

STEMming the tide of student non-engagement

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“If the structure does not permit dialogue the structure must be changed” (Paulo Freire)

Introduction

Ireland faces a crisis. The uptake of STEM subjects (Science, Technology, Engineering and Maths) at secondary levels is declining. Students are disengaging from these subjects at a growing rate. Research reveals that this disengagement happens early in the Junior Cycle when some students start to enjoy their schoolwork less as they move through the system. In Ireland there is an urgent need to counteract this decline. As Ireland becomes a global scientific hub, the market’s demand for a scientifically literate workforce is ever increasing. In a few years the demand on a scientifically literate workforce will surpass the number of science graduates. So is there a way to avoid this crisis?

In recent years, the Irish Government and the EU have committed to investing in the education of STEM subjects (Science, Technology, Engineering and Maths). The attention is now on developing strategies to improve science teaching. For example, the EU has an increasing interest in facilitating good practice in IBSE (Inquiry Based Science Education) to replace the traditional teaching methods of science.

So what is IBSE?

It is a problem-posing and student-centred teaching methodology. Students are faced with a problem, to solve it they have to construct their own knowledge by making observations, planning investigations and experiments, gathering data then analysing it and communicating the results. They deduct general theories from specific practices to advance their science literacy, critical thinking and problem solving skills.

Despite the considerable investment in IBSE that is designed to inspire young people interests in the sciences; the uptake of subjects such as Physics and Chemistry is still declining. It seems as if IBSE is missing an extra element to reach its potential in engaging students to a level where they uptake science subjects in the Senior Cycle.

Where are we going wrong?

To find out we *must* start to critically question the political and economic implications of the STEM education and its role in engaging students effectively and find alternatives. This is where my research comes in.

Research aim

Research found that culturally insensitive curricula have served to legitimize discrimination towards racialised, classed and gendered students by preventing them from enjoying full and active democratic citizenship and engagement.

This research focuses on the S in STEM. The main aim of this research is to develop a “Critical Inquiry Based Science Education” (CIBSE) curriculum by adding elements of Critical Theory to IBSE to stem the tide of student non-engagement. It questions the dominant discourse of STEM education. A Critical IBSE curriculum is a culturally sensitive curriculum that is relevant to students’ social lives. The cultural relevance is the degree to which the curriculum content and classroom experience speak to a student’s social self-identity (e.g. race, class, gender, sexuality and ability) through a problem-posing methodology that focuses on using real-world and locally meaningful situations. This research argues that a culturally relevant IBSE approach increases the students’ effective engagement and subsequently will have a positive influence not only on science subject uptake at secondary level but also on democratic citizenship.

This study aims to explore the effectiveness of CIBSE on increasing students’ engagement in STEM subjects and subsequently on STEM subject uptake, advance the teachers’ practical skills to implement CIBSE effectively and relate science education to teaching for citizenship and moral development. It will also study the effect of a culturally relevant science curriculum on students’ engagement

But the question remains; does the integration of CIBSE curriculum into Junior Cycle respond to the contemporary need in Ireland for both a scientifically literate workforce and a fair and equal society for young people?

Critical theory

To be able to understand what a CIBSE curriculum is, one ought to start by defining Critical Theory. Critical Theory is a theory that aims to ‘humanise’ students by treating them as ‘subjects’ who have the ability to change their circumstances rather than just objects who are made to follow orders. It is a framework of belief systems that directly engages members of culturally diverse groups with a focus on social justice issues. This approach includes the perspectives of the participants (the students and the teacher) and the structures within which their interactions take place (the school and the classroom). It

aims to improve the students' social awareness about issues of recognition, representation, and power relationships. It focuses on dialogue to interrogate dominant views and what is accepted as 'common sense'.

Rationale

Recent rapid changes in the world economy have highlighted the need for a workforce that is scientifically literate. However, there is a steady decline in the proportion of young people taking science subjects within upper secondary education. Traditional didactic learning remains dominant in our education system. Research found that science take-up tends to be higher in schools which emphasise practical work and students' participation in classroom activity. Active learning is currently being promoted in the new reforms to the Junior and Senior Cycle. The European Commission regards pedagogical practices based on inquiry-based methods as more effective for the teaching and learning of science. It has identified gaps in knowledge related to the necessary pedagogical skills needed by science teachers to promote teaching and learning environments for IBSE and to implement it in their classrooms more effectively. This research aims to bridge this gap by providing in-depth evidence of the processes and skills needed for a more effective implementation of IBSE.

Research suggests that didactic practices limit the students' effective engagement in the learning process. The disengagement of students has subsequent societal costs tending to reproduce social inequalities between middle and working class students. Crucially however, my study also suggests that the current trend towards IBSE is in danger of underestimating the complex factors involved in enhancing student engagement, citizenship and participation. However, by developing a Critical IBSE curriculum, this research study provides a concrete way of offering lower-income and disaffected students a greater opportunity to shape the discourse of science and reflect on its social, economic and political priorities, rather than solely introduce them to basic scientific concepts and methods.

Objectives

This research argues that engaging students in creating their own culturally reflective Inquiry Based Science Education curriculum (CIBSE) increases their engagement and subsequently their uptake of science subjects at secondary level. Together the students and I (researcher/teacher), identify and co-investigate scientific themes that are relevant to the students' own culture. This approach not only develops scientific literacy but also equips students with critical thinking skills and a sensitivity to issues of social justice.

The key objectives of this research are to explore the current levels of students' engagement in STEM subjects, incorporate students' social realities into the co-creation of a

science curriculum and deploy it and to explore how the new curriculum opens up opportunities for meaningful student engagement and enhanced science literacy. This study assesses the students' emerging skills of enhanced science literacy, critical thinking and democratic citizenship and their effect on meaningful engagement and devises effective and meaningful strategies for science teachers to confidently deploy an innovative, creative, and culturally-relevant CIBSE curriculum which simultaneously addresses science literacy and social justice related issues. The final objective is to create guidelines for a better understanding of inclusionary practice and social diversity through 'science learning'

Methodology

I, the researcher who is also a qualified science teacher, will co-investigate and co-develop a CIBSE curriculum with a group of Transition Year students. It is a science curriculum that is owned by the students rather than being imposed on them by the teacher. It deals with scientific themes that are relevant to the students' own culture, gender, class, sexuality, ethnicity and ability. This curriculum challenges dominant social views about the teaching and learning of science as 'objective' and 'neutral' knowledge and locates it in its wider political and economic context towards a more inclusive and socially aware classroom. It explores how students are empowered (or disempowered) by science education. It is a methodology where both teachers and students inquire, learn and teach interchangeably; they advance through mutual dialogue towards becoming critical, scientifically literate and democratic citizens. Even though this research encourages students' autonomy in setting up the curriculum, the teacher's role is crucial in guiding this process.

This methodology will argue that an apolitical approach to science education is in itself a political act in which educators are consciously or unconsciously involved in serving the interests of the 'dominant group'. For example an uncritical science teacher could play a key role in justifying an exploitive economic and political system, ignore the scientific contribution of non-Western scientific traditions and attribute people's hindered achievements to biological or geographical factors. Hence, an uncritical teaching and learning of science, as currently practiced, inevitably engages the teacher and learner in maintaining structural social injustices. The process of co-creating a CIBSE curriculum with the students through dialogue insures the representation of both the dominant and marginalised views to empower and engage both groups.

The choice of the Transition Year cohort as research participants is justified by the following:

- CIBSE is closely related to modular development in Transition Year. CIBSE gives the students a greater opportunity to shape the discourse of science and reflect on its social, economic and political priorities, rather than solely introduce them to basic scientific concepts and methods

- The Transition Year is a key year for the students to revive their engagement with STEM subjects influencing their up-take decision in 5th year
- Research findings and recommendations would help re-shape the emerging Junior Cycle curriculum

In order to examine the main research question about the impact of a CIBSE curriculum on students' engagement, data is collected through: pre- and post-research assessment interviews; the teacher's informed observations and weekly self-reflective journaling; and students' periodic self-evaluations, as part of the 'assessment' process. A comparative thematic analysis is conducted in relation to behavioural, cognitive and affective engagement before and after the research takes place as follows:

- Behavioural engagement:
 - Social engagement
 - Academic engagement
- Cognitive engagement focuses on students' efforts put to comprehend complex ideas
- Affective engagement is examined through studying feelings of identification and belonging to the school environment and the wider community

Social identities such as those related to class, race, ability and gender are always re-produced, defended, challenged and reconstituted in schools as they are affirmed or dismissed at different times and in different contexts within educational settings. Hence the co-creation of a CIBSE curriculum and data analysis will be done in the light of the contemporary concept of 'intersectionality'. Intersectionality is a concept that maps the intersections of race, gender, class and ability and disrupts the tendencies to see them as exclusive or separable when addressing key issues related social injustice. This research will use this concept as a tool to uncover the shifting interplay of inequalities facing students at subcultural, peer and institutional level.

The data collected is qualitatively analysed highlighting the development and the transformation of the process and the challenges and limitations faced. Based on the data analysis, recommendations are given.

Methods

This research is conducted in two schools with the Transition Year cohort. It includes the following methods

- Observations: Two one-week observations — one week within each school observing Transition Year Science classes

- Semi-structured interview: Twelve Semi-structured interviews — four science teachers and two school principals — pre and post research
- Focus Groups: Four focus groups — pre and post research assessment interviews — two within each school
- Age appropriate, methods is used to stimulate discussion
- Two terms of teaching Transition Year Science classes during which CIBSE modules with extensive ICT resources are co-created and co-developed with the students
- In line with the principles of critical enquiry and driven by its participatory approach, this research accentuates the voice of young people as central to the project. A students' advisory group provides input to the methods and feedback on initial data analysis

Conclusion

Concerns have been expressed regarding the declining interest in science. The manner in which science is taught in junior cycle contributes to the fall-off in the take-up of science subjects at senior cycle, with follow-on impact at third level. The lack of interest in science education, particularly its perceived lack of relevance and abstraction, seems to be a particular concern identified by the European Commission. This research not only identifies gaps in knowledge regarding STEM education, but also conceptualises a pedagogy that increases students' engagement in STEM subjects at a secondary level and subsequently develops STEM skills needed for a scientific workforce in the current Irish economy. Furthermore it questions the effects that 'teaching for the market's need' has on students' identities.

The findings of this research are crucial on national and international level. They contribute to knowledge methodologically as this kind of research is under-used in Irish contexts. Empirically, they give insight into the context of Junior Cycle reforms and the social and political issues around it particularly for marginalised students. And finally this research conceptualises the processes through which curricula could be co-created for social justice progress.

The Author wishes to thank his supervisors Dr Stephen O'Brien and Kevin Cahill and his colleagues.