A pedagogy for epistemic agency in the judgment of accuracy and reliability

John Cripps Clark, Chris Rawson*, Linda Hobbs*,*
Christine Oughtred, Kathleen Hayes*,*
Leissa Kelly, Julie Higgins**

Abstract

In an online environment rich in unmediated content, the ability to evaluate sources of knowledge for credibility is a key component of digital literacy. However, most instruction on judging the accuracy and reliability of information relies on giving students checklists of criteria and this has only fleeting changes to skills and behavior. To have the flexibility to productively participate in a society awash with emerging and disruptive forms of knowledge creation and distribution, students need to be taught the skills to collaboratively develop their own criteria for evaluating the validity of information.

This paper describes a formative intervention, based on Vygotskian principles, in which students confront contradictions in their practice as a stimulus for their learning and development. A second stimulus is provided by the collaborative creation of a mediating conceptual artifact, a tool for accuracy and reliability of digital information, which is reformulated and applied. Using such artifacts to evaluate the accuracy and reliability of complex and problematic sources externalizes the generation of criteria. This process nurtures students' emerging identity as scientists through

* Deakin University
Correspondig author: john.crippsclark@deakin.edu.au

increasingly sophisticated decision making and metacognitive reflection, and motivates students to embed more sophisticated, reasoned judgments.

Keywords: Digital literacy, epistemic agency, identity, collaboration, creativity, critical thinking, double stimulation

The evaluation of knowledge is a fundamental skill across all disciplines. In previous knowledge environments, prior to the internet, information was always explicitly mediated by, inter alia, teachers, librarians and editors. In the digital environment, we now have access to unprecedented quantities of information but its mediation is chaotic and hidden within technologies and by the creators and masters of these technologies. Thus the burden of selecting and evaluating knowledge has shifted from providers and curators to consumers. It is therefore important for graduates to have the knowledge, skills and dispositions to take responsibility for assessing the accuracy and reliability of knowledge, so that they have control over their own decision making, and act responsibly in the world.

1. The challenges of digital literacy

Digital literacy involves using digital technologies to find, use and disseminate knowledge. Students need to become sophisticated consumers and producers of knowledge within a rapidly evolving digital environment. However, students are often reluctant to critically assess the knowledge they are sourcing (Lankshear, 1997) and their knowledge selection processes are often motivated by expediency. Students tend to choose knowledge from sources that they are familiar with or which are convenient (Denison, & Montgomery, 2012; Mbabu, Bertram, & Varnum, 2013), or to satisfy teaching directions or assessments with a minimum of effort and time (Warwick, Rimmer, Blandford, Gow, & Buchanan, 2009). Research has shown that students often never try to access further knowledge (Biddix, Chung, & Park, 2011; Colón-Aguirre, & Fleming-May, 2012; Connaway, Dickey, & Radford, 2011) even when they understand that other sources are more credible

(Metzger, Flanagin, & Zwarun, 2003). Students, as do most citizens, select knowledge that supports their pre-established opinions and beliefs (Stapleton, & Helms-Park, 2006) or make judgements on the basis of its appearance or search ranking (Connaway Hood, Lanclos, White, & Le Cornu, 2013; Doyle, & Hammond, 2006; Walraven, Brand-Gruwel, & Boshuizen, 2008).

Interventions in which students are provided with a set of criteria, such as a checklist, do not result in sustained change in the students' behavours and attitudes (Dahl, 2009; Ostenson, 2013; Walraven, Brand-Gruwel, & Boshuizen, 2009) because they do not engage students' critical thought and judgement (Meola, 2004) and assume students will passively use the checklist (Ostenson, 2013). Ironically, this passive engagement is what the checklist is designed to discourage and their introduction usually does not influence students' behaviour (Mandalios, 2013; Shanahan, 2008).

1.1. The program as double stimulation

Our teaching and research project was premised on having students active in and reflecting on the process of making reasoned judgments about the accuracy and reliability of knowledge by collaboratively constructing artefacts, rather than simply being given a static set of criteria. The pedagogy involved in this intervention is inspired by Vygotsky's method of double stimulation. Vygotsky used a variety of terms interchangeably: *experimental-genetic*, *instrumental*, or *historical-genetic methods* and the *method of double stimulation* (Engeström, 2011, p. 604). Van der Veer and Valsiner describe double stimulation as:

> To actively promote the transition from the current state of affairs to a new (not yet existing) one ... the subject is put in a structured situation where a problem exists ... and the subject is provided with active guidance towards the construction of a new means to the end of a solution to the problem (1991, p. 169).

One of Vygotsky's key ideas is that as educators we can give up control and allow students to exercise their own creativity:

The main design of our experiment will not suffer in any way if instead of giving the child prepared external means, we will wait while he spontaneously applies the auxiliary device and involves some auxiliary system of symbols in the operation. ... In not giving the child a ready symbol, we could trace the way all the essential mechanisms of the complex symbolic activity of the child develop during the spontaneous expanding of the devices he used (Vygotsky, 1999, p. 60)

The second stimulus [auxiliary device] gives agency to the student to organize and give meaning the knowledge and skills:

The person, using the power of things or stimuli, controls his own behavior through them... subjects to himself the power of things over behavior, makes them serve his own purposes and controls that power as he wants. He changes the environment with the external activity and in this way affects his own behavior, subjecting it to his own authority. (Vygotsky, 1987b, p. 212)

Paavola and Hakkarainen (2014) have described this knowledge creation within a digital environment in terms of a *trialogical approach* involving "technology-mediated processes and practices that involve collaborative efforts of building and creating knowledge artifacts and practices together" (p. 69). In the Judging Accuracy and Reliability of information (JAR) program, new knowledge practices were developed through collaborative creation of artefacts.

Underpinning this intervention was an assumption that the reasoning processes involved in judging the accuracy and reliability of knowledge are critical factors in students' development of epistemic agency as future scientists and engineers.

1.2. Developing students' epistemic agency

Essential to being inducted into the community of science is the ability to reason critically about what counts as knowledge and what evidence justifies this knowledge (Duschl, 2008). Thus developing an authentic understanding of what it is to *do science* implies the development of epistemic agency (Stroupe, 2014). Epistemic agents are not simply

the recipients of scientific knowledge, but take on responsibility for building knowledge and practices within a community. Encouraging students to think of themselves as active participants in the scientific community motivates them to participate in discussions of the social and epistemic, as well as material dimensions of science (Damsa et. al. 2010; Stroupe, 2014). They are given licence to consider themselves as epistemic agents by the explicit creation of what Ritella and Hakkarainen (2012) describe as "epistemic artifacts" which "crystallize" the judgment of accuracy and reliability.

To this end, learners worked collaboratively to enculturate critical communication (Hargreaves, 1998). When learners form groups to make reasoned judgments and communicate their responses, they actively participate in an interpersonal dialogue which is intended to be internalised and thus become transformed into intrapersonal development. This reflects Vygotsky's (1978) view that "*internalization of socially rooted and historically developed activities is the distinguishing feature of human psychology*" (p. 57).

This paper will explore the factors critical to the effectiveness of the teaching program and how collaboratively assessing the trustworthiness of a source of knowledge led students to read with a *scientific* lens and position themselves as emerging scientists.

1.3. The teaching program

The *judging accuracy and reliability of information* (JAR) teaching and research development project was a collaboration between Library and Academic staff. It has been taught for the past three years across two campuses to over 300 students at an Australian university. The project forms part of a compulsory Science Communication unit for first and second year science students and is an elective in other courses. The program was conducted face-to-face with a one-hour lecture and two 3 hour tutorials. A group assignment was undertaken over the subsequent two weeks. All activities were undertaken in groups of four which were voluntarily formed (with the guidance of tutors). The structure of the teaching and research program is presented in Table 1. Lectures were 50 minutes long and tutorials 170 minutes long.

Table 1. Outline of the teaching and research program

Activity	Program	Purpose
Lecture (50 mins)	Delivered by Library staff	Provide an overview of principles of judging the accuracy and reliability of information, based on Ngo (2012).
First tutorial	Small group and classroom discussions.	Reflect and report on information seeking behavior, and on current practices when judging the accuracy and reliability of information.
	Dissemination and collection of consent forms by Library staff.	Provide students the option to indicate informed consent to participate in a research program.
Second tutorial, first activity	Critical reading of preselected online sources that contributed to debate surrounding a socially acute question (Simonneaux, & Simonneaux, 2009).	Development of critical digital literacy as applied to judgments of accuracy and reliability of web sources.
	Selection of textual fragments from online sources, which students could defend as accurate and reliable (or not) with confidence.	Application of strategies and criteria for making these judgments.
	Justification of student's decision.	Develop ability to communicate, persuade and negotiate judgments amongst peers.
Second tutorial, second activity	Reflection on the processes and principles applied during the first activity, and how they could be improved.	Metacognitive reinforcement of literacy development.
	Students develop an artifact in small groups. The artifact is designed to enable another group to make judgments of accuracy and reliability of information resources.	Applied metacognitive reinforcement of literacy development by constructing a representation (Tytler, Prain, Hubber, & Waldrip, 2013).
	Artifacts distributed to other groups, who provide feedback.	Peer assessment and review. Groups communicate and negotiate principles and process of judgments of accuracy and reliability.
	Revision of tool based on feedback. Artifacts from consenting groups collected for research purposes.	Discussion and application of peer feedback.

Small group assessment task	Students create a *Media Watch* style video, using complex and problematic source material that contributes to debate on social acute question(s). Preselected materials were available, however students mostly sourced material, with advice from teaching staff. The video presents a short account of the accuracy and reliability of source material by reviewing how individual claims, and the source material's contention, held up to scrutiny. Videos from groups consenting to participate in research were collected.	Further develop, apply and demonstrate a sophisticated ability to review and analyze the accuracy and reliability of complex source material that contributes to a debate around socially acute questions.
Second tutorial, preliminary assessment activity	Groups give dramatic presentation of the script for the video assessment task	To provide an opportunity for teaching staff and peer feedback prior to final submission of assessment piece.
Assessment of video	Assessment of student generated artifacts (*Media Watch* style video) according to criteria including: o Concise and accurate reporting o Review and analysis of the source material's argument o Demonstrated sufficiency of the research underlying the review and analysis o Accuracy and reliability of the review and analysis o Clarity, concision, coherence and audience engagement in communication.	
Focus group interviews with students	Small groups of students who had indicated their consent participated in a focus group. These sessions were recorded, transcribed and then coded. Students were asked a series of questions relating to • Evolution in their personal judgments of accuracy and reliability • Identification of the most, and least, useful elements of the teaching program • Ongoing awareness of the need to critically evaluate accuracy and reliability	Ascertain student's perceptions of • Personal evolution in making judgments of accuracy and reliability • Effectiveness of the teaching program • On-going value of the teaching program / transformative nature (or otherwise) of the teaching program
Focus group interviews with teaching staff	Teaching and library staff were interviewed individually. Conversations were recorded, transcribed and then coded. Teaching and library staff were asked to discuss the following topics, in order to ascertain their perceptions of: • The partnership between teaching and library staff, and its outcomes. • The effectiveness of the teaching program, and its assessment.	

2. Methods

A case study methodology (Yin, 2014) was used. Focus group interviews with students explored experiences in the classes and development of dispositions and knowledge. Ethical approval could not be obtained for video or audio recording of the student interactions because of the fear of coercion. Consequently, post-hoc interviews were the primary data source which were triangulated with tutors' observations and the artefacts (resources and videos) produced by students. Interviews of teaching and library staff were conducted individually, reflecting on their perception of the value of the learning activities and the students' assessment artefacts, their own experiences, and their observations of students in tutorials. Interview questions can be found in Appendix 1.

The interviews were transcribed and analysed using nVivo with a combination of open and emergent coding. Initially, the broad issues of concern were identified by consensus among all the researchers. This was followed by finer grained analysis of emergent issues involving three researchers independently undertaking a thematic analysis of the data. Consensus was then developed on a set of themes and these were used to code the transcripts and tabulate excerpts. Quotations are coded SG – student group; S – individual students; and T – tutors; then by line in the transcript.

3. Results and discussion

The analysis identified the pedagogical components that were identified by participants to have contributed to the success of the learning program in creating new knowledge practices of digital literacy. These were: active learning, reinforcement, authenticity, collaboration, creativity, critical thinking, empowerment, and identity. The following quotes, from both students and teaching staff, illustrate these pedagogical labels and typical components.

The teaching program is claimed to have a significant impact on students' perceptions of using knowledge sourced online, particularly as they reported that they intend to modify their behaviour as a result

of the JAR program: "We can't unsee what we've seen" [SG3.46]; "Yeah, for sure, the practice of doing it over and over, it's like burnt into our brains. Now I can't look at a website without looking for references or the author" [SG3.39].

The teaching program enabled the students to be active in their learning through a series of activities which reinforced and built on each other. They were framed around three key components: the critical analysis of a socio-scientific website; the creation of the artifact another group could use to judge accuracy and reliability; and the assessment task, a *Media Watch* style video report (as outlined in Table 1). In each of these activities, by working collaboratively on the production of an artifact students were required to use their creativity and critical thinking. Empowering the students thus engaged their identity as scientists, mathematicians and engineers and led to the development of epistemic agency. Table 2 frames these activities in terms of Vygotky's double stimulation.

Table 2. Structure of the JAR program in terms of double stimulation. [based on Figure 3 (Engeström, 2011)]

	Process	Outcomes
New Practice	Creation of video report	Epistemic agency
Second Stimulus (neutral artefact)	Creation of artefact	Development of criteria for judgment
First stimulus (contradictions & disturbances)	Critical analysis of a socio-scientific website	Identification and critical evaluation of claims

Following the lecture delivered by the library giving a framework for digital literacy in terms of "find, use and disseminate" (Deakin University Library, 2015), the learning activities allowed students to actively discover, process and represent new knowledge: "It was more interesting doing it as a video rather than coming into class and having to look at one and then do a test on it" [SG2.28]. Enabling students to take a hands-on role gave them ownership over their learning, in contrast to teaching practices which rely on transmissive modes of

knowledge delivery (Ostenson, 2013). Active learning is associated with autonomy, critical thinking, and collaboration (O'Loughlin, 1992).

We constructed tasks so that students could make judgments about increasingly complex source materials, supporting them to integrate this skill into scientific practices by encouraging them to take responsibility for the evaluation of knowledge sources. The iterative nature of the tasks provided space for refinement of skills. As one tutor observed, "I found my students certainly got better at it towards the end, they really started to question things" [TR6.10].

Students also commented: "I found the whole thing helped to refine the skills I already had ... The website looks authentic but might not be authentic, it gave me more skills in how to determine that, how to see past that" [SG3.28] and "I think my methodology would have been severely flawed prior to class, I thought I knew what I was doing but I definitely didn't after that experience" [SG2.2].

Many students expressed a need for these skills earlier in their academic journey: "Looking back at a lot of my assessments, I'm like, 'well, I could have done that differently'" [SG2.71] and "I'm doing second year now, and that would have saved a bit of time off my research if I had of known what exactly I was looking for" [SG2.72]. "They should be doing this at high school; that would have made life so much easier" [SG2.77].

The JAR program allowed the time for development of critical thinking skills and the repetition allowed students to reflect on their judgements through a critical lens and iteratively increase their sophistication.

Giving students responsibility for representing their decision-making process required them to exercise metacognition. They had to: analyse real websites; develop and agree on the criteria for decision making; develop an artefact for assessing accuracy and reliability; evaluate the artefacts of other groups; and modify their own artefact and then use it. The knowledge and skills they had developed to analyse and communicate an evaluation of the accuracy and reliability of complex source material contributed to debate around socially acute questions. This allowed epistemic mediation by "deliberately creating, organizing, and working with artifacts aimed at knowledge

advancement. Crystallization, externalization, and materialization of ideas to knowledge artifacts facilitate advancement of inquiry" (Paavola, & Hakkarainen, 2014, p. 62).

Teaching staff saw that the interactive task facilitated a deeper engagement than traditional checklist activities: "The decision tree was good in that they actually got to handle and interact with it, as opposed to listening to us reiterate a checkpoint, do this – do this, getting them more involved" [TR2.2]. Making the decision-making artefact prompted students to think more deeply about the criteria required: "[it] introduced some into a new way of thinking ... analysing a wider source of digital info they're exposed to on an everyday basis" [TR2.2]. The artefact was simultaneously intensely practical: "It was really useful, gave us a good mechanism for actually pulling apart the website" [SG3.10]. and was then used in the assessment video: "the artefact that we made for the exercise... after we made the video we got it back out and used it as a checklist to go through our own work" [SG2.17]. Teaching staff expressed the view that the authenticity of the task was essential for students to be active in their learning, resulting in a deeper and longer lasting learning experience.

At the heart of the program was "collaborative and iterative work with external artifacts and develop concrete ways of doing things together" (Paavola, & Hakkarainen, 2014, p. 58). Students collaborated on all aspects of the tutorial activities and assessment task: developing criteria; creating the decision-making artifact; investigating websites; and documenting their learning through a video. The program was a "social activity" and a "process of enculturation" (Hargreaves, 1998) into a team-based method of working. The benefits of learning from others in the group was a recurrent theme in the interviews. Students appreciated the benefit of experiencing different perspectives: "it was great hearing other people's methods" [SG1.8]; and increasing the breadth of ideas: "[You] find stuff you wouldn't have found by yourself ... you've got a lot more content than you'd normally have" [SG1.32].

Students' ideas were critiqued not only by other members of the group but also by members of other groups when artefacts were swapped and tested against problematic sources of knowledge. This

was also a strong motivation to contribute because of both the perceptions of their work ethic and the final product: "Because we know the rest of the class are going to see it, we don't want to look like idiots, do it properly" [SG1.28]. One student mentioned that they were motivated by not "let[ting] your group members down, like where you would have slacked off normally you probably don't as much because you've got people relying on you" [SG1.31]. This commitment to a group, developed through social interaction and communication, both motivated the students and contributed to the development of the experience of working as part of a community of aspiring scientists. This collaboration can facilitate the internalisation of otherwise extrinsic motivations; even if this was rationalised in terms of fear: "I put a lot of work into it because I thought my peers would see it so I was scared into doing a good job" [SG2.32].

On the other hand, several students felt that working with others reduced the individual workload and made the task more manageable: "If I had to make a movie on my own, I would have been freaking out the entire time, it would have seemed too big of a thing to do ... it was so easy in a group" [SG2.49]. For many first year students for whom this was one of their first assessment tasks: "a lot of us are first years, so coming into a subject where Assessment 1 is a group assessment is kinda a weight off your shoulders" [SG2.50].

The interdependence of the tasks meant that students had to listen to and match their own ideas with others in their group (and then the whole class), and assimilate and transform these ideas (Adams, & Hamm, 2005). Accountability to their group provided motivation to meaningfully contribute. Finally, the process of metacognitive reflection and critical and comparative reading in the context of a group of aspiring scientists helped to establish an emerging identity as a scientific community, which was a source of pride.

Students were given creative freedom to produce a decision-making artefact that articulated the criteria their group developed for evaluating knowledge. The wide variety of decision-making instruments that were produced demonstrated students' creativity when approaching the task. To present content creatively, a learner must consume it, interpret it, and represent it in a way that is relevant

and meaningful both to themselves and the social group within which they are working (Sannino, & Ellis, 2014).

It was observed that students appreciated the freedom to explore and design criteria: "I think the students appreciated the creative element of it. Even in this exercise, I try to get them to be as creative as possible all the time" [TR4:38]. Students used this freedom to produce a wide variety of artefacts: "I was amazed at the creative element of people from the unit, because they did everything from 'snakes and ladders' [games] to stories" [TR5.29].

Requiring students to critically and collaboratively reflect on their judgements identifies critical thinking skills as '*interpretation, analysis, evaluation, inference, explanation, and self-regulation'* (Facione, 2011, p.5). Critical thinking requires purposeful and reflective judgement-making, and involves not only knowledge and skills, but also dispositions. Indeed, teaching staff observed development in student's critical thinking after completing the program, and in students' dispositions to approaching knowledge-seeking tasks: "I found my students certainly got better at it towards the end, they really started to question things and I noticed their work and analysis of stuff was better at the end than at the beginning" [TR6.10].

Students reported an improvement in their ability to think critically; that is, to interpret, analyse and evaluate knowledge: "I found the whole thing helped to refine the skills I already had... techniques. The website looks authentic but might not be authentic, it gave me more skills in how to determine that, how to see past that" [SG3.28].

Students also recognised growth in their capacity to approach sites critically, and are more mindful, intentional, and thoughtful than in the past: "I think my methodology would have been severely flawed prior to class, I thought I knew what I was doing but I definitely didn't after that experience" [SG2.2]. Students also became more critically aware of potential bias implicit in knowledge: "After what I was taught, I knew to go much further with my research, try to find more specifically who was behind making the page, where the money was coming from, what agendas the people had" (SG3.25).

In developing critical thinking skills, the students were able to recognise how this experience set them up for future learning. For

some students, this was a turning point in their approach to evaluating online sources. For example, in preparing them for subsequent learning and assessment, the next assessment task in the unit required them to produce a poster on a scientific paper: "It's a perfect segue into the next thing we're doing, which is looking at scientific papers. It makes sense to do all this stuff straight away before we do anything else" [SG2.76].

The public image of science is dry, logical and abstract rather than creative and dynamic. This misconception was challenged throughout this program. Students engaged in rich, open tasks that gave them permission to explore beyond conventional forms of scientific expression to creatively communicate their understandings. Furthermore, the tasks allowed for multiple representations (Tytler et al., 2013). This experience of multiple representations, of the process of judging accuracy and reliability of information, prepares them for the representations that they will encounter as they move into different knowledge environments and that they will encounter as technology changes the way knowledge is created, mediated and disseminated. We gave to them the responsibility of speaking as a scientist, thereby empowering them as epistemic agents.

4. Conclusion

The developing of epistemic agency was empowering and pleasurable as was evident in the following exchange between a group of students:

> It was quite enjoyable, [more] than just getting the steps and following it out. ... it was fun [SG1.17 S7].
> It's always fun ripping apart an article [SG1.18 S8].
> Yeah just attacking it, well not attacking, but finding out what it does [SG1.19 S7].

This exchange reveals a less dramatic example of Clarà's (2016) interpretation of perezhivanie as experiencing-as-struggle where students become agential as they move from the struggle to analyse knowledge ("ripping apart", "attacking") towards a feeling of mastery

("finding out what it does"). They move from being critical of the knowledge to understanding and mastery.

Furthermore, the emotional dimensions of learning are revealed in the terms "enjoyable" and "fun". Students conceived of themselves as in a position of power with respect to the source. This gave a deeper engagement, involving emotions, experience, environment and cognition. It is this relationship that is crucial to our pedagogy. Vygotsky highlighted the dialectical relationship between cognition and emotion. They cannot be divorced from each other: "The life of consciousness concerns the connection between *intellect and affect*. ... thinking [cannot] be divorced from the full vitality of life, from the motives, interests of the thinking individual" (Vygotsky, 1987a, p. 50). Vygotsky discusses this in terms of *perezhivanie* which integrates the internal and environmental elements of emotion.

> Perezhivanie is always related to something which is found outside the person – *and on the other hand, what is represented is how I, myself, am experiencing this*[1], i.e., all the personal characteristics and all the environmental characteristics are represented in perezhivanie ... So, *in perezhivanie we are always dealing with an indivisible unity of personal characteristics and situational characteristics, which are represented in perezhivanie* (Vygotsky, 1994, p. 342).

Science students have many motives; however, most are willing to identify as emerging scientists. Associated is a commitment to the idea of *science*, even if this is only vaguely understood or defined. This commitment to scientific epistemology manifests itself in a desire to arrive at reasoned positions supported by scientific evidence, scepticism and consensus. This research has shown that, for undergraduate science students, these positions are conceived of as in opposition to unreasonable, misinformed, biased, inaccurate or unreliable narratives. The ability to identify, disregard and/or correct such a narrative was seen by students as a skill extending beyond the unit. As one student stated, "I was already really sceptical of a lot of things

[1] This was originally delivered by Vygotsky as a lecture and the italics are probably an interpretation by the students who transcribed the lecture.

and now I'm even more sceptical. It's great. It has been really good and outside of this subject it is going to benefit most of us, all of us really" [SG2.66]. Each source was selected to be more complex than the next. Repetition allows students to arrive at consensus and reinforce their sense of empowerment and identity, which in turn helps motivate students to continue their inquiry into scientific practice and knowledge.

The development of identity occurs through social interactions (Daniels, 2012). Students' understandings and dispositions towards the accuracy and reliability of knowledge, in the context of the close reading of a source, are informed by socially mediated interpretation. Placing students in groups was designed to engage students in a discursive process of enculturation (Hargreaves, 1998) in which they must think critically and communicate effectively in order to achieve a consensus on the nature and interpretation of evidence. Such discussions are negotiations of the underlying principles and practices of science and this positions the student to conceive of themselves as developing scientists. Given that they were asked to perform this task using issues of political, social and environmental controversy, it also asked students to reflect on themselves as privileged and empowered members of the wider community. This is a powerful motivator for students and facilitates the development of new knowledge, skills and dispositions.

The exponential growth of digital knowledge freely available on the web, together with the seductive power of search engines, has resulted in citizens having easy and direct access to vast amounts of information. Furthermore, the ways we access knowledge will change in the next decade as profoundly as the past decade. In previous generations, gatekeepers such as academicians, editors and librarians mediated this knowledge. It is thus necessary for students to cultivate the ability to generate and use, collaboratively and with reference to expertise, their own mediators that will enable them to make more sophisticated judgments of the accuracy and reliability of the knowledge they will use. We cannot predict the knowledge environment they will find themselves in, but we can equip them with the epistemic agency they needed to generate their own criteria for evaluating it.

References

Adams, D. M., & Hamm, M. (2005). *Redefining education in the twenty-first century: Shaping collaborative learning in the age of information*. Springfield, IL: Charles C Thomas.

Biddix, J. P., Chung, C. J., & Park, H. W. (2011). Convenience or credibility? A study of college student online research behaviors. *The Internet and Higher Education*, *14*(3), 175-182.

Clarà, M. (2016). Vygotsky and Vasilyuk on perezhivanie: Two notions and one word. *Mind, Culture, and Activity*.

Colón-Aguirre, M., & Fleming-May, R. A. (2012). "You just type in what you are looking for": Undergraduates' use of library resources vs. Wikipedia. *The Journal of Academic Librarianship*, *38*(6), 391-399.

Connaway, L. S., Dickey, T. J., & Radford, M. L. (2011). "If it is too inconvenient i'm not going after it:" Convenience as a critical factor in knowledge-seeking behaviors. *Library & Knowledge Science Research*, *33*(3), 179-190.

Connaway, L. S., Hood, E. M., Lanclos, D., White, D., & Le Cornu, A. (2013). User-centered decision making: A new model for developing academic library services and systems. *IFLA journal*, *39*(1), 20-29.

Dahl, C. (2009). Undergraduate research in the public domain: The evaluation of non-academic sources online. *Reference Services Review*, *37*(2), 155-163.

Damşa, C. I., Kirschner, P. A., Andriessen, J. E. B., Erkens, G., & Sins, P. H. M. (2010). Shared epistemic agency: An empirical study of an emergent construct. *Journal of the Learning Sciences*, *19*(2), 143-186.

Daniels, H. (Ed.) (2012). *Vygotsky and sociology*. New York: Routledge.

Deakin University Library (2015). *Elements of digital literacy*. Retrieved from http://www.deakin.edu.au/library/teach/digital-literacy/elements-of-digital-literacy.

Denison, D. R., & Montgomery, D. (2012). Annoyance or delight? College students' perspectives on looking for knowledge. *Journal of Academic Librarianship*, *38*(6), 380-390.

Doyle, T., & Hammond, J. L. (2006). Net cred: Evaluating the internet as a research source. *Reference Services Review*, *34*(1), 56-70.

Duschl, R. (2008). Science education in three-part harmony: Balancing conceptual, epistemic, and social learning goals. *Review of Research in Education*, *32*(1), 268-291.

Engeström, Y. (2011). From design experiments to formative interventions. *Theory & Psychology*, *21*(5), 598-628.

Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations*. Newark, NJ: American Philosophical Association.

Hargreaves, D. J. (1998). Addressing the transition to tertiary education in engineering. *European Journal of Engineering Education*, *23*(1), 79-89.

Lankshear, C. (1997). *Changing literacies*. Buckingham, UK: Open University Press.

Mandalios, J. (2013). RADAR: An approach for helping students evaluate Internet sources. *Journal of Knowledge Science*, *39*(4), 470-478.

Mbabu, L. G., Bertram, A., & Varnum, K. (2013). Patterns of undergraduates' use of scholarly databases in a large research university. *Journal of Academic Librarianship*, *39*(2), 189-193.

Meola, M. (2004). Chucking the checklist: A contextual approach to teaching undergraduates Web-site evaluation. *Portal: Libraries and the Academy*, *4*(3), 331-344.

Metzger, M. J., Flanagin, A. J., & Zwarun, L. (2003). College student Web use, perceptions of knowledge credibility, and verification behavior. *Computers & Education*, *41*(3), 271-290.

Ngo, L. (2012). *Evaluating resources*, University of California, Berkeley Library, http://guides.lib.berkeley.edu/evaluating-resources, retrieved 14/10/16.

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching*, *29*(8), 791-820.

Ostenson, J. (2013). Reconsidering the checklist in teaching internet source evaluation. *Portal: Libraries and the Academy*, *14*(1), 33-50.

Paavola, S., & Hakkarainen, K. (2014). Trialogical approach for knowledge creation. In S. C. Tan, H. J. So, & J. Yeo (Eds.), *Knowledge Creation in Education*. Singapore: Springer.

Ritella, G., & Hakkarainen, K. (2012). Instrumental genesis in technology-mediated learning: From double stimulation to expansive knowledge practices. *International Journal of Computer-Supported Collaborative Learning*, 7, 239-258.

Sannino, A., & Ellis, V. (2014). Activity-theoretical and sociocultural approaches to learning and collective creativity. In A. Sannino, & V. Ellis (Eds.), *Learning and collective creativity: Activity-theoretical and sociocultural studies* (pp. 1-19). London: Routledge.

Shanahan, M. C. (2008). Transforming knowledge search and evaluation practices of undergraduate students. *International Journal of Medical Informatics*, *77*(8), 518-526.

Simonneaux, L., & Simonneaux, J. (2009). Socio-scientific reasoning influenced by identities. *Cultural Studies of Science Education*, *4*(3), 705-711.

Stapleton, P., & Helms-Park, R. (2006). Evaluating Web sources in an EAP course: Introducing a multi-trait instrument for feedback and assessment. *English for specific purposes*, *25*(4), 438-455.

Stroupe, D. (2014). Examining classroom science practice communities: How teachers and students negotiate epistemic agency and learn science-as-practice. *Science Education*, *98*(3), 487-516.

Tytler, R., Prain, V., Hubber, P., & Waldrip, B. (Eds.) (2013). *Constructing representations to learn in science.* Rotterdam: Sense Publishers.

van der Veer, R., & Valsiner, J. (1991). *Understanding Vygotsky: A quest for synthesis*. Oxford, UK: Blackwell.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987a). *The collected works of L.S. Vygotsky: Volume 1 Problems of General Psychology*. New York: Plenum Press.

Vygotsky, L. S. (1987b). *The collected works of L.S. Vygotsky: Volume 4. The history of the development of higher mental functions* (N. Minick, Trans.). New York: Plenum Press.

Vygotsky, L. S. (1994). The problem of the environment. In R. Van der Veer, & J. Valsiner (Eds.), *The Vygotsky reader* (pp. 338-354). Oxford: Blackwell.

Vygotsky, L. S. (1999). *The collected works of L.S. Vygotsky: Volume 6 Scientific legacy* (M. J. Hall, Trans.). New York: Plenum Press.

Warwick, C., Rimmer, J., Blandford, A., Gow, J., & Buchanan, G. (2009). Cognitive economy and satisficing in knowledge seeking: A longitudinal study of undergraduate knowledge behaviour. *Journal of the American Society for Knowledge Science and Technology*, *60*(12), 2402-2415.

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. (2008). Knowledge-problem solving: A review of problems students encounter and instructional solutions. *Computers in Human Behavior*, *24*(3), 623-648.

Walraven, A., Brand-Gruwel, S., & Boshuizen, H. (2009). How students evaluate knowledge and sources when searching the World Wide Web for knowledge. *Computers & Education*, *52*(1), 234-246.

Yin, R. K. (2014). *Case study research: Design and methods*. Los Angeles: SAGE.

Appendix 1

Student Interview Questions

We want to talk about judging the accuracy and reliability of digital knowledge and in particular the work you have done in Communicating Science in Tutorials 2 and 3, Assignment 1 and Lecture 2.

1. Thinking back to before you started this unit how did you judge the accuracy and reliability of digital knowledge?
3. Thinking about the activities you did in Tutorials 2 and 3, which elements did you find useful in improving your judgments of the accuracy and reliability of digital knowledge?
   And which were not as useful?
4. Did Assignment 1, making the *Media Watch* video, help you make better judgments of the accuracy and reliability of digital knowledge? If so, how?
   Were there elements of Assignment 1 that were not useful?
5. What did you learn about accuracy & reliability by working in a group (both in tutorials and your assignment)?
6. What were the best and worst aspects of the work you have done in Communicating Science on judging the accuracy and reliability of digital knowledge?
7. Have the tutorial activities and assignment changed the way evaluate the accuracy and reliability of knowledge? Can you give an example?

Staff Interview Questions

1. Can you tell us about your experience of the collaboration between library and teaching staff to produce learning experience for your students?
   ° What went well?
   ° What could be improved?
   ° Would you support a partnership with the library again in future?
2. To what extent has the partnership supported *teaching* in your unit?
   ° Did the assessment task gave students a fair and reasonable opportunity to demonstrate that they met the intended learning outcomes?
   ° Were there any unexpected outcomes?
   ° Were you satisfied with student's results, and performance with this task more generally?

3. How do you feel that the collaboration with the library influence your teaching?
4. How has your understanding of digital literacy been changed by the collaboration?
5. What do you feel you contributed to the collaboration?