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This article explores STEM (science, technology, engineering and mathematics) student associations of assessment with individual achievement, becoming part of a discipline or profession, or developing an orientation towards society. This perspective is based in Frankfurt School critical theory, which argues for the inter-relation between individual and social wellbeing. From a critical theory perspective, education should facilitate movement from a conception of the individual as autonomous towards the individual as a member of society: this is the foundation of social justice. We consider this philosophical position against the empirical experiences of students to explore the extent to which their engagement with assessment has helped shape a sense of interconnectedness between themselves and others in society. Herein we describe a longitudinal and comparative study among chemistry and chemical engineering undergraduate students at universities in England, South Africa and the USA. The study finds that only a very small number of students display any orientation to society when discussing assessment. This is surprising because there are a number of socially-related assessment tasks within the curricula. More may be required to achieve a higher education oriented to social justice than simply the deliberate inclusion of socially-related activities in the curriculum or as assessment tasks.

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This article explores STEM (science, technology, engineering and mathematics) student associations of assessment with individual achievement, becoming part of a discipline or profession, or developing an orientation towards society. This perspective is based in Frankfurt School critical theory, which argues for the inter-relation between individual and social wellbeing. From a critical theory perspective, education should facilitate movement from a conception of the individual as autonomous towards the individual as a member of society: this is the foundation of social justice. We consider this philosophical position against the empirical experiences of students to explore the extent to which their engagement with assessment has helped shape a sense of interconnectedness between themselves and others in society. Herein we describe a longitudinal and comparative study among chemistry and chemical engineering undergraduate students at universities in England, South Africa and the USA. The study finds that only a very small number of students display any orientation to society when discussing assessment. This is surprising because there are a number of socially-related assessment tasks within the curricula. More may be required to achieve a higher education oriented to social justice than simply the deliberate inclusion of socially-related activities in the curriculum or as assessment tasks.

### **Keywords**

Assessment, social justice, critical theory, chemistry, chemical engineering, STEM, authentic assessment, assessment for social justice

### **Introduction**

This article explores STEM (science, technology, engineering and mathematics) student associations of assessment with individual wellbeing or achievement, becoming part of a discipline or profession, or developing an orientation, and inter-relationship, between themselves and society. We write from an explicit, though not uncritical, commitment to higher education having a social orientation, and particularly to the development of greater social justice within and through higher education. The link between assessment and broader social justice has been increasingly explored, particularly with the idea of assessment for social justice (eg. McArthur 2016, 2018; Hanesworth, Bracken, and Elkington 2019).

Like the concept of assessment for social justice, our perspective is based in Frankfurt School critical theory, which argues for the inter-relation between individual and social wellbeing.

From a critical theory perspective, education should facilitate movement from a conception of the individual as autonomous towards the individual as a member of a larger society.

Indeed, individual wellbeing is only realised, at least in part, through contribution to social wellbeing. In this article we consider this philosophical position against the empirical experiences of students to explore the extent to which their engagement with assessment has helped shape a sense of interconnectedness between themselves individually and others in society: the core foundation of a critical theory approach to social justice.

Assessment in STEM necessarily focuses on the development of competence in key areas, such as the ability to demonstrate an understanding of specialised concepts. In addition, in the laboratory-based subjects such as chemistry and chemical engineering there is a fundamental association between theoretical knowledge and its practical application within a laboratory setting (Prades and Espinar 2010). Such disciplines also involve cumulative learning and there are many challenges in how this can be achieved, and in particular assessing the gains in knowledge over time (Rootman-le Grange and Blackie 2020).

Assessment is generally intensive in early years in these disciplines with regular, continuous assessments as the building blocks of disciplinary knowledge are developed, moving into larger projects in later years. They are also characterised by a progression within the laboratory environment of working with laboratory scripts early on, where the outcomes of assessed tasks can be to some extent controlled and predicted, to greater independence as students gain in competence, but thus also less predictability in the outcome of larger assignments. It would therefore be misleading to present these disciplines as ones in which assessment can focus simply on whether the student can arrive at right answers for tightly specified problems. While this may be true of some of the building blocks of disciplinary knowledge, such as the behaviour of a chemical at a certain temperature or the rate of flow of

fluids through pipes, the combination of theory and practical application which is a key outcome in these programs is necessarily more complex.

We suggest it is also misleading to assume these disciplines, including their assessment, necessarily have less orientation to society than others such as sociology, politics, medicine or law. Such a view, however, is suggested by Biglan's (1973) influential categorisation of these as 'non-life' disciplines in his schema of pure/applied, hard/soft and life/non-life. The life/non-life distinction is the least used of Biglan's concepts, and thus it is also generally under-researched. But there is also research which suggests that, when STEM students begin their degrees, they do have less of an orientation towards social justice issues than non-STEM students (Garibay 2018; Nicholls et al. 2007). They are also reported to have a reduced sense of being able to effect positive social change once they leave university (Garibay 2015, 2018). But such orientations may be socially constructed and influenced by the structure of the curriculum and assessment practices. They are not, in other words, necessary or inalienable. Despite the categorisation of these as 'non-life' disciplines, we suggest these disciplines have huge social justice implications which place them very much in the foreground of human and social life. For example, chemistry influences the development of safe and affordable pharmaceuticals, while chemical engineering significantly impacts of the environmental safety and sustainability of our production methods.

Important research which explores the possibility of orientating engineering towards a social justice dimension has been carried out in a South African context by Case and Marshall (Case 2013; Marshall and Case 2010) and Walker and McLean (McLean and Walker 2012; Walker and McLean 2015). We build on this research by our specific focus on assessment. In many STEM environments individualised and competitive forms of assessment are taken as a proxy

for assuring the rigour of the assessment. But there is no evidence to suggest that this link is necessarily warranted. We seek to explore how assessment can, and should, nurture a social orientation and a sense of human interconnectedness which is at the heart of a critical theory understanding of social justice.

Exploring student orientations to assessment is one of several dimensions of a broader project considering the link between an orientation to society and undergraduate students' engagement with knowledge and understandings of higher education in chemistry and chemical engineering. This "Society" project is, in turn, one of four themes to have arisen from a much larger Centre for Global Higher Education project on "Understanding Knowledge, Curriculum and Student Agency" (UKSA) undertaken with colleagues in England, South Africa and the US. This study is comparative and longitudinal, following students for up to four years of their undergraduate education.

The focus on assessment in this article, therefore, is to illuminate important aspects of these students' experiences but is not intended to be the whole story of how, and if, we encourage an orientation to society among such students. Nor do we seek to evaluate individual assessment tasks used in these degree programmes. The article is, however, predicated on research which demonstrates that assessment plays a vital role in what and how students learn (Carless 2007, 2009; Bloxham and Carver 2014; Boud and Falchikov 2006). As our larger project is focused on how students engage with knowledge, and how this engagement changes over time, then assessment plays an important part in this engagement. Particularly in STEM subjects, the engagement with knowledge is often task-oriented, and thus also assessment oriented. Such disciplines reinforce the view that assessment often serves different purposes in higher education, ranging from certification to nurturing current and

future learning (Ashwin et al. 2020). This is not to suggest that assessment acts alone in either shaping engagement with knowledge or a social orientation.

In this article we analyse interviews with chemistry and chemical engineering students, in three countries and six institutions (the larger study). Our analysis focuses on whether there is a growing sense of connectedness between assessment tasks and students' relationships with others. We thus proposed three orientations to track, what we hoped, would be an emerging sense of self and society:

- an orientation to self (eg. Assessment helps me to learn)
- an orientation to discipline/profession (eg. Assessment prepares me for working in the profession)
- an orientation towards society (eg Assessment is preparing me to make the world a better place).

Findings demonstrate that when asked directly about the purposes of assessment the vast majority of students orientate this to themselves, even when they are on degrees that have socially-related assessment tasks. These results are fairly consistent across disciplines, years and national contexts. Orientations to society are rare and, importantly, do not show any pattern of developing over time during their university experience. Indeed, some students may begin university with a strong social orientation and then lose it along the way. This article seeks to explain this phenomenon by considering why simply having a socially-relevant assessment task (in the spirit of authentic assessment) might not nurture a clearer orientation to society within individual students.

This article is in four parts. After this introduction, we briefly explain the way we understand the relationship between assessment and social justice. This is followed by an overview of the larger project from which this study is drawn, including our methodology. This leads to the main discussion of students' different orientations in the context of assessment and identifiable trends between cohorts. We conclude by considering the future implications for assessment design and the pursuit of greater social justice within and through higher education.

### **Assessment and Social Justice**

Assessment for social justice in higher education seeks forms of assessment that are more just for individual students and which nurture greater social justice in society (McArthur 2016, 2018). This is based on the critical theory idea of intersubjective self-actualisation (Honneth 2004a) whereby individuals achieve their potential through the apparent paradox of both co-operation and autonomy. This means that individual and social wellbeing are intrinsically linked: we can only recognise our own wellbeing to the extent we recognise our role in helping others to achieve their own wellbeing.

A key aspect of assessment for social justice is the idea of *responsive assessment*, which refers to assessment that encourages students to see the interconnections between what they are doing and the world around them. Drawing on Honneth's critical theory, McArthur (2018) argues that responsive assessment is important because it enables students to see themselves as developing skills, knowledge and dispositions which are useful (in a social justice sense, not a purely instrumental way) to broader society. In many ways, STEM approaches to assessment are already about the practical application of knowledge, and thus lend themselves potentially to this responsive approach. But the key difference being

proposed here is this distinction between instrumental application and socially-informed application.

This then leads to a critical theory concept of social good (McArthur 2020a) in which individual and social well-being are dialectically inter-related. The implication of this is that an individual cannot foster their own wellbeing solely through being inward-looking, but must consider also how their actions help foster the wellbeing of others. This suggests that we should question the idea of knowledge disarticulated from ethics or achievement disarticulated from social contribution. This doesn't mean there is no place for individual pride and students justly have a right to feel proud of their higher education achievements. But at some point, the source of pride and achievement should shift to a consideration of its social orientation. Again, the argument is not that assessment is the only vehicle through which this social orientation can and should be nurtured. Rather, we are saying that assessment cannot be exempt from these social justice concerns that may otherwise feature within the curriculum or teaching approaches. If we want our students to value knowledge in a social context, then assessment is one of the clearest ways in which we show students that that is what we value.

### **Larger Project and Methodology**

The larger project on which this article is based researched undergraduate degrees of chemistry and chemical engineering in two sites each within England, South Africa and the USA. This is an ongoing longitudinal study and this article reports on data from years 1-3 in England and South Africa and years 1-2 in the US. 203 students were interviewed in first year and from these a number were selected to follow through for four years, wherever that took them. We selected 115 longitudinal study students, most of whom were interviewed



once per academic year (or are in the process of being interviewed). There was a small amount of attrition in this participant group, mostly among the US cohorts. Initial participants were self-selected so we did not try to account for gender balance, but found that it was broadly in line with the degree populations. In selecting the longitudinal participants, we did try to ensure a balance of gender.

One lecturer in each degree programme was interviewed each year, following a recording of their lecture which informed the interview. These lecturers varied each year and were chosen in consultation with our main contact person in each degree programme. We also collected relevant course materials and institutional data

All institutions and participants are anonymised in line with the ethical approval granted by Lancaster University as lead institution in the research (Reference Number FL15035). Ethical approval was also obtained as required at each of the six research sites. The six universities in this research were given pseudonyms based on chemical elements to protect anonymity. These are:

- England - Erbium University and Europium University
- South Africa - Sodium University and Samarium University
- USA - Argon University and Astatine University.

Students have also been given pseudonyms reflecting the cultural diversity of the cohorts.

Semi-structured interviews followed a common protocol with questions covering students' background, route into university, study practices, understanding of disciplinary knowledge, assessment experiences, views on diversity and future aspirations. All students were asked to

bring a copy of a piece of assessed work to the interview, the aim of which was to act as an artefact to help focus and nurture the discussion. We asked each student to talk through the piece of work they had brought, including its purpose and how they went about completing it. First year students were asked to bring an assignment of their own choice. There was, therefore, considerable variety including tutorial worksheets, lab reports, lab books, tests and other forms of coursework, and from different modules- organic, inorganic, physical and analytical chemistry, biology, physics, mathematics and general engineering modules. In second year we specified the assignment because we wanted students to bring and discuss the same assignment that was considered core to the curriculum. Choice of the assignment was informed by our main contact person in each degree programme. In third year we again wanted something core to the curriculum which was often the third year dissertation/research project (chemistry) and the design project (chemical engineering). In our South African institutions this could also be a significant tutorial or practical exercise.

Using NVivo, student interview transcripts were first coded into broad areas: Me, Studying and Wider experience. These codes emerged from the initial reading of transcripts, were then trialled to ensure they provided a robust framework and then applied to all transcripts. We broke our analysis down into four, inter-related themes which represented different facets of the core research phenomenon of understanding knowledge, curriculum and student agency: Personal Projects, Knowledge, Society and Agency in Study Practices. Each theme had between four and six members from the larger project, ensuring a representation of different national contexts and, where possible, discipline and research interests. The Society theme was formed by the four authors of this article, which is reporting here on the first dimension of our larger work.

The Studying code was then broken down in the initial project-wide coding work, with a specific sub-code of Assessment (including feedback) which forms the basis for this article. Assessment here is interpreted in its broader form, encompassing both summative and formative aspects. Any references to assessment in any part of the transcript were given this code. It therefore includes both answers to direct questions about assessment (such as what is the purpose of assessment? Or describing an assessment they have brought to the interview) and responses where assessment came up in response to questions in other sections of the interview (e.g. describing what a Chemist/Chemical Engineer does or the nature of disciplinary knowledge).

The first author read every transcript and allocated student references to assessment into the three categories: self, discipline/profession and society. These categories were not generated by the data but represent a continuum which reflects a critical theory understanding of the relationship between individuals and society. These categories are not mutually exclusive and different categories could also be used in different parts of the interview, however, this proved to be rare and only happened in four instances. The three categories reflect a possible expansion of how students are orientating themselves to others, beginning with reflecting on their own learning or achievement, to then conceptualising this in terms of the discipline or profession and finally to make a connection between themselves and society as a whole. We generated these as broad categories to ensure they were as inclusive as possible of different ways in which students might express an orientation. The explicit critical theory perspective guiding this analysis meant that we did hope to see a growing orientation to society but we did not assume this would be the case, nor did it turn out to be. There were two category of responses that did not necessarily map directly onto our conceptualisation of self, discipline/profession and society. Firstly, a very small number of students positioned

assessment as serving a purpose for the university or their teachers: to ensure teaching was being done appropriately. These we did not include because they appear to address a different issue than the focus of our analysis. Secondly, some students said that they wished to do well in their assessments because it would help them support their families (these examples tended to be in South Africa). Here we used judgement to either categorise them as self, when the key motivation seemed to be personal/family wellbeing or society when the key motivation seemed to be the wellbeing of a broader social group, of which the family is an important part. There were not many responses where we faced this judgement, but they do reflect an important dimension of some students' orientation.

This data is largely analysed qualitatively, although we do rely on some simple quantitative analysis of how many students in each cohort make a response in any of these three categories. Numbers do not refer to the number of individual mentions of, for example, an orientation to self, but to the number of interviews in which students made such an association. While broad quantitative data can be illuminative it is used with caution in this study for two reasons. Firstly, while the whole project interviewed a substantial number of students, once this is broken down by institution, year and discipline we are looking at relatively small cohorts (ranging from 14 to 24 in first year and 5 to 11 in subsequent years). Secondly, these were genuinely semi-structured interviews which ranged over a large number of areas and were deliberately intended to give voice to the students' account of their experiences and attitudes. This means that not every student was asked the same questions, and particularly in relation to some assessment questions, this has resulted in some variety between interviews.

Where appropriate we also draw upon the lecturer interviews to better understand the intentions of a particular degree and look beyond the assessment data to illuminate longitudinal aspects of the students' experiences. Finally, the methodology of this larger project owes a considerable debt to a previous project looking at students' engagement with knowledge in sociology (see McLean, Abbas, and Ashwin 2018).

### **Orientations of assessment to self, discipline/profession or society**

In broad terms the pattern of student orientations to self, discipline/profession and society is as expected (although not as hoped) with self being the most common, society least common and discipline/profession in between. Out of 427 interviews analysed, the following number displayed one or more instance of these orientations:

- To self – 303 interviews
- To discipline/profession – 108 interviews
- To society – 21 interviews.

What is surprising is just how few instances of a social orientation there are, particularly given this is a longitudinal study (would we hope to see this develop over time?) and given the ways in which curriculum and assessment design has integrated socially-relevant issues in many of these degrees.

The other broad observation to make about the data analysis is that when directly asked about the purposes of assessment the vast majority of participants answered in terms of self. Most references to discipline/profession or society were tangential comments when students were discussing other aspects of assessment, such as when talking about a piece of assessment they had brought to the interview. This reinforces the value of semi-structured interview approach

and the use of artefacts in the interview to enable the collection of complex and nuanced accounts from the students.

### ***Orientation to self***

Out of 427 interviews there were 303 interviews in which students demonstrated an orientation towards self when discussing assessment. There is, however, considerable variation in the ways in which students express this orientation, which in turn reflect a range of views on the purposes of assessment. In addition, an orientation to self should not be negatively imbued with an idea of self-centredness. It is perfectly natural to consider one's learning and assessment in terms of self. The purpose of this article is to consider how or why students may begin to look beyond this, building on this orientation to self; expanding it into inter-relationships with others.

The clearest theme emerging in this category is the strong association students make between **assessment and learning**:

When I was in high school, I used to think the purpose of an assessment was just to show the teachers that you can do it, look I'll get this mark. Since I've come to university, I've seen that it's about making the knowledge stronger in your head. For the future years. (Rafia, Year 1, Chem. Eng. Europium University).

Among English institutions, all cohorts returned an orientation to self of over 80% across all years, except for third year chemistry at Europium University, where there was a sizable shift to discipline/profession. The picture is broadly similar in South Africa, with three exceptions. A considerably lower orientation to self (47%) in chemistry at Sodium University in first year, but this rises to 90 and 100% in subsequent years. Chemistry at Samarium University follows a similar pattern with 69%, 80% and 100%. Sodium University chemical engineering in first year appears anomalous across the three categories,

with much lower numbers, suggesting assessment for some reason did not feature as much in these interviews. Within the US sites there is a high orientation to self in first year and this drops by nearly half in second year, except for Astatine University chemical engineering. But we had a very small second year cohort here so we cannot really draw any firm conclusions from this.

Assessment was frequently associated with **checking students' progress**. Many students demonstrated an awareness of the distinction between testing knowledge and actually improving knowledge/learning. Indeed, quite a few students expressed the view that assessment should nurture knowledge and not just test memory:

I really, really like the coursework that we just did. I thought it was a good way to challenge people. It's challenging your understanding rather than your ability to memorise a few equations, which I think is a much better way to see how people are understanding the course. (Harrison, Chemistry, Europium University)

Some students, however, did feel a **tension between the importance of genuine learning and a dominant culture of valuing high marks/grades**. Only a small number of students made a distinction between learning and actual marks, while quite a number assumed that marks were a valid indication of how much you have learned: the higher the mark, the more you know:

if you get 40%, you probably don't understand it. The person who gets 100% is clearly better at it in some way than you. (Levi, Chem. Eng. Erbium University).

Assessment could also be a **personal motivation**, intrinsic and/or extrinsic. When asked the purpose of assessment, this student replied:

Just to make sure we're actually learning stuff and worth the £9k to be honest, £9,000 that's quite a lot of money. I think without the assessments I don't think I would have actually put my head down. The assessments really help a lot. (Ruben, Chem. Eng. Europium University).

In a few cases students spoke of assessment as a **form of surveillance**, referring to it “checking up” that they had done the work and/or attended lectures.

you have got to be assessed, to make sure you are engaging, and you are listening in lectures, and you are going away and doing your work (Hayley, Chemistry, Europium University).

One anomaly was Argon University in the US, where a number of students referred to the phenomenon of “weeding out” and believed a legitimate and necessary purpose of assessment was to get rid of weaker students (but presumably not themselves).

This category includes responses that said the purpose of assessment was to get a degree or to qualify as a chemist/engineer because the focus here is not about actual engagement with the community of the profession or discipline but about simply accreditation of themselves.

### ***Orientation to Discipline/Profession***

In 108 interviews of the 427 conducted, the students displayed an orientation to the discipline or to the future profession when discussing assessment. Common here was a sense that the assessment tasks helped them to think or behave as a Chemist/Chemical Engineer, or that it was vital preparation for going on to work in the profession.

This is the most revealing category in terms of changes over time. Looking at all responses across the two disciplines and all institutions, the rise in percentage orientations to discipline/profession is as follows: first year – 22%, second year – 24% and third year – 40% (noting third year is only England and South African institutions).

This increase in orientations to discipline/profession can be partly attributed to curriculum and assessment design. It is particularly strong in 3 of the 4 English sites in which the third



year normally involves a large project which students see as preparation for either further disciplinary study or going into industry. For example:

I think the design project is probably going to be the most useful, because it is... I am finding it really difficult, but I do think you do learn more from challenging yourself. I think the design project is the most close to what life is going to be like in the future, actually in the field. You'll be working with teams trying to design something. (Leo, Chem. Eng. Erbium University).

The chemistry students at Europium University were also required in third year to write a 3000 word research report of publishable quality, thus again building a direct link to the discipline and its knowledge generation into the assessment design.

The English exception is Europium University chemical engineering where there were far fewer instances of an orientation to discipline/profession. This was unexpected as a number of these students had this as a placement year. So one might expect that would induce an orientation to the profession, but perhaps not one students associate with assessment; assessment being seen as a university-based activity.

It is surprising then that in national comparison English students were twice as likely to demonstrate an orientation to discipline/profession than South African students. It should be noted, however, that the English first year is different to that in the US or South Africa, where the first year tends to be more equivalent with A levels (final school qualification). There was, however, also a decline in this orientation over time at both South African universities.

### ***Orientation to Society***

There are far fewer interviews in which there is any sense of an orientation to society when discussing assessment, numbering just 21 out of 427 in total, and in these the comments are

often fleeting or tangential. Initial analysis suggested that such an orientation to society might be nurtured by particular assessment tasks, and even the broader curriculum and assessment design. Certainly it was rare for a student to display an orientation to society when directly asked about the purposes of assessment. Rather it tended to come up in the discussion of a particular assessment task, thus was heavily dependent on which assignment the student chose to bring to interview. But given the fact that the assignments which a small number of students orientate towards society are shared by others in their year, we must address the case that many other students who did the same assignment have either chosen not to discuss it or have discussed it but made no link to the social benefit. We know this to be the case because, particularly in England and South Africa, the degrees are highly structured with few optional or alternative courses. These findings suggest that if our goal is to enable students to develop as full social beings, through a sense of achievement in being able to contribute to broader society, then this involves more than simply putting socially-relevant assignments in place. We return to this later, but first here is a broader overview of responses in this society category.

Most students who displayed an orientation to society did so in first year (even taking account that we interviewed more students in first year). It appears something they came into higher education with, rather than developed through their studies. Particularly worrying, are the few instances in which a student demonstrates a social orientation in first year and then this declines over time. Take Scarlet from Sodium University chemistry. Her first year interview is full of comments about making the world better and doing things to help people, yet by third year all this is absent and she simply talks in terms of getting a job in large industry:

Year 1: if I want to go into research and if I want to change the world, if I want to change a problem in South Africa, I will have to study and get my degree and go further on

Year 3: I want to be able to walk out as a chemistry student that companies would like to hire.

There was a small difference between disciplines, with 13 responses coming from chemical engineering students and 8 from chemistry students, and this may reflect the more applied nature of the former. In fact, it arises from the association several students make between engineering and environmental responsibility. Though, clearly, this is not all that is going on because many other students undertook these same tasks but did not mention them in ways reflecting a social orientation.

There may be a gendered aspect to demonstration of a social orientation, with the majority coming from female students, though again numbers are too small to draw any major conclusions. Interestingly, the slightly higher orientation to society in South Africa is not linked directly to issues of race or social justice but to water scarcity. Of course, in a South African context water scarcity does have enormous social justice issues, which are related to race and poverty (communities of colour tend to be the poorest and the poorest are most badly affected by shortages of this vital resource). There was also a particular water crisis in parts of South Africa at the time of these interviews. The South African figures are also influenced by a notable cluster of students with a social orientation within chemical engineering at Samarum University, as they make up 8 of the 21 incidents. Indeed, one of the lecturers interviewed at this institution spoke of their deliberate intention to show students that a career in chemical engineering was not confined to big business alone.

So what are the main themes that emerge in responses with a social orientation? The strongest is the perceived connection between (chemical) engineering and balancing economic and environmental issues. It appears clear that many of these institutions do build an environmental sensibility into the curriculum, and this is reflected in assessment tasks.

Within Europium University, two third year chemical engineering students made a similar claim about developing environmentally sustainable solutions to reflect an orientation to society. For example:

The end goal is, basically, to produce methyl chloride. It is that, but we have to do it in a way where it's safe for the environment, it's economical, sustainable and everything and at the end of all that, we have to prove that it is sustainable. (Rafia, Chem. Eng. Europium University).

At Sodium University the first year chemical engineering students have a module on 'professional communication' and an assignment looking at hydraulic fracturing in South Africa:

it was mainly focussing on the extraction of gas through hydraulic fracturing and we wanted to see like how it is done here in South Africa and where it is done, so we just looked at the advantages and the disadvantages of mining it ... then how it helped the energy crisis here in South Africa, because that was the main focus, it was for South Africa, so we looked at how it helped South Africa (Thembi, Chem. Eng. Sodium University).

Again, what is surprising given the focus of this module and this assignment, is that only two students mentioned it in terms of any sort of social orientation.

One quarter of students doing chemical engineering at Samarium University in first year displayed an orientation to society, and here we see clearly the role played by curriculum and assessment design. Most of these students described a project based around the severe water crisis facing their region in South Africa. Interestingly, one of these students did make the link to society when asked directly about the purposes of assessment:

I think they are to again develop us to be holistic learners and I think the projects also are to keep us engaged about what is going on around us and how we can impact people in the community and provide solutions and change the situation in that regard (Nathi, Chem. Eng. Samarium University).

It is clear from these students' responses that the assignment itself was framed as one addressing a very real social problem:

The assignments are also more I feel like to get us to know about what's happening outside of our studies. And, what's actually happening in the real world. So, with chemical engineering for example this year we've been focusing a lot on water because of the water crisis (Naledi, Chem. Eng. Samarium University).

Talking about another project, this student from the same first year cohort makes an explicit link to society:

What I enjoyed about this test was that it was looking at how engineers are making processes that help the population. Like for instance this question was about making ammonia from nitrogen and hydrogen, which can be used to make fertilisers or also weapons and stuff like that. So it is an application of what we would be working towards. (Nina, Chem. Eng. Samarium University)

Other students expressed a more general link to society, rather than a focus on environmental aspects in particular. A first year chemical engineering student from Erbium University, when asked the purpose of assessment, replied:

Probably to see how much knowledge you have of the module, and how well you can understand and apply the things that you've learned in lectures into real problems that would need solving in the real world (Lucas, Chem. Eng. Erbium University).

Thus there is an orientation here towards the 'real world' although it may be a jump to necessarily associate it with social good. In contrast, this first year US student makes a direct link between chemical engineering and ethics:

there's ethical issues within our society of engineering (Cameron, Chemistry, Argon University).

And at Astatine University a chemistry student discussed how certain assignments had to be related to 'society, to the work, to life, actually' (Katia, Chemistry, Astatine University).

Two first year chemistry students at Sodium University displayed an orientation to society based on their interest in the medicinal aspect of chemistry:

I think a Chemist is like a doctor, they have the potential to save lives ... with Medicinal Chemistry you can also see a patient die but you see it under the microscope, you don't see it in person, or you see a person that is going to heal, that is going to be saved, just you don't see the person, you see the life under a microscope and a chemist is someone that basically invents and constructs molecules and I think that is a really pretty, that is a pretty image, that is quite an amazing image to think that we have the power to construct molecules and make new things (Scarlet, Chemistry, Sodium University)

So they gave us different topics and we had to choose one and we chose to do our assignment on medicinal plants and their effect on us if it is better than using synthetic medicines (Sarah, Chemistry, Sodium University).

Another example where the orientation to society comes through interest in the medicinal aspects of chemistry comes from this third year student at Europium University discussing his dissertation topic:

Plants have always been supposed miracle cures or alternatives to synthetic medicines. ... Some synthetic medicines, especially when you look at the American pharmaceutical industry, are ridiculous in terms of price. I think the HIV treatment drug, in America, has gone up hundreds of percent in price for no other reason than the fact that they know those people have to buy it, so they make it expensive, which is pretty damn awful to be honest (Harrison, Chemistry, Europium University UN2-C-27).

Such an orientation has not been nurtured by assessment design as such, but where there has been the opportunity to develop this orientation through his assessment works, such as the dissertation, he has displayed agency in taking the opportunity. Interestingly, he only came to have the option of this particular dissertation topic by chance – there is not free choice and he initially did not get this, his first, choice. We can but imagine what would have happened if he had been forced to do a dissertation on a topic that could not accommodate his interest in helping people through drug design. The administrative convenience of forcing

undergraduates into particular topics must be weighed against the possible costs to individual and social wellbeing.

The idea that assessment should have some orientation to society is not entirely new, although it remains under-realised. The increasingly popular concept of authentic assessment, for example, is typically described as assessment linked to the *real world* (eg. James and Casidy 2018). This connection to the real world is exactly what we mean by an orientation to society. But much of the authentic assessment literature, such as James and Casidy, conflates the real world with the world of work (McArthur 2020b). We recognise that work is important to human wellbeing (Winch 2002). And yet too often the world of work is then narrowed to simply be what employers want. As McArthur (2020b) argues: ‘the economic sphere should not be reduced to simply what employers want and the economic sphere cannot be disarticulated from the social’ (9). Critical theory is firmly based on recognition of the importance of the economic sphere, including to social wellbeing, but never in a way which separates the two. The economy therefore is understood in broad terms, and as a historically created moral sphere. We see this study as helping with the task of problematising what we mean by authentic assessment, and adding to arguments that we think of this in ways that reflect the inherent link between our social and economic worlds.

### **Implications and Conclusions**

Most approaches to authentic assessment rest on designing an assessment task that mirrors a real-world problem or application of knowledge. On this basis, a socially-just assessment would appear simply to involve a task or problem that addresses issues of social justice, such as pollution, water scarcity or affordable medicines. Our research, however, suggests that this is not the case, and simply having a socially-relevant assessment does not necessarily mean students will associate that task with a growing sense of social membership. Indeed, by

the 3<sup>rd</sup> year where these students begin to do larger project work with this clearer social orientation, they have often become enculturated into a high stakes assessment culture in which aspirations for degree classification or getting a job can overshadow a sense of how and why one might go on to use this disciplinary knowledge. This may explain the troubling phenomenon of students beginning university with a social orientation and losing it along the way.

Also, if we return to the original idea of assessment for social justice (McArthur 2018) then the focus here is not so much on tasks, but on relationships and dispositions. A chemical engineering student can try to minimise adverse environmental impacts within a project about building a new processing plant by ensuring they meet statutory requirements. This is not something to be critical of, however, it is an entirely different relational sense of self and society for one to consider not just the regulations but also ‘how will this plant affect the community within which it is based?’ Or ‘how ethically will its supplies be resourced from other communities?’

Our findings suggest there is more to do, but they also suggest some reasons for optimism. It is clear that academics creating curricular and assessment tasks do see the clear social application of these disciplines and are bringing it into undergraduate degree programmes. The challenge remains for students to see the relational implications of this: to see that assessment can be about their own self and learning, and about future membership of a discipline/profession and about a relationship with broader society. What critical theory suggests is the essential importance of bringing these layers together so that individual and social wellbeing are recognised as mutually contingent.



We are not suggesting either that all assessment is necessarily targeted to developing a social orientation or that assessment is the only factor in developing such an orientation. Indeed we recognise that in these disciplines it is essential that students learn technical and theoretical knowledge. It will not always be appropriate to explicitly tie individual learning or assessment moments into other, broader social issues. And yet, surely it is equally problematic if we do not pay sufficient attention to helping our students think about the world in which they will use that knowledge? Assessment is important for focusing students' minds on what appears to be valued by their teachers and by their discipline. Therefore, if our aim is to nurture students so that their disciplinary knowledge is not an end in itself, but seen as something they can meaningfully use to contribute to broader society, then assessment has to be part of a conversation that rejects the disarticulation of knowledge from the world in which it is learned and applied.

As Boud et al (2018) argue assessment is important because it is the means by which students develop their own evaluative judgement: their own sense of the quality of their engagement with knowledge and the application of this knowledge. This perspective complements that of a critical theory-inspired assessment for social justice, in which the students' development of their own relational awareness and ethical judgement is key.

If we accept that we cannot disarticulate knowledge from the society in which it is learned and applied, then the lesson from this research is, we suggest, not that we abandon the connection between assessment and social justice, but that we reconsider the full implications of it. We do not suggest that we explicitly tie every laboratory on how a chemical behaves at certain temperatures or the ways in which fluids flow through pipes to a grand social purpose. But we are suggesting that we nurture an environment in which when students reflect on what

they have learned and place value in the idea that this is building knowledge through which they can make a positive contribution to society. It is very hard to completely revolutionise the summative aspect of higher education assessment, and certification is a legitimate purpose of assessment (Ashwin et al. 2020). We can, however, challenge the formation of self-worth purely on the basis of summative assessment results. And the paradox made clear by critical theory (building here particularly on Honneth 2004b) is that students who associate achievement only with individual gain, and not social contribution, actually undermine their own individual wellbeing.

This surely accords with the professional and disciplinary commitments of academics in chemistry and chemical engineering. The future of these disciplines and their associated professions depends on students not seeing a particular grade or mark as an end point, but in having a commitment to the specialised knowledge of the discipline. It simply makes no sense to say that such a commitment should be reflected in the curriculum and in the classroom but then put aside when students sit down to do an assessment of what they have learned through that curriculum and in that classroom. In this way, we believe this study also has relevance to other professional and academic disciplines, beyond chemistry and chemical engineering.

### **Acknowledgements**

This article is from the Centre for Global Higher Education (CGHE) Understanding Knowledge, Curriculum and Student Agency Project. We acknowledge the contribution of project team members: Paul Ashwin, Jenni Case, Margaret Blackie, Jan McArthur, Nicole Pitterson, René Smit, Ashish Agrawal, Janja Komljenovic, Kayleigh Rosewell, Alaa Abdalla, Benjamin Goldschneider.

### **Funding Details**

The support of the Economic and Social Research Council, the Office for Students and Research England (grant reference: ES/M010082/1) and National Research Foundation,

South Africa (grant reference: 105856) are gratefully acknowledged along with support from CGHE.

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