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Motivating female students in technology education: Staying and thriving on the Technology Education pipeline of STEM

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Vicki Knopke completed her PhD at Griffith University, Qld, Australia. Her research was focused on primary technological literacy and then Secondary Education, Teaching Methods and Curriculum Theory and Gender in Technology Education. We acknowledge her contribution to the field of technology education. She will be sorely missed. Editor

Abstract

Learning is an active process that functions optimally when student's motivation is autonomous. This paper will critique elements of motivation that impact on students' engagement in Technology Education subjects with an emphasis on female students in senior secondary years of schooling.

After interpreting Technology Education and motivational factors, the critique will examine elements identified by various authors as those which motivate modern day youth to engage in non-compulsory education. In fact, the origins of personal and group motivation need to be explored in terms of how youth utilise self-values to engage in practices that schools program for them. Of particular interest are the steps taken by schools to engage females in technology centred programs. Australian data show that young female learners are not articulating through to Mathematics, Science, Engineering, or Technology (STEM) classes and in turn not enrolling in tertiary courses such as Engineering.

The critique takes a feminist constructionist view and will draw on research undertaken in senior secondary schools in 2013. Earlier studies have claimed that the artefacts to be made and freedom of choice in the learning process had the most effect on the motivation of students as participants in Technology Education. For some students these elements have affected their intrinsic motivation by expanding their reflectivity and feelings of autonomy. By providing an apparent freedom of choice in materials, techniques, and products to be made, student motivation appears to rise.

In examining the research studies on what motivates youth - values are seen to be inextricably linked to the interests and motivation of both individuals and groups. Thus, values will be explored in the context of educational settings of students in the secondary years, with a focus on Technology Education.

The implications of the findings in the paper will provide practitioners with strategies to alter the ecology of classrooms for female participants in Technology Education programs in the long term. Those strategies are not about plugging the leaks in the STEM education pipeline, but rather about

building a gendered pipeline where girls feel at home doing Technology regardless of whether their school or class is co-educational or single-sex.

Keywords

STEM; technology education; motivation; females; youth.

Introduction

This paper explores elements of motivation that impact on students' engagement in Technology Education subjects. It is posited that learning functions optimally when students' motivation is an active and autonomous process. The focus stems from a research study on factors that influence the participation of female students in the senior secondary years of schooling and the outcomes of the study (Knopke, 2015).

In examining elements which motivate modern day youth to engage in non-compulsory technology education the origins of personal and group motivation have been explored in terms of how youth utilise self-values to engage in technology education practices that schools programme for them. Of particular interest are the steps taken by schools to engage females in technology centred programmes. Australian data, in line with European data, show that young female learners are not articulating through to Maths, Science, or Technology classes into STEM related tertiary fields (Bøe et al., 2011, Parliament of Australia, 2012). Despite the long-term goals of educators, females are still not enrolling in senior secondary Technology courses that will lead to tertiary courses such as Engineering, Mathematics or Technology Studies. The figurative pipeline mentioned earlier refers to the point where students commence in Technology Education and then continue to engage along a continuum of studies related to Technology with a view to a post-school pathway. Given that all students in lower secondary high school (Years 7, 8 and 9 in Queensland), participate in some studies in Technology, female students need to be encouraged to remain in this learning pipeline and to strive to reach senior secondary levels and beyond in order to have input into the engineering community.

Technology has been defined as the innovation, change or modification of the natural environment to satisfy preconceived human needs and wants (International Technology Educators Association (ITEEA), (Association and Project 1996, Association, 2006). Technology education, as a context, encompasses all subjects that have design processes as the key learning activity. In the Australian context subjects such as agriculture, business studies, industrial arts and design, graphics, home economics, hospitality, information and communication studies, technology studies and engineering studies, fall into this definition. Whilst there is currently much debate surrounding the term, it links to past and present syllabus and curriculum practice in the Australian education system.

ACARA (Association and Project 1996, Australian Curriculum Assessment and Reporting Authority) under the 2008 (Gillard, 2008) Act have developed the technologies syllabus for Australia requires that students engage in technological capabilities and with technological and computational thinking (Australian Curriculum Assessment and Reporting Authority, 2012). Less of a definition, but rather a concept which is not centred on objects but focused on capabilities those students will achieve.

The social constructionist view used in this paper is defined by Shotter and Gergen (1994) cited in Potter (1997).

> [Social constructionism] has given voice to a range of new topics, such as the social construction of personal identities; the role of power in the social making of meanings; rhetoric and narrative in establishing sciences; the centrality of everyday activities; remembering and forgetting as socially constituted activities; reflexivity in method and theorising. The common thread underlying all these topics is a concern with the processes by which human abilities, experiences, common sense and scientific knowledge are both produced in, and reproduce, human communities. (p. i)

A feminist constructionist stance which sees gender as a construct that is not created by nature as a result of biology but rather created by and contingent on social and historical processes (Stanley, 1993; Oldenziel, 2003; Restivo & Croissant, 2008) is adopted in this paper. To prepare students for the future, technology educators must seek alternative ways to conceptualise their subject matter to reach the diverse population of citizens in society (Wright, 1992). Technology educators must rethink the way in which they legitimise the knowledge of technology education for students in order to meet their needs and wants. Wright stated the social commitment must legitimise the principle of difference, to encourage and multiply different kinds of people and positions and values for their own sake, within the bounds of social order. It is through the legitimacy of difference that new and necessary forms of rationality will emerge and a motivation to engage will occur.

In examining the literature on what motivates youth, values will be explored in the context of educational settings of secondary school students, with a focus on Technology Education.

Motivation through values

Motivation is defined in the broadest sense as 'the process whereby goal–directed activity is instigated and sustained' (Pintrich & Schunk, 2002). Values, argues Rokeach, have a motivational function: to guide human activity in daily situations, their more long-range function is to give expression to basic human needs. Values' components include motivational, cognitive, affective and behavioural elements. Instrumental values are motivating because the idealised modes of behaviour they are concerned with are perceived to be instrumental to the attainment of desired end goals. Terminal values, according to Rokeach (1973), are motivating because they represent goals beyond the immediate, biologically urgent goals. They are the conceptual tools that we employ to maintain and enhance self-esteem. Terminal and instrumental values are relevant when considering types of behaviour students engage in in classrooms.

Values that are internalised as a result of cultural, societal, and personal experience are psychological structures that, in turn, have consequences of their own (Rokeach, 1973). Klapwijk and Rommes (2009) note values in their use of the phrase 'career anchors'. Values are determinants of all kinds of social behaviour: of social action, attitudes and ideology, (Schunk et al., 2012) valuations, moral judgements and justification, comparisons and presentations of self and others, and attempts to influence others.

A person's actions may then vary depending on the priorities they place on social and personal values. Their actions will vary depending on whether their social or personal values have priority. An increase in one value may see a decrease in the opposite, that is, social or personal. Personal values arise from participants in relation to their learning within technology classrooms and how they interact with artefacts on a daily basis. Terms such as personal and social ambition, self-control, capability, imagination and independence can be identified by participants in terms of which particular aspect motivates them to succeed (Knopke, 2015). Pavlova and Turner (2007) examined the critical issue of values in Technology Education and discussed the design process as a starting point for internal and external values. Custer (2007) argues that values and Technology are intimately connected.

> In the modern world, it has become virtually impossible to disentangle technology, in its variety of forms from ethical implications. Ethics and values shape and drive demand of new technologies. New technologies in turn mirror and reflect what we value. The two have become inextricably woven together. (Custer, 2007, p. 139)

A value system is thus defined as an enduring organisation of beliefs concerning preferable modes of conduct or end states of existence along a continuum of relative importance. Rokeach (1973) says that values, like all beliefs, have cognitive, affective and behavioural components.

Feminist constructionist view

This paper takes a positivist perspective in unearthing the voices of females in technology education. Modern socio-cultural liberal feminism and awareness of gender issues enables young women to move past their historic roles in society to achieve some degree of equality in learning. It is awareness and a willingness to achieve that is sustaining a change in the inputs and context of the Technology education pipeline.

Socio-cultural approaches to learning provide instruction which recognises and empowers linguistically and culturally diverse students. Socio-cultural theory describes learning as distributed, interactive, and contextual and the result of a learner's participation in a community of practice. Bernetein's (2003a , b) papers suggest that it is the collaboration of thinking that results from these processes opens up access to research data on thought processes and provides avenues to uncover distinguishing characteristics that can lead to change and transformation.

Learning within a techno-social sphere may be the best environment for females. Bijker (1995) claims that there is a process of closure, reflecting on aspects of technical change and stability over time which shows that everything can fit into a technological frame comprising knowledge, goals, and values as well as artefacts.

Postmodernist theories such as Wright's feminist theories encourage diversity in their view (Wright, 1992). Feminist theories, like other forms of postmodernism, encourage us to tolerate and interpret ambivalence, ambiguity, and multiplicity as well as to expose the roots of our needs for imposing order and structure. If we do our work well, reality will appear even more unstable, complex, and disorderly than it does now (Flax, 1990). Zuga (2007) suggested that both postmodern and feminist theories point to diversity as a direction for the future. These theories provide some of the ideology for Technology educators' avoiding a restricted cultural view and creating change in the profession.

The research of Zuga (2007) and Wajcman (2004) has examined the stigma of artefacts and highlighted the sociotechnical constructivist approaches born of, but modified from, social studies of Technology. It was the characterisation of Wacjman's 'techno-feminist' which represented a major development in theorising the gendered character of Technology. Haraway's cyborg-feminists and socialist feminist inquiry was pivotal in exposing the gender blindness of main stream techno-science studies in order to show the possibilities this area offers women and how they could strategically engage with Techno-science within Technology (Wajcman, 2004).

Recent studies have claimed that the artefacts to be made and freedom of choice in the learning process had the most effect on the motivation of students as participants in Technology Education (Bøe et al., 2011; Thaler & Zorn, 2010). Authors such as Campbell and Jane (2012) have demonstrated that for some students, elements of individual choice have affected their intrinsic motivation. By expanding the amount of internal feedback, their feeling of high levels of autonomy, choice and self-direction, providing an apparent freedom of choice in materials (autonomy), techniques, and products to be made, student motivation appears to rise through more active engagement and a willingness to persist. Similarly, Autio (2013) claims self-confidence and expectations for success give value to the options available to females who are studying in Technology Education today.

In order to bring about change, the approach must be to raise the consciousness of gender and the feminist uses of the construction of ideas and the delivery of programmes in the broad area of Technology Education. Biological differences between sexes do not determine gender, gender attributes, or gender relations. Gender, is a constitutive social construction, a social category whose definition makes reference to a broad network of social relations, not anatomical differences (Hacking 1999). Motivation can be championed through pedagogy that suits not just girls but many boys who are themselves not a single homogenous group (Haslanger, 2005) .

In exploring the perceptions held by students, technology education continues to be perceived as masculine in nature, procedural in delivery, and lacking conceptual dimension. Such an enduring perception serves to restrict female interest in the subject (Dakers et al., 2009) . Similarly, Klapwijk and Rommes (2009, p. 406) note the problem with the stereotypes “that women prefer working with people and men with things – that if we repeat [them] often enough [they] become the norm…. Repetition makes it impossible to loosen the unilateral connection….”

Research studies suggest that motivation can be raised through addressing technology education as a positive concept which they (females) come into contact with often and hence develop skills and knowledge. Frequency of exposure and role models can be the link between technology and femininity (Daker et al., 2009; Kolmos et al., 2013). Wajcman (2004) would say this links back to a masculine definition of Technology.

Motivational strategies and gender

The following provides possible strategies for increasing participation of female students through the participant observation research undertaken in three senior secondary schools.

Social values

If females are provided with more knowledge of how careers in the STEM fields could be a vehicle to enact altruistic goals and values, they would be prepared to undertake study along the STEM pathway (Colvin et al., 2012). Social values are ranked highly by female students. Women are attracted to careers that help and work with people and enact communal goals. Knopke’s (2015) research in secondary schools in Queensland has shown that values can and do motivate students in technology education classes. Values motivate female students more so than male students. Internal and external values as noted by Pavlova and Turner (2007) come into play at different points of learning for students. Instrumental values meant more for students starting in technology education classes. Learning for fun or for life skills was important to begin with. As students matured over time the terminal values of life and career goals came into play and the purpose for participating in technology education classes changed. Driven by internal values students were self-motivated to achieve in order to reach their end goal.

Self-efficacy

Self-efficacy is a second strategy in motivating female students in technology education. A belief that one has the capabilities of exercising courses of action to manage certain situations has been seen as a positive predictor of achievement in task specific goals and success for women in non-traditional career areas. Cognitive and metacognitive skills focusing on self-efficacy provide motivation to learn. Marra et al. (2009) examined positive outcomes that were achieved with women to understand student satisfaction, achievement and ultimately, retention in engineering programmes. Influencing environments, in turn, sustained persistence and enabled mastery experiences in complex design projects through strategies of instructional demonstrations and encouragement. Positive success led to long term participation. This is the same factor that the research found for younger students in the senior secondary context. Students who achieved degrees of mastery of skills became more persistent and resilient in learning within the Technology education course of study, becoming leaders within their peer group (Knopke, 2015).

Level of challenges

Self-regulation and the level of challenge females set themselves, the amount that students mobilise and persist in the face of difficulties comes back to the level of self-efficacy, and the confidence and support provided by both peers and teachers. Ultimately the level of success and self-satisfaction achieved in the design task for a project was the motivational factor for the students. The work of Dweck (1986) could shape further investigations in this area; however the female students in the case studies did not see difficulties as negatives but rather challenges they would investigate and overcome. The female students appeared to set themselves high level complex tasks within the assigned projects and they worked to attain standards that rivalled the top male achievers in the classes (Knopke, 2015).

Process or product

The process of transmission of technology, the use of aids and the pedagogic interest which an artefact or object creates can be questioned in terms of a balance point of view with regards to gender. Process or product can make a difference to the motivation of female students. Not all teaching devices are viewed as neutral and females are more sensitive than males to study aids; they will use more creativity and inventiveness and take more risks than boys on items they are familiar with. Perhaps there could be a reuniting of females with Technology through changing approaches. Feminising the pedagogy with habitat, clothes, inventive and creative skills, and informal learning interactions may, in the long term, attract more females.

One for all: All for one

One school in the research study motivated students to a higher degree than others (Knopke, 2012). Competition to gain entry into the technology education classes began in Years 8 and 9. Students were taught to excel via an encompassing school culture. The essence of achieving was to not only gain great personal results but to uphold those averages of all the fellow students in a year cohort and keep the school as an academic lighthouse. A discussion with one boy was about his potentially letting the cohort down and how hard he needed to work not for himself, but for his peers. His determination demonstrated how important this was as a motivational factor for students to consistently produce high quality work. The self-efficacy notions of Marra et al. (2009) have proved through the research study to stand true in what remains a non-traditional area of learning.

In elaborating on the findings from the research study, terminal values and career aspirations were a key factor that motivated students in the classes. The second factor that heightened participation and, in turn, motivation was choice of design tasks. Freedom to select what an artefact would appear to be important to the students. Once the female students made a design choice they were rarely swayed from that decision. Once they understood the task, they are able to project manage, plan and then execute the task. This does not imply they personally completed all the steps but they are able to plan to have them done to reach the outcomes they aspired to. The research viewed the final practical artefacts as well as the written presentations from each of the students. The products exceeded any that were viewed in other similar learning contexts in the other sites in the study.

The pedagogical approach of the teacher in the context of the classroom ecology was the third factor that motivated the female students. A relaxed working atmosphere where students shared ideas, learned from one another, and collectively solved design problems added to the independent drive of students in the classes that were observed. Teaching for critical thinking was discussed in a number of the research sites during the study. A recent study by Muirhead et al. (2016) claims that students may be more motivated if they use critical thinking to improve problem solving abilities, enhance their decision making skills and be more effective team members and leaders in their area. The challenge says Muirhead et al., is how to organize the diversity of critical thinking ideas and concepts. Lai (2011) suggests a paradigm with three areas: abilities, dispositions and background knowledge.

1. Abilities: examine arguments, use inductive and deductive reasoning and problem-solving skills.
2. Dispositions: confident, flexible, determined, open-minded, relies on reason and intuition, discerning, curious, creative, seeks knowledge, considers different perspectives, has intellectual integrity and concern for equity.
3. Background knowledge: good working knowledge of subject area, evaluate ideas/problems using appropriate criteria, able to explain and apply knowledge

These attributes provide a picture of elements that frame a critical thinker. They are those which are identified foremost in female learners. If educators limit the opportunities for female students to develop and use their critical skills (reflectivity) it will impact on the potential they have in their course work. There is much research still to be done in this area.

The presence of female technology teachers was a supporting factor in motivating female students to take on technology and academic challenges within technology and to succeed at them (Knopke, 2015). The female staff members often taught the younger classes but did contribute to the energy and the social dynamics of the technology workshops where the senior female Technology students were engaging. All students appeared to value the female staff member's opinions and this added to the collective, shared problem-based learning which occurred at the site.

Concluding remarks

The findings send a message to practitioners in the post compulsory area of senior secondary technology education. There are strategies outlined that may assist teachers to revisit and alter the ecology of their classrooms and department to accommodate female participants in technology education programmes. This paper has shown, through current empirical and theoretical research that strategies to promote female participation involve long term planning, short term immediate support and constructionist considerations. This stage of schooling is almost too late to gather more support save for entry to universities.

The short-term strategies are important but it is the long-term planning and human resource components that appear to be making key impacts on female participation and motivation in technology education in early secondary school. Role modelling, peer supportive environments, elements of choice and sustainability and the processes to achieve artefacts are the factors which will bring about further changes. The longer term strategies are about changing the phenomenon that is socio-culturally and psychologically rooted and constructed "Women need to be given the explicit message that technology, in all its aspects, is suitable for women" (Klapwijk & Rommes, 2009, p. 405).

These strategies are not about plugging the leaks in the pipeline, but rather about building a 'gendered pipeline' where females are motivated to feel at home *doing Technology*.

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