How well will the Australian Curriculum: Science prepare students for a post-truth world? An epistemic cognition perspective

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Abstract
The science curriculum's potential for developing students' scientific literacy offers the ideal opportunity for addressing global concerns such as the 'post-truth' epidemic. In this article, we review the Year 10 *Australian Curriculum: Science* for its capacity to help students become producers and consumers of knowledge. We adopt a theoretical framework of epistemic cognition to analyse the curricular intentions evident in content descriptions and elaborations. A deductive content analysis based on our epistemic cognition framework reveals limited opportunities for students to formulate active perspectives towards the production and evaluation of science knowledge. Implications for national and state curriculum developers, science teacher educators, and science teachers are offered for positioning students to better prepare for a post-truth world.

Keywords: epistemic cognition, ACARA, science curriculum, post-truth

Introduction

> Science literacy is desirable not only for individuals, but also for the health and well-being of communities and society. More than just basic knowledge of science facts, contemporary definitions of science literacy have expanded to include understandings of scientific processes and practices, familiarity with how science and scientists work, a capacity to weigh and evaluate the products of science, and an ability to engage in civic decisions about the value of science.
>
> (National Academies of Sciences, Engineering, and Medicine, 2016, p. 1)

This definition of scientific literacy captures what science curricula have sought to achieve in many countries over time. Such views on scientific literacy emerge from a time before the unprecedented spread of dis- or mis-information we see today via social media. Social media is being weaponised and used to spread 'alternative facts' in an era designated as the 'post-truth world', urging calls for education systems to respond (Brooks-Young, 2021; Greene et al., 2016; OECD 2019; Sinatra & Hofer, 2021). This is the world in which our young people are growing up. Although the spread of dis/mis-information has a long history, a post-truth world alerts us to the need for critical awareness and understandings of differences between information and facts, and knowledge and opinion. Human thought about such matters is captured under the notion of 'epistemic cognition'. Briefly, epistemic cognition refers to an individual's ideas or thoughts (cognitions) about knowledge and how it is produced, known as 'episteme' (Chinn & Rinehart, 2016; Greene et al., 2016). Parallels between the focus of epistemic cognition and scientific inquiry are unequivocal as science inquiry involves the creation and evaluation of knowledge (e.g., Duschl 2003, 2008). Moreover, the dual goals of science curricula for developing future scientists and preparing a scientifically literate citizenry are generally acknowledged (Roberts, 2011). Connections between epistemic cognition and the dual goals of school science make science curricula an ideal means for developing young people as future citizens who have capacity to navigate the post truth world through a deep understanding of knowledge and how it is produced scientifically.

Designing curriculum and instruction that helps develop young peoples' epistemic cognition is identified as one of the more useful approaches for addressing the post-truth problem (Greene et al., 2016; Sinatra & Hofer, 2021). In the context of a post-truth world, we reviewed the most recent iteration of the Year 10 *Australian Curriculum: Science*, a final draft proposed by the Australian Curriculum and Assessment Authority (ACARA) as part of a curriculum refresh process, to answer the following research question:

> To what extent does the curriculum support teachers in designing instruction for scaffolding students' epistemic cognitive development?

We first outline the framework of epistemic cognition we used in our analysis of the curriculum, before providing an overview of the *Australian Curriculum: Science* and presenting our study design and methods. Following this, we present our results and the implications for science teachers, teacher educators, and curriculum developers.

Epistemic Cognition: Nurturing scientific literacy for a post-truth world

The field of inquiry dealing with people's ideas about knowledge is called epistemic cognition. In this study, we adopt Greene et al.'s (2016) definition of cognition, which refers to mental representations and mental processes such as attending, remembering, decision-making, reasoning, and perceiving. In this way, epistemic cognition is the application of cognitive processes to episteme, or knowledge, knowing, and ways of knowing.

A further distinction that we make for analytical purposes is to define 'epistemic aims', the creation of 'epistemic products', and the 'evaluation of epistemic products' as the three dimensions that encompass epistemic cognition (Chinn & Rinehart, 2016). When an individual forms goals towards knowledge, they construct epistemic aims. For example, one might formulate the aim of finding knowledge about whether a meat-based diet leads to inflammation in joints. Epistemic aims include seeking knowledge, understandings, scientific models, theories, true beliefs, avoiding false beliefs, identifying sound evidence, and formulating sound arguments. Having formed an aim, individuals may then generate some representation of the situation to which their aims are directed. Individuals who form representations in this way have met their aim and generated an epistemic product (i.e., the representation). For example, by conducting a study of the relationship between meat-based diets and inflammation, the person has generated an epistemic product: a representation of knowledge about the relationship. When the outcomes of such a study are scrutinised, or if individuals scrutinise the outcomes of other studies about meat-based diet and inflammation, they have engaged in the evaluation of epistemic products. Evaluation of epistemic products involves the application of criteria and standards for deciding the validity of the knowledge that has been produced. Although these three dimensions provide a useful framework for interpreting curriculum documents in terms of developing students' epistemic cognition, they are not viewed as discrete categories. Epistemic cognition cannot exist or develop without all three dimensions.

Overview of Draft *Australian Curriculum: Science* Year 10

We selected the Year 10 *Australian Curriculum: Science* (*AC Science*) because it represents the last instance and highest level of science learning reached by most of the populace. Given that this is the last stage of formal science learning for many Australians, it offers the final opportunity for students to learn about the production of knowledge and its evaluation. The *AC: Science* consists of three strands: Science Understanding (SU), Science as a Human

Endeavour (SHE), and Science Inquiry Skills (SIS). The curriculum document informs teachers that the strands are seen as reflections of the work of scientists and should be integrated during planning and instruction: that is, students' learning is built around scientific inquiry and reflects the nature of science as a unique way of knowing and doing. Of relevance to this study, the advice to teachers regarding implementation states that students should emerge from their science studies with the ability to recognise how science can be applied to their lives and its role in society. Each strand is further sub-divided into sub-strands in the curriculum as follows:

Strands	**Sub-Strands**
Science Understanding	Biological sciences Chemical sciences Physical sciences Earth and space sciences
Science as a Human Endeavour	Nature and development of science Use and influence of science
Science Inquiry Skills	Questioning and predicting Planning and conducting Processing and analysis data and information Evaluating Communicating

The curriculum sub-strands are each comprised of content descriptions and elaborations.

Content descriptions describe what is to be taught and what students are expected to learn, whereas elaborations are described as optional elements of the curriculum and are designed to present teachers with ideas for instruction (ACARA, n.d.). For this reason, both content descriptions and elaborations were included in our analysis, as detailed in the next section.

Study Design and Methods

Using content analysis, the 4 authors coded the content descriptions of the *AC: Science* using the three epistemic cognition dimensions: epistemic aims, epistemic products, and evaluating epistemic products (Mathison, 2005).

After a trial analysis, it became evident that focusing on content descriptions alone limited our understandings of how teachers could use the curriculum to support or scaffold students' epistemic cognition. A decision was then taken to broaden our analysis to include the elaborations. We copied the 20 content descriptions and 119 elaborations making up the Year 10 *AC: Science* into a spreadsheet, and each team member independently coded these before meeting to discuss the initial codes. We approached this by reading the content description and elaboration holistically, assigning a value of 1 to any combinations that represented epistemic aims, products, or evaluation and a value of 0 when these elements were not evident. We then refined our categories and coding by revisiting the conceptualisation of epistemic cognition and the coding categories in relation to our initial analyses of curriculum statements, after which we repeated our independent coding. Two researchers (AB & RM) then reviewed any codes that did not align across the team. We met to arrive at a consensus for all the coding categories and shared and discussed these to reach full consensus. Although our epistemic cognition framework defines epistemic aims as student-generated goals towards acquiring and generating knowledge, we coded all content descriptions with a value of 1 for epistemic aims. This choice was made because the curriculum statements imply that students must adopt the content descriptions as their own aims.

Results

Curricula Affordances for Developing Students' Epistemic Cognition
Based on our analysis, there are 8 opportunities presented in the curriculum for supporting students' epistemic cognitive development. Given the low number of content descriptions and elaborations that address epistemic cognition, we reproduce the total set in Table 1.

An example where we identify all dimensions of epistemic cognition is the following content description and associated elaboration from Science Inquiry Skills. We use red text to indicate epistemic aims, blue for epistemic products, and green for epistemic evaluation. In the example below, the students' development of investigable questions, predictions, hypotheses or models reflects the generation of epistemic aims.

> Content description — develop investigable questions, predictions and hypotheses to test relationships or develop explanatory models (AC9S10I01)
>
> Elaboration — discussing how a tested hypothesis may lead to further predictions and testing to determine if the prediction is supported (AC9S10I01_E7)

Epistemic products, in this example, are implied by the need for students to answer their questions, predictions, hypotheses, or through development of a model. Products are captured in the elaboration by the term 'discussing how a tested hypothesis' (and presumably questions etc.), which implies that hypotheses or questions have been answered. Evaluation is evident in the elaboration where mention is made of testing predictions. The combined content description and elaboration provides scope for standards and criteria to be applied as students decide if their evidence supports, or challenges, their predictions, questions, hypotheses, or models. We note that it is only through the combination of content description and elaboration that the scope for developing epistemic cognition is possible. Focusing on the content description alone would only allow aims and products to result and, based on our framework, would not be conducive to students' epistemic cognitive development. Six other content descriptions and associated elaborations from the Science Inquiry Skills strand, as shown in Table 1, offer opportunities to develop students' epistemic cognition in similar ways to the example outlined above.

We now turn to a borderline case from our analysis because it represents the only disciplinary sub-strand in the curriculum that, with some minor modifications, has the capacity to foster epistemic cognitive development. Our second example is drawn from Earth and space sciences:

> Content description: investigate how the big bang theory models the origin and evolution of the universe, including the formation of stars and galaxies, and analyse the supporting evidence for the theory (AC9S10U03)

In the content description above, the term 'investigate' invites students to generate aims towards generating knowledge about the big bang theory, the given epistemic product in this instance. The phrase 'analyse the supporting evidence' invites teachers and students to evaluate a range of epistemic products (i.e., evidence for big bang theory). Presumably, one can engage students in learning about standards and criteria appropriate for determining the extent to which available evidence supports the theory. We note that there is no direct mention that suitable standards and criteria ought to be applied when the students evaluate the given evidence.

Table 1: Opportunities to develop students' epistemic cognition in content descriptions elaborations.

Strand	Sub-strand	Content description *Students learn to:*	Elaboration
Science Inquiry	Questioning and predicting	develop investigable questions, predictions and hypotheses to test relationships or develop explanatory models (AC9S10I01)	discussing how a tested hypothesis may lead to further predictions and testing to determine if the prediction is supported (AC9S10I01_E7)
	Planning and conducting	select and use data generation equipment with precision to obtain useful sample sizes and repeatable data, using digital technologies as appropriate (AC9S10I03)	explaining how estimation affects precision and examining the inaccuracy introduced when reading between scale markings (AC9S10I03_E8)
	Processing, modelling, and analysing	select and construct appropriate representations including tables, graphs, descriptive statistics, models and mathematical relationships to organise and process data and information (AC9S10I04)	describing sample properties such as mean, median, range and large gaps visible on a graph to make generalisations, acknowledging uncertainties and the effects of outliers (AC9S10I04_E9)
	Evaluating	assess the validity and reproducibility of methods and evaluate the validity of conclusions and claims, including by identifying conflicting evidence and areas of uncertainty (AC9S10I06)	analysing conclusions and claims to identify facts or premises that are taken for granted to be true, and evaluating the reasonableness of those assumptions (AC9S10I06_E12)
		construct arguments based on a variety of evidence to support conclusions or evaluate claims and consider any ethical issues and cultural protocols associated with accessing, using or citing secondary data or information (AC9S10I07)	constructing a scientific argument showing how a range of evidence supports a claim relating to the age of the universe (AC9S10I07_E8)
			engaging in evidence-based debates about the role of human activity in global climate change (AC9S10I07_E9)
	Communicating	create multimodal texts to communicate ideas, findings and arguments effectively for identified purposes and audiences, including selection of appropriate content, language and text features, using digital technologies as appropriate (AC9S10I08)	writing a report on a scientific investigation ensuring only relevant data and observations are reported in the results and including a discussion that presents: an argument based on the results with comparisons related to accepted values; an explanation of outliers; and the effect of possible sources of error (AC9S10I08_E6)

Science Understanding	Earth and Space Sciences	investigate how the big bang theory models the origin and evolution of the universe, including the formation of stars and galaxies, and analyse the supporting evidence for the theory (AC9S10U03)	explaining how each different type of evidence such as cosmic microwave background information, red or blue shift of galaxies, Edwin Hubble's observations and proportion of matter in the universe provides support for the acceptance of the big bang theory (AC9S10U03_E5)

In presenting the above Earth and space science example, we caution that the criticality required when evaluating a scientific claim is not evident in the statement. The above statement can easily be interpreted as stating that students are presented with supporting evidence for the big bang theory and are then shown connections (i.e., analyse) within this evidence that are supportive of the theory. At no point does the statement suggest that students will deal with the ambiguity of different sources of evidence that support or challenge the theory. Nor do students have to make decisions on how well supported the theory is on the balance of the evidence. In other words, it is easy to teach to this descriptor by simply presenting evidence for the big bang theory to students uncritically. For this reason, although the three elements of epistemic cognition are identifiable, the quality of the statement is not strong in supporting a scientific view of knowledge and the production of knowledge. In this regard, the elaboration associated with the content description reinforces our claim:

> Elaboration: explaining how each different type of evidence such as cosmic microwave background information, red or blue shift of galaxies, Edwin Hubble's observations and proportion of matter in the universe provides support for the acceptance of the big bang theory (AC9S10U03_E5)

The elaboration presents big bang theory as a foregone conclusion. The danger with a statement like this is that it can create the impression that science is based on foregone conclusions rather than a systematic process of inquiry that involves critique of evidence. Such statements are more likely to hinder students' learning about scientific inquiry rather than support it.

In contrast to the Earth and space sciences example, the Science Inquiry Skills strand reflects greater openness to students making decisions about the aims they set, what products they generate (i.e., predictions, hypotheses etc.), and the need to evaluate these self-generated elements. The content descriptions and elaborations in this strand are of a higher quality than the Earth and space sciences pairing in supporting development of students' epistemic cognition.

An interesting observation that arose during analysis is that the cognitive verbs (written in regular verb form or as past participles) at the beginning of content descriptions and elaborations are indicative of active or passive student positioning towards the production and evaluation of knowledge. That is, some statements position students as the creators of their own questions, hypotheses, predictions, or models. Whereas other statements tend to reflect a more passive positioning where students must accept given ideas.

Missed Opportunities to Develop Students' Epistemic Cognition

We found that if our coding remained focused on the holistic nature of epistemic cognition, that is, the interrelatedness of aims, products, and evaluation, there were very few curriculum statements that supported teachers to scaffold students' epistemic cognition. For this reason, we also documented any instance in the curriculum where we could identify at least one of the epistemic cognition dimensions (i.e., aims, *or* products, *or* evaluation) as summarised in Table 2.

Based on our coding process, which identifies any of the three dimensions of epistemic cognition in curriculum statements, it is possible to identify descriptions and elaborations containing one or two of the elements. Such statements offer promise for revising content descriptions and elaborations in the future, in ways that are more supportive of epistemic cognitive development. We note that, although all content descriptions and elaborations are coded for the category 'epistemic aims', this is largely due to the assumption that students will adopt the curriculum statement as their personal aim towards forming knowledge.

Table 2: Number of epistemic cognition dimensions across curriculum strands.

	Dimension of Epistemic Cognition		
Curriculum Strand	**Epistemic Aims**	**Epistemic Products**	**Epistemic Evaluation**
Science Understanding	119*	60	12
Science as a Human Endeavour	119*	0	28
Science Inquiry	119*	88	108
Totals	357	148	148

The Science Understanding strand offers limited scope for a student to generate their own aim towards obtaining scientific knowledge as it represents canonical science concepts that are to be acquired. In this sense, most content descriptions and elaborations in Science Understanding position students as passive receivers of the canon. An effort has been made to begin each content description in that strand with 'investigate', but this can lead to contrivances as the remainder of the statement is more indicative of learning established scientific concepts, as our example of the big bang has shown.

As seen in Table 2, there are no instances of epistemic products identifiable in Science as a Human Endeavour. Wording of statements in this strand do not indicate what knowledge a student is to generate about the contexts represented. This further supports our results and analyses related to Table 1, indicating how a lack of integration of Science Inquiry Skills with the other two strands can limit the scope for epistemic cognition to develop.

In relation to evaluation, the epistemic cognition framework states that evaluation can be directed at products generated by oneself or those made by others. In this case, Table 2 shows that all strands are supportive of epistemic evaluation to varying degrees. Perhaps unsurprisingly, the lowest instances are found in Science Understanding where transmission of canonical science appears to be the dominant focus.

Discussion

In this study, we have focused on the extent to which the Year 10 *Australian Curriculum: Science* curriculum structure (i.e., strands, sub-strands, content descriptions, elaborations) supports teachers to design instruction that forges students' epistemic cognitive development. Developing students' epistemic cognition is seen as desirable because it offers a way forward for society to address the post-truth problem (Greene et al., 2016; Sinatra & Hofer, 2021). Our rationale for taking this approach is that science education offers an obvious disciplinary curriculum where students can learn about the nature of knowledge and knowing, and thereby offers scope to prepare scientifically literate citizens who can cope in a post-truth world.

In relation to our research question, 'To what extent does the curriculum support teachers in designing instruction for scaffolding students' epistemic cognitive development?', our analysis has shown that there are only 7 effective content descriptions and elaborations in the draft that can support epistemic cognitive development. With some minor modifications, an eighth statement in Earth and space sciences could present another opportunity for supporting students' epistemic cognitive development. Our results also indicate that without the integration of Science Inquiry Skills into the other strands, there would be no opportunities for students to develop epistemic cognition based on the current nature of curriculum statements. We find that for one school year of science learning, 7 opportunities to develop epistemic cognition is restrictive. Moreover, the relegation of all of these to the Science Inquiry Skills strand implies that the realisation of epistemic cognition in school science may rely on the incorporation of science inquiry in classrooms, which is often limited by time and resources. This restriction of opportunities to one strand is limiting, and this limitation is exacerbated by the fact that, in numerous cases, the opportunities to develop epistemic cognition are found in the elaborations, not the content descriptions. Given that elaborations are not mandated aspects of the curriculum structure, teachers may ignore them in their planning, thereby further diminishing the available opportunities for developing students' epistemic cognition.

What our results suggest is that curriculum developers and teachers will need to consider carefully how opportunities might be structured and distributed across the school year to *maximise* opportunities for developing students' epistemic cognition. It stands to reason that, based on there being 20 content descriptions and 119 elaborations, more than 7 opportunities could be crafted and distributed across the school year. However, this will not be achieved if the Science Inquiry Skills strand is not used effectively in designing instruction that integrates the curriculum strands. Our results also suggest that it is worth evaluating all year levels in the curriculum to see what opportunities there are for developing students' epistemic cognition in developmentally appropriate ways throughout the schooling experience.

Our analysis finds discrete instances where one or two of the three dimensions is evident in curriculum statements (i.e., Table 2). Notably, there are no instances in Science as a Human Endeavour that suggest a knowledge product might be necessary when ideas from this strand are applied to planning and instruction. As there is no identifiable knowledge product within this strand, the importance of strand integration is critical if Science as a Human Endeavour is to play any role in students' epistemic development. Alternatively, statements in this strand need thorough revision so that knowledge products and evaluation of those products becomes a prominent feature.

Analysis of the 7 content descriptions and elaborations in Science Inquiry Skills that are supportive of epistemic cognition, reveals 4 positive qualities of those curriculum elements that provide scope for developing students' epistemic cognition:

a. the curriculum structure contains cognitive verbs that support epistemic cognition;
b. the nature of information in the content description or elaboration is consistent with the cognitive verb and does not close off the possibility for epistemic cognition;
c. the three elements of epistemic cognition are interconnected and interwoven within a set of content descriptions and elaborations; and
d. a holistic curriculum writing style positions students to formulate knowledge aims, develop knowledge products, and evaluate knowledge products.

These 4 qualities can serve as guides for curriculum design and implementation.

We now offer three examples of reworked curriculum statements from the SU, SHE, and SIS strands that would be more likely to support development of students' epistemic cognition by making sure an epistemic product and evaluation are present as well as an overall aim.

1. Science Understanding

Strand / Sub-strand		**Content Description** *Students learn to:*	**Original Elaboration** *This may involve students:*
SU	Chemical Sciences	investigate how the Bohr model of the atom explains the structure and properties of atoms and relates to their organisation in the periodic table (AC9S10U06)	examining how elements are organised in the periodic table and recognising that elements in the same group of the periodic table have similar properties (AC9S10U06_E1)
			Modified Elaboration *This may involve students:*
			analysing patterns to discern that elements in the same group of the periodic table have similar properties and critiquing this representation as an organising system (AC9S10U06_E1)

2. Science as a Human Endeavour

Strand / Sub-strand		**Content Description** *Students learn to:*	**Original Elaboration** *This may involve students:*
SHE	Use and Influence of science	investigate how the values and needs of society influence the focus of scientific research (AC9S10H04)	considering the use of genetic testing for decisions such as genetic counselling, embryo selection, identification of carriers of genetic mutations and the use of this information for personal use or by organisations such as insurance companies or medical facilities (AC9S10H04_E13)
			Modified Elaboration *This may involve students:*
			evaluating the use of genetic testing to argue for/against genetic counselling, embryo selection, identification of carriers of genetic mutations and the use of this information for personal use or by organisations such as insurance companies or medical facilities (AC9S10H04_E13)

3. Science Inquiry Skills

Strand / Sub-strand		**Content Description** *Students learn to:*	**Original Elaboration** *This may involve students:*
SIS	Use and Influence of science	assess the validity and reproducibility of methods and evaluate the validity of conclusions and claims, including by identifying conflicting	addressing assumptions through choice of equipment, variable control or further testing (AC9S10I02_E14)
			Modified Elaboration *This may involve students:*
			evaluating the methodological rigour of a science inquiry including choice of

		evidence and areas of uncertainty (AC9S10I06)	equipment, variable control or further testing (AC9S10I02_E14)

For examples of science inquiry instruction informed by research, we refer readers to recent ideas offered by Tytler & Prain (2021, August 24). Such examples offer great scaffolds for teachers when interpreting revised curriculum statements such as those we propose above.

An effort has been made to begin the Science Understanding content descriptions with the term ‘investigate’. This active cognitive verb is commendable, however, it is so often associated with descriptions of canonical science such that, if one is to investigate the topics as described, this can lead to a path of discovering already established facts. Such an approach undermines the development of understandings of science inquiry and generates instruction akin to the inappropriate application of discovery learning (e.g., Scott et al., 2018). That is where students are invited to discover known-answer problems or instruction is framed as inquiry, but students are given the answers rather than having to arrive at them. Our analysis of the Earth and space sciences content description and elaboration offers an example of this.

Overall, we find that the Science Inquiry Skills strand is the dominant strand for positioning students as active agents in the production of knowledge. We did not focus on analysing agency in this study, but our observations about the way in which curriculum statements may position students as active or passive towards achieving curriculum goals warrants further investigation. A framework such as Krajcik & Merritt’s (2012) approach to epistemic agency would offer scope for such research.

Science as a Human Endeavour, although clearly connected to contemporary and past topics of social debate, reads much like the Science Understanding strand in that students are positioned to accept a given perspective on a social issue. This problem is a reminder of Schwab’s (1958, p. 378) stance that science should be “a process of problem-detecting, formulating, and solving,” rather than “the study of a history or a justification of a current theory”. In the draft curriculum, under Science as a Human Endeavour, there is a paucity of opportunities for evidence-based inquiry that considers a range of evidence on an issue, or to evaluate the evidence based on appropriate criteria. In some ways, this may be viewed as politicising the science curriculum, feeding back into the debates of post-truth narratives.

There is no specific number of opportunities for developing epistemic cognitive processes that students should experience that we can recommend. What our results suggest is that curriculum developers, teacher educators, and teachers will need to consider carefully how opportunities might be structured and distributed across the school year to *maximise* opportunities for developing students’ epistemic cognition. It stands to reason that, based on 20 content descriptions and 119 elaborations, more than 7 opportunities could be crafted and distributed across the school year. However, this will not be achieved if the Science Inquiry Skills strand is not used effectively in designing instruction. Our results also suggest that it is worth evaluating all year levels in the curriculum to see what opportunities there are for developing students’ epistemic cognition in developmentally appropriate ways throughout the schooling experience.

Cognitive Verbs and Epistemic Cognition

A key reason why statements such as those in Table 1 are supportive of students’ epistemic cognitive development, whereas other curriculum statements are less so, is due to the choice of cognitive verb used to describe the actions students are expected to perform. We recognise that cognitive verbs are frequently presented as a present participle (e.g., investigating rather than investigate), but we convert these to verbs for ease of discussion. We find that the draft curriculum contains some verbs aligned with engaging students in forming knowledge aims, products, and evaluations. Examples include 'formulate', 'propose', 'evaluate', and 'plan'. However, weak verbs such as 'consider', 'discuss', 'recognis[e]', and 'acknowledg[e]' are evident in multiple places that suggest limited intellectual engagement. These verbs do not match the curriculum vision and intentions about producing a scientifically literate citizenry. For example, the verb 'consider' can lead to design of instruction that simply requires students to attend to a range of information. Stronger options include: 'discern', 'compare', 'evaluate', and 'discriminate'. Verbs such as these will push instruction to the point where students must form evaluative stances towards some knowledge product, and thereby such verbs are more conducive to developing students' epistemic cognition.

The curriculum document contains only three uses of the verb 'evaluate'. This is a surprising result for a science curriculum and helps to explain why few instances, where epistemic evaluation might occur, are identified in our analysis. We find instances in the curriculum statements where the verb 'consider' is used, when 'evaluate' would support stronger epistemic cognitive development. One example is provided below from Science Inquiry Skills strand:

> Content description: plan and conduct valid, reproducible investigations to answer questions and test hypotheses, including, as appropriate, developing risk assessments, considering ethical issues, and addressing key considerations regarding heritage sites and artefacts on Country or Place (AC9S10I02)
>
> Elaboration: considering possible confounding variables or effects and ensuring these are controlled or accounted for in planned methods for data collection and analysis (AC9S10I02_E10)

The standard descriptor here offers promise because an investigation can involve formulation of aims, products, and evaluation of products. However, the passive nature of the verb 'consider', in the participle form 'considering', provides limited scope for teachers to design robust instruction that supports students in applying scientific standards and criteria for evaluating decisions. In addition, the language that describes actions consistent with evaluation could be strengthened by including mention of using ideas such as validity and reliability and standards and criteria to critique knowledge claims. As discussed earlier in relation to Earth and space sciences, teachers can design an expository form of instruction that asks a student to consider information about variables without generating products based on that consideration. If 'consider' is replaced by 'identify and account for' there is greater chance that an evaluative stance is encouraged. It is also not clear what epistemic product a student might develop, or that there is a need to evaluate such a product, in the above statement. Moreover, a weak verb like 'consider' creates an impression that in evaluating epistemic products all ideas are equally valid. This can communicate the wrong impression about science.

We have found that the curriculum draft has missed opportunities to support students' epistemic cognitive development and predominantly positions students in passive ways towards knowledge and knowing. One way to address these issues is to reformulate statements with better verb choices and by changing some of the content descriptions and elaborations to reflect how science is conducted. We offer examples in this article of what this might look like.

Conclusion

The nature of science, which involves the systematic study of phenomena, is reflected in the theory of epistemic cognition that explains the ways in which humans apply their psychological processes to think about knowledge, its production, and its evaluation (cf. Chinn & Rinehart, 2016; Greene et al., 2016). In this way, epistemic cognition has proven to be an appropriate and useful framework for evaluating the science curriculum.

This investigation of the Year 10 *Australian Curriculum: Science* has identified limitations of the curriculum document in supporting students' epistemic cognition. We consider this to be a limitation for two reasons. One reason is that the limitations affect students' development toward understanding the processes of science through insufficient opportunities for epistemic cognitive development. The second reason is that the diminished development of epistemic cognition misses the chance to prepare a future citizenry with the knowledge and capacity for dealing with the post-truth world. Effective science curriculum casts its gaze in two directions: the preparation of future scientists (linked to our first reason); and the preparation of a scientifically literate citizenry (our second reason) (cf. Roberts, 2011). Without modification, the curriculum it is unlikely to be as effective as it could be in achieving these two curricular directions. We have offered examples of modifications to the content descriptions and elaborations that would move the curriculum closer to these goals.

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