



Citation for published version:

Watermeyer, R 2010, 'Discover!ng women in STEM: Girls into science, technology, engineering and maths.', *International Journal of Gender, Science and Technology*, vol. 2, no. 1, pp. 26-46.

Publication date:
2010

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

Publisher Rights
CC BY

University of Bath

Alternative formats

If you require this document in an alternative format, please contact:
openaccess@bath.ac.uk

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



International Journal of Gender, Science and Technology

<http://genderandset.open.ac.uk>

Discover!ng Women in STEM: Girls into Science, Technology, Engineering and Maths

Richard Watermeyer and Vicki Stevenson

Cardiff University, UK

ABSTRACT

This paper explores the role of *Discover!* Saturday Clubs as informal educational spaces devised as a means of broader dissemination and experiential learning for school-aged girls, with fledgling interests in Science, Technology, Engineering and Maths (STEM). *Discover!* Clubs are a UK based initiative organised by Women into Science, Engineering and Construction (WISE), researchers at Cardiff University and Careers Wales. STEM is traditionally characterised as suffering from a dearth of female representation at school and within the work force. This paper explores the extent to which *Discover!* works to remedy this deficit and enable young women to take an active interest and involvement producing a new version of knowledge worker, benefitting the wider knowledge economy. We draw explicit links between educational attainment and credentials and labour inclusion, to interrogate notions of worth and validity of extra mural/after-school activity. Ultimately, *Discover!* is approached as a STEM initiative, indicative of a general trend towards the proliferation of public awareness, understanding, inclusion and participation within science, technology, engineering and mathematics.

KEYWORDS

Female Learners; STEM; Single Sex Learning; Same Sex Role Models; Experiential Learning; Science Engagement.



This journal uses Open Journal Systems 2.2.2.0, which is open source journal management and publishing software developed, supported, and freely distributed by the [Public Knowledge Project](#) under the GNU General Public License.

Discover!ng Women in STEM: Girls into Science, Technology, Engineering and Maths

INTRODUCTION

Discover! clubs are devised as learning spaces dedicated to changing dominant cultural attitudes and to widening access and recruitment of women into STEM; subject and occupational fields traditionally dominated by men (Burke and Matthis, 2007; Bystydzienski and Bird, 2006). They are a learning tool devised to capture the imagination and interest of young school-aged girls, close to selecting their General Certificate in Secondary Education (GCSE)¹ choices. They provide a learning zone where dominant gendered constructions of curriculum and occupation that discourage young women from pursuing STEM are potentially disassembled. *Discover!* sets out to offer young female learners the opportunity to encounter 'alternative' career aspirations, which they may have previously imagined as closed off or simply have not entertained.

Young women are encouraged to imagine and explore school and work-based identities, commonly perceived as exclusive to their male counterparts. In doing so, female versions of agency, efficacy and entitlement may be renegotiated as patriarchal constructions of subject and occupation that limit female choice. We argue that *Discover!* encourages a repositioning of female learners which may contribute to what Ivinson and Murphy (2007) depict as a developing sense of legitimacy in STEM. We do not suppose, however, that such repositioning will result in a synchronizing of learner behaviours and meaning making between girls and boys. Indeed, we suggest it would be naïve to imagine that the legacy of female disassociation in STEM will not continue to polarise gender. As such the facility and legitimacy in negotiating meaning will continue to differ and thus separate girls from boys (Ivinson and Murphy, 2007). This, however, is a desired outcome in so much as different perceptual outlooks may actually enrich and diversify constructions of STEM.

This paper forms the basis of a more extended inquiry into the *Discover!* clubs with ethnographic fieldwork planned for January-March 2010. This research is the result of continuing conversations between colleagues at Cardiff University broadly involved in public/science interface. The lead author is currently investigating aspects of the public engagement of science and technology and happened across WISE serendipitously. Conversations with the chairperson of WISE (Wales) and advisors at *Careers Wales* culminated in the writing of this initial paper.

This paper provides an initial discussion of the objectives of the *Discover!* programme and of the themes identified from evaluation data of the project collected over a three-year period. As may be the case with post-activity evaluations, this data had been largely untreated. The research team was provided with yearly programme reports, but these were rather generalist

and triumphalist in tone and made no attempt to engage with the evaluation data. Nevertheless these reports gave some clues into the experiences of participants, which may be generally characterised as positive. This paper forms part of an iterative process, that first sets out a thematic analysis in order to theoretically ground ongoing ethnographic inquiry². It provides a critical reflection of *Discover!* as a possible model of informal and experiential learning that may broaden aspirational horizons. We consider the potential efficacy of *Discover!* as a source of critical pedagogy that challenges and uproots embedded gendered assumptions and stereotypes that proscriptively assign and inhibit subject and occupational choice. In a final analysis we explore how *Discover!* has the potential to perform not only as a means of recruiting for STEM, but as a process of 'piggy-back' learning, which disseminates to and thus engages a broader public.

Within transformative learning zones, young female learners may discover the basis of their own entitlement to participate and excel within STEM and as such contribute to a gender neutral reframing. In so doing we propose that young female learners in conjunction with female role models may forge an equitable continuum of knowledge co-operation, production and aspiration building, thus enabling the proliferation of women in STEM.

BACKGROUND

The *Discover!* Clubs

The *Discover!* club begins with a launch event where secondary school girls, between 13 and 14 years of age (Years 9 & 10) and their parents meet organisers and session leaders and are briefed on the content of activity sessions. Following the launch event the girls attend eight activity sessions, which are held on consecutive weekends. Each session is designed to provide the girls with the opportunity to 'try on' a range of different occupational roles such as geneticist, medical engineer, designer, and astronomer. The sessions include activities such as: DNA analysis; development of a prosthetic hand; mineral based textile design; use of a telescope; analysis of synthetic mucus; and industrial visits to a power station and a civil engineering project on a major motorway. In previous years, the project finale has taken place at a British Airways maintenance depot, where a tour of aeroplanes being refreshed on the shop floor is followed by a 'graduation ceremony', attended by participants' parents. The programme began in Cardiff, capital city of Wales, in 2006 and has since opened clubs in other Welsh regional localities, principally Wales' second city, Swansea. The programme enters its fourth successive year in 2010.

Four of the eight weekend activities were held at different venues across the central campus of Cardiff University. Of the other four, one was based at a local science education centre, another at a power station, one at a construction site and the last, a commercial airport. It is important to stress that every session was led by a female expert.

Saturday sessions were fairly uniform in their structure, allowing participants to become quickly accustomed to the *Discover!* format. Industry or off-campus visits usually began with a tour of location premises. Participants were given the opportunity to handle equipment, whilst being presented the roles of key personnel, including the activities they carried out and their responsibilities within the workplace. Other related activities would follow culminating in a ten- minute question and answer or 'buzz' session, where group members could pose questions to the session facilitators. Participants' questions tended to follow further probing into facilitator's roles and responsibilities, associated careers and guidance on career paths. On-campus sessions tended to follow a similar format, albeit with the occasional introduction of 'ice-breaker' games.

Project Evaluation

The evaluators used two types of questionnaire – one for child participants and the other for their parents. In this way, two participant groups emerged: Immediate Participants (The Children) and Proxy Participants (The Parents). The evaluation sample for each of the years tended to fluctuate between 14-17 immediate and 14-17 proxy participants. In capturing the perspectives of both groups evaluators were able to more firmly determine the impact that *Discover!* had beyond the group sessions. Analysis of this data yielded a major emergent theme of *Discover!:* incidental or 'piggy-back' learning. The two perspectives were valuable in providing insight into how the children made sense of the session activity including the impact parents had as role models and advocates of STEM; prolonged dialogue concerning each session, particularly where this occurred in the home setting; and, how attitudes to STEM and choice changed over the course of the programme.

The questionnaires for both groups were based on 10 simple questions. Some of these were open-ended, demanding more detailed reflective accounts, whilst others were based on Likert frequency scales. Questions for immediate participants ranged from what participants found most interesting and which activities they enjoyed most to how their perceptions of women in STEM had changed; what key skills they had developed, and whether the programme had influenced in any way their future subject choices and/or occupational aspirations. The questionnaires for proxy participants followed a similar line asking parents to detail their own observations of the effect of *Discover!* on their children. They were also asked whether their own perceptions of women in STEM had at all altered. We should note that it was the programme's intention for all proxy participants to be of the same sex as their children.

Evaluation data was complemented by informal interviews with the principal co-ordinators of the *Discover!* programme. Interview data provided a fuller appreciation of the programme's objectives, its aspirations and the obstacles it faced. These conversations were also valuable in contextualising or personalising the *Discover!* programme from the perspective of those

involved not only in the popularisation of STEM for girls, but a broader public understanding of science.

Emergent themes from the evaluation and interview data were coded and arranged into distinct thematic categories. These are discussed below in relation to prominent research literatures covering gender and experiential learning and public understanding or engagement with science.

DISCUSSION

We begin our discussion with an overview of the programme's intentions, exploring notions of choice, experiential learning, issues of inequality and processes of decision-making. This is followed by consideration of three principal emergent themes that have arisen as a result of our initial analysis of the programme's evaluation data, and which will inform the ongoing collection and analysis of data during future stages of the project. These themes are gender complexity, role models -including the parent as role model and adjunct learner, and individualism, agency and self-efficacy.

Intentions

Discover! is a learning programme designed to attenuate female learners' inhibitions to STEM that restrict educational and occupational choices. The programme attempts to do this through insistent and positive gender affirmation. In so doing, young female learners may be first made aware of, and then taught to resist, highly stereotyped and embedded frames of reference, so infused and ubiquitous to discourse surrounding curricula and occupational choice, as to be unobservable and thus deemed unproblematic (Murphy and Whitelegg, 2006). Research does show however that girls later in their formal educational careers are more sensitive to gender bias and frequently associate science classrooms as uncomfortable and unsafe environments for risk taking (Delamont, 1990; Orenstein, 1994; Riddell, 1992). *Discover!* attempts to counter curriculum stereotyping (Lee and Marks, 1992; Salisbury and Riddell, 2000); boys domination at points of collective interaction such as science experiments (Tobin and Garrett, 1987); and disproportionate levels of attention favouring boys (Jones and Wheatley, 1990; Shepardson and Pizzini, 1992).

Discover! responds via a process of 'show and tell', exposing learners to gender related discrimination; often undetected or unsuspected in formal educational settings. It imagines an empowering of female learners through an immediate and visceral visualisation of latent forms of prejudice previously obscured by dominant gendered discourse (Foucault, 1974). As a consequence, *Discover!* anticipates female learners' growing capacity for critical reasoning and the emergence of resistant or anti-hegemonic *subversive* behaviours. Accordingly, *Discover!* may be seen as a response to the claim that for women to be aware of the impact of male domination they must first undergo women-focused re-education or consciousness raising (Weiner, 1994). *Discover!* also, though we imagine unwittingly, espouses a poststructuralist feminist sentiment that what it means to be a woman

vacillates with change in discursive practice and cultural and social history and therefore requires constant scrutiny (Wallach Scott, 1988).

Discover! accordingly challenges participants to acknowledge and combat the inequity inherent to subject choice at school, and resist dominant gendered constructions of curricula and learner pathways. It approaches learner choice in an informal, playful setting, outwith the usual knowledge laboratories of home and school, and develops a referential framework that may be subsequently adopted as a visualizing tool or aide-memoire. External or complementary sources of knowledge, found in many extra mural activities, are worthy additions to formal learning, harnessing learners' awareness and enhancing a perceptual fluency and diligence (Halpern, 1999).

As a source of external knowledge, *Discover!* endeavours to broaden learner capacity in facilitating informed and independent choice, that does not passively succumb to inherited familial orientations (van de Werfhorst et. al., 2003). It attempts to consolidate learner autonomy and safeguard against the intrusion of albeit unintended, replicated and reinforced forms of sexism. *Discover!* is therefore intended to not only expose children to a diversity of choice, but equip them with the tools to enact this choice. Simultaneously, it may help to more accurately inform or rescue from misguided or mis-prescribed counsel gained from school or home, by providing learners with impartial and professional advice. *Discover!* also proposes to scaffold the learner in ways that complement and enhance the classroom dynamic; offer occupational advice based on industry insight and not teacher guesstimates; empower autonomous learning; and, solidify abstract or notional aspects of the curriculum, through real-world examples.

Discover! is best characterised using Kolb's (1981) model of experiential learning, as an interactive forum that provides female learners the opportunity of participative and integrated learning. It gives pupils a hands-on experience, which may prove effective in not only capturing and sustaining their enthusiasms, but allowing them to develop beyond a partial or passing interest (Dewey, 1938). *Discover!* is thus imagined as a pedagogical building block, which first reveals STEM beyond and against common and prejudicial gendered constructions, and then builds layers of understanding enabling fuller and lengthier involvement, which may culminate in a chosen occupational field. Learning and knowing is accordingly positioned as a process of relations among people engaged in activity in, with and emergent from a socially-constructed world (Lave and Wenger, 1991).

As a model of experiential learning, *Discover!* aspires to what Borzak (1981: 34) calls a 'direct encounter with the phenomena rather than merely thinking about the encounter, or only considering the possibility of doing something about it'. The physical evincing of subject expertise and occupation provides a far clearer and compelling narrative integral to the development of learners' aspirations. Similarly by offering concrete examples, and using interactive techniques, which sidestep transmission model and didactic

pedagogy, learner impact and retention are deepened (Hooper-Greenhill, 2007).

Show and share forms of learning tend to be imbued with a dynamic which is both educational and entertaining. The fun element of this experience is essential in convincing learners that they are not in just another classroom. Similarly as subjects come alive in entertaining and interesting ways, young learners are more inclined to participate, remain captive and interested. This in turn may stimulate interest in other comparable subject areas. There is however no evidence to suggest that by making STEM subjects fun, they are intellectually diluted or 'dumbed-down'. Aspects of STEM designated as fun should not be conceived as either intellectually lightweight nor unimportant. Instead fun or playful learning should be viewed positively and as a means to innovative thinking, experimentation, risk taking and reflective thinking (Watermeyer, 2010).

It is necessary to state that *Discover!* clubs in no way act as a substitute for in-school syllabus nor are they devised as intentionally complementary to the national curriculum. They are intended as a useful aide enabling young female learners to penetrate gender prejudice and discern more easily, in a co-operative, equitable environment, a myriad of occupational opportunities. In so doing they may more readily develop, self-direct and sustain positive learner identities, unaffected by gender related obfuscation and bias. Furthermore, consolidation of these learner identities allows for heightened female visibility and the gradual dissipation of obstructive prejudice that inhibit the fuller integration of multiple (gendered perspectives).

Subject diversity is an important aspect of the *Discover!* programme. Attention is given to ensure against an over concentration or saturation of one subject area, and by extension a singular professional outlook. Instead its plurality aims to ensure that students are kept interested and made aware of the multitude of options open to them. *Discover!* arguably also avoids seeming tokenistic, by exploring and advocating a variety of subject areas/career choices far from commonplace or beyond the learners' radar.

Young female learners are a group that continue to be alienated and excluded from active and equitable status in STEM subjects. This is evidenced by conspicuously low rates of female participation in STEM as a subject and occupational choice (National Academies Press, 2007). We suggest that this is the result not only of gender bias in the curriculum, classroom and pedagogy, but also of insufficient provision in attending to the development of self-esteem, confidence and aspiration of female learners (Orenstein, 1994) at a critical formative stage when, as Johnsen and Kendrick (2005) claim, they are perhaps most vulnerable. This can only further exacerbate the problem of withdrawal. Female learners characterised as confident and high-achievers tend to demonstrate the opposite effect. Indeed, research has shown that gifted girls actually benefit from and tend to excel in highly competitive mixed-sex learning settings (Hernández Garduño, 1997; Gavin,

1996). These remain, however, very much a minority and tend to be associated with those manifesting high cultural capital and social status.

Inequality of this kind is not an issue exclusive to young female learners. A similar deposition can be made for white working class masculinities and narrowing aspirational trajectories intensified by the enforcement of negative expectations and low levels of esteem (Archer et al., 2001; Lucey and Walkerdine, 2000). Fundamentally the two groups share a similar discourse of disadvantage and exclusion based on a correlation between social typology and restricted future imaginings/realities.

Occupational choices are frequently seen to correspond to a history of academic success or proclivity (van de Werfhorst et al., 2003). They are characterised by a limited awareness of post-16 employment and training opportunities (Foskett and Hemsley-Brown, 1997); demonstrate vague and unrealistic expectations (Howieson and Semple, 1996); and correspond to the same tentative, speculative (self)perceptions of suitability and fit that informed earlier subject choices (Ryrie et al, 1979; Kelly, 1987). Moreover subject choices may, as Salisbury and Riddell (2000: 123) argue be 'overly influenced by the traditional attitudes and unequal opportunity structures of society'. This culminates in what Kelly (1981) refers to as the double-edged process of subject choice whereby, parental, peer, teacher, wider cultural influences and pressure to conform, cause girls to choose 'girl's subjects', thereby curtailing future career choices.

Although many schools support students with career counselling this often tends to occur when time for careful deliberation is sparse and pressure to commit to choices is high. Rash or rushed choices may thus detrimentally affect or close off prospective career pathways. Furthermore the extent to which work-experience³ actually enriches and positively impacts the learner is largely unexamined (Guile and Griffiths, 2001).

The extent of subject/career guidance may tend to be limited, with few pupils afforded bespoke occupational surgeries where they can be involved in a workshop or begin to visualise subject or occupational futures. Accordingly many pupils' subject and career choices may prove to be accidental, inherited or unintended (van de Werfhorst et al., 2003). Worse still, some subject choices, whose occupational link is obscure, may be discarded without thorough consideration. Without explicit linkage, the learner is extremely limited in visualising the journey from subject to career or unable to project future identity with limited mediating concepts (Engeström et al. 1995). Accordingly occupational aspiration is not only curtailed but mythologized. Such was the sentiment of Dewey (1997) who argued that the object and context of learning should not be separated and that the intimate linkages between learners' cognition and the context of its happening be defended.

Arguably one of the greatest challenges for the schoolteacher is in translating the applicability and utility of curriculum or mediating the relationship

between individual, object and mediating artefact (Vygotsky, 1978). In this respect, the teacher also represents a principal agent in regulating the gender order of the classroom (Dixon, 1998). The complaint that certain subjects lack real world merit or relevance, is challenged by informal learning programmes such as *Discover!* which as cumulative knowledge transactions, try to make the crossover clear. Skilful mediation therefore between understanding and knowledge generated in the classroom and the real-world application of such knowledge is absolutely essential not only in situating the individual in the context of her learning (Vygotsky, 1978) but in stimulating and retaining interest in STEM. What Piaget (1979) then refers to as the accommodation and assimilation of knowledge, or intelligent adoption forms the blueprint of *Discover!* as a holistic, informal pedagogy.

Emerging themes

Gender complexity

When education in Britain first began to diversify and include members of the bourgeoisie, it was arranged predominantly as single-sex schooling (Ivinson and Murphy, 2007). School curriculum appropriated societal definitions of the male and female spheres that positioned men in the public domain, and women in the private domestic domain (Delamont and Duffin, 1978). Despite significant migration of women from the private to public sphere, access and progression remain inhibited by gender differentiation, which reflects the continued pervasiveness and authority of gendered stereotypes that distinguish women's work and men's work. The continued prevalence of these stereotypes in the labour market is all the more confounding, given evidence that sex group differences are for the vast majority of the population insignificant, especially when compared within-group differences (Halpern, 1992). Nevertheless, gendered differentiated curricula and occupations persist and continue to feature as non-exceptional.

In the course of this paper, we argue that there is a complexity attributable to the formation of learner identity and the gendered mediation of learning that advances notional dualisms of girls as passive and boys as aggressive, that may be often attributed. The production of female identity as 'complex and problematic' is a case in point. Walkerdine et al. (2001: 3) argue that the woman is now remade as a 'modern neo-liberal subject of self-invention and transformation who is capable of surviving within the new social, economic and political system'. However, as Arnot and Mac an Ghail (2006) comment this transformative process is only ever available to middle class girls. The complexity therefore of gender dynamics must draw not only on single theories of social reproduction (Bowles and Gintis, 1976) but on theories of class hegemony (Gramsci, 1971), cultural capital (Bourdieu and Passeron, 1990) and educational codes (Bernstein, 1977).

The girls-only aspect of *Discover!* may be conceived as an empowering and emancipatory feature, diminishing the propensity for male learners as a disruption to females learning. In this context learner and parent participants perceived the exclusion of boys to contribute to a learning environment

characterised by lower levels of 'distraction', 'intimidation', and a 'reluctance to participate' to one with more 'comfortable', 'confident' and 'focused' learners.⁴ This complements learner theory that claims that single-sex schooling actually subverts patriarchal relations of domination found in co-educational formats (Sarah et al., 1980). Research conducted by Streitmatter (1999) makes a similar comment, stating that single-sex schooling serves as a type of reparation for girls 'short-changed' in co-educational settings.

Nevertheless one *Discover!* parent commented that gendered exclusivity fostered a learning environment that was devoid of the natural competitiveness of the real world. The single sex approach of *Discover!*, however, is not intended to create a gendered vacuum or interactional hiatus, but provide a period of incubation where the confidence and self-trust necessary for young girls to participate in male dominated STEM environments accumulates. It is not unreasonable to suppose that *Discover!* could operate in a format that is gender inclusive. Arguably, this is something that might be tested at a later time, when the benefits of single-sex mentoring could be examined in situations of gender competitive interaction.

Role models

Research shows that the intervention of school-based or extra mural, same-sex role models, impacts beneficially on the educational attainment (Nixon and Robinson, 1999) and subject choice and occupational aspirations (Hanson, 1996) of young female learners. They provide an aspirational end point, a target to which future subjectivity points, and a source for imitation (Haveman and Wolfe, 1995). Occupational role models provide a visible, tangible idea of future imaginings, setting careers in context. They become the logical conclusion of school subject choice and embodiment of occupational success. Such conclusions are often difficult for school children to imagine and negotiate. Role models may provide a means of decreasing the uncertainty that might obscure the potential benefits of education and training (Nixon and Robinson, 1999). Same-sex role models may not only offer a testimonial of achievement and possibility, but also provide a discursive and relational dynamic within which young women are more likely to succeed (Neumark and Gardecki, 1998).

The role model takes largely notional assumptions of occupational choice and transfers them in an applied, concrete sense. In this way, young minds are able to grasp what STEM subjects are beyond the classroom and textbook. Role models are intended to extend young women's imaginary futures (Whyte 1985). The capacity to imagine new futures occurs as a process of identification, which Wenger (1998) defines as personal visions of broad opportunity that include STEM. Situated in context, STEM becomes that much more accessible, tangible indeed, even plausible for female learners. In its use of same-sex role models, *Discover!* seeks a stimulating and inspirational space for personal meaning making and what may seem as realistic projections of future imaginings. It seeks to induce a personal, intimate

expression of self and future self, neither beleaguered, diverted nor enfeebled by hidden curriculum.

The role model may be seen as central to the process of challenging and changing perceptions, reconfiguring attitudes and setting subjects free. Research does however suggest that whilst role models are useful in changing attitudes towards the possibilities of female futures, they rarely alter personal views (Murphy and Whitelegg, 2006). We argue however, that the variability in role model impact may be explained by approaching gender as immanent, fluid and a feature of interaction rather than an individual characteristic (Ivinson and Murphy, 2007). Future qualitative interviewing of *Discover!* session facilitators as role models and ethnographic observation of their interactions with participants, will help determine this extent.

A learner's ability to contest dominant ideology and alter depictions of femininity is the measure by which role models may be said to succeed. Skeggs (1991) comments that by contesting dominant institutional gender hierarchies a reframing of identity occurs. Dollimore (1991) meanwhile argues that identities only exist in a symbiotic relationship with what they are not. As such the role model repositions what it is to be female from passive oppressed to active positive. She provides a humanistic dimension to expertise, which allows STEM to be accessed more directly, immediately, and with confidence. Evidently, the selection of the right role model is vital in facilitating the growth of the learner and potential attitudinal changes. Same-sex role models are weighted with even greater responsibility as female advocates and liberationists, advancing the possibilities of women to contribute, in parity and without censure, in male-dominated fields.

Discover! thus ventures to dismantle forms of patriarchy and misogyny that covertly infuse many common and embryonic attitudes towards STEM. It not only strives to invigorate female interest but to dismantle prejudicial behaviours, and raise awareness that the barriers that might seem to preclude are surpassable. *Discover!* seeks to upend dominant aspects of gender inequality which Foster, Gomm and Hammersley (1996) situate as unequal distribution of classroom resources, inequality of what is valued in the classroom, socialization into inequality, and the effects of differential treatment to self-esteem. The role model as facilitator or stand-in-teacher is integral to the dissolution of these factors and the fostering of a learning zone based on equity and neutrality. This clearly is no small task and not always a realistic possibility. Nevertheless, the role model may be said to be an effective mediator for meaning making and arguably the most explicit evidence for the inclusion of women in non-traditional contexts (Sonnert et al., 2007).

Female role models offer not only the glimmer of occupational possibilities but a beacon, which defies common prejudicial perceptions. They strengthen the argument for greater female inclusion and suggest that women are not only equal participants but pioneers and leaders (Bettinger and Long, 2005).

Whilst role models advertise the achievements of women in STEM they also disseminate the difficulty of their success (Neumark and Gardecki, 1998). That female role models are a minority, demonstrates there is neither parity nor an automatic entitlement to occupational trajectories unimpeded by gender specification. Indeed the career trajectories of many such role models are seen to be if not peripatetic, cluttered with obstacles. Whilst as role models may promote the virtues of tenacity and determinism, it is not impossible to think that young girls might be dissuaded and revert or acquiesce to more attainable, less arduous and conformist ambitions (Murphy and Whitelegg, 2006). Role models are thus flawed in so much as the conclusion of aspiration, they represent the untenable and out of reach. Concurrently, whilst they attest to the potential of female success in STEM, their celebrity, uniqueness and paucity distinguish them. This raises issues of negative perception with role models presented as aberrations, ill fitting, non-conformist or one-off. In-depth interviewing of *Discover!* presenters will allow us to form a greater understanding of the inherent tensions for the role model and how these are managed.

The Parent as Role Model and Adjunct Learner

The role and contribution of the parental participant as both a facilitator and receiver in the production of knowledge should not be underestimated. The parental figure as a role model is instrumental in the aspirational development of the child learner (Haveman and Wolfe, 1995). In the case of *Discover!* this is manifest in the basic support and encouragement that parents give their children over the eight-week period of Saturday classes. This reflects not only a positive acceptance of *Discover!*'s educational merit but the level of investment dedicated to the broadening of the child's future prospects. In this respect, sustained parental motivation, enthusiasm and interest within and outwith the home, and the impact of cultural capital, may be said to influence the educational choices and occupational trajectories of young women (Dryler, 1998). Whilst *Discover!* may be seen to break new ground of possibility for young female learners, the consolidation of positive attitudes and enthusiasm for STEM remains largely rooted in the influence of family, school and peers (Salisbury and Riddell, 2000).

Research shows that the parent as role model, particularly as same-sex role model, is a powerful influence upon the types of career goals and aspirations chosen by their children (Jodl et al, 2001). Indeed there is a clear correlation between the types of occupational aspirations and choices made of parents and children of the same sex (Dryler, 1998). The cultural capital of the parent, inherited by the child through a process of gender socialization, frames a fledgling understanding of status, orientation and achievement (Stevens, 1986). The work of Rosenfeld (1978), similarly demonstrates how children imitate the occupational roles of their parents, establishing a clear link between the occupational orientations of parents and children of the same sex. In this instance, female learners with mothers in high-status occupations were shown to have a proclivity towards a similar (aspirational) role construction.

The parental participant is also a receiver of new forms of knowledge, albeit indirectly or as an unintended or unexpected project outcome. The by-product of the child learner's experience is the osmotic accrual of knowledge by the parent. The parental participant becomes a satellite or adjunct learner. In this way, a wider public is engaged and brought into the arena of STEM. As 'piggyback learners', *Discover!* parents may become active participants in their children's knowledge acquisition. *Discover!* in this way, represents the itinerant classroom where knowledge is mobilised, encountered and relayed in diverse settings; permeating multiple cohorts of intentional and unintentional learner. The transmission of knowledge from role model to young learner carries on to the parent, enriching and modifying domestic life. *Discover!* in this sense may offer an important interruption to the sequential pattern and trend of cultural reproduction. The (re)aligning of young learners' attitudinal frameworks to STEM may generate a knowledge fallout infiltrating and adjusting the understandings of their parents. *Discover!* may also play an important role in dispelling preconceptions of gender most especially in reinforcing and reproducing cultural memes that encourage female participation and which parents and teachers find difficult to promote.

Individualism/Agency/Self-Efficacy

Discover!'s aspiration for diverse social membership may engender cohesive learning communities and situate a model of social integration to be reapplied in a broader social context. In building a socially integrated learning environment, *Discover!* may develop soft skills⁵ allowing learners to more successfully communicate and interact with a wide and eclectic social mix. Away from the classroom, the single-sex approach of *Discover!* advocates the maturation of social and cognitive competencies in a safe environment. 61% of learner respondents claimed that working in groups had accentuated their key skills; skills, which are increasingly attractive to employers as a mark of excellence.

In developing key skills of intercommunication, team working and problem solving, female learners are provided with a toolkit, benefitting them on return to the classroom and in the long-term context. In some respects this is the beginning, preceding even formal subject choice, of the credentialed citizen. It is perhaps, however, an issue of timeliness that children are made to consider their future careers and make important choices at such an early stage.

Programmes such as *Discover!* do nothing to distil nor interrupt this tendency and if anything are responsible for magnifying the necessity of early intervention in subject and occupational choice. As such *Discover!* is indicative of a contradictory trend whereby learner choice is championed and prioritised yet education is conceived in a singularly and exclusively utilitarian context. The latter 'route-one' thinking may ultimately diminish learner choice by imposing a view of education as a process of cumulative outcomes

or assessments that disavow the learner as anything other than a pursuant of certification. In this instance the threat of self-fulfilling prophecies are not combated but unwittingly maintained. Education thus does not recover from the stringency of stratification, whereby learning is measured in largely artificial and generalist units, where meritocracy is determined more by gender, ethnicity or class than ability, and where creativity serves a neo-liberal economic agenda over a more socially and culturally inclined sense of prosperity. In this respect the prospective GCSE candidate emerges as a construction of market forces, of supply and demand. Navigation of these forces we suggest is used to denote the availability of learner choice and the prevalence of agency in determining occupational futures. *Discover!* should be considered therefore as opening avenues of choice, but choices, which are arguably strictly defined and pre-set.

Discover! also arguably, though unknowingly, buys into the cult or appearance of individualism, that which defines and makes learners and workers distinct, unique and thus highly marketable and competitive within the labour market. The impact of role models in forming a gender ideology and a sense of self-efficacy features highly and is evidenced by parental participants, theme leaders and invited speakers. The building of self-efficacy or a locus of control is a driving force determining how an individual performs her (unique) learner subjectivity and the measure by which she has sovereignty over future (educational and career) choices. It is argued that those with a positive self-efficacy perceive a greater availability of occupational choice, are more interested in occupational diversity, demonstrate greater levels of application, and achieve greater success in their academic work (Betz and Hackett, 1986; Lent, Brown and Hackett, 1994).

Female agency therefore in the context of STEM is highly problematic. The challenge for *Discover!* is not only in reducing or eliminating occupational prejudice and stereotyping, but in challenging and/or overcoming gendered difference that limits self-efficacy. Evidence suggests that self-efficacy occurs in different areas for women and men (Betz and Hackett, 1983; Hackett, 1985) and though women may describe themselves as equally efficacious, they may nevertheless follow gendered occupational paths and so capitalise on their perceived skills (Bandura et al, 2001). At another level, research observes how female learners are not wholly convinced they can achieve the necessary requirements for traditionally male jobs (Betz and Hackett, 1981). Even where there is parity of educational achievement between men and women, fewer females opt for STEM subjects, claiming disinterest and incongruence with occupational aspirations (Bussey and Bandura, 1999).

Whilst much has been done to achieve educational parity between women and men, certainly in the context of university admissions, women still lag behind in prestige or executive positions with high levels of responsibility and power (Collins et al 1998). A 'glass ceiling' effect continues to dissuade women from participating in male dominated occupational roles, posing

questions of self-efficacy and curtailing agency. *Discover!* may be said to reinforce the idea that women are marginalised in STEM areas, and that the paucity of women in senior or executive positions is indicative of the continued male domination of and inherent sexism within Higher Education and the workplace. Yet, in so doing it raises the momentum of debate and activism in correcting gendered disequilibrium.

For women to not only participate but lead in traditional male occupations, a cultural outlook and critical consciousness, that both anticipates and embeds female powers of self-efficacy, confidence and self-knowledge, is necessary. Spaces for the cultivation of positive identities are necessary for the fostering of gender equilibrium in STEM. *Discover!* offers a potential space where women are encouraged, without reservation or consequence, to refute conventional occupational typologies, entertain and realise their occupational aspirations, take faith in their ability and meet their will to achieve. In this micro learning society young girls become active agents responsible for the formation and forecasting of present and future subjectivity, the scoping and strategy of subject and occupational trajectory, and the building of confidence and self-belief.

Discover! accordingly seeks to not only broaden the horizon of career opportunities but as an extra mural activity, develop a vital repertoire of social skills necessary for women to compete in a male-dominated environment. This can be construed as either an act that is awkwardly disdainful, or as a tactical strategy that recognises the inherent difficulties for women in STEM and seeks to provide every possible advantage.

CONCLUSION

Myers (2000) argues that by the year 2000 much of the activism of the 1980s that had spearheaded discourse around gender equality and girls' education had been lost. Towards the end of the first decade of the new millennium, encouraging signs are showing that discussion and more importantly activity around gender equality and girls' education is re-emergent. *Discover!* is arguably one of these signs.

Discover! has the potential to provide a space where female learners may develop as not only participants but pioneers of STEM via an immersion in lived realities. Using Kolb's (1984) model of experiential learning, *Discover!* may be conceived as a form of critical pedagogy, which through the positive involvement and prioritising of the student, diversifies the learning experience. In so doing, the student may develop a desocialized thinking, or what Freire (1973) terms a 'critical transitivity' that enlarges the critical consciousness.

The *Discover!* student is given the opportunity to (re)visit the conditions of the learning contract that curtail if not remove academic and occupational choice in STEM. As such, *Discover!* may be said to not only dispute types of knowledge that espouse gendered occupational segregation, but the factors

that promulgate and reinforce these claims. Consequently, *Discover!* poses questions not only of what is being taught in schools but how it is being taught, and furthermore the rationale that grounds both these.

As a learning experience that empowers the marginalised or silent student, *Discover!* may also enrich teachers' pedagogical repertoires and underline the importance of their contribution in supporting the gender equitable school. Teachers may also benefit from exposure to the *Discover!* model of student learning which necessitates a change in power relations, and the central positioning of the student. There is enormous potential for *Discover!* to not only illuminate STEM, but empower the female learner as an autonomous, flexible and critically reflexive student. Fundamentally however, such learning is not about the accumulation of 'fact' but the ability to negotiate argumentation and deliberation. This is the kind of knowledge acquisition which Shor (1992: 21) terms as 'reflective understanding, not mere memorization'.

Ideas are neither fixed nor immutable but transfer and transmute with experience (Piaget 1979). *Discover!* aspires to be a space where ideas once formed may be reformed. It represents the continuum of knowledge, knowledge as a process, and knowledge as uncertain and disputable. As such, *Discover!* not only evinces discourse of uncertainty, imprecision and flux that characterises STEM but the frailty of conventions that perpetuate academic and occupational assignment by gender.

Finally, *Discover!* may not only open STEM to a young female audience, but a wider public. As a process of incidental, or what we have termed as 'piggy-back' learning, parents of *Discover!* participants are integrated into the learning experience and may enjoy changed perceptual knowledge. At this stage, *Discover!* demonstrates every potential as a solid foundation from which to engage and encourage broad deliberation, centring on the role of women in STEM and STEM as public.

ENDNOTES

¹ The GCSE is an academic qualification, in a specific subject studied for by secondary school children aged 14-16 in England, Wales and Northern Ireland.

² In 2008 Women in Science and Engineering (WISE) made a successful bid to the Welsh Assembly Government for funding which has enabled two other schemes to be launched in Swansea and in Gwent. The Swansea programme was based on the Cardiff model and was run with considerable support from Cardiff University and Careers Wales. The six-week programme involved 23 girls in years 9 and 10 from several local schools selected by Careers Wales West. It opened with an 'interactive launch evening' followed by six Saturday morning activity sessions that took place at Swansea University. The Gwent programme was a shorter programme and was run primarily by Careers Wales. Further initiatives are planned. It is hoped that similar programmes

will be rolled-out in other regions of Wales with the cooperation of Careers Wales and discussions have already taken place with Careers Wales Mid-Glamorgan & Powys. Funding has already been secured that will enable *Discover!* (Cardiff) to continue and Careers Wales West have indicated that they will be able to contribute to the running costs of the Swansea Club. These initiatives will form the basis of continued observation and analysis in 2010.

³ UK work experience programmes provide children close to choosing their GCSE options (see above) the opportunity to spend time outside of the classroom, learning about a specific job or type of work.

⁴ Taken from evaluation questionnaires

⁵ 'Soft skills' or 'personal skills' are personal attributes such as common sense or integrity or interpersonal abilities such as communication or leadership

REFERENCES

Archer, L., Pratt, S. & Phillips, D. (2001) Working Class Men's Constructions of Masculinity and Negotiations of (Non) Participation in Higher Education. *Gender and Education* 13, 4, pp. 431-499

Anot, M. & Mac an Ghaill, M (eds) (2006) *Gender and Education Reader*. London: Routledge

Bandura, A. Barbaranelli, C., Vittorio, C. G., & Pastorelli, C. Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development*. 72, 1
Bernstein, B. (1977) *Class, Codes and Control Vol. 3*. London: Routledge & Kegan Paul

Bernstein, B. (1977) *Class, Codes and Control Vol 3*. London: Routledge & Kegan Paul

Bettinger, E. P. & Long, B. T. (2005) Do Faculty Serve as Role-Models? The Impact of Instructor Gender on Female Students. *American Economic Review* 95, 2, pp. 152-157

Betz, N. E., & Hackett, G. (1981) The Relationship of Career-Related Self-Efficacy Expectation to Perceived Career Options in College Women and Men. *Journal of Counseling Psychology* 28, pp. 399-410

Betz, N. E., & Hackett, G. (1983) *The Relationship of Mathematics Self-Efficacy Expectations to the Selection of Science-Based College Majors*. *Journal of Vocational Behavior*, 23, pp. 329-345

Betz, N. E., & Hackett, G. (1986) Applications of Self-efficacy Theory to Career Development. *Journal of Social and Clinical Psychology*, 4, 279-289

Borzak, L. (1981) (ed) *Field Study: A Source Book for Experiential Learning*. Beverly Hills; Sage

- Bourdieu, P. & Passeron, J. C. (1990) *Reproduction in Education, Society and Culture*. London: Sage
- Bowles, S. & Gintis, H. (1976) *Schooling in Capitalist America*. London: Routledge
- Burke, R. J., & Mattis, M. C. (2007) *Women and Minorities in Science, Technology, Engineering and Maths: Upping the Numbers*. Gloucester: Edward Elga
- Bussey, K. & Bandura, A. (1999) Social Cognitive Theory of Gender Development and Differentiation. *Psychological Review* 106, 4, pp.676-703
- Bystydzienski, J. M. & Bird, S. R. (eds) (2006) *Removing Barriers: Women in Academic Science, Technology, Engineering and Mathematics*. IN: Indiana University Press
- Collins, A.B., Parrish, B.K. & Collins, D.L (1998). Gender and the Tenure Track: Some Survey Evidence. *Issues in Accounting Education* 13 (2), 277-299
- Delamont, S. & Duffin, L. eds. (1978) *The Nineteenth Century Woman: Her Cultural and Physical World*. London: Croon Helm
- Delamont, S. (1990) *Sex Roles and the School*. London: Routledge
- Dewey, J. (1997/1963) [1938] *Experience and Education*. New York: Touchstone
- Dixon, J. A. & Foster, D. H. (1998) Gender, Backchanneling and Social context. *Journal of Social Psychology* 138, pp. 134-136
- Dollimore, J. (1991) *Sexual Dissidence: Augustine to Wilde, Freud to Foucault*. Oxford: Oxford University Press
- Dryler, H. (1998) Parental Role-Models, Gender and Educational Choice. *British Journal of Sociology* 49, 3, pp. 375-398
- Engeström, Y., Engeström, R. & Kärkkäinen, M. (1995) Polycontextuality and boundary crossing in expert cognition: Learning and problem solving in complex work activities. *Learning and Instruction: An International Journal*, 5, 319-336
- Foskett, N. & Hensley-Brown, J. (1997) *Choosing Futures: Young People's Decision Making in Education, Training and Careers Markets*. London: RoutledgeFalmer
- Foster, P., Gomm, R. & Hammersley, M. (1996) *Constructing Educational Research: An Assessment of Research on School Processes*. London: Falmer

- Freire, P. (1970) *Pedagogy of the Oppressed*. New York: Herder and Herder
- Freire, P. (1973) *Education for Critical Consciousness*. New York: Continuum
- Foucault, M. (1974) *The Archaeology of Knowledge*. London: Tavistock
- Gavin, M. K. (1996) The Development of Math Talent: Influences on Students at a Women's College. *Journal of Secondary Gifted Education*, 7, pp. 476–485
- Gramsci, Antonio (1971). *Selections from the Prison Notebooks*. New York: International Publishers
- Guile, D. & Griffiths, T. (2001) Learning Through Work Experience. *Journal of Education and Work* 14, 1, pp.113-131
- Hackett, G. (1985) The Role of Mathematics Self-Efficacy in the Choice of Math-Related Majors of College Women and Men: A path model. *Journal of Counseling Psychology* 32, pp. 47-56
- Halpern, D.F. (1992) *Sex Differences in Cognitive Abilities* (2nd ed). Hillsdale NJ: Erlbaum
- Halpern, R. (1999) After-School Programs for Low-Income Children: Promise and Challenges *The Future of Children: When School is Out* 9, 2 http://www.futureofchildren.org/futureofchildren/publications/docs/09_02_07.pdf
- Hanson, S. L. (1996) *Lost talent: Women in the Sciences*. PA: Temple University Press
- Haveman, R. & Wolfe, B. (1995) The Determinants of Children's Attainments: A Review of Methods and Findings. *Journal of Economic Literature* 32, pp. 1829-78
- Hernández Garduño, E. L.(1997). *Effects of Teaching Problem Solving through Cooperative Learning Methods on Student Mathematics Achievement, Attitudes Toward Mathematics, Mathematics Self-Efficacy, and Metacognition*. Unpublished doctoral dissertation, University of Connecticut, Storrs
- Hooper-Greenhill, E. (2007) *Museums and Education: Purpose, Pedagogy, Performance*. London: Routledge
- Howieson, C. & Semple, S. (1996) [*Guidance in Secondary Schools*](#): A Report to the Scottish Office Education and Industry Department

Ivinson, G. & Murphy, P. (2007) *Rethinking Single-Sex Teaching: Gender, Subject Knowledge and Learning*. Buckingham: McGrawhill, Open University Press

Jodl, K. M., Michael, A., Malanchuk, O., Eccles, J. S. & Sameroff, A. (2001) Parents' Roles in Shaping Early Adolescents' Occupational Aspirations. *Child Development* 72, 4, pp. 1247-65

Johnsen, K. & Kendrick, J. (2005) *Teaching and Counseling Gifted Girls*. TX: Prufrock Press

Jones, M. G., & Wheatley, J. (1990) Gender differences in teacher-student interactions in science classrooms. *Journal of Research in Science Teaching* 27, 861-874

Kelly, A. (1987) *Science for Girls?* Milton Keynes: Open University Press

Kolb, D. A. (1981) Learning styles and disciplinary differences in A. W. Chickering (ed.) *The Modern American College*, San Francisco: Jossey-Bass

Kolb, D. A. (1984) *Experiential Learning: Experience as the Source of Learning and Development*. NJ: Prentice-Hall

Lave, J. & Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press

Lent, R. W., Brown, S. D., & Hackett, G. (1994) Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *Journal of Vocational Behavior* 45, pp. 79-122

Lucey, H. & Walkerdine, V. (2000) Boy's Underachievement: Social Class and Changing Masculinities in Theodore Cox (2000) *Combating Educational Disadvantage: Meeting the Needs of Vulnerable Children*. London: Falmer
Lee, V. E., & Marks, H. M. (1992) Who goes where? Choice of single-sex and coeducational independent secondary schools. *Sociology of Education*, 65(3), 226-253

Myers, K. (2000) *Whatever Happened to Equal Opportunities in Schools? Gender Equality Initiatives in Education*. Buckingham: Open University Press

Murphy, P. & Whitelegg, E. (2006) Girls and Physics: Continued Barriers to 'Belonging'. *The Curriculum Journal* 17, 3, pp. 281-305

National Academies Press (2007) *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*. Washington DC: National Academy of Sciences, National Academy of Engineering, Institute of Medicine

Neumark, D., & Gardecki, R. (1998) Women Helping Women? Role-Model and Mentoring Effects on Female Ph.D. Students in Economics. *Journal of Human Resources* 33,1, pp: 220-246.

Nixon, L. A., & Robinson, M. (1999) The Educational Attainment of Young Women: Role Model Effects of Female High School Faculty. *Demography* 36, 2, pp. 185-194

Orenstein, P. (1994). *School girls: Young women, self-esteem, and the confidence gap*. New York: Doubleday

Piaget, J. (1979) *Behaviour and Evolution*. London: Routledge and Kegan

Riddell, P. (1992) *Gender and the Politics of the Curriculum*. New York: Routledge

Rosenfeld, R. A. (1978) Women's Intergenerational Occupational Mobility. *American Sociological Review* 43, 1, pp. 36 – 46

Ryrie, A., Furst, A. & Lauder, M. (1979) *Choices and Chances: A Study of Pupils' Subject Choices and Future Career Intentions*. London: Hodder and Stoughton for the Scottish Council for Research in Education

Salisbury, J. and Riddell, S. (2000) *Gender, Policy and Educational Change: Shifting Agendas in the UK and Europe*. London: Routledge

Sarah, E., Scott, M., & Spender, D. (1980) The Education of Feminists: The Case for Single-Sex Schools. In D. Spender & E. Sarah (Eds.), *Learning to Lose: Sexism and Education*. London: The Women's Press

Shepardson, D.P. & Pizzini, E.L. (1992) A comparison of the classroom dynamics of problem solving and traditional laboratory model of instruction using path analysis. *Journal of Research in Science Teaching* 29, 3, pp. 243-258

Shor, I. & Freire, P. (1987) *A Pedagogy for Liberation: Dialogues on Transforming Education*. MA Mass: Bergin & Garvey Publishers

Silberman, C. (1970) *Crisis in the Classroom*. New York: Random House

Skeggs, B. (1991) Challenging Masculinity and Using Sexuality. *British Journal of Sociology of Education*. 12, 2, pp. 127-141

Sonnert, G., Frank Fox, M., & Adkins, K. (2007) Undergraduate Women in Science and Engineering: Effects of Faculty, Fields and Institutions Over Time. *Social Science Quarterly* 88, 5

Streitmatter, J.L. (1999) *For Girls Only: Making a Case for Single-Sex Schooling*. Albany: SUNY Press

Stevens, G. (1986) Sex-Differentiated Patterns of Intergenerational Occupational Mobility. *Journal of Marriage and the Family*, 48, 1, pp. 153 – 163

Tobin, K. G., & Garrett, P.J. (1987) Gender Related Differences in Science Activities. *Science Education*, 71, 91-103

van de Werfhorst, H.G., Sullivan, A., & Cheung, S. (2003) Social Class, Ability and Choice of Subject in Secondary and Tertiary Education in Britain. *British Educational Research Journal* 29, 1

Vygotsky, L. (1978) *Mind in Society: Development of Higher Psychological Processes*. MA: Harvard University Press

Walkerdine, V., Lucey, H., & Melody, J. (2001) *Growing Up Girl: Psychosocial Explorations of Gender and Class*. New York: New York University Press

Wallach Scott, J. (1988) *Gender and the Politics of History*. New York: Columbia University Press

Watermeyer, R. (2010) Social Network Science: Pedagogy, Dialogue, Deliberation, *Jcom* 09, 01

Weiner, G. (1994) *Feminisms in Education: An Introduction*. Buckingham: Open University Press

Wenger, E. (1998) *Communities of Practice: Learning, Meaning and Identity*. Cambridge: Cambridge University Press

Whyte, J. (1985) *Gender, Science and Technology*. School Curriculum Development Committee