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Linking Reflective and Authentic Learning: Encouraging Deeper Learning Experiences in a First-Year Civil Engineering Module at a University in South Africa

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ABSTRACT

Teaching and learning in higher education still largely use traditional approaches that promote memorisation of content knowledge. These traditional approaches are in stark contrast to the world of work, which encourages problem-solving and higher-order thinking. In a first-year civil engineering concrete technology course, we used reflection on an authentic learning task to encourage a deeper learning experience for students. We hoped that by including reflection and an authentic learning task in the module, students would be more actively engaged with the module content. The research question addressed in this study is: how does reflective practice and an authentic learning activity support student learning in a practical component within a first-year civil engineering module? Reflection should allow students to think deeply about what worked well and what did not during conceptualisation, development and submission of their authentic learning project. This case study collected qualitative data to generate the findings. The data consisted of student reflections during and after completion of the practical component. Students' reflections indicated that the authentic learning task resulted in much deeper learning as opposed to surface learning and memorisation of content knowledge. The results indicate that the reflective exercise encouraged students to think deeply about their learning and on how to improve their skills, knowledge and attitudes throughout the project. Finally, this process shifted the focus from content knowledge dissemination to development of critical thinking and lifelong learning skills.

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Introduction

Mwangi and Ingado (2020:24) claim that "what was important yesterday, may be obsolete tomorrow". The authors further refer to the skills, knowledge, values and attitudes students will require to participate in the emerging 21st century. As such, new ways of teaching, learning and assessment are vital to ensuring the future success of students. This article encourages higher education practitioners to develop the problem-solving, innovation and critical thinking skills of students rather than focusing on mere content recall. To this end, Plack and Greenberg (2005) argue that reflection gives meaning to experience and nurtures lifelong learning, owing to the fact that it encourages students to identify gaps in their own knowledge. This allows students to attend to their own learning needs. However, this requires innovative teaching practices on the part of lecturers (Plack & Greenberg, 2005). Reflective learning requires critical thinking skills which are a basic requirement in higher education, especially in the field of engineering (Aryani, Rais & Wirawan, 2017; Ryan & Ryan, 2013). Hence the focus of this study is on using reflective learning in an authentic learning task as a means to develop critical thinking skills on the part of first-year civil engineering students. The students were required to participate in a competition requiring the design, development and testing of an egg protection device, which is described in greater detail in the section that follows.

Project Description

The authentic learning experience described in this paper is situated within the engineering discipline. In particular, Concrete Technology is a first-year module offered in the second semester of a four-year program in civil engineering. As a requirement for the module, the students participate in a competition organised by the Concrete Society of Southern Africa, called the Egg Protection Device (EPD) competition. Each group of seven students is provided with pre-packaged materials that are used to design and manufacture a concrete device with specified dimensions and weight. The aim is to protect an egg from breaking when a weight of one kilogram from a height of one metre onto the device. After the competition, students were requested to reflect on:

- the design, shape and manufacturing of their device;
- their concrete mix, including the material and fresh properties of the concrete they produced;
- the communication within the group, as well as their group's dynamics; and
- what they would do differently if they could repeat the assignment.

It should be noted that although the competition was a group activity, the reflection was a non-compulsory individual activity. To provide the students with some guidance on reflective practice, a session on reflection was conducted by an education specialist. During this session, what reflection is and is not, the benefits of reflection, and why it is important as a professional engineer, were discussed.

Literature Review: A Model for Authentic, Reflective Learning in Higher Education

In South Africa, as in other developing countries, unemployment has become an ongoing and ever-increasing problem (Mukhoti, 2019). Communication skills, in particular, have become crucial for thriving in the world of work. This is especially true in the field of civil engineering. Higher education is a key driver in this process, ensuring that students acquire the necessary knowledge and skills that help ensure their employability in the field of civil engineering (Mtshali & Ramaligela, 2020). Civil engineering instructors need to equip students to confidently enter the world of work. The learning process should stimulate students' interest in and cultivate their talent for the world of professional civil engineering.

To this end, reflective learning is not a new concept and should be applied in any adult learning context (Wlodarsky, 2018). Already in 1983, Boyd and Fales described it as "the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self, and which results in a changed conceptual perspective" (Boyd & Fales, 1983: 100). Reflection promotes a process of making sense of our experiences. This links directly to the notion of providing authentic tasks for students, which requires the application of employability skills. These skills require the integration of personal qualities and beliefs, knowledge, skilful practice and the ability to reflect critically and productively on experience in order to progress toward a level of transformative learning (Ornellas, Falkner & Stålbrandt, 2018). We use these skills to guide our future decisions or actions, leading to higher levels of efficacy and success (Mezirow, 1990).

Reflection on authentic tasks can therefore be described as a process of structuring meaning, reviewing meaning schemes – existing or habitual actions – following a process of if-then, cause-effect category relationships and sequential events. Boud, Keogh and Walker (in Mezirow, 1990) define reflection as "a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new knowledge, understandings and appreciation". According to Wlodarsky and Walters (2015:65), reflection includes "different types of

events – authentic or reproduced – which are experienced both through and outside of the individual and his or her socio-cultural history".

Problem-based and experiential learning such as that provided by the Egg Protection Device competition is one way of preparing students to thrive in society, as it is rich with potential for promoting metacognition – thinking about thinking – and/or reflection. It involves creating an awareness of one's own thinking and managing and guiding one's thinking processes towards an outcome (Kuhn & Dean, 2004). In more recent research, Wlodarsky (2018) argues that lecturers should apply reflective learning, not only to their own practice, but also as a strategy to enhance students' overall learning process.

We argue that learning from experience is core to higher education, and that reflection is vital to this process. Experiential learning that includes reflective learning embraces "problem-posing, personal transformation, learning from prior experiences as a primary method, and praxis" (Wlodarsky, 2018: 99). Experiential learning is extended by reflection. Dewey (in Wlodarsky, 2018: 78) argues that reflection is "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends". Dewey's statement supports the idea that critical reflection is core to developing deep learning (Brock, 2010). Thus, it is of great importance that critical reflection should feature prominently in the context of higher education, as it is part of a set of lifelong learning skills that include problem solving, critical thinking and developing the values and attitudes required for living and working professionally in the field of engineering that is characterised by continual and rapid change.

The EPD project is used as a vehicle to demonstrate the value of reflective learning. Students reflected not only on the actual building of the device, but also on their personal skills development. This paper draws on a model adapted from Wlodarsky (2018: 103) as a theoretical and analytical framework. This model is shown in Figure 1. Higher education institutions acknowledge the need to be responsive to the professional needs of industry. Pure content dissemination and recall is no longer sufficient and a more strategic approach for skills development is vital. Lecturers need to focus on employability skills and professional attributes that include skills for new knowledge generation, application of knowledge, values, and reasoning abilities. Perhaps even more important is the students' ability to establish professional connections and to tackle real-world challenges (Department of Basic Education, 2019: 29). These professional skills include generic skills such as critical thinking, problem-solving skills, core skills directly related to the civil engineering industry

and personal attributes, for example the ability to communicate effectively and professionally with various role players in the industry at all levels (Mtshali & Ramaligela, 2020). In addition to the skills mentioned, flexibility, adaptability, lifelong learning and teamwork skills such as mediation and conflict management are invaluable in the current world of work (Hoffart, Gibbard, O'Neill, Nygren & Rosehart, 2017).

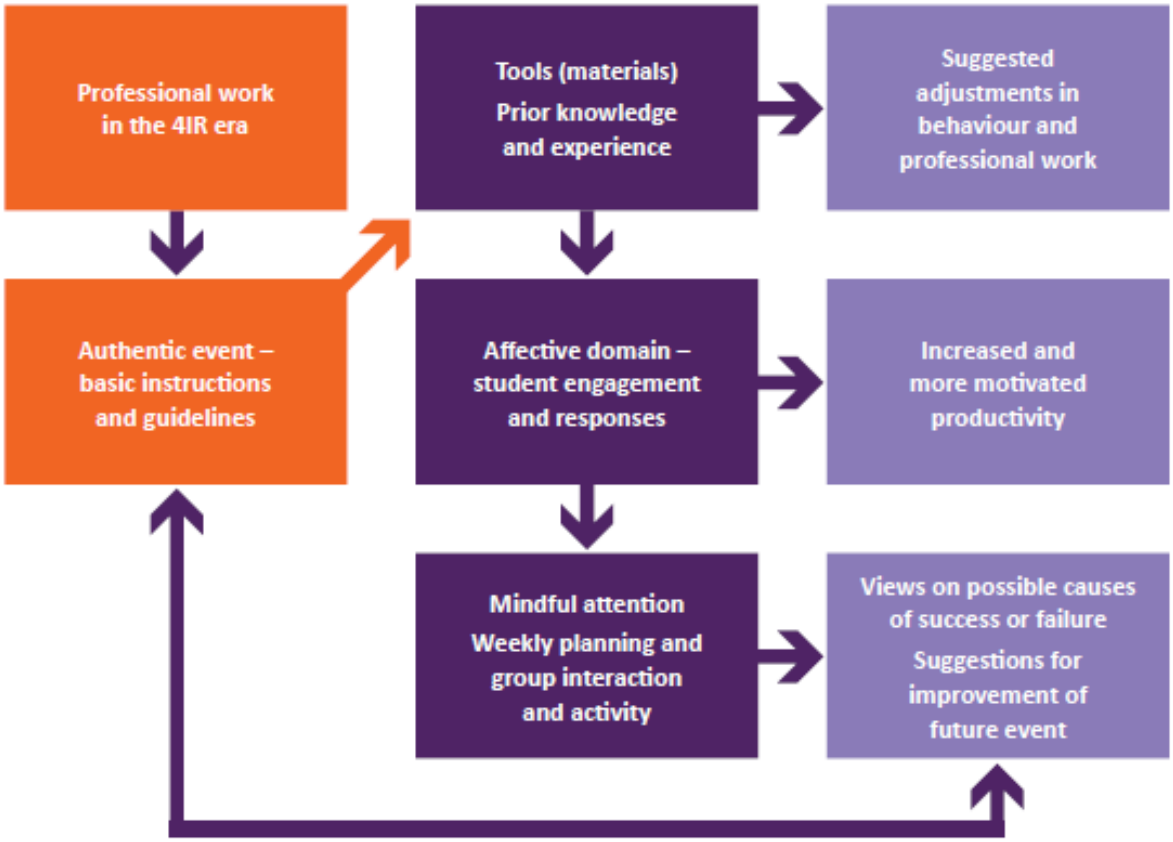

Figure 1: Model for analysis of an authentic reflective learning event (adapted from Wlodarsky, 2018)

The authentic learning event, in this case, the design and development of an Egg Protection Device, serves as the trigger for a reflective learning opportunity. Schön (in Păun & Sava, 2019) distinguishes between reflection-in-action and reflection-on-action. Reflection-in-action implies that students are reflecting while they are working on a project – they are actually thinking ahead, analysing, experiencing, and responding critically to the requirements of the task on hand. Reflection-on-action suggests that students are thinking through experiences, discussing, and engaging in reflective conversations on what worked, what did not work, and where they could apply possible improvement (Schön, in Păun & Sava, 2019). Thus, the students' reflective process was prompted by reflection-in-action and was followed by reflection-on-action. Firstly, the new experience had to be integrated into the existing knowledge of the students. This was one of the main ideas behind

following this approach: to give students an opportunity to transform their prior knowledge by engaging in a transformational learning experience (Alsina & Mulà, 2019).

The affective-emotional attitude of students is a further key element for student engagement. Moriña (2019) mentions that student engagement in groups does not feature frequently among university students' learning experiences. Triggering the affective domain of students could entice students to participate more actively and could serve as a motivational factor for succeeding in a specific task or module (Moriña, 2019). Working in groups involves the affective domain of students. Thus, the affective domain relates to motivating student participation, augmenting their self-esteem and impacts on student's sense of belonging and buy-in to contributing towards a product (Green & Batool, 2017). We believe that working in groups develops interpersonal skills, allowing for management of conflict (Thiel, Harvey, Courtright & Bradley, 2019; Cruz, Zagenczyk & Hood, 2020). Thus, the affective domain alongside the cognitive domain may enhance mindful attention (Wlodarsky, 2018) during the planning, development and implementation of the Egg Protection Device project.

Based on our review of the literature, we contend that tools, as well as the cognitive and affective domain of the lecturer and students, are vital in the final product presented for evaluation. In the reflection-in-action period, students are required to make continuous adjustments to their device based on mindful attention, planning and implementation. All these elements affect the final outcome of the project, either positively or negatively (Wlodarsky, 2018). After the reflection-in-action phase, students identified their successes and failures through reflection-on-action. They were encouraged to identify the shortcomings of the entire project relating to the tools used, the cognitive input and the influence of the affective elements (Wlodarsky, 2018) as it occurred throughout the Egg Protection Device project.

Research Design

As previously mentioned, the students were given pre-packaged materials that were used to design and manufacture a concrete device with the purpose of protecting an egg when a weight of one kilogram falls from a height of one metre. Each group designed the shape of their device and cast it from the pre-packaged materials provided. The EPD devices were then tested the following week to determine how many blows each device could take before the egg cracked.

This study makes use of a qualitative approach, and the researchers analysed the narrative written reflections produced by the students. Ethical clearance was obtained for the study from the relevant faculty research ethics committee. It should be noted that this paper emanates from a much larger study. Only data from students that signed the information letter and consent form was considered in the research. Owing to the fact that the reflection activity was not compulsory, the data used in the research project was initially divided into three groups: no reflection, shallow reflection and deep reflection.

Shallow reflection involved students merely mentioning facts and physical experiences during the learning process. Deeper reflection offered insight and clear evidence of students engaging in reflection by analysing their actual learning experiences. These students made meaning of their successes and failures progressing towards deep reflection and deeper learning experiences resulting in improved practice. As a result, the deeper, critical analysis of the completed activity resulted in students using creative problem-solving skills for future design activities (Parker, Racz & Palmer, 2020). These students could organise their thought processes and reconstruct their perception and application of knowledge (Buckner, 2019).

The same activity of designing and developing an egg protection device was conducted with two groups of students over a two-year period. Similar results indicate the validity, reliability and credibility of this study. Themes and categories were derived from the student narrative reflections.

Results and Discussion

In the first year of data collection, there were 138 students in the class, of which 76 (55%) gave consent to take part in this study. Of these 76 students, 40 students (53%) were adjudged to have engaged in deep reflection, 31 (41%) offered shallow reflections, and 5 (7%) students chose not to reflect on the EPD activity. In the following year, there were 145 students in the class, of which 120 (83%) gave consent to take part in the study. Of these 120 students, 32 (27%) engaged in deep reflection, 47 (39%) offered shallow reflections, and 41 (34%) chose to not reflect on the EPD activity.

As mentioned in the literature review, our contention is that lecturers need to adjust their teaching, learning and assessment strategies to address the development of essential skills over and above

content knowledge. The EPD project offered ample opportunities for students to practice these skills. Below, we discuss these specific skills drawing on extracts from student reflections.

Enhancement of communication skills

Communication is an essential skill in the world of work and the students indicated that they had to gain insight into and practice the skills of communication. For example, one student indicated that:

> Working with strangers is not a simple task as you have to find a common ground of communication; went to the construction site on campus to try and find out from the engineers what type of material we should use for our top part; Discussing ideas with the new people, who have their own views and some don't give others the opportunity to express their points because of underestimating other students ideas taking themselves as genius they know everything.

The first concern identified in the students' reflections was the fact that, in the workplace, they need to be able to communicate with all role players. The EPD project created an awareness of the challenges of working in a diverse team:

> We lacked communication and coordination which was the cause of our downfall; we sometimes couldn't listen to each other or always fail to connect our ideas; the structure to have a low strength or to fail, is the lack of communication among the group members.

In addition, it also strengthened the students' conflict management and negotiation skills:

> We had three designs of which we had to choose from and we chose the design which was going to make our work easier when making the mould and not necessarily the strongest in terms of design; after a lot of debating, we all agreed on our final design; but in the end we were able to come to a certain agreement concerning water content, amount of cement used and stone content as well; became uneasy negotiating with other members who I felt had their own agenda and seemed unwilling to compromise at times; It was no child's play working as a group because at some point there was lack of communication, conflict arose, some group members even considered pulling off, some were free ridings and some were social loafing; we never clearly agreed all of us as a group in some of the decisions we took; initially this was a disaster because we had a lot of disagreements.

These comments show that students had to compromise to get to the desired outcome. This project also created a sense of belonging among these students and highlighted the value of sharing and teamwork. Both positive and negative comments were made by students. While the negative comments included issues such as uneven work distribution, as described above and which is also a common occurrence in the workplace, one particularly positive comment was:

> As we got closer together, we developed a sense of belonging to the team and I can conclusively say that each of the three of us had played different significant role in

> contributing to our team develop; we had great team of dedicated individuals, focused, organised, supportive and each group member contributed their fair share and at the end we got the results we wanted in fact, we managed to achieve more than what we had aimed for; we had great skills diversity, meaning our abilities complemented each other; We ensured that there was effective communication as we were going about it hence the achievement; we listened to each members idea in order to come up with the modified design; during the brainstorming of what kind of device we should build, our priority was the type of material, cement and aggregates were had to use in order to make our device strong enough.

The responses showed that this was an authentic learning event and students had to develop the mentioned skills, in order to ensure a successful outcome.

Commitment and time management

The EPD project also highlighted the importance of planning, commitment and time management skills, which are essential to the civil engineering workplace. Students reflected in the following manner:

> Making the project a reality needed commitment, hard-work, punctuality, discipline, time management, frequent group meetings accountability from each member; what we could have improved in was our discipline; there was quite a lot of time given to us to complete this project but we got somewhat unsatisfactory results; this was a result of lacking time management; the frustrating part was that the late member was the one who the EPD, we had to wait for her to arrive whilst other groups began casting their concrete; not everyone was present and no discussion was made regarding the mixing for the Egg Protection Device.

One of the positive comments indicated that due to commitment and good time management they reached a successful outcome:

> We also consistently reminded other group members on our WhatsApp group that we had created to ensure that everyone kept track of their own tasks.

Another positive outcome was that some groups realised the value of teamwork where multiple inputs could lead to successful achievement:

> I enjoyed working as a team because we would come up with many different ideas to perfect our project and also it made work much easier since we divided the workload amongst the group members; critical thinking as every group was supposed to come out with an idea that provides the best solution; socialising with your colleagues helps when you come across a problem cause when you are in a group everyone has their solution; my group was ready and prepared to work and make sure we could reach our required target; the importance of this project being group work, was to help us learn how to value inputs from other students, the idea is to be open minded to different approaches to the project and eventually agree on a better idea or solution.

Many students realised that working in teams allowed for a division of work, which minimised the workload for individuals. A student could then give more attention to a specific element of the project rather than multiple tasks within a project. Students also acknowledged that diverse ideas could result in improved and successful outcomes. Multiple inputs and critical thinking from different group members could spark new ideas and holds the promise of generating new knowledge.

Affective domain

The affective domain relates to students' feelings and responses and the positive and/or negative sentiments they experienced during this assessment task. The students' responses indicated both positive and negative sentiments related to their participation. Figure 3 provides an overview of the students' negative and positive responses.

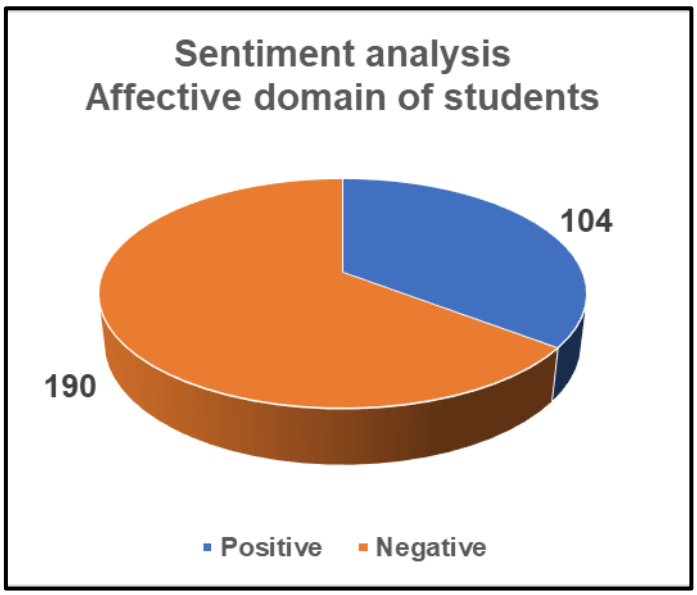

Figure 3: Students' affective sentiments regarding the EPD project

Figure 3 shows that 190 student responses indicated that students experienced the activity negatively and only 104 student responses referred to a positive experience. Closer inspection of the actual responses showed that the students were positive about the actual event and task. However, negative sentiments were expressed regarding the mixing process, not following the instructions and a lack of content knowledge and experience as expressed by one student:

> The EPD had many voids which was a result of bad compaction and no vibration of the concrete while it was in fresh state in the mould; our EPD did not sustain even one blow, because it had less compressive strength and the mix design was done incorrectly; also if we researched the mix design in time and watched some videos about slump test we

> were going to do better; after that much difference we evaluated the problem with our EPD and we saw that it was because of a lot of aggregates; our drawings weren't done well in advance.

Some negative sentiments were related to the actions of their fellow team members:

> Some members wouldn't contribute ideas to the group's EPD; our group was full of procrastinating; us not being comfortable as a group are some of the reasons why our egg protection device failed; members not being willing to play their part, some members not being responsive in the group chat; as a group we did a really bad job and we got really bad marks.

These sentiments indicate that students still need much practice in developing interpersonal communication skills as well as working together in a diverse multicultural environment. The positive sentiments showed that students learnt much from their peers and even from their own mistakes:

> During this whole experience I got to learn from my mistakes; I learned that in life we always get back what we put in; I have come to realise that good quality relationship and communication is very important in team working and achieving high quality performance; we seemed to get along just fine which made me optimistic about the project; it enabled me to develop collaborative skills, both from learning from and contributing to expertise and insight of others; I enjoyed a lot of things about this project. I enjoyed getting to know my group members and that way I was working on my networking skills.

These sentiments indicate that reflection and the activity itself served as an authentic and valuable learning experience.

Discerning determining material properties

Materials also have positive and negative aspects. One group in particular used their previous attempt at mixing concrete as an opportunity to use the materials at their disposal for correcting their errors. One of the students in the group reflected:

> Restarting the mixing after the Egg Protection Device has collapsed when removing the mould material, even though it was an unexpected accident, but it tends out to be a great opportunity because we were all more focused into getting in a competition, and we all paid our attention to each and every step of everything we were doing. Regarding on how we can avoid similar errors to produce a well-done Egg Protection Device, and everyone's idea was considered.

This response indicates that the reflective opportunity awarded the students the possibility for a deeper learning experience. Students reflected critically on their initial effort and improved the subsequent attempt.

However, there were also negative aspects. As illustrated below, even though groups had all the materials available to them, some of the groups did not use these materials effectively:

> What made our EPD to fail was that improper mixing was done, we misused the aggregates and did not consider the w[ater]:c[ement] ratio, and we never clearly agreed all of us as a group in some of the decisions we took.

This particular group made no attempt to correct the errors that they had made. For an engineer to be effective in the ever-changing, real-world environment, they need to be able to quickly judge an outcome of an event and adjust the process on the spot. They should also see these events as opportunities, and not become blinded by their own mistakes. This point is elaborated on in the sub-section that follows.

Adapting to change

One reflection suggested the students positioning themselves as engineers in the making:

> I again learned that group commitment and proper understanding is a vital part in teamwork each group member was supposed to respect the mix design and relevant calculations and specifications of the designer of the EPD, other group members should also follow up on each other's work to ensure standards are kept and this would have made us not be disqualified over a small issue especially considering that we will be working with infrastructure in the near future.

Another reflection indicated that the EPD project was an open-ended exercise, where the finished product was open to the group to decide. This links well with industry, where clients often confront engineers with open-ended problems that should be solved by innovative, creative thinking.

> Clear leadership was what I believe my group lacked, someone who can consider the member's strengths and weaknesses and compensated them through the distribution of tasks. Leadership that would promote the discussion and the implementations of ideas, communications would have not been what it had been. Bold thinking. The task that was presented gave a brief guideline as to what the finished project would look but its overall presentation was left to us, as such we could have incorporated more creative ways to better our results e.g. Arches, steeper or narrower angles to improve strength through triangulation.

This reflection indicates the skill required regarding creative thinking and innovation. Students need to practice their teamwork and interpersonal skills to highlight new ideas and generate new knowledge where the need arises.

Planning

Planning is an integral part of engineering, and as the reflection below acknowledges, there has been development of the 'soft' skills, also referred to as essential skills, so often lamented by industry as lacking in engineering graduates.

> I feel that with the detail, knowledge and skills that I have developed, the process of constructing an EPD would be without fault, for instance I would invest more energy and thought in teamwork, in such a way that everyone in the team has a certain task and each task is linked to the other to give an egg protection device, in this way time is wisely spent and everyone on the group gets to contribute something.

The importance of the development of 'soft' skills is supported by another quote, stating:

> I have learnt during this EPD practical that proper time management and planning is crucial in projects, as well as consulting project partners in achieving a better and more positive outcome.

This quote acknowledges that time management, planning and consultation could achieve better outcomes in projects. As can be seen from the above, the EPD project does develop the 'soft' skills required of engineers.

Concluding Remarks

Higher education practitioners need to develop the problem-solving, innovation and critical thinking skills of students, over and above a focus on mere content dissemination and regurgitation. We recommend that teaching staff focus on a 'learning to be' approach in furnishing students with the soft or essential skills required for participating meaningfully in the world of work. This paper focuses on one approach, namely reflective learning as part of an authentic learning event. The analysis was based on the elements of professional work, authentic learning, tool (or material) requirements and usage, the affective domain, and planning and group interaction, as proposed by Wlodarsky (2018). This project created an awareness among students that mere content recall is insufficient for participating in a real-world industry such as civil engineering. We would therefore recommend that further studies focus on authentic learning that embraces the required essential skills, such as reflection and teamwork. This is essential for students to contribute successfully to the world of work, especially in a field such as civil engineering, where "what was important yesterday, may be obsolete tomorrow" (Mwangi & Ingado, 2020:24).

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