

ALoud IN THE LIBRARY: DEVELOPING YEAR 10 BOYS' SELF-EFFICACY IN A PHYSICS INQUIRY THROUGH THE THINK ALOUD PROTOCOL

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Abstract

In this action research project, use of the Think Aloud Protocol (TAP) as a library learning strategy to enhance boys' self-efficacy was investigated in a Year 10 inquiry unit in Physics. The hope was to help boys become more comfortable with aspects of the research process: self-assessing thinking, normalizing struggle, and building a case for help-seeking as agents of their own learning in the library, a non-classroom thinking environment. Data were collected via Think Aloud recordings using laptops, via participatory methods, including post-recording filmed interviews and an electronic survey. Recordings of classes allowed for revisiting the classes post-action. The data were coded with the assistance of Bowler's (2010a) *Taxonomy of Adolescent Metacognitive Knowledge* and informed by discussions with the boys about self-efficacy, personal epistemology, and social cognition. The boys made choices with the aid of Think Aloud and noted meaning and challenges in the experience. The findings included observations of TAP as meaningful learning where challenges were also present, indications of self-efficacy growth for some in the area of reflection and self-evaluation, and regarding TAP as a stimulus for making thoughtful choices.

Glossary

Self-efficacy: "Self-efficacy beliefs are context specific judgments of personal capability to organize and execute a course of action to attain a set goal" (Zimmerman & Cleary, 2006, p.48). I perceive self-efficacy to be inclusive of expressing opinion, vocalizing struggle, expression and management of emotion, research-specific metacognitive skills (judgments and questioning and self-advocacy).

Think Aloud Protocol (TAP): "Think-aloud is a research method in which participants speak aloud any words in their mind as they complete a task." (Charters, 2003, p.67).

Social Cognition: Effeney & Bahr (2013) explain that "models of [self-regulated learning] development are typically grounded in a social cognitive perspective in which intellectual development and social functioning are closely related and cannot be separated from the contexts in which they occur." (p. 58).

Reflecting on this description I related efforts to learn with or from an expert (a librarian) or other supports (peers, teachers) in the library to this perspective.

Taxonomy of Adolescent Metacognitive Knowledge: “13 attributes of metacognitive knowledge related to the information search process...[that] contribute to the understanding of adolescent information seeking behavior and have implications for information literacy instruction” (Bowler, 2010a, p. 27).

Information Search Process: A model created by Kuhlthau of “affective, cognitive and physical aspects in six stages of information seeking and use” (Research Matters, 2012).

Agency: Aspects of agency in boys are characterized by the International Boys’ School Coalition (*n.d.*), as encompassing: “freedom to develop their own voices,” “ask[ing]their own questions,” “problem-solv[ing]” and “think[ing] deeply.” These characterizations align well with the exploration of the development of capability in the library via verbalizing using Think Aloud, and with the metacognitive skills inherent in the research process as expressed by Bowler (2010a).

Epistemology: Beliefs about knowing. Hofer (2004) explains how this applies to judgements and effort pertaining to the use of information sources and/or search or help strategies.

Develop: Evidence of boys’ efforts to express ideas or reflections related to their research experiences, including thinking related to: emotions, problem-solving, questions and/or search strategies, and actions taken that may lead to a sense of capability or self-efficacy.

Introduction

Background

In teaching students in the library, I am mindful that what they learn with me is transitional to the post-secondary experience and that the library is a context where the student is developing an “academic identity” (Learned et al., 2009, p. 51). My experience working with Year 10 students is that, in the language of Crooks (2017), they are endeavouring, like the post-secondary students in university, to “make sense” and “find their place,” (p. 1). I was curious about the extent to which their spoken beliefs (and other aspects of metacognition tied to searching) were significant to their sense of self-efficacy as novice researchers. I wondered if the Think Aloud tool might assist boys in seeing how refining their thinking processes might help them succeed. I also wondered if the strategy might help to validate help-seeking from a librarian in the boys’ minds, which could, in turn, improve their sense of agency in an increasingly demanding learning context: the Upper School Library. My hope was that this action research might also help to inform the librarian/teacher partnership in building research and inquiry experiences for students that bring thinking and help-seeking out into the open in a mutually informative dynamic and, in doing so, empower students to be agents over their learning.

Action Research Question

How might the use of Think Aloud Protocol in a Physics inquiry develop self-efficacy in Year 10 boys?

Action Research Methodology

My focus was on how students think while searching to address a complex information problem. The search experience is a learning opportunity that is profoundly impacted by the attitudes and advocacy abilities of boys: how or if they question or judge information; how or whether they persist through difficulty, and if (and of whom) they ask for help. My hypothesis was that if a student became clearer on the challenges inherent in searching and was assisted in developing the strategies to notice and address those challenges in himself, he might then approach the exercise from a place of more confident capability.

Each information search, (the capability of the searcher, and the successes and struggles that emerge), is distinct. In light of this variety, gathering qualitative data via action research seemed the most appropriate means by which to characterize my observations and elicit themes that might be addressed in curriculum planning to the benefit of the boys' future learning.

The Literature Review

The urge to evaluate thinking, self-awareness, and self-advocacy issues perceived in secondary students in the context of a library co-teaching model was heightened by the work of Crooks (2017) and Hofer (2004), who address concerns relevant to the cultivation of personal epistemology, or beliefs about knowing, in post-secondary students. Hofer (2004) used Think Aloud in an examination of epistemology in the context of online searching. Studies using Think Aloud in Canadian school libraries to examine aspects of adolescent metacognition (Bowler, 2010a, 2010b; Branch, 2001), lent validity to my inquiry.

“What do I know?” “What have I consulted?” and “What do I need to know?” (Learned et al., p.46) are presented as questions students can ask themselves in a discussion of the value of instructional conferencing in co-teaching from the position of learning support, which is an optimal paradigm for librarians working with teachers at Upper Canada College. In that discussion, the purpose of Think Aloud in instruction is to “make cognitive strategies visible [and to] encourage students to appropriate this type of thinking as a problem-solving routine” (Learned et al., p. 49). Instructional conferencing, where Think Aloud recordings can be reviewed with boys, provide a context in which “students come to develop an academic identity, understand their learning needs, and advocate for themselves” (Learned et al., p. 51).

The work of Effeney et al. (2013) explored self-regulatory learning habits in a group of adolescent boys in a private school. The authors asked from where boys sought help to support their strategies and noted the place of “the social” as related to cognitive growth in adolescents as being of interest. The “social cognitive perspective” is presented by Effeney et al., citing Zimmerman and others. This consideration of where help is sought, from whom, and why, informed polyangulation of my data when working with students to explore their help-seeking patterns and the beliefs that motivated those patterns.

In a discussion of self-efficacy beliefs, Zimmerman and Cleary (2006) underscore the importance of the social in learning. They note, a student's "sense of efficacy can be either enhanced or lowered by the behaviors and/or feedback given by important individuals in their lives such as parents, teachers, counselors and peers" (p. 64). The modeling of strategies by these aforementioned "social agents" (p. 64) is seen to be important, which lent validity to the introduction of Think Aloud as a strategy in my research to improve help-seeking. Whether the boys, as growing agents of their own learning, found the strategy to be helpful was central to the inquiry.

Bandura (2006) explored adolescents' sense of self-efficacy as linked to agency. Again, the notion of belief is present, as it is in Bandura's discussions of epistemology: "Considerable progress has been achieved in documenting the positive role of self-efficacy beliefs in students' academic interest, motivation, management of academic stressors and growth of cognitive competencies" (p. 10), and "firm belief in one's self-management efficacy provides the staying power" (p. 11). Zimmerman and Cleary (2006), who also examined self-efficacy beliefs, make a useful distinction between self-concept and self-efficacy: "Self-efficacy beliefs are context specific judgments of personal capability to organize and execute a course of action to attain a set goal...[self-efficacy] focuses more specifically on the tasks or activities that an individual feels capable of performing rather than a more global assessment of 'how good you are at something' as provided in assessments of self-concept." (p. 48-49).

There is an established interest in examining students' thinking using the Think Aloud method. Valuable advice is offered as to how to use the method in a variety of ways to inform teaching (Charters 2003; Learned et al. 2009; Wilhelm, 2015). Charters (2003) presents the considerations for how to use the method effectively within a qualitative model, underscoring the dimension of a *protocol*, a set of regulated approaches for using this type of work, with adult students (in her context) to best effect. The studies conducted with adolescents in Canadian libraries informed both my use of Think Aloud and provided constructs to inform my coding and evaluation of data specifically aligned with that type of library research experience (Bowler, 2010a; Bowler, 2010b, Branch, 2001).

There is much to know and understand about how best to use the Think Aloud protocol and its benefits and limitations. Charters (2003) provides a summary of the history and application of the strategy, as well as an evaluation. Immediate and familiar applications are presented in the work of Branch (2006), Bowler (2010a, 2010b) and Wilhelm (2015). These studies gave me confidence that there was validity in exploring this approach with my students, albeit qualitatively and small-scale.

Kuhlthau et al. (2012) invite intervention into the work of student researchers in her "Information Search Process" informed by the Vygotskian concept of "zone of proximal development" (p. 20). Kuhlthau's work and approach were noted in a school library study that used Think Aloud (Branch, 2006; Bowler, 2010a). Furthermore, Wilhelm (2012) elaborates on the work of Vygotsky concerning the value to

students of strategically placed intervention. Bowler (2010a) explains the place of understanding metacognitive knowledge in library instruction as another dimension to consider when referring to Kuhlthau's well-respected Information Search Process model and developed a taxonomy as an outcome of her study of "talk as a metacognitive strategy" (p. 27). Bowler's work is most significantly aligned to this action research in that it took place in a school library and addressed aspects of epistemology and facets of adolescent metacognition central to the research or inquiry process. Brookhart's (2011) work also informed the analytical stages of this action research. It explains the value of cognitive taxonomies as useful in learning about "the ways in which students use their knowledge and skills in novel situations" (p. 57).

Research Context

An International Baccalaureate World School, Upper Canada College in Toronto enrolls 1,170 boys in Senior Kindergarten through Year 12, including 88 boarding students representing 26 countries. "Grounded in its mission to deliver transformational learning experiences, the school fosters the development of head, heart and humanity, and inspires each boy to be his best self" (Upper Canada College, 2018). The strategic directions of our school are learning, community, wellbeing, pluralism and service.

The participants in this study were Year 10 boys completing the final year of the Middle Years Programme, (MYP) in preparation for the Diploma Programme (DP). The skills taught in the MYP (referred to as "Approaches to Learning") are an ideal context for instruction and formative assessment of developing abilities in the areas of research and thinking, and "help to prepare students for theory of knowledge in the DP," wherein aspects of epistemology in the learner can be developed (International Baccalaureate Organization, 2014, p. 73).

Units of inquiry central to the MYP provide ideal contexts for the integration of library skills. I had experience working on the chosen inquiry unit in Physics (see Appendix 1), during which the teacher and I identified opportunities to teach boys about better approaches to researching a complex information problem inclusive of epistemological skills, metacognition, and help-seeking. The teacher (and Theory of Knowledge Coordinator at our school) was enthusiastic about, and receptive to, a discussion on how to best prepare students for the DP in my context. The invitation to participate was extended to all students in the class, and consent forms were completed by parents and/or boarding advisors who served in "loco parentis." The boys were invited to participate with the proviso that they could opt out at any point and that the work completed in the study would have no bearing on their assessment in the course. All the boys' identities remained confidential in the production of the findings and materials, and wherever possible the boys' names were replaced with letters, and/or they gave anonymous feedback, to minimize bias.

The Action

Ten boys participated in the study, three of whom were boarders. Nine boys were present at the school in the year prior and took *Canadian History* in which they were taught library skills by me, so a baseline of research ability was assumed. No differentiation on the part of the librarian was applied; all students received the same instruction and the same access to resources. Two students were referred by the classroom teacher to the librarian for support after the TAP experience, which may have had an impact on their success.

Two library classes were conducted. Familiarity with how our librarians approach research instruction was assumed. During the first class I introduced the supporting LibGuide, an online guide that curated information about the inquiry topic, and reiterated the overarching research question: “How do science and technology interact to change culture?” I reviewed the Information Search Process model (Research Matters, 2012), impressing on students the value of asking for help when needed, the likely points of struggle, and the place of self-assessing progress. In reference to this model, I validated the place of emotions in the research experience.

Next addressed were the component concepts and research contexts relevant to the question: society, culture, technology, and physics as related to electromagnetism. Some flexibility regarding the specific topic of focus was permitted. The teacher had given a topic list to the students prior to the library classes and some discussion of the unit requirements had taken place, including a review of what should be researched to inform the article that students were to write. (Appendix 1) I showed a video demonstration of Think Aloud Protocol (LCCAlice, 2014), followed by a brief discussion with students of “what happened.” The students received a handout with instructions on how to engage with the protocol, (see Appendix 2) and also received a small tent card with the wording “Keep Talking!” to place on their monitors.

The guidance given was based on the work of Charters (2003) and Wilhelm (2012) in terms of modeling and encouraging continuous verbalization. Two 10-minute opportunities were given to work with Think Aloud, one in the first class and one in the second. The expectation was that the boys would use the unit LibGuide as the research context for the observation. Normally, the boys would receive instruction that included: validation of help-seeking, the place of emotions in research, the requirement to use the LibGuide, an explanation of search strategies and how to engage with suggested sources. What was new was the capture of, and self-reflection on, the boys’ thinking post-instruction as they worked for themselves to solve the information problem.

Data Collection

Data were gathered at three stages: before the action, to get to know the research participants, during the Think Aloud exercise (using QuickTime and with iPods when using print; the recordings were learning tools as well as a source of data), and post-action through interviews and reflection as part of the inquiry process, and in the context of their assessed work. Pre-action, the Children's Self-Efficacy Scale (CSES) was delivered to nine participants in order to ascertain (to a degree) how capable they felt working in the library and with academic tasks that were similar in nature to those often required in inquiry units. Without a tool to assess capability with the breadth of library research skills, this seemed a reasonable baseline for assessing how capable the boys felt with these, and other, academic skills.

After the classes, participants were given the opportunity to participate in a 15-minute interview regarding one student-chosen TAP recording completed in either of the two classes. Five questions were asked of each participant, which focused on: feelings, strategies, decisions, judgments, plans, observations, or questions that the student felt were significant to him. Questions related to the student's perception of Think Aloud as a learning strategy were asked.

A final survey was conducted once the students had received their assessed work. This survey was reflective in nature and asked questions to see if students were clear on the respective roles of classroom teacher and librarian, whether (and of whom) they sought assistance, and whether they could relate from their research experience to a statement characterizing agency in the library. Students were asked if using Think Aloud resulted in them asking for help at any stage of the process, and if they self-elected to use it again for any purpose.

The variety of questions posed via a range of methods at different stages served both to polyangulate the data and to capture as many authentic and credible perspectives as possible on the boys' experiences. Student bibliographies were analyzed to ascertain whether or not the teacher's expectations regarding the use of academic sources were, or were not, met.

Data Analysis

Data collected during the recordings and interviews were coded using Bowler's *Taxonomy of Adolescent Metacognitive Knowledge* (Bowler, 2010a). It was clear that Bowler's taxonomy is relevant to curriculum design and assessment as the coding process was seamless and all but one category was represented in the students' work. A range of student ability across the taxonomy and other determined criteria, with a group of learners who share some things in common (age, prior experience in the same school, subject context), was apparent. The sample of results in the bibliographies students produced demonstrated a general tendency to use web content, some of which was scholarly in context and/or tone, and some of which was more informal and was reflective of the type of source use that had been discouraged by the teacher. Library databases were used to a lesser extent than web searching. The curated print collections were used minimally.

Discussion of Findings

As a preliminary set of findings, Bandura's scale (2006) served to characterize the participants' sense of capability with relevant skills. It appeared that they felt confident tackling a range of tasks that are characterized by Bandura as "difficult for students" (Children's Self-Efficacy Scale, n.d., p. 326). The data most connected to self-efficacy in libraries or similar domains varied. The most relevant item: "use the library to get information for class assignments" also varied. The boys largely scored highly on the item. "get teachers to help me when stuck on schoolwork," and on, "live up to what my teachers expect of me," although the question might be asked as to whether the boys regard librarians as teachers per se. The large majority of boys also scored highly on, "Learn to use computers." I noted the item, "Get my parents to help me with a problem" as related to the idea of social cognition; the data there were highly scored with one exception. The findings that follow appear somewhat contrary with the groups' self-assessment. Evident in the coded data was a recognition that there was scope for learning, and an awareness among the boys of the challenges of researching by and for themselves. The opportunity to witness the challenges seemed to be a meaningful experience for some boys.

In addition to reviewing the interviews for themes, the application of Bowler's taxonomy (2010a) in coding the Think Aloud recordings helped to characterize the specific metacognitive engagements of the boys and to align those with aspects of agency. The following discerned themes indicate that the Think Aloud Protocol was useful to the boys in information problem-solving and, in both guided and self-directed circumstances, provided a context for the boys' reflection and evaluation of next steps.

Indications of Self-efficacy

Most boys made statements that were indicative of developing self-efficacy in their library lessons. However, I noted few explicit efforts to ask for help or connections to social cognition, none of which involved a librarian. The learner's voice and commitment to effort were clearly present in many recordings. A number of expressions of emotion were noted, from confusion and frustration (one boy intoning "this is haaaard" but regrouping and persisting), to excitement and sense of victory. Vocalizing emotions was seen to be a positive indicator of developing agency, in that the boys felt comfortable being honest with themselves about struggle and success. Others expressed the need for persistence: "Let's keep on looking" and "might not be ... good but I will still give it a try." A few verbalizations of epistemic concerns were noted, inclusive of observations regarding reliability or credibility of sources and regarding going into more sophisticated research terrain. One boy noted the value of looking at the curated print collection and another noted, "I want to search something complex ... something I can flesh out more because it makes a funner [sic], better experiment, instead of like understanding it beforehand." Two boys made clear epistemic references: "These judgements help what I'm going to do in the future ... decide whether this is a good source or not ... decisions is [sic] kind of like interlinked ... all significant," and "sometimes after saying it, it forces you to take a second look over that ...and actually think about whether you want to use a source or not," and also "just making sure I am conducting an unbiased search not just affected by what you were feeling that day or the focus you had that day." Another boy evaluated his own voice retroactively, noting a lack of eloquence, "I could have maybe done a better job of voicing exactly what I was thinking."

Challenges with Think Aloud

While valuing the exercise, the boys also remarked on challenges. One boy found thinking aloud to be a distraction: "made me think too much about talking and made it harder to retain information" Some remarks may have related to a sense of capability as the boys used language related to comfort, confidence, privacy and reluctance to have others review their thinking. One challenge was practical in nature, suggesting using earbuds to minimize distraction from other boys' voices while the class thought aloud together.

A noted phenomenon was the tendency of the boys to have a conversation with themselves as they were thinking aloud, characterized by stream of consciousness, and by demonstrative "as you can see" statements (as if presenting to an audience by whom they might be evaluated), rather than as a capture of spontaneous thought to serve their own agentic learning. This may have related to being challenged by (or less used to) expressing unadorned "raw" thinking that could be viewed by others, although that was not explicitly said by any student.

The context of the library, where Think Aloud was conducted challenged some: “I might not always be in a good environment to think aloud ... most likely at home would be a good place for it,” or “I would do it ... if it was in an environment that allowed me to do think aloud and I was comfortable,” and again “[I would use TAP] in my dorm because I feel like it is a fairly private and confidential thing ... I don't necessarily want other people to know what my thought process is ... I would conduct it by myself ... I still feel like I will feel more comfortable if it stays with myself,” and finally a succinct, “maybe at home.”

Making Choices

Some boys were assisted in making choices and in planning by the use of Think Aloud. Less clear, was the utility of Think Aloud in prompting the act of asking for help. No boys sought out a librarian during the exercise itself; however, two were sent by their teacher after the fact. The boys who disclosed that they sought help during the unit asked their classroom teacher or a parent. It was not clear that TAP was connected in any way to those actions or if the help was related to research. One student noted, “I want to, like, find you for help with using the library better or more wisely,” (however, he also noted that he felt he would have done this anyway, without the assistance of TAP).

When coding the recordings, I noted, in addition to applying Bowler’s taxonomy, any “screen action,” or navigational tactics, i.e. remaining static, (no movement of the mouse), abandoning LibGuide for Google, and rapid or erratic movement of the mouse. Each student used a range of screen actions while thinking aloud; a systematic and strategic approach to “moving virtually” while researching was not apparent. It was noted that a number left the LibGuide and moved to Google or to the course documents, seemingly needing to build a rationale to return to the LibGuide as a context for initiating research. One boy noted Think Aloud as connected to planning: “verbalizing my strategies ... [having a] clear image of what I should do ... [developing] an incremental plan.” In the area of noting next steps, planning post-TAP review there was a range of responses from: “ha ha ... let me ... next steps ... I ... I don't really have an answer for that,” to “going to do more in-depth research ... motors [are] pretty interesting ... [I'm] able to grasp a good preliminary knowledge.” As an indication that evaluating his approach was important, one boy stated: “Sometimes I mention things to myself about the searching ... this would be a more proactive approach as I have a habit of oversearching.”

Meaningful Learning

Some boys noted the Think Aloud experience as meaningful learning for them. Expression of value was evident: “Oh yeah for sure ... it was a valuable experience for me,” and “because you are doing a recording you think a little bit more and after watching it especially too.” Skill was evaluated by boys: “Now that I have some experience searching the databases, some of the stuff now looks like I didn't really know what I was doing,” and, with an indication that he knew of one advised strategy, “maybe I should

have tried to use the search a bit more to be honest ... like trying to use those subject headings.” One student asserted the utility of TAP to another course: “I really hope that this TAP can be implemented in the American History curriculum,” and another felt he would have acted similarly without the use of Think Aloud. A boy validated the opportunity to work with more depth: “[To] verbalize my unconscious thoughts giving an opportunity for me to better understand the thinking process,” and related the practice to reading: “Skimming through all those ideas about the source you think a bit deeper because you said them out loud.”

Conclusions

The findings in this study support the assertion that the modeling and facilitation of Think Aloud Protocol were of value in cultivating research self-efficacy, as fundamental to agency, in the boys. I am curious as to whether assessing Think Aloud work with boys as regular practice (perhaps as homework given their cited concerns with privacy) or allowing boys to assess themselves while using the taxonomy (and in consideration of social cognition) could also strengthen agency by providing a scaffold for a self-directed growth plan: Wilhelm (2012) engaged young students in coding their own data as a learning experience. I also wonder if fulsome regular discussion of the emotions and vulnerability inherent in capturing authentic thinking would be of value in strengthening the boys’ sense of self-efficacy as researchers and if this is hampered by the librarians’ relative physical and relational isolation from the boys. (A review of relational teaching approaches (Reichert & Hawley, 2014), which are inclusive of librarians may be of benefit to the learning dynamic.) Based on this small, yet rich, snapshot of data from ten boys there is indication that boys’ emotions and vulnerability in research is compelling territory to explore. The complexity of the boys as learners and the challenge of the learning task to the boys was clear in the data. There is scope for teachers and librarians to engage in formative assessment of TAP recordings with boys, an outcome of which may be a greater inclination to ask for help, on their own terms, outside of the classroom. In this study, it did not appear that boys could arrive at that next step without guidance.

The MYP Information Literacy statement encompasses skill clusters that include critical thinking, (International Baccalaureate Organization, 2014) but lacks a detailed inventory of the metacognitive skills required in proficient searching and information problem solving. As two of the Approaches to Learning assessed formatively in the MYP, “Research” stands on its own, as does “Thinking.” There is potential for an intersection that may, when assessed and validated as a significant component of research, serve to improve students’ sense of agency in library use. Bowler (2010a) asserts, “perhaps librarians need to teach students to think about their own thinking” (pp. 38-39). If we adopt this expanded understanding of the role of the librarian in teaching boys, we may find that guided agency is as important to the development of their “academic identity” (Learned et al., 2009 p. 51) as guided inquiry.

Reflection Statement

As a learning support Teacher Librarian (rather than classroom teacher) the practicalities of conducting action research were at times a challenge and something of limitation in this study. It is clear how day-to-day relationships and sustained time with students can be a significant factor in engaging boys in projects such as these. Nevertheless, this small study yielded rich data that were meaningful for the student participants and for me as a practitioner. In our context, this study could serve to underscore the value of teachers allowing for more purposeful, co-planned, and assessed time in the library, adding a new dimension to the teaching role of the librarians in our school. As a result of this action research, I have already adopted a “student viewpoint” approach to my pedagogy in teaching search strategies, in that I ask students first how they might approach a task, and then co-evaluate and model rather than beginning with “telling them how.” Themes are emerging in research class interactions that mirror the findings here, and the boys’ observations are opening the door to their consideration of their part to play in their own success. It is too early to tell if there will be a culture shift around help-seeking connected to this approach, but I am hopeful!

The experience of learning the finer points of action research methodology under the guidance of Team Leader Janetta Lien and mentor Barbara Kawasoe has been professionally enriching and such a pleasure. I am grateful for the supportive expertise of both, and for their good humour, encouragement and kindness. Thank you to Professor Leanne Bowler for her kind permission to use her taxonomy in the coding of the data, which proved so helpful in arriving at the findings. I am also grateful to Mallory McKinney, Ryan Archer and Lincoln Smith for their collegial investment of time and expertise and for their practical and unwavering support. It was wonderful to have the perspective and input of Tony Gomes, former IBSC Action Research participant; so helpful to have a “graduate” present in our school. Thanks also to Physics Teacher and Theory of Knowledge Coordinator Chandra Boon, for her enthusiastic interest in the research question, and for her flexibility in working with me to adapt the unit to accommodate my project. Finally, thanks to the group of boys who worked with me in Year 10 physics; it was a rich learning experience! Much discussion is already taking place in our school in the domain of teaching thinking and there is curiosity from my colleagues about this study. I look forward to sharing the findings and to the work ahead in fostering boys’ agency in our library!

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APPENDIX 1

Year 10 Physics Project Document, Chandra Boon, Upper Canada College

Electromagnetism – The Project

How do science and technology interact to change culture?

Science – the field of study that attempts to describe and understand the nature of the universe in whole or in part

Technology – the application of scientific or other organized knowledge - including any tool, technique, product, process, method, organization or system - to practical tasks.

Society – A group of people who have a common homeland, are independent, and share a common culture.

Culture – The ideals, values, and beliefs members of a society share to interpret experience and generate behaviour.

Technological innovation is one factor that can cause social and/or cultural changes.

The Task:

You will **write a journal article** in which

- you research a specific application of electromagnetism and explain how it works (or how some aspect of it works)
- you explain the social/cultural impact of the application
- you seek an answer to the guiding question

Format

The article will be written in a Microsoft Publisher template and saved as PDF

- 3-4 page spread, including relevant images/diagrams
- Make sure the font is not too small because we will compile the articles into a class magazine
- Your **research process will also be assessed**. It is very important that you **do not plagiarize**.
- Use **APA format** for your bibliography and **in-text citations**

Here is a link that will guide you through the **structure of a magazine article**:

<http://www.bbc.co.uk/bitesize/ks3/english/reading/structure/revision/2/>

Requirements

- An effective introductory paragraph in which the specific application is identified
- Detailed explanation of the scientific and/or technological innovations that led to its development, highlighting the role of electromagnetism
- Detailed explanation of how the application works, highlighting the role of electricity or magnetism or electromagnetism
- Detailed explanation of the scientific and/or technological innovations that arose from the application (if possible)
- Detailed explanation of the benefits to individuals and/or society from the application
- Detailed explanation of the risks/problems to individuals and/or society from the application
- Detailed explanation of the extent to which the application caused (or will cause) social/cultural change?
- Detailed explanation of ethical or economic implications of the application (choose either ethical or economic).
- An effective concluding paragraph.

- Only **relevant diagrams/images** should be included
 - The figures must be numbered with captions.
 - Figures are made **relevant by referring to them within the article**

Topics for Research

1. The telegraph
2. The motor
3. Hydroelectric generator
4. Wind generator
5. The transformer
6. The electromagnet
7. Magnetic information storage (computers)
8. Mag-Lev trains
9. Telephone
10. Cell phone
11. Television
12. Video and audiotape recordings
13. Record player
14. Magnetic confinement and International thermonuclear experimental reactor (ITER)
15. The automobile
16. The brain pacemaker (deep brain stimulation)
17. Radio
18. Bionic limbs
19. Digital camera
20. Mine Detector
21. Tattoo machine
22. Robotics
23. A topic you propose

Possible Resources

1. <http://www.astro.virginia.edu/class/oconnell/astr121/guide09-s04.html>
 - Explores science, technology and society; contains a history of electricity section
2. <http://www.yale.edu/ynhti/curriculum/units/1999/7/99.07.07.x.html>
 - Looks at the relationship between technology and social change
3. <http://www.yale.edu/ynhti/curriculum/units/2003/4/03.04.07.x.html>
 - The physics of cell phones
4. <http://www.magnet.fsu.edu/education/tutorials/index.html>
 - National High Magnetic Field Lab website with a very wide range of information
5. <http://www.popsci.com/archives>
 - Popular Science archives (137 years!)
6. <http://www.peep.ac.uk/content/553.0.html>
 - Physics, Ethics & Education Project

Think Aloud Protocol (Student Instructions)

Purpose:

Think Aloud Protocol can serve as a learning tool to capture and observe thoughts as a learner completes a problem-solving task. The learner verbalizes all of his/her thinking as a task is undertaken, records that verbalization and then has the opportunity to review what happened and to reflect and/or to self-assess.

Approach:

As you undertake the problem-solving task, consistently verbalize (speak, talk) any thoughts that you have. These can include (but are not limited to):

- feelings
- strategies
- decisions
- judgments
- plans
- observations
- questions

Do not worry about sounding “correct” or proficient, this is not a test, it is just an observation.

Just keep talking!

Recording Instructions:

To begin:

Type *Shift Command 5*

Choose built-in microphone, Quicktime, click record

You will be prompted by a teacher to stop recording after 10 min

To stop recording: Shift Command 5, click on button to stop recording

Save your recording on your desktop and wait for instructions.