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A Pedagogical Pathway to Enhance Science Identity in Disadvantaged Males

Veronica McCauley, Colin Tierney, Paul Flynn
Centre of Pedagogy and Public Engagement Research, National University of Ireland Galway, Ireland

Abstract

This research considers the multifaceted role science plays in supporting males from socio-economic disadvantaged communities to progress to higher education. School students from these communities tend to perform worse on achievement tests in science than other school cohorts. This can result in male students from underrepresented groups not seeing themselves as capable in the subject or possessing the traits of what it means to be a scientist. Further, in Irish post-primary schools, although the national uptake in senior Biology is 2:1, females:males; in socio-economic disadvantaged communities this escalates to 3:1 respectively. Intersecting literature suggests that increasing student science identity may interrupt this pattern. Thus, this paper considers three interconnected pedagogical strategies to support enhancing male science identify, from disadvantaged communities: integrated teaching, inquiry, and free choice learning. These initial steps in developing a conceptual framework and through dialogue with the field, will lay the foundations for the development of actionable knowledge. This is particularly poignant, considering the global challenges highlighted in recent legislation relating to Climate Action, which rely on scientific and technological innovations, and an engaged public willing to do their part.

Keywords: *Science education, science identity, disadvantaged communities, pedagogical innovation*

1. Introduction

This research considers the multifaceted role science plays in supporting males from socio-economic disadvantaged communities to progress to higher education. Such students often underperform on science achievement tests relative to mainstream school cohorts [1] and do not see themselves as capable in the subject or possessing the traits of a “good scientist” [2]. Further, female students outnumber male students 2:1 in choosing Biology as an examinable subject at post-primary school in Ireland [3], exaggerated further in disadvantaged communities at 3:1 [4]. This trend is evidence of a disadvantaging of male progress through a Biology pathway to higher education and the positive financial careers that may ensue. Intersecting literature suggests that increasing student science identity has the potential to interrupt this pattern. Thus, this paper considers a suite of teaching strategies, designed as a pedagogical pathway to support enhancing male science identity with Biology. Presented here are three lenses which may provoke a favourable response and are considered as a conceptual framework to pave the way to a brighter science informed future for disadvantaged males in Ireland.

2. Science Identity and Self-Concept

Student attitudes towards science subjects are mixed. In school and in their daily lives, young people are exposed to competing images that form their personal understanding of what a scientist is and who can be a scientist. When one chooses to pursue science, they begin to align their identity with the norms and expectations of what they see as scientific [5][6]. However, this process is much easier for some students than it is for others, as social forces play a strong role in determining the requirements for participating in given identities resulting in students balancing their own aspirations and interests with the expectations imposed on them by their peers, families, and teachers [6]. As students get older, they begin to refine in themselves what it means to be a person who is successful in science and whether or not they belong. Some students begin to feel they do not identify as a science person because they do not align with the expectations of a “good” or “brainy” student [7].

Scholarship in this area [7] accentuates the influence of power and social status on science identity. They found that white, male students from families with higher earnings, connection and experience in a science related industry felt the most confident in science subjects. Students who fit into this mould are given more encouragement by teachers, streamed into more rigorous classes, and receive greater

career guidance because they are seen as sufficiently “clever.” As a result, girls, students of colour, and students from families with lower incomes, participate in higher level science classes in secondary school in far fewer numbers despite having strong interest, support from their family, and personally valuing science learning. In Ireland, Biological Sciences are prominent across Higher Education offerings, with over 50% of the students sitting a matriculation Biology exam annually [4]. If students do not take Biology for examination during the final years of study in second level education, a resulting impediment to progress to higher education arises. This clearly illustrates the need to expand the reach of science identity beyond the status quo; to open doors for disadvantaged communities to transition to higher education, more financially rewarding positions, and above all, contribute to a sustainable healthy society.

3. STEM Pedagogical Approaches

Students often perceive the process of learning science as quite removed from their everyday lives [1] indicating that considerable pedagogically framed identity work is necessary if student engagement in science at school is to be improved. A triadic conceptual framework is illustrated in Figure 1 and the rationale expanded below.

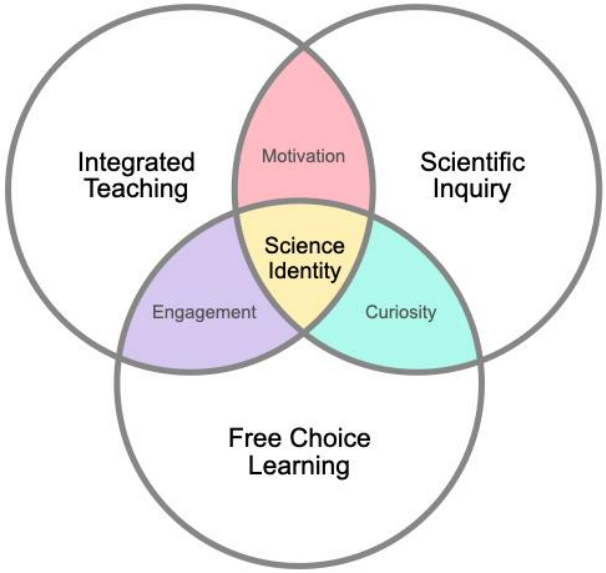

Fig. 1. Conceptual Framework Towards a Biology Pedagogical Pathway for Disadvantaged Males

3.1 Integrated Teaching

Considering the identity work necessary to engage in science learning, it is important that students are allowed to explore how different disciplines are related and used together to solve real problems. Starting from the everyday lived experience of students and applying it to the sciences can be a powerful teaching method as it provides a foundation for more abstract concepts. Interestingly, this blending of disciplines has also been shown to interrupt science self-concept trends and promote participation in biology for male students [8]. Jansen’s [8] research on the composition of course structure on student’s academic self-concept in science revealed that when the three sciences (physics, chemistry and biology) are taught as separate subjects, and compared to an integrated science teaching approach, that males showed higher self-concept and interest in Biology, an unexpected advantage, when taught through this blended science approach. Despite the strengths of this approach, a recent study of Irish science teaching found that interdisciplinary methods are not common in the post-primary setting [4]. As such, one must consider opportunities that allow for an integrated science teaching composition towards enhanced self-concept in Biology for males.

3.2 Scientific Inquiry

Student-led science learning that incorporates inquiry and problem solving is widely seen as an effective method for increasing relevancy and authenticity [1][9][10][11]. Inquiry-based learning allows students to choose their own methods for solving problems [12]. This can, for example, include developing and testing hypotheses through conducting experiments, researching topics, making observations, and collecting or using data. Students are encouraged to experiment and make mistakes while understanding that there may not be one single correct answer, resulting in participation in a more meaningful science experience [11][13]. Inquiry-based learning has been shown to motivate and engage learners who are low-achieving or come from less privileged backgrounds by allowing multiple entry points and perspectives to engage in science learning [14]. This method allows a wider range of participation and feelings of efficacy and acceptance in science classrooms.

3.3 Free Choice Learning

Allowing students to experience science outside of the confines of school can be very impactful. This sort of choice and exploration in less-formal settings is vitally important to motivation and is one of the most significant contributors to lasting science knowledge [15]. Studies have also shown that less formal science education is particularly impactful for students who may not feel that they belong in a science learning environment. As Falk et al. [15] reveals, “Not only do free-choice science learning experiences jump-start a child’s long-term interest in science topics, they also can significantly improve science understanding among populations typically underrepresented in science” (p. 491). However, there is also evidence that children from lower socioeconomic status households are much less likely to experience informal learning opportunities [16]. In short, if students do not see the connection to their lives, if there is no relevancy, they will be less motivated to learn [17]. Further, making these connections will help students see the diverse application of science learning in potential career paths. Therefore, it is imperative that schools address this gap by forging partnerships in the community and providing students with the opportunity to learn independently despite the challenges this may pose [18].

4. Conclusion

In this paper we have highlighted the current access challenge for males from these disadvantaged communites towards a biology pathway, whether to inform their scientific decision making in society, or to progress into a prosperous higher education pathway. Future design-based research [19] intends to enact the conceptual framework and lay the foundations for the development of actionable knowledge. This is particularly poignant, considering the global challenges highlighted in recent legislation [20] relating to Climate Action, which relies on scientific and technological innovations, and an engaged public willing to do their part.

References

1. Department of Education and Skills (DES). (2016). *Stem education in the Irish school system – analysis and recommendations.* https://www.education.ie/en/publications/education-reports/stem-education-in-the-irish-school-system.pdf
2. Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). *ASPIRES 2: Young people’s science and career aspirations, age 10-19*. London: UCL Institute of Education.
3. State Examinations Commission (SEC). (2018). Leaving Certificate 2018 Final Gender Stats - Higher Level/Ordinary Level. https://www.examinations.ie/index.php?l=en&mc=st&sc=r18
4. Department of Education and Skills (DES). (2020). *STEM Education 2020.* STEM Education 2020:https://assets.gov.ie › ...
5. Krogh, L. B., & Andersen, H. M. (2013). “Actually, I may be clever enough to do it.” Using identity as a lens to investigate students’ trajectories towards science and university. *Research in Science Education, 43*(2), 711-731. http://doi.org/10.1007/s11165-012-9285-2
6. Varelas, M., Kane, J. M., & Donahue Wylie, C. (2011). Young African American children's representations of self, science, and school: Making sense of difference. *Science Education (Salem, Mass.), 95*(5), 824-851. http://doi.org/10.1002/sce.20447
7. Archer, L. Dawson, E., Seakins, A., DeWitt, J., Godec, S. & Whitby, C. (2016) “I’m Being a Man Here”: Urban Boys’ Performances of Masculinity and Engagement With Science During a Science Museum Visit, Journal of the Learning Sciences, 25:3,438-485, DOI: 10.1080/10508406.I2016.1187147

8. Jansen, Malte, Schroeders, Ulrich, Lüdtke, Oliver, & Marsh, Herbert W. (2019). The dimensional structure of students' self-concept and interest in science depends on course composition. *Learning and Instruction*, *60*(60), 20–28. https://doi.org/10.1016/j.learninstruc.2018.11.001
9. Godec, S., King, H. & Archer, L. (2017). The Science capital teaching approach: engaging students with science, promoting social justice. London: University College London.
10. US Department of Education (USDE). (2015). *STEM 2026 A Vision for Innovation in STEM Education.* https://www.air.org/system/files/downloads/report/STEM-2026-Vision-for-Innovation-September-2016.pdf
11. Artigue, M., Dillon, J., Harlen, W., Lena, P. (2012). Learning through inquiry: background resources for implementing inquiry in science and mathematics at school. The Fibonacci Project.
12. Martins Gomes, D and McCauley, V. (2016). Dialectical dividends: Fostering hybridity of new pedagogical practices and partnerships in science education and outreach. *International Journal of Science Education.* 38(13-14), 2259-2283. http://dx.doi.org/10.1080/09500693.2016.1234729
13. Whannell, R., Quinn, F., Taylor, S., Harris, K., Cornish, S., & Sharma, M. (2018). Open-ended science inquiry in lower secondary school : Are students' learning needs being met? *Teaching Science, 64*(1), 37-45. http://libgate.library.nuigalway.ie/login?url=https://www-proquest-com.libgate.library.nuigalway.ie/scholarly-journals/open-ended-science-inquiry-lower-secondary-school/docview/2036212064/se-2?accountid=12899
14. Krajcik, J., Marx, R., Blumenfeld, P., Soloway, E., & Fishman, B. (2000). Inquiry Based Science Supported by Technology: Achievement among Urban Middle School Students.
15. Falk, J., & Dierking, L. (2010). The 95 Percent Solution. *American Scientist, 98*(6), 486-493. https://www.doi.org/10.1511/2010.87.486
16. Harvard Family Research Project. 2007. Findings from HFRP's study of predictors of participation in out-of-school time activities: fact sheet. http://www.hfrp.org/content/download/1072/48575/file/findings_predictor_OSTfactsheet.pdf
17. Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020) Implications for educational practice of the science of learning and development, *Applied Developmental Science, 24*(2), 97-140. https://doi.org/10.1080/10888691.2018.1537791
18. Jennifer, L. R., Knutson, K., & Crowley, K. (2013). Informal learning organizations as part of an educational ecology: Lessons from collaboration across the formal-informal divide. *Journal of Educational Change, 14*(3), 259-281. http://doi.org/10.1007/s10833-012-9203-4
19. Flynn, P.**,** McHugh, M., McCauley, V**.**, & Hall, T. (forthcoming, 2022) Design Based Research. In Delahunty, T & Ní Ríordáin, M. "Perspectives in Contemporary STEM Education Research: Research Methodology & Design. Springer.
20. Department of Environment, Climate, and Communication (DECC). (2021). *The Climate Action and Low-Carbon Development (Amendment) Bill.* https://www.gov.ie/en/publication/984d2-climate-action-and-low-carbon-development-amendment-bill-2020/