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Research paper

The levels of cognitive engagement of lesson tasks designed by teacher education students and their use of knowledge of self-regulated learning in explanations for task design

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HIGHLIGHTS

- Examined cognitive engagement levels of teacher education students' tasks.
- Examined types of self-regulatory activity in teacher education students' tasks.
- Most participants' tasks would stimulate constructive and interactive engagement.
- Explanations for task designs showed limited structural complexity.
- Explanation focussed on cognitive activity, little metacognitive activity.

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ABSTRACT

Using the ICAP framework (Chi & Wiley, 2014) we examined the level of cognitive engagement of lesson tasks designed by teacher education students (TES). Explanations for task design were examined for structural complexity and types of self-regulated learning (SRL) activity. Two thirds of the participants designed lesson tasks that would stimulate constructive engagement while the tasks of the remaining participants would be unlikely to stimulate constructive activity in students. Explanations for task design primarily focussed on SRL activity related to cognition in stimulating students' understanding and showed limited structural complexity. Further attention could be given during teacher education to the importance of constructive task engagement and a wider range of SRL activity.

The types of tasks that teachers present to their students during a lesson impact directly on the nature of the students' learning (Hiebert & Wearne, 1993; Watson & Ohtani, 2021). In generating these tasks teachers call upon a range of different types of knowledge such as that associated with the nature of teaching, knowledge about students and knowledge related to the lesson topic. Another type of knowledge that is of relevance for designing a lesson task is knowledge about how students can engage cognitively with the task and how they can manage, or regulate, their learning processes whilst undertaking the task. These types of knowledge are of relevance because the nature of the students' cognitive engagement with task materials and the quality of their management of their learning processes during and after this engagement can be expected to impact directly on the quality of the knowledge they construct during the lesson (Bjork et al., 2013; Chi & Wylie, 2014). To support such knowledge construction teachers need good quality knowledge about strategies for the self-regulation of learning (SRL) so that they can promote these strategies in their lessons (Kramarski, 2018) and because the effective use of these strategies has been shown to have significant effects on

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student achievement (e.g., Bjork et al., 2013; Schunk & Greene, 2018; Winne, 2018). Teacher education students (TES) need such knowledge for their own study and for their teaching practice experience. Thus for both TES and in-service teachers these types of knowledge about cognitive engagement and SRL are of major importance.

Yet concern about the state of teachers' and TES' knowledge about SRL strategies has been evident in research reports (see Dignath & Sprenger, 2020; Lawson et al., 2019). Endedijk et al. (2012) reported that their student teachers became more passive in their regulation of their own learning as they progressed through their teacher education program and Michalsky (2021) found that both pre-service and in-service teachers often failed to notice explicit SRL promotion by expert teachers. Halamish (2018) found that Israeli pre-service, and in-service, teachers had poor understanding about the benefits of well-researched learning strategies that incorporate a sequence of SRL actions. Obst et al. (2015) found that prior to an intervention, their pre-service teacher participants had quite low levels of knowledge about types of SRL strategies. Glogger-Frey, Ampatziadis, et al. (2018) concluded that as teachers their TES participants would be unlikely to foster SRL strategies in their classes and recommended that further research should investigate the kinds of knowledge future teachers bring to their teacher education courses. One such kind of knowledge is the knowledge about SRL that could be used by TES when they design the tasks and activities they would ask their students to do during a lesson.

In this study we examined three characteristics of the tasks that TES designed to provide their students with a good introduction to a new concept. First, we examined the level of cognitive engagement of the tasks using the ICAP framework of Chi and Wylie (2014). We also examined the participants' explanations of their task designs to gain estimates of the state of their knowledge about the self-regulation activity that would help their students develop good understanding of lesson material. Finally, we examined the structural organization of the explanations the TES provided for why the tasks would help their students develop good understanding of lesson concepts, to gain information about the organization and extensiveness of the reasoning underlying the design of their tasks. A point of interest in examining TES explanations for their task design was to examine what Wittrock (1992) referred to as the *generative* nature of teacher knowledge about SRL, knowledge that involved generating "relations both among concepts and between experience or prior learning and new information" (p. 532). Such relationships have been seen to make knowledge use more fluent and adaptive (Mathews et al., 2000). We anticipated that the explanations would elicit and identify the types of SRL knowledge that TES were most likely to activate to design lesson tasks and indicate how the relationships within that knowledge were structured. In this sense we expected to tap into the personal theories (Rando & Menges, 1991) that TES had about which types of engagement and SRL activity would support the development of good understandings. The importance of examining these theories is made clear by Dignath and Sprenger's (2020) research that revealed a wide variation in the availability and use of SRL knowledge in practising teachers.

1. Lesson task design

Lesson tasks are a key part of the agency exercised by the teacher to influence student learning and constitute a substantial part of the influence exerted by the teacher during a lesson (Hiebert & Wearne, 1993; Watson & Ohtani, 2021). Lesson task design is an active area of research in specific areas like mathematics education (Komatsu & Jones, 2021; Watson & Ohtani, 2021) and computer supported learning (Zheng, 2021). A range of features of lesson tasks, especially those concerned with the organization and presentation of content knowledge, the nature of the learning environment and technology support, have been examined in this previous research. To this point analysis of the levels of cognitive engagement of those tasks, the structural organization of knowledge and the types of SRL activity underlying task design have not been the focus of research. We see that the type of analysis undertaken here can inform designers of teacher education programs about the need for further strengthening of these two elements of teacher education student knowledge that would increase the generative level of this knowledge.

The nature of lesson tasks and interaction among students during those tasks has been a focus in the research of work on SRL of Perry and colleagues (e.g., Perry et al., 2020). Although the emphasis on the nature of tasks and student interaction in Perry's work and the focus on task design using ICAP in the current research are closely related, the focus of the ICAP framework is more restricted and specific. Importantly, the time focus in Perry's work on tasks is more extended than that in ICAP. In the former the focus of observation extends across lessons and units of work rather than identifying specific tasks that can change within a lesson. (e.g., Perry, 2013; Perry et al., 2006; Perry et al., 2020). As Perry (2013) noted, the complex tasks most highly rated in her study, 'are operationalized in classrooms as projects or integrated units of study' (p. 50). An analysis of the cognitive engagement characteristics of specific tasks within lessons offers a means of expanding our knowledge of how levels of student cognitive engagement can be influenced in a more immediate sense.

2. The cognitive engagement level of lesson tasks

The theory proposed by Chi and colleagues (Chi, 2021; Chi & Wylie, 2014; Morris & Chi, 2020) identifies four levels of cognitive engagement, Interactive, Constructive, Active and Passive (ICAP) and predicts that each level of engagement results in more effective learning than the following one because it stimulates different, more generative, knowledge-change processes. In ICAP theory student understanding is predicted to be better when more effective processes involved in such activities as selection, analysis, retrieval, elaboration, organization and integration of knowledge are used by the student. In the context of lesson tasks *passive* engagement refers to tasks that orient students to lesson materials but do not explicitly require students to do anything with that presented material. *Active* engagement is stimulated by tasks that require students to focus on and manipulate lesson materials, but not to generate anything beyond the provided materials. It is in *constructive* engagement tasks that students are stimulated to change the lesson materials to generate new knowledge, perhaps by making new connections, making inferences or predictions. The most cognitively engaging tasks require *interactive* engagement in which students work with others in constructive engagement mode, but in a manner that stimulates them to generate new connections beyond those generated by individual members of the group. Chi (2021) also refers to interactive engagement as involving *co-constructive interaction* (p. 455).

Roscoe et al. (2014) used the ICAP framework to examine the cognitive engagement levels of lesson tasks set by practising teachers involved in a long-term professional development program. A related analysis of lesson tasks of in-service teachers involved in professional development was also reported by Stump et al. (2018). The ICAP framework has also been used to examine teacher questioning (Morris & Chi, 2020) and undergraduate study strategies (Zepeda & Nokes-Malach, 2021) and interactions (Mende et al., 2017). The current study involving TES extends earlier work undertaken by Chi's group with in-service teachers to examine the levels of cognitive engagement of lesson tasks.

As noted above the ICAP levels of cognitive engagement are linked closely to a range of different types of knowledge-change processes, such as storing, activating, connecting, inferring, and reflecting. The major focus in previous research has been on SRL cognitive activity stimulated by the different ICAP levels. However, it is also possible that these tasks can be designed to influence a range of related types of self-regulation in addition to cognitive activity. In this research we have examined the knowledge of TES about these processes using a framework of different types of self-regulation activity.

3. Self-regulation of learning

The focus of research on self-regulation of learning is examination of "the process of systematically organizing one's thoughts, feelings, and actions to attain one's goals" (Usher & Schunk, 2018, p. 19). Panadero (2017) has identified substantial overlap in the major theoretical models of SRL that are concerned with common categories of individual student action: emotional, motivational, cognitive, metacognitive and behavioral actions (e.g., Boekarts, 1997; Efklides, 2017; Mayer, 2017; Pintrich, 1999; Schunk & Zimmerman, 2013; Winne, 2001).

Students at all levels of education need to be able to regulate their learning and such management has been recognised as an important survival tool in school (Bjork et al., 2013). Yet as Hacker and Bol (2019) noted, teaching about such management is "an often missing yet critical component of formal education" (p. 647). When they are being students, TES must manage their moment-to-moment learning, like the students in school classrooms. Effective management of learning is critical because during a large proportion of class time and in private study, school and university students direct their own learning (e.g., Galton & Pell, 2012). Recognition of the high level of responsibility we place on students for self-regulation makes it imperative that they know, and can use, appropriate learning strategies because effective strategy use has positive effects on achievement (e.g., Bjork et al., 2013; Dunlosky et al., 2013; MacArthur, 2012; Schunk & Greene, 2018; Winne, 2018). For students preparing to be teachers there is an additional layer of responsibility: During teaching they will also need to help their own students develop and use such knowledge about learning (English & Kitsantas, 2013; Peeters et al., 2014).

4. Categories of SRL activity

Inspection of the models of SRL noted earlier and of the findings from related research (e.g., Schunk & Greene, 2018) shows that regulation of learning by the learner can be identified as occurring in a number of spheres. As shown in Table 1 we have conceptualised the range of self-regulation of learning as comprising seven categories: beliefs about learning, emotion, motivation, cognition, metacognition, regulation of the learning environment, and regulation emerging from social interaction.

4.1. SRL activity linked to beliefs

When students approach a learning task, beliefs about learning and about themselves may be influential. They may believe that intelligence is fixed and cannot be increased, or that it is malleable and can be increased through practice and effort (de Backer et al., 2018). These beliefs influence the strategies they select to work on a task, and their use of those strategies. Learners may also activate epistemic beliefs about knowledge and knowing (Brownlee et al., 2017; Muis & Singh, 2018) that can influence their strategy use and the information they monitor and evaluate during learning. If students have epistemological beliefs that knowledge is simple and certain, it has been found that they limit their engagement in processing information (Gill et al., 2004).

4.2. SRL activity linked to emotion

Students also need to manage emotions that can impact on their learning (Butler & Cartier, 2018; Rao & Gibson, 2019; Sweller et al., 2019), as noted in current definitions of SRL (Efklides, 2014; Sinatra & Taasoobshirazi, 2018). It is recognised that self-regulated learners' feelings influence their motivational beliefs about how they approach learning tasks (Dignath & Buttner, 2008). Emotions can impose additional cognitive load (Plass & Kalguya, 2019) and positive or negative affect has been found to influence students' task engagement (Efklides, 2006). Taasoobshirazi et al. (2016; in Sinatra & Taasoobshirazi, 2018) found that positive emotions were linked to higher motivation, course grades, task engagement, and conceptual change. It is interesting to note that reducing negative emotions may be even more important than fostering positive emotions for science learning (Heddy et al., 2017; Heddy & Sinatra, 2013).

4.3. SRL activity linked to motivation

The role of motivation in SRL is described in major reviews (e.g. Boekaerts, 1997; Efklides, 2017; Mayer, 2017; Pintrich 1999; Schunk & Zimmerman, 2013; Winne, 2001). Self-regulated learners can generate activities for regulation of their learning derived from distinct components of motivation such as causal attributions, efficacy expectations, incentives or value, outcome expectancies and utility value (Winne & Marzouk, 2019). Each of these components identify different regulatory activities that a learner might use during a learning episode. Thus, different attributions of the cause of a learning outcome, say to ability or effort, are likely to influence the learner's subsequent learning actions.

Table 1
Categories of SRL activity.

Category of SRL activity	Description
Beliefs	Activity based on beliefs about learners and learning, about SRL and about beliefs related to SRL such as epistemology and intelligence.
Emotion	Activity related to affect, emotions, feelings, and mood and regulation of emotion.
Motivation	Activity related to goals, interest, self-efficacy, attributions, and reward.
Metacognition	Activity related to planning, monitoring and evaluation of learning outcomes.
Cognition	Activity related to perception, attention, task analysis, rehearsal, memory, imagery, elaboration, organization of knowledge for storage, retrieval and integration of knowledge.
Environment	Activity related to the organization of the learning environment and resources available for use during learning.
Social	Activity focused on regulation through interaction with other learners or teachers and sharing of regulation with others.

4.4. SRL activity linked to metacognition

The concept of SRL directly implies metacognition. In SRL, learning actions are assumed to be managed or controlled by the learner (Bjork et al., 2013). In this sense metacognition shares considerable overlap with the notion of human agency central to social cognitive theory (Bandura, 2006). Metacognitive regulative activity is typically represented as encompassing planning, monitoring and evaluation of learning processes and outcomes as a learning task is carried out (Vandevelde et al., 2013). Analysis of a task is sometimes also included as part of metacognitive activity (Winne, 2018).

4.5. SRL activity linked to cognition

A wide range of cognitive activity can be initiated during self-regulation of learning and there is no single agreed list of such processes, even though there is a large degree of commonality in different accounts of cognitive processes. In his discussion of cognitive activity, Mayer (2008) emphasised selecting, organizing and integrating processes that operate on sensory, working and long-term memory. In a related representation, using different language, Winne (2018) identified processes concerned with taking in and producing information. Chi (2021) summarised the knowledge change processes in cognitive engagement as involving storage, activation and inference. In this study we draw together the different accounts of cognitive processes in models of SRL noted earlier and focus on regulative activity concerned with attention, task analysis, encoding, elaboration, rehearsal, organization for storage, retrieval, and integration of information.

4.6. SRL activity linked to management of the learning environment

In describing SRL, Pintrich (2000) pointed out that learners may also regulate the context or situation in which learning occurs, such as when they remove distractions from their study context. Pintrich noted that this activity is distinct in the sense that the focus of the regulative activity is outside the learner, in the study situation. In similar vein Vandevelde et al. (2013) argued that the learning environment may be regulated to enable the learners to exert more control over their learning.

4.7. SRL activity linked to the social environment of learning

Regulation of the social nature of learning is separated in our framework to enable identification of this form of regulation of learning. Students may employ social processes as they learn, such as co-regulation and help-seeking (Hadwin, Jarvela & Miller, 2018; Hadwin & Oshige, 2011), where they interact with a teacher (or another person) and so can share regulation on a learning problem. In this way the regulation of learning may also have an important social element.

In addition to examining the participants' explanations in terms of these different categories of regulative activity we also investigated the structural nature of the relationships specified among these regulative activities. Our interest in exploring the structural organization of this part of TES SRL knowledge was to gain a different type of information about the generative status of this knowledge in addition to the likelihood of stimulation of higher levels of cognitive engagement.

5. The structural organization of explanations

As noted earlier, our interest in participants' explanations was to gain estimates of the generative state of the knowledge related to SRL that was being used in the design of their lesson task. The approach used to examine the structure of explanations was related to approaches that researchers have taken to examine various qualities of students' knowledge about learning. Wittmann (2011) considered differences in quality of cognitive strategy knowledge of teacher trainees using the surface/deep distinction made with respect to approaches to learning by Biggs (1993). More recently Glogger-Frey, Deutscher, et al. (2018) coded the *structured-ness* of their pre-service teacher education students' knowledge about comprehension-oriented strategies using measures of coherence and comprehensibility. Our approach to examining structural features of explanations was prompted by the framework for examining the quality of knowledge set out by Lawson & Askell-Williams, 2012 The structural element of that framework describes the configural organization of knowledge in terms of connectedness and degree of development in terms of readily activated knowledge, elements of quality that could be expected to emerge in explanations for task design. The point of interest here is to gain information about the strength of participants' SRL knowledge relevant to the design of engaging, effective lesson tasks as an indicator of the likelihood that this knowledge will be easily activated by TES during lesson task preparation (Anderson, 2020).

Connectedness is depicted here in a node-link structure and degree of development, or extension, of activated knowledge in terms of layers or depth (Chinnappan & Lawson, 2005; Dansereau, 2005). Consideration of the structure of explanations provides information about these different dimensions of the generative nature of the teacher education students' knowledge about SRL, one that is additional to ICAP level and type of regulative strategies. In the current study we have derived measures focusing on the node-link structure of the knowledge TES activated in forming their explanations.

6. Research questions

Four major research questions were the focus of the research reported here.

1. What is the level of cognitive engagement of tasks that TES designed to stimulate good understandings of a new concept in their students?
2. Which types of SRL activity are included in explanations for the design of lesson tasks?
3. What is the nature of the structure of TES' explanations of how those tasks will assist their students to develop such good understandings of a new concept?
4. What is the pattern of relationships among the measures of participant background, ICAP level and measures of explanation structure?

7. Method

7.1. Participants

Participants in this study were 115 pre-service and in-service teachers (TES) attending Australian universities, 47 attending Site 1 and 68 attending Site 2. Participants were recruited to participate in a professional learning program on ICAP. The data analysed here were gathered prior to the commencement of that program. Complete responses were available from 89 participants, 31 from Site 1 and 58 from Site 2. Participants ranged in age from 19 to 62 years, with a mean age of 31.8 yrs. Most of the participants were females ($n = 72$). Most participants had no teaching experience, while three had less than five years and 11 more than 5 years' experience. Those with teaching experience included 14 participants who had current registration with the relevant government school teaching authorities. Thirteen participants were focussed on early childhood and elementary school levels, with the remainder involved with teaching fields across the high school curriculum.

7.2. Materials

As part of a larger project the TES completed demographic items and two open-ended questions prior to other project-related activity. The questions had been used in related projects and referred to ‘good understanding’ so as to suggest development of effective knowledge without priming participants’ thinking through use of terms like “well constructed knowledge”. Similarly Question B asked for an explanation in a manner that would enable participants to activate any knowledge of SRL that they thought relevant. For both questions the objective was to prompt the activation of relevant knowledge about the aspects of learning that were the focus of the research questions. The two open-ended questions that are the focus of this paper were:

Question A: Please describe a task that you think would enable your students to provide a good learning introduction into a new concept (such as, ‘how to write a story’ or ‘what is energy?’)

Question B: Why do you think the task you have described would help your students gain a really good understanding of that concept?

7.3. Ethics

The research was approved by the relevant ethics committees at both sites.

7.4. Analysis of responses

7.4.1. ICAP coding

As described by Chi et al. (2018) the ICAP framework “defines different ways that students can engage with instructional materials to learn more deeply” (p. 1778) and as described above identifies four different levels of engagement, each of which subsumes the lower levels. In coding the responses to Question A, we introduced a modification to the original four-level structure to recognize tasks that included collaboration between students involving just Active engagement. This is labelled as Active-Collaborative in the five-level description of ICAP codes below.

Passive codes recognised tasks where students are just receiving input from the teacher or technology. In such tasks, teachers might ask students to listen, look at, or read materials. Active codes identified tasks that involved the manipulation of presented information without any requirement to generate anything beyond what was presented. For example, the task might require students to choose, circle, copy, describe, find, identify, or record. In tasks receiving the active-collaborative code teachers would ask students to work in pairs or a group, but only to undertake an activity defined as being at an active level of engagement. Constructive engagement codes recognised tasks that required students to go beyond the presented information to generate ideas that were not part of the presented materials. Examples of requirements for students at this level included asking questions, building new connections, making comparisons, generating explanations, making predictions, or creating new representations, solving problems, or making summaries. Tasks coded as interactive required the students to work together on a constructive task, with the expectation that each partner would take turns discussing the work, and that the majority of their talk would be constructive and would take the extent of knowledge change beyond what one individual could have generated alone. In these tasks teachers might ask students to agree upon a solution and defend that solution, or work with group/partner in a think, pair, share task, or to argue, defend or justify a position or provide critique.

Groups of responses to Question A were coded by two independent coders and codes compared and discussed, with decisions on coding being added to a coding guide developed for the coding exercise. When coders finished this process of refinement of codes a final sample of responses was coded independently and this showed a percentage agreement of 88% and a Cohen’s k of 0.83 which can be interpreted as strong agreement (McHugh, 2012). Final ICAP codes were then completed by one coder.

7.4.2. Explanation coding for SRL activity and structural organization

The coding of explanations provided in responses to Question B focused on identification of types of SRL activity and the structural organization of activated knowledge described above. The definitions of types of SRL activity used in this coding are set out in Table 1. The structural organization coding scheme was based on the node-link structure outlined by Sporns and Betzel (2016) and in Mayer’s (1975) analysis of knowledge connectedness. Three measures of structural organization were identified: node, depth and branch. *A node* identified a concept or idea proposed by the participant as having explanatory influence on learning. D*epth* recognised distinct layers along an explanatory *branch*, such that if just the explanatory idea was stated there would be a depth of 1, and if that idea was explained to a further level, or its effect described, a depth of 2 was recorded. If a response advanced an explanation for why the task would help learning, the task itself was identified as the first node. An explanation given by a participant is shown in Table 2. In this response two sources of explanatory influence are identified, activation of prior knowledge and collaboration. Each of these nodes was identified as the beginning of an explanatory branch. These two branches were identified as being at a depth of 1. An effect of collaboration, building on, was then further specified and was coded at a depth of 2.

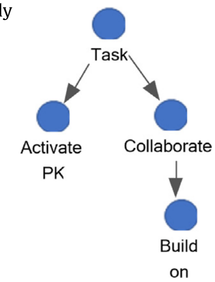
The coding of types of SRL activity and structural organization was undertaken at the same time. Two coders initially rated a sample of responses on each of these measures, then discussed differences in ratings to develop more precise definitions of codes which were noted in a scoring guide. When no further refinements were made in these trial rounds of coding the two coders completed independent coding of a further sample of responses. This showed a percentage agreement of 88% and a Cohen’s k of 0.81 which can be interpreted as strong agreement. Final explanation coding for SRL activity and structural organization was then completed by one coder.

8. Results and Discussion

8.1. Comparison across sites

Demographic profiles of the participants in the different sites were similar, except for the educational qualifications held prior to entry to the teacher training program where postgraduate degrees were required at Site 2. On measures designed for this study, although the scores for Site 2 participants tended to be higher, the differences between the groups on levels of experience and on ICAP, nodes, branches and depth measures were not statistically significant. The data from the two sites for these measures were combined for subsequent analyses.

Table 2
Example of coding explanation structure.

Example from responses	Structure	Nodes	Depth	Branches
This activity would allow students to activate their prior knowledge on the topic and also would allow me to informally assess the students' levels of understanding. It is also a good whole-class collaborative activity that encourages students to build on each other's ideas. (#67)		4	2	2

8.2. ICAP scores

The profile of ICAP scores shown in Table 3 indicates that 31.5% of the tasks proposed by the TES would be likely to prompt either passive, active or active-collaborative engagement with lesson materials. In 9% of these the students would be in passive mode, such as listening or watching. Clearly in all such tasks rated as passive it might be the case that some students would, by themselves, engage in detailed ways with the teacher's presentation, but the task set by the teacher would not explicitly prompt such engagement, so that some students could well be off task.

Most of the TES responses (68.5%) described tasks that could prompt the higher levels of Constructive or Interactive engagement. These participants designed tasks that could prompt their students to engage with lesson materials in ways that would enable them to generate new information in their individual engagement with the materials and when engaged with fellow students. For more than a quarter of the responses the proposed tasks would bring students into interaction with other students in ways that could stimulate generation of new information beyond the level that students might attain on their own. For example, one participant described the task as follows:

> "Present a simple story (fairy tale, kids' story). Get them to collaboratively unpack the elements involved. Get them to choose their own story in small groups. Identify what similarities there are with the first, teacher-chosen one. Come up with a hypothesis about the elements of a story. In pairs, discuss how they would approach writing a story. Consider if they would make similar decisions as the authors of the first two texts. Why/why not? Teacher asks probing questions, asking if students had considered particular elements traditionally associated with story writing." (#20)

In a Design Technologies lesson on cultural storytelling through cloth and stitch, part of the description of the task by participant #33 was:

Table 3
ICAP level scores for the response to Question A (n = 89).

ICAP Level	%
Interactive	28.1
Constructive	40.4
Active Collaborative	4.5
Active	18.0
Passive	9.0

> "The focus of this lesson would be to introduce students to understanding, and reflectively considering, cultural storytelling through textile artworks. Students would be positioned to reflect on how individuals or groups of individuals have communicated meaning through cloth and stitch. The introductory task would be a collaborative, whole class, activity.
>
> The task.
>
> - Without explaining or introducing detailed context to the new concept, display first cultural textile artwork on the ppt presentation - this will be an abstract example of cultural storytelling through cloth and stitch.
> - Invite students to write single words on post-it-notes that they think describes/represents/inspires the textile artwork they are viewing – to then come forward and post their word on the whiteboard under the corresponding title
> - For 1–2mins – direct students to discuss, with the student to their left, why they wrote the word, discussing interpretation and understanding of the visual and reasoning for their written word/s
> - Repeat activity with a second textile artwork of a contrasting nature – this will be a more explicit representation of cultural storytelling through cloth and stitch
> - Direct student to again write one word on a post-it note and stick to it to the other half of the board under the corresponding title
> - Invite student to turn to the person to their right and discuss once more."

Both these tasks provided opportunities for students to interact in constructive ways and required the elements of explanation or critique that provided the opportunity for understandings to be generated beyond that initially held by an individual student. In a source analysis lesson in History the student pair activity would stimulate students "to back up their arguments and opinions about events, and the whys and hows." (#69). In a science task, students would need to "share and draw on their prior knowledge and understanding to discuss, justify and critique their views." (#22). In a story writing task "students form groups to discuss a great sensational start utilising the synergies created from more than one student." (#93).

The levels of engagement in the tasks above stand in contrast to others that did not specify any form of manipulative or constructive activity. For example, in a lesson whose stated objective was to illustrate that gases are made up of particles, the task description was:

> "Task: Liquid nitrogen is poured over an inflated balloon. Observe, that only a thin skin-like object is left over from the balloon. When it is warmed up, the balloon regains its original volume and shape." (#37)

In this case the students were positioned in a passive mode of engagement, as they were in other task descriptions:

> "I usually start introducing a new learning task by showing a summary in the form of book reading or a short video that explains the new concept." (#46)
>
> "The basics of the subject, watch videos etc" (#60)

Students were expected to engage in an active manner in the following task, though there was no specification of engagement beyond the manipulation of the lesson material:

> "I would like to try using play dough as an introduction to fraction manipulation. I believe that asking students to break a lump of play dough in half and that half into three bits would be easy for most students who would normally struggle with the idea of multiplying a half by a third." (#9)

The addition of a collaborative element to an active task, coded as active-collaborative, was specified as follows:

> "Ask students to discuss with a partner what they already know about the topic and/or share what the new concept might entail." (#92)

Constructive engagement was evident in task descriptions like the following where students were prompted to go beyond the information provided in the lesson materials to generate new knowledge connections:

> "Students could develop a concept map to organise their prior knowledge about the concept." (#21)
>
> "Develop a mind map" (#56)
>
> "Come up with a hypothesis about the elements of a story" (#20)
>
> "Come up with the rule for the 'Ambiguous Triangle' and explain how it comes about." (#79)

8.3. *Types of SRL activity included in explanations*

The frequency of the major categories of SRL activity included in explanations is shown in Table 4. By far the most common type of activity specified in the 280 codes was cognitive activity. Eighty of the 89 participants included at least one type of cognitive activity in their explanations, with 45% referring to more than one cognitive process. Motivational, social and metacognitive regulation processes were the next most frequent nominations, with nominations in the remaining three categories at very low levels.

Table 4
Types of SRL activity in explanations.

Type of regulative activity	%
Belief	0.7
Emotional	1.0
Motivational	14.3
Cognitive	61.7
Metacognitive	8.0
Social	13.6
Environment	0.7

8.3.1. *SRL activity related to cognition*

Details of the explanation elements related to cognitive activity are shown in Table 5. When considered as a collective theory of how lesson tasks can facilitate learning, the representation in Table 5 has strengths in the focus on activation of prior knowledge and the elaboration and organization of new knowledge with existing knowledge, as in the need to "modify existing schema to relate to new concept." (#33).

This explanation recognises the importance for lesson task design of accessing a related memory structure. There is also strength in the frequency of elaborative activity that could embellish or re-represent activated knowledge. These elements in the explanations suggest that many of the TES saw that learning can be influenced through top-down processes associated with existing knowledge and more immediate processes associated with elaborative activity. However, the quite low frequency of specification of regulative activity related to attention, task analysis and selection of information suggests that the importance of these key activities that can be applied to new information presented in a lesson task may not be sufficiently recognised by the TES. Across the group of explanations for the design of the very varied tasks, paraphrase, prediction, rehearsal, use of feedback were each identified only once. No mention was made of such activity as making notes, summarising, chunking or drawing inferences, all of which can have benefits for long term understanding. The low levels of reporting related to these types of cognitive activity may, of course, have been associated with the questions we presented to students.

8.3.2. *SRL activity related to motivation*

Almost all motivational activity in explanations focused on interest. Hands-on or practical activities were identified as important for stimulating engagement. There were four other references to other motivational processes, one focusing on building student confidence, one referring to autonomy and two to student agency; "When given the freedom to interpret the works students are afforded agency over their thought process, to activate deeper thinking …" (#32). Other components of motivation, such as goal orientation, attributions and utility were not mentioned.

8.3.3. *SRL activity related to social processes*

Just over 40% of the TES saw that various forms of social activity could influence the development of student understanding. Most nominations of social regulation of learning referred to activity such as pair work, think-pair-share, and student collaboration. Although many influences were seen to emerge from the broad influence of discussion or collaboration, other specific effects of interaction were identified: "benefit from others' perspectives", "building on others' views", "providing support and encouraging 'buy-in' to the lesson activity". One participant went beyond the specification of social activity as being an important influence on learning and identified social interaction as a key belief that was critical for generating a good understanding in students: "Learning is a social process. Through discussing with their peers, students may reflect on their initial arguments and seek new evidence to form their own historical theories" (#99).

8.3.4. *SRL activity related to metacognition*

Metacognitive activity was noted infrequently, with 69/89 participants not identifying any instances of metacognitive activity as influential in developing a good understanding. Regulation of learning through evaluation made up half of the codes in this

Table 5
Types of cognitive activity.

Cognitive process	%	Examples
Activation of prior knowledge	28.9	Activate prior knowledge
Elaboration	27.8	Visualise, use models/hands-on, predict, paraphrase, explain, represent, rehearse, apply
Organization	26.0	Make connections, draw links, construct
Attention	6.3	Focus
Integration	5.2	Link new knowledge and prior knowledge. Relate to existing schema.
Transfer	2.3	Transfer knowledge
Task analysis	1.7	Break the learning down
Selection	0.6	Identify the flow
Use feedback	0.6	Provides formative feedback
Higher order thinking	0.6	Uses higher order thinking skill

category, with planning, reflection and identifying gaps in knowledge also seen as influencing understanding. Participant #21 noted that the task "might bring their attention to gaps in their knowledge." Another participant suggested that teacher feedback to students would require them to undertake "a recursive process of refinement" (#42). However, although it might have been implied in some explanations, there was no other explicit identification of on-going monitoring of understanding as a key influence on development of student understanding.

8.3.5. SRL activity related to beliefs

Although the task given to participants might not be expected to stimulate discussion of beliefs, there were three such statements. Two of these statements that were related to beliefs identified learning as a social process, as being socially constructed, as noted above. The remaining belief statement addressed the issue of presentism that could influence students' learning in history (Stoela et al., 2017). In this response the participant explained that: "the tendency to interpret past events in terms of modern values and concepts - so when introducing a new historical concept, it is particularly important to equip students to be able to recognize their own values and concepts in order to attempt to distance themselves from those attitudes when learning about the past" (#40).

8.3.6. SRL activity related to emotion

Two of the codes related to emotion focused on the importance of having fun in the lesson task. One other drew attention to the importance of having students notice feelings and the remaining example noted that the planned lesson would have the effect of "reducing the intimidation" of the task (# 43).

8.3.7. SRL activity related to management of the environment

The only resource management elements in the explanations referred to the provision of time for students to undertake appropriate learning.

8.4. Explanation structure

The descriptive statistics for the node, depth and branch measures are shown in Table 6. These scores suggested that, on average, the TES' explanations included two explanatory elements in addition to the task node, involving two branches of explanation, with one or two layers of extended explanation of a branch. Fifteen explanations comprised five or more nodes, with three including eight nodes. Sixteen TES did not specify any explanatory elements beyond the statement of the task. Five branches were identified in the explanations of three participants.

Table 6
Descriptive statistics for structure measures.

	Mean	SD	Range
Nodes	3.07	1.78	0–8
Depth	1.59	0.71	0–3
Branches	2.16	1.04	0–5

The scores for depth showed that 41 of the TES did not extend their analysis of how a stated explanatory element assisted learning, coded as a depth of 1. Thirty-nine participants did provide one additional layer of explanation and eight provided a third explanatory layer (depth 3). For a History lesson task one participant argued as follows: "By analysing and explaining the form of different perspectives, students may take into account the resource creators' position and identity in history and how these factors influence their perspectives when analysing resource" (# 99). In layer 1 the lesson task requires the students to undertake analysis and explaining that, in layer 2 could generate understanding of the writer's position that could, in layer 3, lead to understanding the influence of perspectives on a given resource.

As indicated in the just noted example, the structural analysis did enable mapping of complex explanations for why a lesson task could assist learning. However, it was the case that almost half of the TES did not extend their explanations beyond identification of explanatory elements (Depth = 1). The presence of extended networks of explanation was the exception for this group.

8.5. Correlational analysis

Spearman correlations for measures are shown in Table 7. The correlations among these measures were of interest for two reasons. First, given the variety of backgrounds in the participant group, it was of interest to see if differences in study backgrounds and teaching experience would be significantly related to other measures. However, none of these background measures showed significant levels of association with the ICAP and structure measures. This supports the findings of Halamish (2018) in relation to the lack of difference in the SRL strategy knowledge profiles of pre-service and in-service teachers, emphasizing that greater experience of teaching is not sufficient to stimulate activation of more complex knowledge networks that might be reflected in lesson

Table 7
Correlations among background, ICAP, Nodes and Depth measures.

	ICAP Score	Nodes	Depth
Age	−0.16	−0.14	−0.14
Degree	−0.06	−0.09	−0.07
Registration	−0.15	−0.04	−0.12
Experience	−0.19	−0.02	−0.23
ICAP score		0.38**	0.33**
Nodes			0.76**

**: significant at $p < .01$ level.

tasks requiring constructive activity. The second point of interest in this analysis was to examine the associations between the ICAP and structure measures. The significant correlations between ICAP and both structure measures suggest that the tasks rated higher on the ICAP scale tended to be accompanied by more structurally complex explanations.

9. Discussion and conclusion

The analysis above provides information about an important part of teaching. For a teacher, the design of the tasks that students will undertake is an activity that requires attention in the preparation and execution of each lesson. Lesson task design is also of critical importance because it is a major influence on student learning activity. For these reasons it is an important area for ongoing research.

In the findings above we see considerable areas of strength in both task design practice and in justification of the task design. Around two-thirds of the TES designed tasks that would be likely to stimulate constructive or interactive engagement in their students. While there was no requirement in the question prompts that the proposed tasks should stimulate constructive engagement, it is reasonable to predict on the basis of ICAP theory and related research that it is this type of engagement that would help students develop the good understanding that was the focus of the questions presented to the participants. These findings add weight to the findings of Perry et al. (2006) who found that a majority of their student teachers could design complex tasks, following interventions with both the student teachers and their school mentors.

Complementing this finding is the presence of important SRL regulative activity that was generated in explanations for why the tasks would stimulate good understandings. The frequency of important cognitive, motivational, social and metacognitive activity implicated in the explanation responses suggests that many of the TES have a knowledge base related to SRL that could be activated to explicitly promote SRL strategy use in their students. However, such explicit promotion is not guaranteed to occur, as research noted earlier makes clear. References in explanations to the activation of prior knowledge, stimulation of interest, elaboration activities and organization of new knowledge suggest that many of these participants have knowledge that could support the promotion of cognitive strategies that has been identified as important in teaching (Dignath & Sprenger, 2020).

Other types of regulative activity, such as metacognitive activity, were included in explanations at much lower levels. To an extent this might have been expected given the nature of the lesson design task with its focus on development of a good understanding. This focus might be seen to draw most attention to cognitive activity involved in construction of a memory representation and thus biased the explanation process toward the predominance of cognitive activity shown in Table 4. However, as noted earlier, the relatively low frequency of references to monitoring of level of understanding is surprising given the need for students in the lesson to construct an understanding of good quality, that might be expected to have prompted the need to evaluate the adequacy of that understanding. The presence of only two statements related to resource management is also somewhat surprising. Again, it might be argued that the prompt question would not be expected to draw attention to this type of activity. However, this pattern might also indicate that the TES group does not give attention to the importance of the embedding of tasks within a classroom environment that allows the constructive and interactive activity identified in the designed tasks to be enacted. With respect to the categories of regulative activity showing very low frequencies, the response levels related to these types of activity may have been associated with the design of the questions the TES were given. However, the patterns of response for some activity noted above were at very low levels which suggests that these were not at high levels of activation in students' knowledge bases and so may be worth further attention in both research and teacher education.

One less optimistic finding is that almost a third of the TES did not design tasks that would be likely to push their students toward constructive and interactive engagement with lesson materials. If these tasks were used in actual lessons, a sizeable group of students in the classrooms of these teachers might not construct adequate understandings of the concepts central to their lessons. It seems likely that this sizable group of TES may not place sufficient weight on the importance of relevant regulative activity, or may not have adequate knowledge of such activity. The pattern of correlations among engagement and structure measures gives weight to these possibilities.

The pattern of regulative activity included in explanations also suggested that some TES could pay more attention to the importance of early cognitive activity that is directed at selection of key components of a task, and also to later integration of new knowledge with existing knowledge. Although the TES showed concern for motivational regulation that has not been apparent in other research (Askell-Williams & Lawson, 2001), the importance of attending to levels of self-efficacy and types of goals could be given further attention given their importance for the engagement of less confident students.

The analysis of the structural features of the explanations suggests that there was room for further development of knowledge related to SRL in these participants. The degree of structural development of the typical explanation identified in the typical participant profile was not an extended one, showing both limited branching and limited depth. Although as noted in the findings above there were some quite extended explanation responses, the structural analysis suggests that the body of theoretical knowledge related to SRL that was readily activated was not extensive for most participants. It is such readily activated knowledge that is likely to help the teacher generate lesson tasks. If this knowledge became more complex, and was stronger, more readily activated, TES could be expected to use it during their teaching practice to design tasks that encouraged more constructive activity. In this respect the findings emerging from the different types of data used here, from ICAP analysis and explanations, both point to areas for further development of knowledge about learning for many of the participants.

The pattern of findings here has implications for teacher education programs. The design of lesson tasks is a frequent and central activity across these programs. Consideration of the nature of lesson tasks could help TES make stronger links between parts of their training that focus on the nature of learning and development and those that have a curriculum area focus. The findings suggest that one way to stimulate such integration of study areas during teacher preparation and teacher professional development, would be to make provision in both areas of study for explicit attention to the characteristics of lesson tasks and the ways in which these tasks could stimulate constructive engagement and regulative activity in students. The example reported in the findings related to beliefs also points to ways in which teachers could draw connections between disciplinary knowledge and knowledge about learning.

The findings from the structural analysis may indicate that although there was evidence of knowledge about SRL in many students, the generative power of this knowledge would be limited. The generative power of this knowledge would be limited if it was not sufficiently complex or if it could not be readily made explicit. More complex knowledge about SRL that could be readily activated would be likely to provide teachers with an expanded set of alternatives for the design of lesson tasks that could stimulate their students to construct more complex knowledge related to the lesson topic. This might also provide opportunities for teachers to promote new SRL strategies to students. The inclusion of more tasks involving interactive constructive engagement during teacher preparation would be likely to increase this generative power. Use of both the ICAP and SRL activity frameworks discussed in this research could provide practical guidance for lecturers and teachers wishing to stimulate more explicit promotion of SRL strategies. Such promotion could occur during explanation of lesson tasks at the start of lessons and in interchanges with students during lessons. Findings from research on SRL suggest that both forms of explicit promotion would benefit students.

The findings here also point to implications related to the concern noted in the introduction about teacher use and promotion of SRL strategies during lessons. One question that arises here is whether some teaching environments, including teaching environments during teacher education, do not encourage attention to constructive and interactive cognitive engagement so that some of the TES who designed such tasks in this study would not maintain this practice after a period of teaching. It might also be the case that the positive influence of constructive and interactive activity on student levels of achievement needs further emphasis among practicing teachers. Both these features of school environment would be useful areas of future research.

Finally, we see that the point of focus in this study – lesson task design – can be a productive area for both research and for teaching during teacher education and professional development. Our purpose in presenting the two focus questions to participants was primarily academic in that we wanted to understand more about the nature of the tasks they would design and more about the qualities of the knowledge that was drawn on in task design. We see that there are further possibilities that can be exploited beyond our specific academic interest. Reflecting systematically on the purposes for student learning of specific lesson tasks could be of immediate value to teachers during their training and across their time of teaching.

10. Limitations

This research is an initial investigation in this area of teaching. It is not an observational study of classroom practice or a study involving in-depth interviewing of participants. It is also important to note that the participants in this study had volunteered to participate in a professional learning program that might suggest that they had a higher level of interest in this area of teaching than other TES. A further limitation is that the nature of the questions that were the basis for TES responses may have under-stimulated knowledge relevant to regulative activity. Perhaps in some TES there was a repository of knowledge that was not activated by these questions and so further studies, including probing interviews and teaching practice observations are needed.

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Author contributions

Michael J. Lawson: Conceptualisation, methodology, writing. **Penny Van Deur**: Conceptualisation, methodology, writing review. **Wendy Scott**: Formal analysis, writing review. **Helen Stephenson**: Formal analysis, writing review. **Sean Kang**; Writing review. **Mirella Wyra**: writing review. **Igusti Darmawan**; Methodology, formal analysis. **Stella Vosniadou**: conceptualisation, writing review. **Carolyn Murdoch**: writing review. **Emily White**: writing review. **Lorraine Graham**; writing review.

Data availability

Data will be made available on request.

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