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Educating scientists in South Africa in the 21st century

In South Africa, teaching science at a tertiary institution faces a particular confluence of societal forces which can be seen as a major threat to the educational effort. These forces include strong pressure from the government to accept a mark of 30% at the school exit level as 'university entrance'; a call for a decolonised curriculum; and an increasing prevalence of conversation around the Fourth Industrial Revolution. These then translate rather crudely into a sense that we have students who are less prepared, aiming to achieve preparation for a job market no-one knows about, using a curriculum that we have to make up from scratch. Of course, to put it in these terms is to both trivialise the issue and to problematise it in such a way that we have no recourse other than to sit around wringing our hands, lamenting for the good old days when we were students.

Nonetheless, each of these issues pulls in a slightly different direction. But I contend that investigating what is actually at stake can provide a perspective which, rather than suggesting a triple threat which will sink our educational efforts, might afford a perfect opportunity to seriously interrogate our current educational efforts. This requires an acknowledgement that we may not be quite as adept at teaching as we have fancied ourselves to be. It does not take a brilliant teacher to lead a student who is well resourced and has been trained to be intellectually curious.

We are not likely to be able to substantially change the school system. Even if the current position that 30% somehow constitutes a 'pass' was reversed, it would have no impact on the reality that most learners are taught how to pass exams and maximise their marks, rather than to seriously explore any knowledge area. The long legacy of the Bantu education system will not be easily shifted at the primary and secondary levels of education. This situation, coupled with the shrinking attention span induced by social media and the information age, does not immediately incite hope. But this does not mean that the students entering higher education are not capable of intellectual curiosity. They just have not yet had sufficient exposure to the idea of the tension of inquiry which can be broken by the delicious sweetness of a flash of insight. So, the first question emerges: How do we create an environment in which we can help students to begin to tolerate the tension of inquiry?

In a different way, the call for decolonisation of curricula is often dismissed by academic scientists as being irrelevant. From the perspective of a scientist, it seems obvious that one can teach principles of literary analysis as effectively using Chinua Achebe in place of William Golding. Of course, this fails to critique the value of the current forms of literary analysis itself! But science is science is science – is it not? Is it not this that makes it science? However, if we approach the issue from a different angle, we begin to discover a world which makes many scientists slightly uneasy. What if we take seriously the notion that some of our students do genuinely experience alienation in our lecture theatres? What is the source of that alienation and is it our task to address it or attempt to manage it in any way?

Against the backdrop of this confluence of pressures, it is easy to feel slightly despondent. However, I would like to argue that this triple threat can be seen as an opportunity. An opportunity to really question what we are doing as educators on undergraduate science programmes. The sense of dis-ease in the system means that we cannot pretend that all is well with the status quo. Is there another way?

I believe the work of Bernard Lonergan[1,2] offers us a theoretical framework within which we can begin to imagine a truly educative offering in science. Those of us who choose academia, do so because somewhere along the line the satisfaction of the periodic breakthrough of insight began to outweigh the discomfort of the hours spent in the tension of inquiry. At some point the satisfaction gave way to passion – either in a memorable moment, or in the gentle shaping that takes place over hours, days and weeks of focused effort. And yet, there is a strong message which shapes our time which resists any form of discomfort. It is against this that we need to begin to talk positively about the tension of inquiry. The space of not understanding *yet* is in fact a vital part of the educative process. Precisely because new knowledge needs to be constructed in the mind, it is not simply a process of information transfer. The connections need to be made before insight can be achieved.

Lonergan offers us a four-part model of the educative process.[1] It is probably important to state from the outset that Lonergan is both a man of his time and of his tradition and as such some of his language and imagery may not be immediately palatable in South Africa today. Nonetheless, if we can forgive him his cultural formation, his model provides a coherent framework in which many aspects of educational research can find their home. His major guiding principle is that of 'self-appropriation'. Lonergan is seeking to provide an educative framework that can provide the scaffolding for the fulfillment of a person's potential. The equivalent in my mind in education-speak is 'critical citizenship'.[3] We want to facilitate the development of a person who is capable of engaging responsibly, and intelligently, in the community in which they find themselves. And that immediately summons Amartya Sen's notion of 'capabilities' to the conversation.[4]

For now, though, Lonergan's intellectual curiosity is an attempt to understand understanding. Doubtless, as a philosopher and theologian, his own route to self-appropriation was through engagement in a plethora of intellectual tasks. Whether this route is the only one to self-appropriation is perhaps a good question, but given that we are in the business of trying to educate, Lonergan's exploration into the intellectual serves us well. His route to self-appropriation is through an educative scaffolding and so has the potential to be applicable without too much adjustment to fit. It comprises experience, insight, reflection and decision-making.

Experience comprises both cognitive and physical engagement. Anything that provides stimulus will provide experience. But it is worth noting that the person who makes meaning of prior experience will create a filter through

which they will interpret current experience. Experience of a particular intellectual problem will induce the tension of inquiry. The tension of inquiry is the interior experience of knowing that there is a specific intellectual problem that I do not yet grasp.

Insight is the glorious moment of intellectual breakthrough when the tension of inquiry gives way to a flash of understanding. It is the spark in the eyes that warms the heart of any educator. But that understanding may or may not be accurate. And understanding may be partial. It must be tested.

Judgement is the outcome of the reflective process which must follow understanding. Just because I think I understand does not mean that I understand correctly. I must test my understanding in some way. Either through attempting to solve a problem that previously eluded me, or by returning to the textbook or some other primary source and reading what has been said.

Decision-making is the final step. Once I have made my judgement, I must consider the consequences. What action does my judgement require of me? If I have assessed my judgement to be accurate, do I want to move onto something new, or do I want to consolidate?

There are several important facets to this framework. Lonergan's argument is that any subject matter can provide the trajectory towards self-appropriation. Self-appropriation is the outcome of the practice of responsible decision-making based on reasonable judgement which itself requires attentiveness to experience such that shifts in understanding can be observed. To achieve this through an undergraduate science degree, we therefore need a system of education that is scientifically sound, and appropriate to the specific science which is being taught. The primary goal here is to facilitate the process whereby a graduating student would know – with some confidence – both the limits and extent of their knowledge and understanding of the field. Some graduates may indeed continue in the field, but all will know what it is to know, and therefore are well placed to be life-long learners. Note that this does not require a diminishment in any technical sense of what we are teaching. But it does mean that we have a clear criterion upon which to include or exclude things from the curriculum – depth of content knowledge is more valuable than breadth. We cannot possibly expose students to all the new and exciting emerging fields, but if they are confident in their ability to appropriate knowledge then they will be able to move into new fields as they emerge. Confidence in the ability to appropriate knowledge is contingent on having had the experience of shifting to greater and greater depths of understanding. This is only possible in a system which favours depth over breadth.

The question we must then ask is what is 'depth'? The concept of 'depth' may need to be understood and used differently in the different sciences. For example, teaching human physiology requires engagement with the whole human body whilst it is possible to teach physical chemistry without any real depth of understanding of organic chemistry. The example I offer here is from chemistry and may need to be applied and adapted within another discipline.

In chemistry, we tend to focus on the development of robust conceptual understanding. We want to make sure that the student is able to successfully use the mol concept for example. Oftentimes, that focus means that we fail to make connections between different concepts explicit. Whilst we see a web of interconnecting ideas, the student sees isolated bits of information. To use an analogy, we focus intently on each individual puzzle piece, making sure that the student can reproduce it faithfully, but we may fail to show the student the big picture or completed puzzle. In chemistry then, teaching depth requires both attention to the puzzle pieces and attention to the connections between pieces.

Lonergan's system shows that the big picture is impossible to create without attention to the individual pieces, but the real value in education comes from the capacity to assemble the bigger picture and to see where the inevitable holes are. Powerful knowledge requires that we are aware of the limits of our understanding.

Lonergan's system also makes clear that student engagement is important. Teaching in an engaging manner matters and providing memorable illustrations is important to provide a rich experience. But this alone is insufficient. We need to make sure that we are helping our students to feel and become comfortable with the tension of inquiry so that they can taste the joy of insight. And then provide them with pointers to appreciate that reflection is a necessary part of the process.

Of course, there will always be students who just want to pass the course to obtain the credits. But hopefully, if we begin to think about the greater educative possibility of our science degrees, the student will engage on this greater level in at least one of their major subjects.

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