Teaching Advancement at Universities

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Individual Institutional Project Report

Establishing an Honours module focusing on a human-centered STEM context and approach

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Introduction

Many physiologists and research scientists view their discipline as ''neutral'' and devoid of any socio-political and historical contexts, forming part of a broader phenomenon known as "scientific elitism'' (Amick, 1974; Loudon, 2018). This became evident during the Covid-19 pandemic and the so-called post-truth world where scientific facts mattered less in terms of shaping public opinion (Keane, 2018). Such concerns therefore highlight the need to introduce a broader curriculum to Science, Technology, Engineering and Mathematics (STEM) students, that includes a critical focus on the nature and context of the scientific process and its applications, and evaluating the role and impact of various influencing factors. In support Mathews (2012) in his highly cited article writes: *''There has been a long tradition advocating the cultural, educational, personal and scientific benefits of infusing the history and philosophy of science, into science programmes and curriculum..''*. He further notes that major scientific organizations such as the American Association for the Advancement of Science stress that learning about the history and methods of science should result in a beneficial impact on the critical thinking of students (American Association for the Advancement of Science, 1993).

This TAU project attempted to address this knowledge and training gap by focusing on a curriculum renewal process at Stellenbosch University. Importantly for this project, program renewal and the realization of graduate attributes form two of the five strategic priorities listed in Stellenbosch University's Strategy for Teaching and Learning (2017-2021). In terms of program renewal, the university aims to *''engage in a process of continuous curriculum renewal at both programme and module levels, in response to contextual imperatives''* (Stellenbosch University's Strategy for Teaching and Learning [2017-2021]). These priorities provide a strong impetus to address the relative lack of socio-political and historical contexts within the STEM and biomedical sciences curriculum at Stellenbosch University to enable graduates to better shape the future in South Africa and beyond. Furthermore, it is also in accordance with the university's stipulations that graduates ''*should be assisted in cultivating skills, values and ideas that enhance his/her own humanity''* (Stellenbosch University's Strategy for Teaching and Learning [2017-2021]). In order to address this, Nussbaum's (2006) ideas were incorporated into the project, as she emphasized that curriculum planning within the STEM disciplines should adopt an increased understanding of human complexities. She therefore argued for the ''cultivation of humanity'' and highlighted three capacities that are required to achieve this: a) critical examination of the self and traditions, b) students recognizing themselves as human beings bound to others, and c) the adoption of an empathetic approach versus simply the acquisition of factual and subject-specific knowledge.

Keeping this broader theoretical framework in mind, this project focus was for biomedical science students to gain increased insights and a critical and deeper understanding regarding the complexity of the scientific process. This is well summarized by Mathews (2012): *''..where it is repeatedly stated that students will gain appreciation of nature of science positions and issues, and competence in nature of science thinking, rather than declarative knowledge of nature of science. It is unrealistic to expect students, or trainee teachers, to become competent historians, sociologists or philosophers of science.''*

Aim

The major aim was be to develop and establish a new 3-week BSc (Hons) module (forming part of a one-year degree program) focusing on the features of science and broader societal contexts that may impact on biomedical fields such as Physiology, using design-based principles. Once successfully established, further aims include sharing information gathered regarding the nature of the module, and its implementation, with other departments and institutions.

Processes and methods

A design-based research methodology was adopted for this project. The module curriculum was constructed in line with the following design principles: *1) choose meaningful, real-world problems for teaching and learning* (Rule, 2006: *2) employ engaging discourse in class by allowing for open-ended discussions and sharing of diverse views* (Rule, 2006; *3) promote a holistic and critical understanding of the scientific process* (including aspects of history and philosophy) (Nussbaum, 2006; Matthews, 2012); *4) promote self-reflection by students to enhance their synthesis and validation of knowledge, and to increase their empathetic capacities and social justice* (Boud et al., 1985); and *5) employ open-ended and self-reflective tasks together with authentic assessments* (Rule, 2006). The design principles were employed to enable a transformative teaching and learning experience.

The course content covered 8 x 90 minute virtual sessions with the BSc (Hons) (Medical Physiology) class (16 students) (Stellenbosch University). In brief, the topics covered included the social contract of science (with society), a critical examination of the scientific process of knowledge creation, science versus pseudoscience, the views of philosophers (Karl Popper, Thomas Kuhn), the notion of ''scientific elitism'', definition of an ''expert'', the impact of the post-truth world on science, neoliberalism and higher education/science, scientific racism and decolonization, social justice in the scientific context, conspiracies (psychology behind it and effective ways to debunk myths), the cultivation of humanity in science, and effective scientific communication. Students were required to complete selected readings (in advance) focusing on the topics to be discussed. I then discussed the topics in a Socratic manner with open-ended questions, self-reflection, and by continuously encouraging interaction from all the students. A safe space was created for such discussions, with the aim for students to freely share and express their opinions and beliefs.

Student feedback was assessed through the completion of an anonymous survey and a thematic-type analysis (anonymous) of their self-reflective journals. In addition, pre- and post-module tests were completed (without any preparation and advanced studying) to evaluate whether the students displayed any improved insights regarding their understanding of concepts discussed in classes. The students also tackled a group project on various open-ended research topics that culminated in a formal presentation to the Division of Medical Physiology's (Stellenbosch University) staff and students. The students also had to submit an essay on the role of scientists in the post-truth world that was submitted after completion of the module.

As a further attempt for the Hons students to cultivate empathy and a more humane approach in their future careers, a cross-faculty opportunity was created by working together with the Department of Visual Arts at Stellenbosch University. Here, I initially met with the second-year arts class and explained aspects regarding the nature of the scientific process and examples of cardiac pathological complications. On a later occasion, the BSc (Hons) students viewed the exhibited art works, which was followed by discussions with the arts students, together with a summary of their thoughts.

The students completed the necessary consent forms for the completion of the survey, analysis of their self-reflective journals and arts exhibition writings. The study was ethically cleared by the Research Ethics Committee (Social Behavioural and Education Research) at Stellenbosch University (#24378).

Achievement and challenges

Feedback indicated that students found the subject content interesting and relevant, and that the safe spaces allowed for different viewpoints to be freely expressed. The open-ended type of discussions in classes were well received and students indicated that it added considerable value to their learning

experience. They also felt that the module enhanced their understanding of the complexity of the scientific process, while raising their awareness of humanity, empathy, and social justice.

Analyses of the self-reflective journals in line with the five design principles of this study revealed further insights. For example, for the draft principle *choose meaningful, real-world problems for teaching and learning,* the issue of eugenics was discussed that included links between science and the socio-political consequences e.g. in Nazi Germany. A retracted article on ''coloured'' South African women and lower cognition abilities was also discussed in detail. Of note, the lowest score for the survey data related to whether students experienced any discomfort regarding the subject content covered. The analysis of the self-reflective journals revealed that this especially applied to the discussions relating to science and race issues. For example, one student wrote *Before class [race and science] I found myself being very anxious as we have never discussed race before within an academic session..(St #7).* Another commented as follows: *It is a sensitive topic [race and science] for a lot of people, so I had no idea how the class would have turned out (St #8).* Delving into such case studies resulted in a significant impact on the students regarding flaws in the scientific process and how it can result in detrimental outcomes for broader society. Such sentiments were discussed in class and linked to social justice and for e.g. whether there is indeed a need for ''race-based'' scientific studies and that its roots may lie in modern western science.

For the draft principle *employ engaging discourse in class by allowing for open-ended discussions and sharing of diverse views* the students were anxious at the beginning of the module as they were not usually asked to share their opinions and several also feared public speaking. However, the students managed to adapt as the classes progressed and settled reasonably well into the Socratic nature of the discussions. For the draft principle *promote a holistic and critical understanding of the scientific process (including aspects of history and philosophy)* it emerged that the students developed a better grasp for the complexity of the scientific process and the importance of research integrity and ethical behavior. For example, one student wrote: *What was entirely new to me was being taught to understand that scientific thinking goes beyond the linear nature of gathering facts or information but can also involve thinking critically and philosophically about various topis (St #3).*

For the draft principle *promote self-reflection by students to enhance their synthesis and validation of knowledge, and to increase their empathetic capacities and social justice* the analyses showed that some felt that self-reflection may be beneficial in their lives. In addition, the module appeared to create a greater awareness of ''the other'' and the importance of being more inclusive in terms of the scientific process. There was also reflection regarding the humane aspects related to the scientific process and its application and that such issues deserved further attention: *I found this module to be thought provoking and helpful..It has allowed me to reevaluate my empathy towards humanity, to understand the importance of collaboration and honesty in the field and to remember to have ethical neutrality throughout the scientific process (St #14).* The students also enjoyed their visit to the arts exhibition and their reflections revealed key themes when viewed in a collective sense. Here, some acknowledged that although science often focuses on the detail, this experience taught them to consider the whole and bigger context, and to include community and societal aspects. They also indicated that although science (objective) and the arts (subjective) focus on different aspects, there is an overlap and interconnectivity between the two disciplines. Scientists should therefore sometimes take a ''step back'' from the detail to be open to different perspectives. Hence, our postulate is that this should enhance creative thinking that can subsequently lead to innovation and discoveries.

For the draft principle *employ open-ended and self-reflective tasks together with authentic assessments* the students seemed to appreciate this as they felt it resulted in greater critical thinking and a chance to express their own views regarding such issues. The journals also revealed that the group presentations were a real success and enjoyed by the students. For example, one commented

that: *This was my favorite part of the project [group presentation work] because during the [group] meeting, we had the most incredible conversations where we debated and bounced ideas off each other and it was an amazing experience (St #16).* The pre- and post-module tests that were written (without any preparation and studying) revealed a significant improvement in student performances and retention of topics discussed in class.

Upon reflection it is clear that despite the relatively successful rollout, the module can be further strengthened, and some of the design principles be refined fro the next iteration. The module is currently not accredited and should now be formally adopted as part of the course content. It is important that classes be done in face-to-face fashion as this should enhance the impact of such engagements and assist by promoting open-ended type of discussions. The availability of additional class slots would be useful as it would allow for the introduction of more case studies and group presentations as requested by the students (''comments'' section of survey). A cohort of lecturing staff would need be co-opted who are willing to undergo training to ensure the longer-term sustainability of this program. Moreover, efforts for its rollout to other science departments at Stellenbosch University (and beyond) should be enhanced, as this study revealed its implemnation is logistically feasible and that it was enthusiastically received by the students.

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