Transforming Knowledge and Learning through Technologies and Modalities: Teacher's Perceptions of Pedagogy and the New Life Sciences

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Abstract: Notwithstanding the increasingly rapid emergence of New Life Sciences as a meta-discipline, teachers' understandings of their own pedagogy in relation to the New Life Sciences have not yet been explored. Using an un-timed, semi-structured interview style, we interviewed 12 Senior Biology teachers about the nature and importance of the most recent unit studied in class and of Biology overall, about their pedagogical approach to that unit and to Biology overall, and about other factors that might influence their teaching. The most recent unit studied differed between teachers. Quantitative and qualitative analyses revealed variations in teachers' focus on New Life Science content and their use of digital technologies to represent New Life Science and other content, with much variation based upon teacher age, school resources, and individual differences. Furthermore, all teachers who had begun to teach New Life Science content in the classroom reported a lack of confidence in their knowledge of the material. These findings serve as a basis for future efforts to enhance multimodal teaching and learning of the New Life Sciences.

The New Life Sciences are a meta-discipline of increasingly specialised areas of neuroscience, biochemistry, genetics and other bioscience fields. In a previous publication we present evidence that Australian senior Biology teachers have begun to introduce aspects of the New Life Sciences in the classroom, albeit in conjunction with more traditional content (see Nichols & Barton, 2008). In addition to these classroom observations, however, we also considered teachers themselves to be a critical source of information about their planning and teaching of the New Life Sciences. Here we explore teachers' pedagogical and epistemological approach to the New Life Sciences relative to more 'traditional' bioscience units.

The emergence of the New Life Sciences raises questions of disciplinary variation pertinent to Biology teaching: about how these fields relate to traditional biosciences and to other disciplines with which they are sometimes connected (e.g. Chemistry, Earth Science), and about how they are distinct. At their most fundamental level, disciplines are sets of propositions, dispositions, and communicative preferences about the nature of evidence and knowledge and the purpose of enquiry (Freebody & Muspratt, 2007; see also Jewitt, 2008). Advocates for the pedagogical significance of disciplinary variation point to the way in which disciplines have evolved to provide increasingly robust, profound, distinctive, and "most well-honed" answers to recurring questions about human

experience (Gardner, 2000, p. 144). The New Life Sciences are a unique case-in-point, evolving from traditional biosciences yet differing in their treatment of knowledge. In the New Life Sciences much new knowledge is produced and disseminated via digital technology, and, due to the complex nature of the phenomena studied, much is represented using visualisations and other related modalities (cf. verbal representation).

The issue for educational theorists and researchers, then, concerns the potentially negative consequences of using pedagogies that are better suited to the teaching of 'other' disciplines and epistemologies. New investigations must consider which modes of communication best represent what content, and, in particular, how teachers can best plan and teach both traditional bioscience and New Life Science units. As yet, however, the emergence of the New Life Sciences as a meta-discipline has not been systematically been matched with teacher professional development or training programs, despite the gradual inclusion of New Life Science topics in various state curricula.

To enhance planning and teaching of the New Life Sciences it is necessary to first analyse not only the current range of practices employed, but also how and why these practices are employed. As Campbell states, *"If students are to be literate in modern biology, then teachers will need to be aware of the impact that new molecular information are having on all areas of biology* (2003, p.98)". Whilst classroom observations (e.g. Nichols & Barton, 2008) provide valuable information about *what* practices are employed in the classroom, including the provision of New Life Science content and the modalities by which different types of information are represented, teacher interviews allow us a unique insight into the questions of 'how' and 'why'.

In the following study we asked senior secondary school teachers a series of questions about the nature and importance of the unit most recently in class – with or without the potential for New Life Science material to be included - and of Biology overall; about the teacher's approach to that unit and to Biology overall, including resources, teaching strategies, and learning outcomes; and about other factors that may influence teaching and learning, such as the school and the students.

Method

Participants

Twelve senior Biology teachers from seven schools participated: two teachers each from the Australian states of Queensland and South Australia, and eight from New South Wales. Teachers had each participated previously in the observation of their classroom activities across one unit of work (4-6 weeks). A further three teachers also participated in classroom observations but, due to the scheduling of exams and other school activities following the observed unit of work, were unable to continue their participation further.

Procedure

Teachers participated in an un-timed, face-to-face interview. They were asked 15 pre-determined questions using a flexible, semi-structured interview style in which answers that were deemed by the interviewer to be either incomplete or particularly important were discussed further. In order to ensure that teachers were comfortable with their

interviewer, the same researchers who had previously observed the teachers in their classrooms also conducted the interviews.

Importantly, a number of different senior Biology units had most recently been studied, and each had different potential for the inclusion of New Life Science material. Thus, by asking teachers questions about the most recent unit studied in class we were able to tap into teachers' thoughts about both the New Life Sciences and more traditional material.

Materials

Initial interview questions asked were:

1. Can you briefly describe your school Science program?
2. Can you briefly describe the students that you teach?
3. Does this impact the way that you teach?
4. How do you go about planning a unit of science?
5. What do you intend the students to learn about this topic
6. Why is it important for students to know this?
7. What are the difficulties or limitations connected with teaching this topic?
8. What knowledge about students' thinking influenced your teaching of this topic?
9. Could you describe a typical lesson for your senior Science class?
10. What kinds of teaching strategies do you usually use in lessons?
11. Why do you use these teaching strategies?
12. In what specific ways do you ascertain students' understanding of this topic?
13. What are your strengths and weaknesses in teaching Science?
14. What are your students' strengths and weaknesses in learning Science?
15. What do you think are the benefits your students are getting from learning Science?

Care was taken to ensure that the questions and follow-up discussions did not prompt directly for information about the New Life Sciences or the use of multi-modalities.

Coding and Analyses

Interview responses were analysed quantitatively and qualitatively. During quantitative analyses each response was coded according to a range of plausible responses. In each case the coder was required to select the category or categories that best represent the teacher's answer. Table 1 provides an example of this categorisation scheme.

Table 1. Quantitative coding of Question 5 from the Teacher Interview Coding Scheme

5. What do you intend the students to learn about this topic?
5.1 Not explicitly mentioned
5.2 Development of practical skills
5.2.1 Test / assessment preparation
5.2.2 Real world application
5.2.3 General
5.2.4 Other
5.3 Acquisition of knowledge base
5.3.1 Test / assessment preparation
5.3.2 Real world application
5.3.3 General
5.3.4 Other
5.4 Development of metacognitive awareness and reflection on learning
5.5 Development of social skills
5.6 Development as a 'whole person'
5.7 Develop scientific thinking / learn about Biology as a discipline

Following the categorisation of each interview response, frequency tables were used to depict the pattern of responses among teachers (note that there was insufficient power to conduct inferential statistics on these categorisations).

Results

Background information about the school, teacher and students

To gain background information about the teachers we interviewed and the teaching environment in which they work, we asked teachers about their school, about why their students were studying Biology, and about their own background.

Three of the 12 teachers believed that their school values Science strongly; four stated that their school is more focused on Performing Arts than Science, and five cited a general 'academic' focus or no particular focus.

These values were reflected in student interests: most teachers reported their students to be either academically oriented or oriented towards the Performing Arts, with only one reporting an orientation towards sports. Students attending the schools were overwhelmingly of either middle class or mixed socio-economic status, with only one student body of predominantly low socio-economic status and one student body of predominantly high socio-economic status reported. Students' primary motivation for studying Biology, according to their teachers, was because they find the discipline interesting. Teachers did not typically mention whether or not they expected their students to use Biology in their future education or employment.

Teachers themselves had mixed expertise in Biology. Half our sample of teachers reported a tertiary background in Biology or a sub-discipline of Biology, with the other half specialising in another Science. No teacher reported a background in the New Life

Sciences: a factor that may influence the degree to which New Life Sciences are taught in the classroom.

> *"If we want to give these students the best science education and the best touch of what each of these sciences involve then you must put a specialist in front of them … we're in partnership with the University of Queensland but there's so much politics happening it's very hard to get that interaction happening. There's a lot more that needs to happen there because I need to be kept current … I would have loved them to come in and contribute to my biotechnology in my classroom; real scientists in front of them; I do find that a little frustrating"*

In the above excerpt a teacher discusses her desire to include more Biotechnology content in the classroom, despite not feeling competent to introduce the material herself without specialist help. Her experience was not unique: as will be discussed further below, teachers who had selected electives or designed units with the potential for New Life Science content to be included frequently reported feeling out of their depth, despite acknowledging a desire to engage their students with cutting edge material.

Teachers' planning and teaching of Biology

To determine how teachers typically approach a senior Biology unit we asked our sample how they go about planning each lesson, what kinds of resources and strategies are used to plan and to teach, and how and why they might modify their teaching in response to student background and learning needs. We were particularly interested in the pedagogical flexibility teachers would exhibit in response to their students and their use of digital technology in planning and teaching.

All teachers reported planning their lessons with colleagues to some degree, either by developing material collaboratively or by deriving ideas from others. Furthermore, for teachers from New South Wales where the syllabus is more prescribed than in other Australian states, the syllabus was a significant determinant of what must be taught: *"The senior syllabi are so prescribed … you're told you know blow by blow, dot point by dot point what you must cover."*

Despite these common approaches to planning and a limitation to the kinds of material that can be introduced in the classroom, however, teachers' pedagogical responses to their students' backgrounds and interests varied. Figure 1 presents the different ways in which students' backgrounds and interests impact their teaching. Note that some teachers modified their planning and teaching in multiple ways.

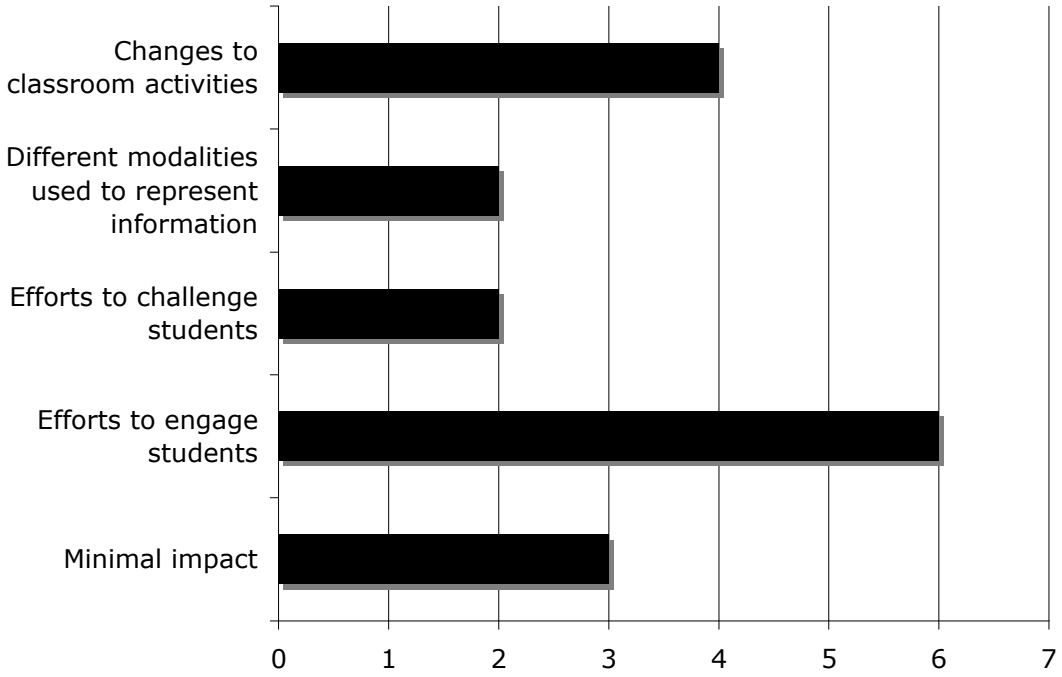

Figure 1. Ways in which teachers' knowledge of their students' backgrounds and interests impacts their teaching

Importantly, further investigations revealed that teachers who made changes to either their classroom activities or the modalities used to present information typically increased their use of digital technologies. For example, some teachers held the belief that students are typically more engaged when digital representations are used.

> *"Technology here we use all the time so I spend a lot of my planning time finding sites that provides the students with animated explanations of the things they need to learn not just word sites but animated sites so that because these kids are digital learners I mean you've got to cater to the way they now learn and they learn via that digital technology"*

> *"I try to use a variety [of interactive PowerPoint slides], mainly because I think that's because you hear a lot about different learning styles and I think well, good, visual learners and auditory learners. I know that you're always going to have every type in your classroom"*

Whilst these results indicate the willingness of at least some teachers to increase their use of digital technologies where they see the need, there was nonetheless significant variation in the degree to which teachers use digital technology during planning and in the classroom. Consider the following:

> *"Well I've been teaching science since 1986 so I've acquired a fairly extensive knowledge base but when I obtain new information now it's usually from science programs on television that can be very good … I generally encourage students to use the internet more than myself."*

The contrast between this response and the above two responses is clear. In the first two responses, teachers search for the digital representations they believe will best match the learning styles of their students. In the second example the teacher relies more strongly on a well-established body of background information acquired before digital technologies and the New Life Sciences existed, thus limiting his engagement with newer disciplines and their representational modes. Teachers themselves seemed to be aware of the variations in digital technology use amongst their colleagues, and nominated several reasons that these variations may occur. First, one teacher suggested that age may be a factor.

> *"Obviously depending on age bracket and things like that, there'll be less, I don't know whether less willingness is the word, but you know to want to use slide shows and things like that. So for example I'm in the process of producing slide shows for every unit of work … some of the younger teachers definitely have used them, particular as a revision at the end of each topic. And I know that others, although the offer is there, they choose not to use it 'cause they have their own way"*

Second, several teachers cite school resources as a limiting factor in their teaching; in terms of both digital resources and more specialised New Life Science equipment.

> *"You might be going into a lesson where you've planned to use technology then oops, it's not there any more and you have to quickly backtrack and find out, you know, sort of find an alternative way of communicating the message for that lesson."*

> *"The difficulties for most people [in studying biotechnology] I haven't found it 'cause I've done fundraising myself is the equipment. You've got to have real equipment. … schools can't afford to keep up with the current technologies. We're losing them as scientists because they're not going to be engaged."*

> *"Computers for research are a big issue at this school … you-know the Library books are out of date they don't have the sort of up-to-date information that the Internet does. And that also limits you to use interactive teaching with science side of things"*

Finally, over and above age and resources, individual differences appear to explain some variation in digital technology use during planning and in the classroom.

Pedagogy and the most recent topic studied in the classroom

When teachers were asked what they intended for students to learn about the most recent unit studied in the classroom, teachers each discussed the acquisition of specific knowledge, such as '*the nature of heredity*' and '*the discovery of DNA, its structure, its role in protein synthesis*' (note that one teacher did not explicitly answer this question).

Although most teachers cited test or assessment preparation as at least one reason students should acquire knowledge about the topic, when asked *why* it was important for students to know this teachers tended to give more general reasons focused on the ways in which he student will be able to interact with the world. For example, five teachers stated that the topic would allow students to describe or explain the living world, and five stated that students would be equipped to make informed ethical decisions and weigh into ethical debates facing society. Figure 2 depicts these responses.

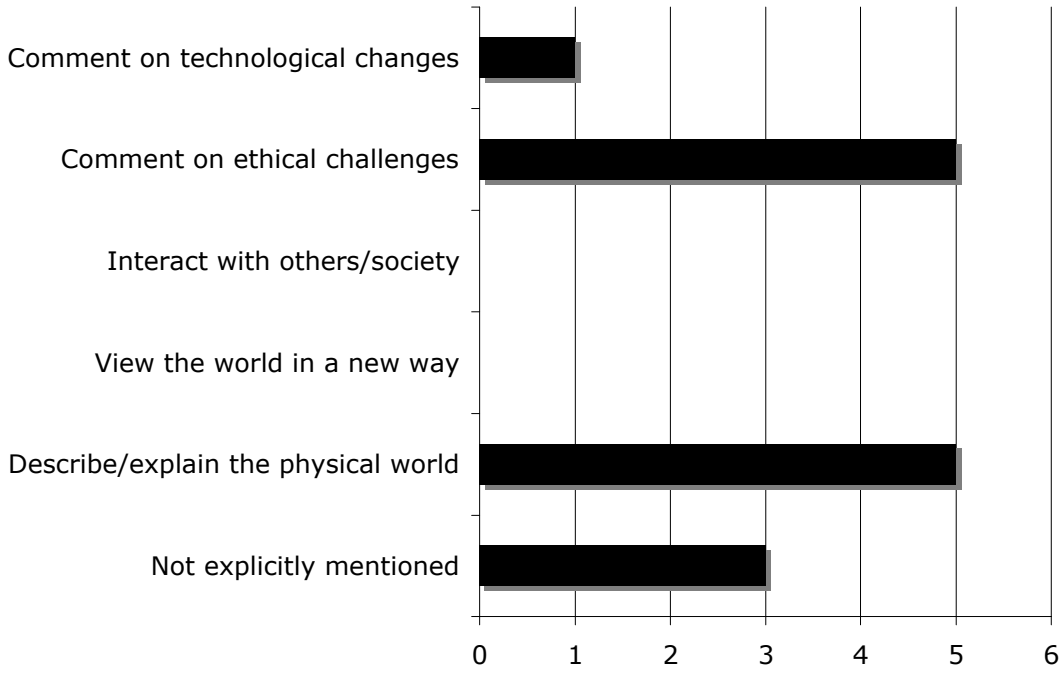

Figure 2. Ways in which the most recently studied topic allows students to interact with the world.

In addition to the acquisition of knowledge about the topic, one teacher also aimed to develop her students' practical skills, and two aimed to develop their students' understanding of Biology as a discipline.

Interestingly, only one teacher mentioned the ways in which a New Life Science versus other content might require different ways of representing information, stating that she had no 'typical' approach to lesson planning because the topics are all so different. In contrast, another teacher stated that her school had adopted an interdisciplinary approach to the New Life Sciences and traditional biosciences:

> *"We try and focus on the new sciences as well such as biotechnology and nanotechnology which wouldn't traditionally be a part of a science curriculum; [this] makes us a bit different though is that we try to integrate the sciences together around a particular topic for example biology and chemistry aren't taught separately they're taught…together as a whole"*

Nonetheless, the emerging trend for those teachers who had recently taught a unit with New Life Science potential that the rapid emergence and development of the New Life Sciences as a meta-discipline made it hard for them to master the material:

> *"As fascinating as it is, I think it's such a new area that's undergoing such rapid development I probably, if I was writing the syllabus I probably wouldn't put it in. I just think it's really hard to find focus in there of what the students need to know."*

> *"It's a cutting edge topic with so many things like the Gene Cascades etc, which I find very difficult myself (laughs)."*

> *"I suppose also there's sometimes a lag between the information that's in the text book and the information that's in the syllabus and changes that are happening. Like the last dot point of this topic eight which is all about embryonic development and homoeobox genes, I just find there's not a lot of up-to-date information about all that stuff or there's stuff that comes out that you don't know about until you've taught and it's hard to keep up-to-date with some of the topics and some of the examples"*

No comments of this kind were made about units without the potential for New Life Science content, suggesting that it is the cutting edge nature of the New Life Sciences that make it hard for teachers to keep pace. This finding emphasizes the need for new professional development activities focused on the introduction of New Life Science topics in the classroom.

Pedagogy and Science teaching overall

When teachers were asked what benefits their students were getting from studying Biology overall, as opposed to the most recent unit only, results differed somewhat. Teachers did not mention the acquisition of a specific body of knowledge or practical skills. Instead, more general reasoning skills were discussed (see Figure 3).

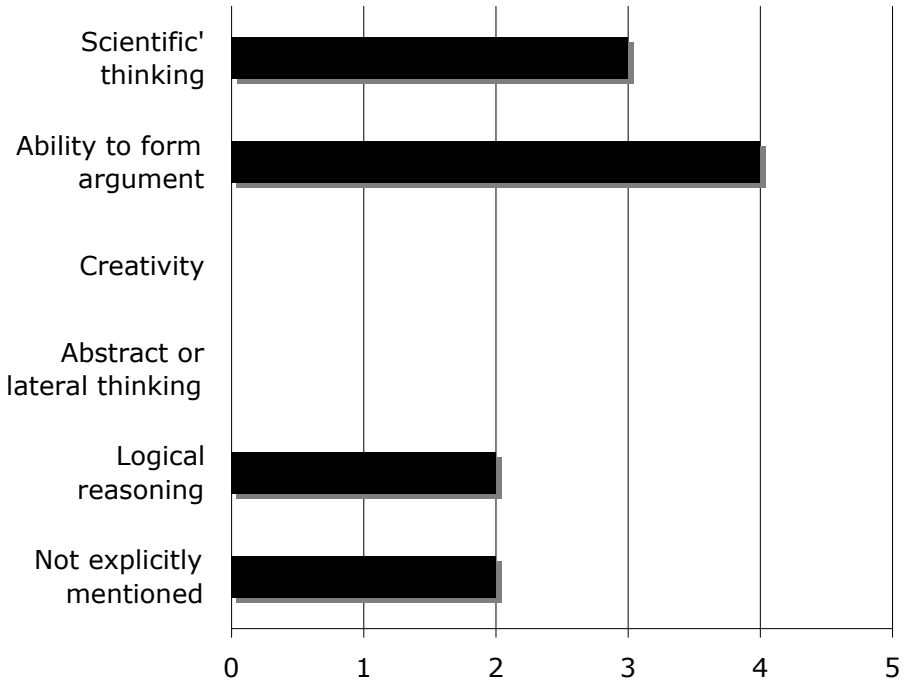

Figure 3. Thinking and reasoning skills developed through the study of Biology

Nonetheless, teachers did again focus on the ways in which the student will be able to interact with the world, with seven teachers referring to students' ability to describe or explain the world in some way and five referring to their ability to make informed contributions to ethical dilemmas faced by society.

> *"Yeah, oh I think they're just learning about ... they're just learning about the world and their bodies and how it works and ... yeah, current, contemporary issues and controversial issues and I just think it's really great."*

Ethical issues cited included those of the New Life Sciences, such as those related to genetic engineering, but also of more traditional biosciences, such as environmental issues.

Summary and Discussion

Two key findings emerged during our interview analyses. First, teachers face a dilemma. Given the rapid emergence of the New Life Sciences they must come to terms with these emerging sub-disciplines rapidly, reshaping their understandings and practices, or risk falling behind. However, at present they must do so without theoretical or empirical guidance. Whilst at least some teachers in our sample were willing to engage with New Life Science material, citing the interesting and cutting edge nature of the work, they also reported feeling out of their depth due to the rapid progression and specificity of knowledge in the field.

Second, there are significant variations in teachers' use of digital technologies for planning and teaching. Three contributing factors emerged: teacher age, and thus, presumably, their familiarity with ICTs, school resources such as internet access and more specialised practical materials, and individual differences.

Teachers' discussions of limited school resources in particular mirror the classroom observations of Nichols and Barton (2008), in which significant variations were observed in teachers' and students' access to laptops, projectors, and the internet. Without having previously heard from teachers themselves, however, it was necessary to entertain the perhaps unlikely possibility that these particular teachers may not have used the resources anyway. That many teachers explicitly cite these constraints as having a direct impact on their teaching now provides concrete evidence against this possibility.

More generally, variations in teachers' use of digital technologies implicate the modalities that they are likely to use in their representation of knowledge and, by inference, the potential for New Life Science content to be included in their teaching. Whilst concepts of disciplinarity and technology in the New Life Sciences have not previously been investigated, investigations into the modalities used in the Science classroom show that knowledge is constructed via a range of modalities, each its own communicational affordances (Jewitt & Scott, 2002; see also Kress, Jewitt, Ogborn, & Tsatarelis, 2001), and that students need '*much more … in the future than we are now giving them … photo images, video clips, sound effects, voice or audio, music, animations, or more specialised representations'* (Lemke, 1998, p.288). This message rings especially true in the case of the New Life Sciences, in which much knowledge is represented digitally and in which knowledge construction is inherently multimodal.

Taking these findings and those of our classroom observations into account, we aim to better theorise the teaching and representation of New Life Science concepts in senior secondary schooling. This re-theorisation should in turn serve as a base for the development of interventions aimed at enhancing teachers' awareness of the New Life Sciences and of effective digital and multimodal representations in the classroom.

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