# Chapter 15
# Where Are *All* the Students? Factors that Encourage Female Participants in Technology Education


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**Abstract** Females are significantly underrepresented in technology education classrooms in senior secondary schools. Participation rates for female students in Science, Technology, Mathematics and Engineering (STEM) subjects are lower than those of males. Data show that this has a flow on effect on females entering subjects such as Engineering at the tertiary education level. Williams (Intl J Des Educ 7:1–9, 2011) argues that gender issues in technology education have been under-researched. This chapter aims to identify positive influences that encourage female students to participate in technology education. Using a qualitative, feminist ethnographic case study methodology guided by a sociocultural framework, the study aims to demonstrate how classroom teachers may take steps to engage young female learners in technology education.

## The Research Questions

The topic was examined through three research questions. The first research question asked – what factors have influenced female student's choices to take technology education classes as part of their senior school pathway? The investigation was undertaken through an examination of the social construction of realities from the individual and the collective group point of view (Bijker et al. 2012), drawing on theories of women's ways of knowing by Belenky et al. (1986).

The second research question asked – how was teaching and learning conducted and approached in selected technology education classrooms? The study investigated Year 11 female students in three secondary schools. In doing so, the ecology of the learning environment, the context of the learning and social interactions were analysed and triangulated from the staff, student and administrators perspectives.

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Looking at the three views of the people in the study (the students, the staff and the administrators) helped ensure that the observations and responses to questions that were asked and activities that were observed were confirmed and based on the curriculum within the classroom as well as its intended outcomes.

The third research question asked – what values were addressed in the teaching and learning in specific contexts in technology education? This aspect examined the multifaceted interpretation of values and analysed the engagement of youth and the teaching staff with the concept of values. The aspect of values was important given that the feminist methodology hoped to find if there was a difference between what male and female expectations were in technology learning. Was there a sociological difference in approaches of females to joining these classes and then how they participated? The adjunct to this inquiry was how teachers should encourage female learners in an environment where there are so few.

Belenky et al. (1986) research lead me to the question of how different genders may learn. The dominance theory does not solve the issue of gender difference. Danilova and Pudlowski (2010) argued that one size does not fit all when it comes to technology and engineering studies. The shrinking pipeline (a term coined to refer to the loss of female numbers in engineering studies) could be due to the use of learning styles that attract some participants and not others. This is as relevant to curriculum planners as it is to administrators and teachers in schools.

The questions were important as they shaped the parameters of the research. The aim of this study was to examine the factors that encouraged and facilitated female students to participate and engage in technology education classrooms and, as a consequence, increase participation rates in the long term.

The research questions provided the steps within the study and guided the investigations that I undertook. The three sub-questions were also designed to look at the practical side of what was really happening in the technology education classrooms with respect to female interactions within the technology setting. The questions enabled one to unpack the broader issue of how to increase the participation of female students in technology education. While the issue has been addressed by writers over the past decades, the issue remains one needing further research as numbers of female students have not increased despite efforts of teachers to attract them as participants.

## How I Tried to Answer the Questions

The research questions were answered through the use of social constructivist methodology. This qualitative methodology provided the steps which would cater to the feminist stance that was being used to examine the school settings that were being researched.

An ethnographic case study design was chosen as a framework for the investigation. The ethnographic research design aided the study of the behaviour, beliefs, language and how shared patterns of interacting in an educational setting could be

developed over time. Ethnography is the systematic study of people and cultures. It is designed to explore cultural phenomena where the researcher observes society from the point of view of the subject of the study. It can also be a process of analysis to which the data is subjected (Pole and Morrison 2003). 'Ethnographic research in this case aimed to use close-up, detailed observations of what was occurring naturally as evidence' (Yin 2003, pp. 1415). The aim is to enhance the understanding of a social action within an educational setting in order to view the wider social and economic context of the class in its location, time and setting. This study was bounded by technology studies, classes and female students in Year 11. This year level is the first of two post-compulsory years of senior high school, prior to university study. The females as a group could be described, analysed and interpreted through patterns within the context of culture-at-work. Ethnography enables in-depth examination of the students in the study. As the researcher I was also the participant observer in the classroom. It was possible to work beside the students and get to know them on a professional level. There were no restrictions on recording or photography or moving about the rooms and talking to both staff and students. This allowed the researcher to interact and be a practical observer, as well as participant, within the technology classrooms which were part of the study.

The research focused on females who were the subject of the study and were identified as the culture-sharing group. The female participants were drawn from within the targeted classes which were Year 11 students who were entering the subject for the first time as part of a 2-year senior studies program. They volunteered to be part of the study and parental permission was gained. Culture by definition covers all human behaviour and beliefs and includes the study of language, rituals, structures, life stages, interactions and communications. The study looked for shared patterns of behaviour and group interactions, similarities, which occurred across the three school sites which were used. The time frame was one teaching unit which generally spanned a term (6–8 teaching weeks) early in the school year.

For each case study the school and environment was described. Data were analysed through four data sets. These included interviews, observation data, audio recordings and photographs taken by the researcher. The interviews included conversations with the female students, the teachers in each of the case studies and the Heads of Department (HOD/administrators).

Data collected through interviews used open-ended questions which were supplied as part of the study and which had received ethical clearance. The interview questions related to the research questions. The schedules were different for the students as compared to the teacher/HOD. Some interviews were individual while others were conducted as a group, but each had a schedule completed and recorded responses where possible.

The sample schedule of questions provided some continuity across the research sites and enabled for a comparison of data when the interviews were transcribed at a later date (Knopke 2015). Not all the participants chose to address every question; however consideration was given to there being enough overlap to enable the researcher to address the three research questions and the seven themes under examination.

Observational data was completed by the participant observer while in the classroom where possible, or shortly after. Overreliance on note making early on in the study meant that interactions were missed so the technique was modified. Photographs were taken and recorders placed as close to participants and field notes referenced and completed soon after the class was finished. Students were asked to complete a repertory grid that related to the artefact they made during the time of the teaching unit which the researcher observed. This was discussed for verification later with the teacher.

An outcome of this type of research is to identify change and actively advocate for change as a result of the findings. The findings were classified into seven themes which emerged as a result of the literature and the pilot study. Data were categorized and systematically analysed in order to answer the research questions in line with the key topic of what could teachers do to further enhance the participation of female students. The seven themes were learning ecology, gender and technology education, language use in classrooms, motivation, role modelling and peer support, sociocultural approaches to learning and values within technology education.

## What I Found Out

What I found as a result of the study is summarized in several ways. The first finding related to the methodology used and the second with respect to the content that would address the key research question. More detail will be outlined in relation to how the findings can be directly applied to alter teaching practices in the later part of the chapter.

The focus of this study was on females who identified strongly with one another within the Technology departments of each of the school sites. Despite females from older and younger year levels coming into the workshops, at times the females in the classes I observed did identify as a culture-sharing group and did lend support to one another. These groups varied in size from 2 up to 5 members depending on the timetabling of certain classes in a context of a class of 25 students in total. The awareness of the female learners was not just in the classroom itself but also the educational community in which they operated. The broader community of male design and technology teachers and the professional association were aware of the issues and supportive of any steps to overcome the underrepresentation of gender in this area.

As a result of using a qualitative ethnographic case study approach, the research was able to find some of the voices of the females in the technology classes and analyse the data under the seven themes that developed. Five of the themes emerged from the literature, and two developed as a result of the pilot study which was conducted in one school site.

The analysis of the study was conducted using the seven themes which were:

- Learning ecology
- Gender and technology education

- Language use in classrooms
- Motivation
- Role modelling and peer support
- Sociocultural approaches to learning
- Values within technology education

The structure of the methodology used in this study provides a basis for the replicability of the research in similar studies in the future. There were three research sites, triangulated data from students, teachers and administrators and finally data was analysed and coded via the seven themes listed above. The themes coincided with the sub-questions.

The procedures, processes and instruments used to collect and record the data could be replicated in other research studies. There are a large number of sociocultural factors related to gender and technology in classrooms that need more long-term, in-depth studies.

Each of the seven themes will be outlined, and the following provides a discussion as to what I found as part of the study as they related to the research questions.

## *Learning Ecology*

Learning ecologies that promote learning in technology environments have been described by Siemens (2006) to contain seven elements for knowledge sharing. These elements are flexibility, a tool-rich environment, consistency of practice and time, trust, simplicity, decentralization of learning and a high tolerance for experimentation and failure. Learning ecologies, to Brown (2000), are dynamic, living states. It is a social concept, a practice that is the social construction of reality which stems from humans as social beings acting on their interpretation and knowledge of reality. Learning ecologies can be further analysed as knowledge ecologies: open systems, that are dynamic and interdependent, diverse, partially self-organizing, adaptive and fragile (Brown et al. 1989). A learning ecology is then a collection of overlapping communities of interest, cross pollinating with each other and constantly evolving somewhat analogous to ecosystems such as rituals, response groups, individual class contexts and niches which are managed through the dependent role of members.

One recommendation from the research study was the need to build pedagogical ecologies for technology education. It is suggested that these learning ecologies are based on an awareness of learning styles and values that are unique to females' ways of learning (Knopke 2015). Student backgrounds in terms of socio-economic experiences influence what female students choose to study within school settings. Life experiences and the vocational aspirations of students contribute to student's study plans. In turn their engagement in the learning area shapes what skills the students will develop which in turn shape their contribution to twenty-first century skills. Changing any of the learning ecologies to suit female participants will assist in gaining awareness and participation in the area for all the learners within that system.

## *Gender and Technology Education*

The research uncovered three basic principles stemming from the social constructivist feminist theory of Bijker et al. (1987). Gender as a term is a construct, not created by nature as a result of biology but rather created by and contingent on social and historical processes (Oldenziel 2003). The author acknowledges that power relationships can benefit one group and not another. Social constructivism stems from gender assignment prescribed at birth. Paechter (1998) in her research argues that gender which is usually ascribed to babies at birth shapes our assumptions and expectations about a child's future; however it has more to do with social and cultural values related to that gender than with body features. Secondly, feminist theory can be seen as an ideology as much as a methodology which makes inequalities obvious (Willis et al. 1999). As teachers reflect and discuss issues of gender difference and engagement, the discussion and realization may bring about a change to practice through a reduction of marginalization and listening to the voices of the minorities, notably the female participants.

## *Language Use in Classrooms*

The research reinforced the notion of Spender (1985) that there is a dominance of male language. Men have use and control of language and thus ensure themselves the opportunities to use it from a power perspective. This research could only support the ownership of technology terminology existed because so few females were present to pass on their knowledge of terminology and concepts. The females quickly learned that they needed a mastery of the language to be able to function and compete effectively in the classroom context. For this subject to be socially valued, there is a need to incorporate the values and language of diverse participants. The promotion of a shared language of technology can promote the synergy and harmony between technology and nature exemplified via female language.

## *Motivation*

Motivation is defined in the broadest sense as 'the process whereby goal–directed activity is instigated and sustained' (Pintrich and Schunk 2002). Values, argues Rokeach (1973), 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.

The research of Zuga (2007) and Wajcman (2004) examined the stigma of artefacts and highlighted the sociotechnical constructivist approaches to teaching

females in technology education. Haraway's cyborg-feminists and socialist feminist inquiry was pivotal in exposing the gender blindness of mainstream technoscience studies in order to show the possibilities this area offers females and how they could strategically engage with technoscience within technology (Wajcman 2004).

Artefacts to be made and freedom of choice in the learning process appear to have an effect on the motivation of students as participants in technology education (Thaler and Zorn 2010; Boe et al. 2011). 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 programs in 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).

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, 406) note the problem with stereotypes: *that 'women' prefer working with people and men* (males) *with things – that if we repeat it often enough it becomes the norm.… Repetition makes it impossible to loosen the unilateral connections….*

The research suggests that motivation can be raised through addressing technology education pedagogy as a positive concept which they (females) come into contact with often and hence will develop skills and knowledge. Frequency of exposure and role models can be the link between technology and femininity (Dakers et al. 2009; Kolmos et al. 2013).

## *Role Modelling and Peer Support*

This theme is closely aligned with motivational factors and communities of interest. It takes into consideration the social factors that teens identify with. Role modelling refers to the individuals who support learners and the guidance given to participants in given situations. Pintrich and Schunk (2002, 384) refer to part of this support as 'peer networks'. These networks are groups with whom students interact in a sociocultural manner. There are further role models of older, respected and familial people in the lives of students. Individuals model themselves on and learn from a range

of people. Toren (1996) argues that the human activity in terms of the research relates to the social interactions that can be observed.

Role modelling is the factor which appeared to afford a sense of well-being to female students. Assured support appeared to provide some security of their place when female students commenced their study in a technology class. Increasing female participation would appear to involve a combination of curriculum content, pedagogy and cognitive challenges in a safe and supportive environment. The importance of relationships and acknowledging difference was the key to the plurality of the approach that gained more female participation in the technology education classes.

## *Sociocultural Approaches to Learning*

Sociocultural approaches to learning cover two areas: firstly, the social interactions of learning and secondly, the position and voices of the participants in the study. This study was mindful of the type of critique used by feminist writers and took a positivist view to find the voices of the females in the technology education classes. This perspective addressed the second of the research questions. Sociocultural approaches to learning provide instruction which recognize and empower linguistically and culturally diverse students. Learning in this sense is distributed, interactive and contextual and the result of the learner's participation in a community of practice (Merriam 1998). The collaboration of thinking that results from these processes opens up access to examining thought processes and provides avenues to uncover distinguishing characteristics that could be assigned to gender and could then be addressed by using certain teaching styles and methods ahead of others.

## *Values Within Technology Education*

Values were examined from two aspects: firstly, values and technology education and secondly, values and motivation. Values have been examined within technology education research; however, they appear to be treated as gender neutral. It is the issue of personal values that underlie the feminist perspective, and how these translate into education at the local level which was the focus in this study.

Technology is a human activity requiring a complex understanding of technology, human activity and cultural values that extend beyond the science and engineering of how things work. The Technology for All Americans Project (Dugger 1997) saw the underpinning of technology education as having an ethical and values-based understanding. Technological literacy and goals as noted by Ritz (2009) contribute to this notion. Values in the broad sense of ethical behaviour are those embedded in the Melbourne Declaration as part of the *National values for schooling in Australia* (MCEETYA, Ministerial Council on Education Employment and Youth Affairs 2008).

Research by Pavlova and Turner (2007) demonstrates that sustainable development (SD) learning activities could take place through a conceptualisation of values education. Sustainable development established the cognitive, moral and practical basis for learning, and these factors should be considered during the planning process.

Values, argues Rokeach (1973), have a motivational function to guide human activity in daily situations, with a long-range function to give expression to basic human needs. Values' components include motivational, cognitive, affective and behavioural elements. Instrumental values are motivating because of the attainment of desired end goals, while terminal values are motivating because they represent goals beyond the immediate, biologically urgent goals. They are the conceptual tools we employ to maintain and enhance self-esteem (Rokeach 1973). Terminal and instrumental values are relevant when considering types of behaviour students engage in in classrooms and drive the motivation that individuals employ to achieve their short- or long-term cultural, social or academic goals. In this sense by promoting female language and values, educators are expanding the potential for youth to strive for individual achievements in this sphere of learning.

## *In Conclusion*

This research aimed to contribute to reform processes, encouraging practical and theoretical reflection on the part of the teachers and administrators who were part of the research conversations.

Overall the study found that the impact of curriculum on technology students has an influence on what female students choose to study. Student's backgrounds in terms of socio-economic status largely influence what they choose to study within school settings. Life experiences and vocational aspirations also contribute to female study plans. Having knowledge of the benefits of the subject area, the development of thinking and hands-on skills and the advantages of what technology learning may afford participants appears to make a positive difference to the engagement of female learners.

A female-oriented pedagogy that meets mixed learning styles with structure but provides individuals with independence to problem-solve and discuss issues appears to be an undervalued aspect of technology education programming. The female students who came into the classes had little or no background in any type of technology activity since undertaking compulsory classes in the junior part of high school. What the female students were good at was taking on an understanding of the task at hand, discussing it between their peer group and at times teachers or other adults in the learning environment and then undertaking a project management style of learning to achieve each section of the task. This did not mean that they did each section of the skills – at times some of the females were given outsourcing options, and other male students would offer to plane a piece of wood or cut an angle. The females watched the adept students and then undertook the task, but the

teaching staff was wary in that they had encountered female students in the past who had organized others to complete all the tasks to complete an artefact, and they had simply undertaken the assembly and seen it as a successful outcome.

The worth of the output (whether it is a final artefact or a technology activity) and its social and ethical value is part of the criteria that female students use to judge the relevance of the technology education content and courses. Broadening the information base about the subject area will expand its appeal to potential participants.

What the research has demonstrated is that female ways of knowing and doing (Belenky et al. 1986) are different to how many males operate in the technology education.

## *How might this be used to improve teaching and learning?*

The following section looks at how the results of the research may be used to improve the teaching and learning of female students in technology education with respect to curriculum planning, teaching methods, assessment for learning and finally student engagement and participation rates for females.

### Curriculum Planning

Curriculum planning is the basis for structuring an inclusive technology curriculum. Support of female teachers and peers appeared to make a difference to the participation of some of the female students in the research study. As the female students began to feel comfortable within the learning environment, they actively engaged in becoming familiar with specific technical terms through discourses conducted at the workbenches. In finding their own identities in the workshops, the female students engaged and participated in the learning to the point where they were able to surpass many of the other students. De Vries et al. (2007), writing on institutional design, noted the need for varied teaching approaches and practices which accommodated differing learning styles, interests, prior knowledge, comfort zones and socialization needs.

Teachers need to re-examine some of their practices in order to entice female participants to participate in technology for the long term. The following explicitly outlines some techniques which could be employed in order to cater to female language and understanding in traditional technology classrooms. These include the use of planning techniques; structured learning styles; management and interactive skills with female students, staff and peers; and freedom to employ one's values to self-motivate for learning.

Techniques used by skilled teachers motivated students in their classes. Of specific appeal to the female students was the pedagogy which provided a structured program that encouraged learning styles which female learners best engaged with. Clear scaffolding provided problem-solving avenues from which flowed project and time management skills and planning that the female learners excelled in. The

apparent freedom to learn within what was a sophisticated structured environment did motivate the female students to succeed. This is consistent with Hattie's (2009) claims that student motivation is at its highest when students are competent, have sufficient autonomy, get feedback, set meaningful goals and are affirmed by others. Females will take on internal motivational factors ahead of males who will externalize their academic achievements (Hattie 2009).

The third case study demonstrated that positive learning environments made a positive difference to the female students and their willingness to engage in technology education learning. Feelings of support and the notion of feeling special and unique in a service oriented activity appeared to enhance the engagement of female students. Research by Blackmore (2011) on feminist educational thinking suggests that the discourses of educational change since the 1990s have helped progress the notion of feminism and that the transformation for women in education have brought about changes in social relationships. 'In an era of post masculinity, women need to exhibit strength, strong relations, care and collegiality' (2011, p 208). Lingard and Keddie (2013) in their feminist critiques propose that it is the political agenda which needs to be addressed before the gender divide can be meaningfully changed.

The research of Brizendine (2006) serves to dispute some of these claims but does support the argument that we do need to cater to the learning styles and functionality of females differently to those of male students. Indeed, we need to take into account the cognitive and affective aspects of learning as well as the creative aspects (Knopke 2012, 2015 p.43). This research showed that with some intervention females could find their voice in a technology classroom and use their skills to achieve highly in this context. In teaching what some believed to be a gender-neutral curriculum, male teachers at times missed the potential of the female voices in their thinking skills and organization. In catering to both voices, the whole would be greater than the sum of the individual or divided parts and provide greater appeal.

## Teaching Methods

A technology education curriculum, employing language about technology that is intended for all students, needs to incorporate the diversity of people, positions and values in order to reach students and to serve as a socially valued subject in the school curriculum (Zuga 1996). Dakers (2006) argues in a related way that technological literacy and its links to language, values and understanding may provide the criteria and links to teasing out the actions in classrooms and school settings. The research showed that it was the teacher's implementation of language, content and process which contributed to the participation of girls in the classes which were studied.

The study found that a planned female appropriate pedagogy through a structured curriculum has an impact on female students' engagement. Student backgrounds and socio-economic status influenced what they choose to study within school settings. Life experiences and vocational aspirations contributed to the female students' study plans. Having knowledge of the benefits of the subject area,

the thinking skills, physical skills and the pathways which the learning may afford participants appeared to make a difference to female choices. These same attributes can be seen in the values orientations which shaped the research questions.

A female-oriented ecology that promotes pedagogy of teaching and learning that mixes learning styles with structured teaching along with the independence to problem-solve and discuss issues has been an undervalued aspect of teaching in technology education. The worth of the output and its social value is part of the criteria that female students use to judge the relevance of courses. More emphasis and focus on values and sustainability should appeal to female participants. Broadening the information base about technology education in the earlier school years will further expand its appeal to potential female participants. The information base could be the provision of an information booklet which provided structure for the project or the course or information on where technology may lead students by way of a career path that was not only for males. Using values such as community contribution, collegiality or sustainability, which appealed to females in projects, was a selling point for the subject.

## Assessment for Learning

While this was not a topic which the research focused on, it did emerge during the interviews and class observations with students and teachers. Several points have been noted in relation to gender and technology.

Female participants:

- Want structure in their assessment and will use the teacher provided outlines to guide their work practices.
- Were meticulous in following the criteria and the results of those in the study showed high levels of achievement in the outcomes of both written and practical work over the term they were observed. The criteria provided guidance for achievement but did not stifle the creativity and independent thinking that the female students displayed.
- Were diligent in their paperwork and referred to directions and printed guidance to clarify issues before approaching a teacher.
- Would seek feedback and assurances before proceeding further.
- Achieved outstanding results within the technology classes.

Teachers:

- Believe more females should be undertaking their courses
- Do not believe they are biased in language use and delivery of the technology courses
- Understand the need for structure of assessment and provide this in assessment planning
- Know that female students may require different approaches to teaching – especially in the workshop environment

- Do not believe that they need to alter their practices in any significant manner
- Know that female students who engage in the classes will be high achievers because of their motivational practices

The results have shown that female students will carefully follow the teacher planning, undertake the set activities and follow through with careful presentations and will be the outstanding achievers in their cohort. It is a time factor to gain technological literacy skills which may restrict them and lower their confidence levels when they first enter the technology classes. Teachers need to spend time at the start of a unit or project to ensure that female students have an understanding of the terminologies which will be used on a specific task or project. Teachers did provide technical demonstrations for all students, but this did not ensure engagement or understanding of how to perform that skill until it came up in a particular task. This can be seen as a time factor by some teachers.

### Student Engagement and Participation Rates for Females

The female participants in the research study were highly motivated to achieve once they had made the decision to participate in the class. The research looked at whether motivation and values were the first strategy the student's used for selecting to enter the technology classes. The results showed that it was a personal motivation more than an employment motivation that brought about their participation. It was not values related to sustainability. One of the female students in case study 2 felt she had time to make her own decisions at her own pace. She in turn exhibited a confidence and self-assurance over what she was doing and was able to bolster and mentor other students. Belenky et al. (1986) and Ekert and McConnell-Ginet (2003) argue that the emotional control as much as the physical empowerment enables females to be successful.

> *The teacher's expectations are of a high standard of what will be done and despite there being a lot to get through they are really helpful.* (S2) Knopke (2015, 207).

Self-efficacy was the second strategy in engaging and motivating female students in technology education. A belief that one has the capabilities of exercising courses of action to manage situations has been seen as a positive predictor of achievement in task-specific goals and success for females in nontraditional 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 programs. Influencing environments in turn sustained persistence and enabled mastery experiences in complex design projects via 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 secondary context. Students who achieved degrees of mastery of skills became

more persistent and resilient to learning within the technology education courses of study becoming leaders within their peer group (Knopke 2015).

The findings send a message to practitioners in the post-compulsory area of senior technology education. A strategy that may assist teachers to revisit and alter the ecology of their classrooms and department to accommodate female participants in technology programs is key to their participation. This research study 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 for entry to universities at the career level (Knopke and de la Barra 2013).

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

## *Recommendations for Teachers and Learners*

The research indicates that if teachers undertake some of the recommendations provided, then they would be progressing towards a female-oriented pedagogy. This study contributes to knowledge and practice for teachers due to the seven areas of analysis concerning females in technology education.

These comprise of the ecology of classrooms, gender, language use in classrooms, motivation, peer support, sociocultural contexts and values. Female learners, who are the new entrants to the subject of technology education, need to be shown how to adapt to this new learning environment, the language practices that are part of the ecology and the procedures and techniques which again require some depth of learning for technology.

The learning, thinking skill, physical skills development and project management skills enable female students to learn in a relatively new environment. These skills equip them to apply their knowledge to future challenges. Technology departments need to provide time for female learners to develop skills and language that will enable them to function confidently in workshop environments.

A female-oriented pedagogy provides scaffolding problem-solving and skills development through group discussions, collaborations, demonstrations and reasoning in an open context. These factors enable female learners to have choices and make decisions that will motivate them to further engage in technology education.

Teachers need to be mindful that there is no such thing as a 'gender-neutral curriculum'. The making of jewellery boxes instead of tool boxes does not address this

issue. Catering to student choices and the reasoning of students provides an understanding and motivation to participate in meaningful projects. Some may be to benefit the community while others have personal meanings. Understanding the technical language quickly, once females enter a technology environment, has been seen as a key factor enabling students to engage with projects, materials and tools. Structured learning booklets/guidelines have assisted self-directed females to progress at a fast pace once they understand the concepts they are working with.

The research showed that peer support and shared group goals enabled females to excel in some areas of technology. Peer support was not limited to same gender or role in the class; however it was relevant to the female learners to have a person to discuss issues of the project with.

The gender-neutral claim by teachers fails to enable female learners to use their voice in the technology classroom or contribute to alternative strategies in a learning context. The female learners often knew the answers a teacher posed but failed to use their voice to propose a solution to a problem. The females had the answers and alternative strategies to achieve the outcomes however they perceived themselves as restricted in a male-dominated environment. Females would collaborate, discuss options and move onto testing solutions and often arrive at higher end results that their male counterparts had not achieved. Use of instruction that focuses on females requires collaboration, discussion of options at all transition points in the program and testing solutions that provide more depth of inquiry.

Teaching strategies and practices which require collaboration, discussion of options, testing solutions and alternative thinking patterns and strong time and project management skills are sound strategies for both female and male students. It is not only the females who will benefit but so will their male peers. The prevailing pedagogy should encourage and perhaps require that these factors are included in technology practices.

Finally, values that females engage with can be different to those upheld by male colleagues. The reason one wishes to engage in a project is at times more important and relevant than the skills needed. Females wanted to see the big picture and then work back through the skills needed to achieve the goal. Teacher planning for joint/shared project development that has a social value would appeal to more females and heighten the view of the worth of what they were engaging in. This relevance of projects and skills should become a sales point for such an engaging subject area for younger female students. There is no short-term fix but rather long-term planning on behalf of the teachers to find the social worth and engage in it.

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