Student self-determination by teacher task engagement code.

Task code (teacher)	Frequency of student self-determination		
	No choices	Minor choices	Major choices
Passive (n = 27)	23 (85.2%)	3 (11.1%)	1 (3.7%)
Active (n = 29)	22 (75.9%)	2 (6.9%)	5 (17.2%)
Active/Collaborative (n = 1)	0 (0%)	1 (100%)	0 (0%)
Constructive (n = 10)	9 (90%)	0 (0%)	1 (10%)
Interactive (n = 9)	3 (33.3%)	5 (55.6%)	1 (11.1%)

5.4. Student self-determination

In the great majority of cases, the students were not given any choice over their learning, especially when they were involved in Passive and Constructive tasks (Table 6). Most of the choices were given when the students were engaged in Active and Interactive tasks, and they were minor. One major self-determination was observed in a Passive task, however this choice related to the teacher's remark during lecturing that the students could engage with some revision materials at home or at school and not to the expectations for the Passive task in which they were engaged at the time.

5.5. Relationships between teachers' beliefs and their instructional practices

We used independent sample t tests to investigate differences in the beliefs of the teachers who belonged to Group 1 (low-ICAP) and Group 2 (high-ICAP). As can be seen in Table 7, significant differences were obtained between Groups 1 and 2. Teachers in the high-ICAP Group 2, on average, expressed significantly less agreement with beliefs that the main purpose of teaching is to transmit subject information (TRANT at 10% significance level), and that learning is quick and natural and does not need to be taught (NAT at 5% significance level) than teachers in the low-ICAP group. There were no statistically significant differences between Group 1 and 2 in their self-reported measures of teacher self-efficacy (SEEF).

6. Discussion

The research developed an ICAP-based coding guide and used it to analyze transcripts of filmed classroom observations. It builds on previous work by Chi and her colleagues (Chi, 2009; Chi et al., 2018; Chi & Wylie, 2014) and extends this work further to the analysis of 'raw' classroom observation. The ICAP-CG focused on the analysis of lesson tasks in terms of student engagement. Tasks are the essence of a lesson; the main way teachers choose to promote the learning of their students. The advantage of the ICAP theory and the ICAP-CG derived from it is that it distinguishes the generic concept of active learning into three separate and hierarchically organized modes of student cognitive engagement—Active, Constructive, and Interactive—and links these separate modes of engagement to different learning outcomes. The theory offers well-defined criteria that allow the evaluation of lesson tasks in terms of the student engagement they promote. Moreover, the coding of the minutes of instructional time teachers devoted and students spent in the identified tasks provides a detailed record of student engagement that takes place in the classroom that can create a basis for realistic recommendations for the improvement of the quality of instruction. Overall, the research introduces a new perspective from which observations of classroom instruction can be examined and offers a promising model of classroom observation in measurable terms, adding to other suggested frameworks in the literature (Dignath & Büttner, 2018; Dignath & Veenman, 2021; Dignath-van Ewijk, Dickhäuser, & Büttner, 2013; Perry & VandeKamp, 2000).

Regarding the first research question, the results indicated that the teachers designed few tasks at the Constructive and Interactive modes of student engagement. There were only 19 such tasks out of a total of 76, or 25% of the total tasks identified. On average, the students spent 29% of their total observed learning time in Constructive and Interactive activities compared to 71% in Passive

Table 7
Comparison of ICAP Group 1 and Group 2 teachers on Belief scale scores.

Factor	Group	N	Descriptive			Levene's test			*t*-test	
			Mean	SD	SE		F	Sig	*t*	*p*[a]
Constructive	1.00	8	3.18	.38	.13	EVA	.541	.472	−.071	.472
Learning	2.00	11	3.20	.41	.12	EVNA			−.072	.472
Constructive	1.00	8	3.17	.31	.11	EVA	.292	.596	−.925	.184
Teaching	2.00	11	3.32	.39	.12	EVNA			−.960	.175
SRL Important	1.00	8	3.24	.39	.14	EVA	.583	.456	−.779	.223
	2.00	11	3.38	.42	.13	EVNA			−.788	.221
Quick Learning	1.00	8	1.76	.26	.09	EVA	.195	.664	1.803	.045[c]
	2.00	11	1.52	.32	.10	EVNA			1.863	.040[c]
SRL not Important	1.00	8	1.87	.35	.12	EVA	.252	.622	−.144	.444
	2.00	11	1.90	.37	.11	EVNA			−.145	.443
Teaching is to transmit knowledge	1.00	8	1.95	.50	.18	EVA	.102	.754	1.548	.070[b]
	2.00	11	1.62	.43	.13	EVNA			1.513	.076[b]
Teacher	1.00	8	3.31	.39	.14	EVA	2.091	.166	1.116	.140
Self-efficacy	2.00	11	3.13	.33	.10	EVNA			1.083	.149

Note.
[a] One-tail.
[b] $p < 0.1$.
[c] $p < 0.05$, EVA = Equal variances assumed, EVNA = Equal variances not assumed.

or Active activities. The Passive tasks involved either listening to a lecture, watching a video, or situations such as welcomes, recaps, and the presentation of administrative information (36% of total tasks). The Active tasks involved activities such as filling in forms, finding answers to questions, doing calculations, taking notes, and whole-class discussion (39% of total tasks). Although there is a place for Passive and Active tasks in a classroom, student learning would benefit if students spent more of their time engaging in the Constructive and Interactive activities that promote deep conceptual understanding for a larger portion of their instruction time.

Regarding the second research question, the findings showed that the teachers engaged the students at the intended mode of cognitive engagement most of the time (94%). Most discrepancies occurred in cases of classroom discussion where the teacher asked questions but only one or two students responded. In some of the observed classrooms the whole-class discussions went on for a very long time leaving the majority of students disengaged. The longest stretch of time observed for a teacher was 12 min of whole-class discussion, but there were only 8 min of Active engagement for students before they became off-task (and thus Passive). This result suggests that it might be better to keep whole-class discussions short in duration to retain student engagement.

With respect to the third question, the results indicated that the teachers gave little or no freedom of choice to students regarding their learning, especially in the context of Passive or Constructive tasks. Minor freedom of choice, such as where to sit or with whom to work, was given to students when involved in Interactive or Active tasks. The students were given major choices over content-related aspects of their learning, such as determining the topic of a research project or what to read or watch, when involved in a research project or revision task. In these cases, the mode of student engagement was usually Active and not Constructive or Interactive, a finding suggesting that the participating teachers did not have good knowledge of how to design constructive activities that also gave students some freedom to determine their learning.

An important finding of the research concerns the differences among the teachers in their lesson task design. In eight of the 20 classrooms, the students were engaged only in the Passive, Active, or Active/Collaborative engagement modes. The teachers in these classrooms belonged to the low-ICAP Group. They designed activities that required no or very little constructive cognitive engagement. In contrast, the remaining teachers, who belonged to the high-ICAP group, designed Constructive and Interactive tasks that in most cases lasted for more than 10 min of the classroom observation time. In five of these lessons, the Constructive and Interactive tasks lasted for more than 15 min, and in one case for 30 min. In these classes, the teachers offered the students many possibilities for the construction of deep knowledge about the lesson content.

A closer look at the data showed that the teachers in the low-ICAP group were more likely to teach Hard Science courses in the Less Advantaged schools. On the contrary, all the high-ICAP teachers taught (mostly Soft) Science or Mathematics courses in the More Advantaged schools. This finding could be interpreted to suggest that the teachers in the low-ICAP group might have been influenced by a belief that less advantaged students, perhaps especially those enrolled in courses with subject matter deemed highly challenging, were more suited to teacher-directed content delivery than student-directed constructivist learning. Care must be exercised in making this suggestion because of the small sample size and because there could have been other differences in the teachers' backgrounds that were not investigated.

The above-mentioned results are nevertheless consistent with the literature showing that teachers' expectations and beliefs about student performance influence their teaching and student learning. Teachers expect less from children coming from less advantaged backgrounds and provide them with less rigorous academic instruction (Brophy, 1983; Buehl & Fives, 2009; Hallinger, Bickman, & Davis, 1996; Zimmerman & Campillo, 2003). The findings also agree with research showing that teachers with teacher-centered beliefs exhibit less growth in their teaching following professional development courses (Beck, Czerniak, & Lumpe, 2000; Fang, 1966; Roehrig & Kruse, 2005) and, in general, provide further support to the research showing important links between teachers' beliefs and their practices (Dignath-van Ewijk, 2016; Fives & Buehl, 2008; Lombaerts, De Backer, et al., 2009; Lombaerts, Engels, & van Braak, 2009; Pajares, 1992; Richardson & Placier, 2001; Spruce & Bol, 2015; Warfield et al., 2005).

This interpretation is also consistent with the findings from the analysis of the BALT test in relation to our fourth research question. These findings showed that the teachers in the low-ICAP group expressed significantly higher agreement than the teachers in the high-ICAP group with the beliefs that learning is quick and natural and does not need to be taught and that the main task of the teachers is the provision of subject knowledge. Previous research with pre-service teachers has shown these two beliefs to be significantly correlated with each other and to be strong negative predictors of pre-service teachers' study strategies and academic performance (Vosniadou et al., 2020, 2021). Teachers who believe that learning is quick and natural are not likely to give opportunities to students to improve their learning and are more likely to believe that the delivery of content information is teachers' most important task. The delivery of content information, on the other hand, is often associated with lecturing in the Passive mode or with recall and repetition tasks in the Active mode.

Overall, the results indicated that there are large numbers of students, especially less advantaged students and those taught higher level Science courses such as Physics and Biology, for whom learning happens only at a superficial, shallow level, which will likely limit their performance. These students were not given the opportunity to engage in constructivist activities that can develop their critical thinking and reasoning, produce long-lasting subject learning that transfers to situations outside the school environment, and develop and practice their skills for self-regulated learning.

6.1. Recommendations for the improvement of the quality of instruction

One of the main findings of the research is that many teachers appeared to not know or to not fully appreciate the importance of how their lesson tasks could stimulate different modes of student cognitive engagement. This is not surprising. The education literature usually emphasizes the importance of undifferentiated 'active learning', with the distinction between Active and Constructive/Interactive engagement not made salient enough. Indeed, this distinction might be the most important contribution of the ICAP theory to instruction. It is important for this distinction to be discussed and emphasized in education courses and professional learning opportunities for pre-service and practicing teachers. Concrete examples need to be developed that clarify the differences between Active tasks and Constructive/Interactive tasks with explanations of how the latter have the potential to create student learning in the different subject areas.

A promising area of intervention concerns whole-class discussion, especially in view of the finding that whole class discussion was the most common type of task observed in the present sample (24% of the total tasks). As mentioned earlier, some whole-class discussions lasted for a very long time and the teachers failed to keep the students engaged. In most of these whole-class discussions the mode of student engagement was Active. Changing the mode of engagement of whole-class discussion from the Active to Constructive would go a long way towards increasing the amount of time students were exposed to constructive activity in the classroom. Involving students in stimulating whole-class discussion is an essential part of effective teaching (Alexander, 2008; Lennon, 2017; Resnick, Asterhan, & Clarke, 2015; Topping & Trickey, 2007). Whole-class discussion can be used to generate constructive activity if the teachers use appropriate questions that compel the students to critically think about the material to be learned, compare it to what they already know, and transfer it to other situations. However, there was only one instance of a whole-class discussion that was assigned a Constructive code in the present sample. The teachers tended to ask the students to recall information from a prior lesson or provide answers for problems they had finished working on. There were only a few instances where the teachers asked inferential questions or engaged the students in critical discourse. These results are consistent with the findings by Chi and colleagues (Chi et al., 2018; Menekse et al., 2013) that many teachers failed to distinguish inferential questions from questions that test the memory of facts (Morris and Chi (2020).

In view of the important role that whole-class discussion can play in a lesson to develop students' critical thinking and reasoning, this is an area where further professional development is needed. Morris and Chi (2020) showed that professional development based on the ICAP framework was effective in changing the questions used by two middle school science teachers from questions requiring mostly the recall of information to inferential questions associated with deep conceptual understanding. Indeed, not only did the teachers show marked improvement in the use of inferential questions; their students' scores also improved, supporting the claims for a positive relation between constructive questions and student learning.

Another recommendation for the improvement of instruction stems from the finding that there was a significant difference between the high- and low-ICAP groups in their beliefs about learning. Many teachers have entrenched beliefs that the delivery of subject content is best achieved through lecturing to students who are passively listening or by engaging them in Active tasks that require the repetition of provided information. This seems to be especially the case when teachers are working with less advantaged students and complex subject content, but not only. There can be many other reasons related to the teachers' background and education that lead them to such beliefs that need to be explicitly addressed in professional development courses.

6.2. Limitations

A limitation of the research is the small sample. Further research involving larger samples is needed to use the extended ICAP-CG to analyze a larger number of classroom observations to investigate the kind of instruction that takes place in schools. It is particularly important to examine in greater detail the differences observed in teacher lesson design in terms of student cognitive engagement that the present research identified and understand some of the reasons why some teachers are so successful in designing tasks that promote Constructive cognitive engagement in their students while others are not. Differences in teachers' beliefs about learning and teaching is one possible reason, and this is an area that should also be further investigated. There are, of course, other factors that might underly the pattern of findings here, including differences in teachers' experience, teaching styles, education, and knowledge as well as contextual and situational factors such as the school environment. Further research is needed to answer these questions.

The ICAP-CG did not allow a deeper investigation of the tasks in terms of the quality of subject content knowledge that they reveal or how their subject content is related to the curriculum being covered, although it did reveal some differences in the kinds of tasks the teachers used to promote student cognitive engagement in the different subject areas. The teachers who taught mathematics tended to use Constructive tasks that involved problem solving, while most of the Constructive tasks used by the science teachers involved generating research ideas, designing research, and conducting experiments. These differences need to be explored further in future research. The purpose of the ICAP-CG is to be used as a domain-general tool to enable the observer to evaluate learning that takes place in the classroom. Additional criteria can be added to make future observations more domain specific and more qualitative, employing ecological approaches where appropriate, as well as to examine the questions, worksheets, and problems teachers use and the relevant student outputs.

7. Conclusions

The extended ICAP-CG, derived from the ICAP theory and applied for the first time to the analysis of 'raw' classroom observations, has produced further information about how teachers promote the cognitive engagement and independent learning of their students through the design of lesson tasks, and provides a fruitful framework for the measurable analysis of student cognitive engagement in future observation studies. The results showed that, on average, teachers designed many more Passive and Active tasks than Constructive and Interactive ones. However, the results also showed that there were significant teacher differences in lesson task design. Some teachers were knowledgeable and capable of engaging their students constructively, while others were not. The reasons for these differences need to be further investigated. The detailed information about lesson task design generated by the research can be used to guide future interventions and the development of professional learning courses for teachers that can have a significant impact on enhancing student cognitive engagement. Finally, the ICAP-CG can also be used by teachers themselves as a tool to help them analyze and reflect on their instruction.

Data availability

Data will be made available on request.

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Appendix. Criteria for Associating Teachers' and Students' Action and Talk With the Five Modes of Cognitive Engagement

Mode of Cognitive Engagement	Overview	Corresponding Verbs (noted in teacher's whole-class instructions or observed in students' behavior)
Passive	Learners are oriented toward and receive information from instructional materials without overtly doing anything else related to learning.	Engage, Go through, Listen, Look, Observe, Read, etc.
Active	Requires some form of motoric behaviors that cause focused attention.	Add, Annotate, Break down, Calculate, Categorize, Check, Choose, Circle, Click, Complete, Copy, Cover, Cross out, Delete, Describe, Expand, Fill in/out, Find, Fold, Guess, Identify, Include, Keep/Take notes, Label, List, Match, Measure, Move, Name, Number, Order, Paraphrase, Pick, Place, Plot, Practice, Re-organize, Recall, Record, Refer to, Review, Round to, Show, Type, Use, etc.
Active/Collaborative	Requires collaboration between two or more partners that does not meet the criteria established further below for the Interactive Mode of Cognitive Engagement	Active verbs as listed above
Constructive	Requires students to produce additional outputs or products beyond those provided in the learning materials. It requires actions and generates new ideas that go beyond the information given.	Ask questions, Brainstorm, Build, Come up, Comment, Compare, Connect, Construct, Create, Decide, Defend, Determine, Draw, Explain, Generate, Graph, Justify, Predict, Put/explain/write in own words, Represent, Set goal, Sketch, Solve, State, Suggest, Summarize, Support, etc.
Interactive	Requires collaboration among two or more partners that meets two criteria: Both partners' utterances must be primarily *Constructive*; and A sufficient degree of turn taking must occur. Generates knowledge beyond the original learning materials and beyond what the partner has said; both partners need to be *Constructive.*	Constructive verbs as listed above, but in *pairs or small groups*; Interactive verbs that elicit co-Constructive engagement: Argue, Ask/Answer each other's questions, Build upon, Correct, Critique, Debate, Defend, Elaborate, Explain, Justify

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