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The impact of class activities on engineering students' success

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This work reports on a methodology used to assess the impact of class activities on engineering students' success. The module that was assessed in this work is Mineral Processing: Chemical Principles II (MNP20XT). The module is in the 1st-year students' studies, offered in the first semester for a duration of six months, and consisting of 6 study units. The module has 14 credits and students are required to pass this module to do second year modules, and thus a pass is important. In the academic year 2019, the success rate in this module was a poor 55%. The module is offered at the Department of Chemical, Metallurgical and Materials Engineering, Faculty of Engineering and the Built Environment (FEBE), Tshwane University of Technology (TUT).

New class activities were introduced in the module for the year 2020 that were not used in the module before (in 2019). The activities introduced are think-pair and share, concept test, class quiz and tutor taking register for all students who consult during a tutorial. These methods will also be for the purpose of achieving the study aim. These new activities were implemented in the different six study units. The students wrote an assessment following the completion of a study unit as per TUT practice. The assessments were class tests and semester tests. The student performance after writing the class test or semester test was analyzed using a grading format (details given in the research methods section). Students' achievement in each assessment were compared against each other to assess the impact of introducing new class activities.

The methodology used in this work suggests that class activities directly affect engineering student's success. The work indicates that well implemented and monitored class activities is a strategy that can be used by lecturers and managers in their academic environment to promote student success. The think-pair and share method achieved the highest drop in failures after it was implemented. However, in this work it has been observed that even better student success in an engineering module can be increased by incorporating the aforementioned class activities concurrently.

Keywords
Activities, student, success, concept test, tutorial.

Table of contents

1 Introduction

In this work, I evaluate the impact of class activities on engineering students' success at the Tshwane University of Technology (TUT), Faculty of Engineering and the Built Environment (FEBE). At the FEBE student success is low and it is the lowest in the University. This work will report new activities that were previously not employed in a course module. The findings with the methodology used will assist other lecturers and managers at the TUT to know the effect of class activities on student~~'s~~ success. The new module developments that were introduced and implemented in the year 2020 included: think-pair and share, concept test, class quiz and tutor taking register for all students who consult during a tutorial. These methods were not used in the previous year's module.

This work will report on the findings of the module development work and recommend strategies learned from this experience to lecturers and managers. Not only will this be useful in improving student's success, but it will also be instrumental in helping lecturers to pick students at risk early on, and therefore implement timely intervention strategies to assist students at risk. The module in question is a core course worth 14 credits. It consists of two types of classes: lectures and tutorial sessions. Tutorial sessions are normally 45 minutes of a class session. A complete class session is 90 minutes long. To successfully complete the module, students are required to get an overall mark of 50% or more.

2 Problem Statement

The battle for access to higher education for students within South Africa has been a success through the development of policies and funding schemes that make it attainable for all. However, for most engineering students who endeavour to have a career in this field, low success rates and elevated levels of attrition in undergraduate studies are still a challenge (Tewari & Ilesanmi, 2020). This has resultantly placed pressure on higher education institutions and relevant faculties for interventions that would mediate the problem while maintaining high-quality teaching practices. This falls on the backdrop of an increasingly diverse demographic of students with an even wider diversity in backgrounds, prior schooling practices and languages. Some of the factors affecting engineering students' success range from school level deficits, student themselves, lecturers, universities, and some are at a governmental level (Van der Merwe & Maharaj, 2018).

The Department of Higher Education and Training (DHET) reported an overall increase of student intake with 16% in all programmes and 23% observed for Science, Technology, Engineering and Mathematics (STEM) fields in the years 2010-2017 (DHET, 2017). Accodining to Van der Merwe, et al., (2020), the low student success rate is attributed to increased dropout rates and students taking longer to complete their studies. In their case in STEM (Science, Technology, Engineering and Mathematics) fields, they uncovered statistics published by the South African Council of Higher Education confirming that only 51% of enrolled students continue to complete their 3rd year undergraduate studies. Furthermore, of those that did complete, some students took as long as 6 years in those degrees. The remaining 49% either took longer than 6 years or unfortunately never managed to complete their studies.

The Council of Higher Education 2018/19 report indicated that within the duration, specifically 2011-2017, the students' success, represented by percentage of course modules passed within a year never exceeded 79% (CHE, 2019). These figures include STEM fields and raise the question on how student success can be approached internally at a classroom level to circumvent some of the external factors that require institutional and governmental changes. Sheshikala, et al., (2020) studied the impact of using classroom activities with engineering students in an attempt to improve student success. The authors discovered that it not only improved their academic performance but also improves memory retention, participation in the classroom and to an extent, attendence. The activities included role-play, stump your partner, group solving problems, concept tests, and think-pair share. The challenges observed were mitigated by the use of interactive teaching assistants, who were observed to improve the participation of students in classrooms.

The success of students in the faculty of engineering and built environments at the Tshwane University of Technology (TUT) is the lowest. Even though the faculty is the best performing in terms of research and innovation, the faculty has the lowest success rate for undergraduate students, which affects the finances of the faculty and more importantly students finishing their qualifications.

Student class activity is important and has a direct correlation with students' success (Sheshikala, et al., 2020). However, TUT, and more so higher education in general, still has no operative strategies to promote student classroom attendance.

3 Study Objective

The aim of this study is to assess the impact of class activities on engineering students' success. The success of students in the engineering module Mineral Processing: Metallurgical Principles has been one of the major concerns in the engineering faculty. To assess the impact of class activities in this engineering module some methods will be applied that were not used before in 2019 but employed in 2020 and will be a new development in the module. These methods will also be for the purpose of achieving the study aim. The aim will be achieved through the following objectives:

1) Assessing the effect of conducting concept tests in class prior a planned assessment such as a semester test
2) Evaluating the effect of class quizzes on student performance
3) Assessing the effect of introducing the think-pair and share student's success.
4) Evaluate the effect of tutorials given in class and tutors taking a register of student's interaction. This will be made possible by answering the question 'Is there a relationship between students' activity with the tutor and student success?'

4 Literature Review

This literature covers a review of research about the impact of classroom activities on engineering students' success. It also includes factors that adversely impact the implementation of these activities, the challenges during implementation and additional factors that affect student performance. The works cited within this literature are mainly from case studies and works done in engineering fields of study ranging from chemical engineering, mechanical engineering, computer science, software engineering amongst others. Other Science, Technology, Engineering, and Mathematics (STEM) fields explored within this work include medicine and biotechnology.

4.1 Introduction

Classroom activities are events carried out by students inside the class which are part of engaging or applying the empirical part of the lesson. These are usually done when the theoretical part has been presented by the lecturer/teacher. These activities prompt the students to discover more information via visiting relevant resources which have information that is core to their studies, and applying the environmental practices etc. Classroom activities relate to diverse kinds of technique-based strategies, games, and collaborative activities which helps the students' educational development. The goal of these activities is to improve the students' understanding and their effective skills acquisition in an area, through the engagement of various learning styles. These activities are also meant to introduce some fun into these learning stages which are devised to encourage the students' self-confidence and their ability to think analytically (Goh & Ong, 2019).

With regards to classroom activities, effective learning in education in both primary-secondary school level and higher education has been a subject of concern for education policy-makers, researchers and learning institutions in STEM (Science, Technology, Engineering and Mathematics) fields of study. This concern developed from the possibility of having a society that is not educated within the STEM fields and that fails to meet the growing industry demands (Ardies et al., 2009). The need to advance to a higher stage of STEM mastery in the population is often raised in debates about ways to solve challenges in STEM courses. The major way to assess developments in STEM, specifically via an economic perspective, is to focus on the method of delivery around STEM courses. This method of delivery illustrates a flow of student involvement from primary school to enrolment into secondary and higher education institutions for STEM subjects.

There are various individuals who are in high demand to unravel practical-world challenges. These include people with knowledgeable mastery of STEM as they are required to solve

the difficult challenges emanating from everyday life situations in the world. The mastery of STEM is a persistent economic concern. Imminent national output requires efficient personnel capable of filling empty seats in STEM-associated jobs so as to resist global competition. Therefore, one of the ways to curb the challenges encountered by student individuals in STEM courses is to enhance classroom activities (Abdurrahman, Nurulsarİ, Maulina, & ArİYanİ, 2019). To achieve this effective learning for a wide range of STEM fields, several approaches have been explored to increase student engagement, at the center of which is classroom management and activities.

The traditional approach to teaching has always been a lecture-centred one with the student participating as passive listeners. In the traditional system of education, there are some constraints of place and time which serves as a problem to learners. As in all traditions, new methods appear and approaches that circumvent or entirely flip the practices of these traditions. Within the higher education learning space, the development of technologies that facilitate online or out-of-class learning which were accelerated by the COVID-19 pandemic are one such disrupter (Fogg & Maki, 2021). This is considering the mounting pressure on higher education institutions to improve upon the efficacy and efficiency of their teaching strategies through incorporating innovative technologies. The desire behind this is to increase the engagement of students through active learning to maximise knowledge transfer from lecturers to students. The prevalent form of active learning being the subject of research and experimentation in universities is “flipped learning” (Bhat, et al., 2020). Figure 1 shows some of the most used imitational approaches in higher education within the 2018-2019 timeframe.

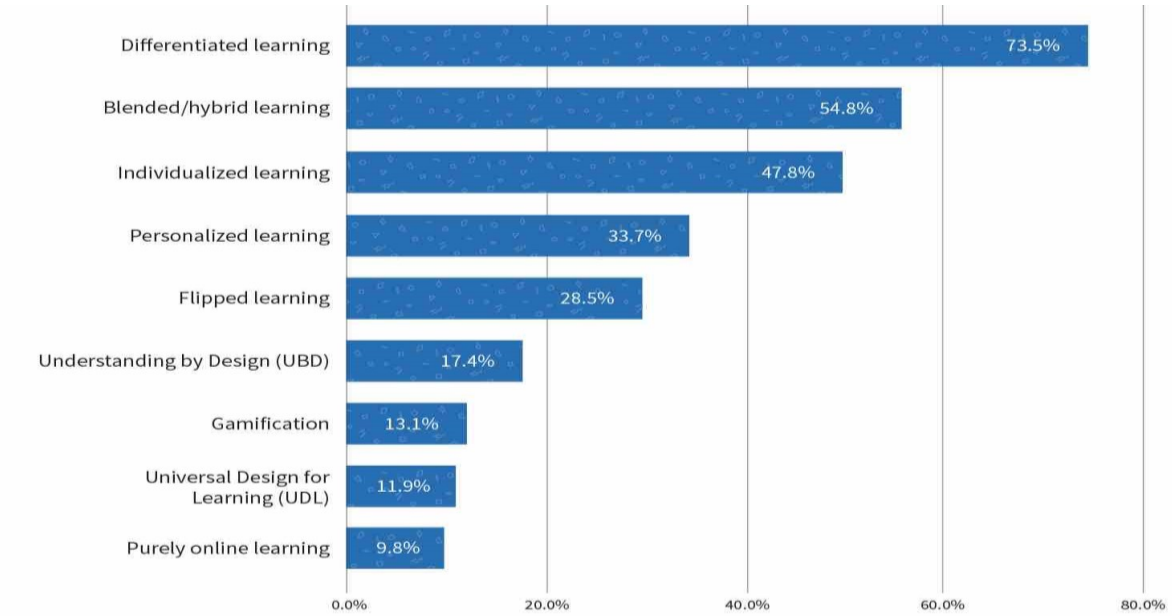


Figure 1. Most used instructional approaches (Trach, 2020).

The concept of flipped learning focusses on shifting the center stage from the lecturer to the student by having them facilitate the active learning process. It utilises modern media technologies to create learning content to be used out of class, e.g., recorded lectures, online quizzing platforms, slides, etc. This leaves the in-class time allocated for hands-on activities e.g., group problem solving, think pair share, concept test, etc. (Turnbull, et al., 2019). In flipped classrooms there is redefinition of in-class activities. In-class teachings associated with flipped classrooms may entail traditional homework problems or action learning, amidst other techniques devised to support students with the learning content. In-depth laboratory experiments, project-based education, peer reviewing, mathematical technologies, speech or debate presentation, math manipulatives, concept practice or skill development, current event discussions, original document analysis etc., are all diverse class activities. These categories of active learning permit for highly distinguished lessons, on higher-order thinking techniques. More time can be exhausted in class on problem-finding, work in groups, collaboration, conceptualizing knowledge with the aid of their peers and teachers. In a flipped classroom, the interaction of teachers/lecturers with students can be less didactic or personalized and students are keenly engaged in knowledge construction and acquisition as they are involved in assessing their learning (Bolotnikova & Pushkarova, 2021). Figure 2 below depicts the differences between the traditional and flipped styles of teaching. With flipped learning, lecturing takes place through various media outside of the classroom, and students come to the class are having gone through the material and prepared for classroom activities.

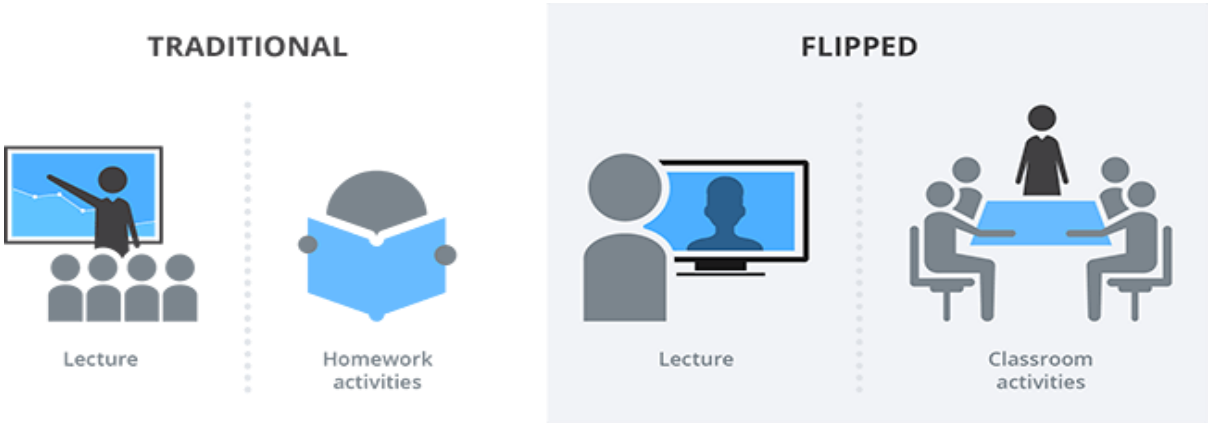


Figure 2. Difference between traditional and flipped classroom model (Chernova, 2019).

This active learning model priorities the “what the student does” over “what the lecturer does”. Doing so develops a self-learning culture by promoting accountability for their own learning on the student’s side. On the lecturer’s side, the responsibility shifts towards developing and/or designing classroom activities and resources that are geared towards the student achieving master of the subject content (Blaschke, 2012). This shift considers the

evolutionary nature of scientific knowledge, that is, the continual formulation and testing of hypotheses which leads to new inventions and bodies of knowledge. The STEM field is plagued at its core with the dual knowledge of “what is known” alongside “what is unknown”, which necessitates the subjects being content heavy. As such, flipped learning is not a trivial task that simply combines the online learning platforms with in-person problem solving classroom activities (Rathner & Schier, 2020). For the most part, it requires a more sophisticated comprehension of teaching methods that enable a transition or interplay between the active learning and traditional teaching models.

Prevalla and Uzunboylu (2019) indicated that lectures teaching engineering modules are faced with the task of balancing the theoretic fundamentals of engineerng with the knowledge of developed and/or developing tools used to carry out tasks. That is, they are pressured to teach the “lastest and greatest” softwares, processing techniques, without sacrificing any of the fundamentals and still maintain or increase class enrolments within said programs. This in turn conflicts with the very task as the higher enrolments, i.e., growth of these programs, results in a reduction in contact time between lecturers and students. This makes flipped learning a viable alternative as it combines traditional lectures and problem-based learning activites with learning theories and methods founded upon behaviorist principles.

This setting fosters collaborative work amongst a student and their peers to complete in-class activities while the lecturer serves as a guide when difficulties are encountered. In this manner, the lecturer is able to engage just-in-time with teaching when a common stumblig block is encountered amongst the students. The activities themselves include brainstorming around a concept or scenario, gradual building of nontrivial problem-solving tasks, discussion of complied learning resources, design work, amongst others. Bhat, et al., (2020) outlines the roles a lecturer and a student would have to undertake in this new form of teaching (Table1).

Table 1: A comparison of lecturer-student roles in the traditional and flipped model.

Course Characteristics	**Traditional Model**	**Flipped Model**
Role of instructor duing class	Information provider	Guide
Role of student during class	Information recipient	Active participant in class
Out-of-class activities	Sloving problems, reading textbook, preparing for tests/exams	Watch online lecture or read assigned material (before class), complete problem sets and prepare for test/exams (after class)
In-class activities	Instructor-led lecture	Varies (i.e. problem-solving, projects, discussions,

		brainstorming, field trips, etc)
Role of assessment	Primarily summative in nature	Formative “gate checks” to ensure preparedness: Both formative and summative assessment.

For an effective implementation of the flipped learning within an institution, a colaborative effort from a faculty level is very beneficial. This has the added advantage of combining subject specialists, pedagogical experts and learning technologists in an effort to reduce some of the limitations. Talbert (2014) postulated that for one to carry out an effective flipped learning classroom model, it neccesitates the following points being covered:

- A comprehensive organisational structure for pre-class assignments so as to ensure that new theoritical knowledge is well presented and assimilated by the students.
- A coherent system and associated resources for student accountability that ensures that students completed all pre-class assignments as well as other out-of-class work necessary for the flipped class.
- A thorough planning and design of activities in accordance to the content in an appealing manner that sparks student engagement for the duration of the class.
- Channels of correspondence should be developed and maintained through the duration of the module/program for free communication between students and the lecturer.

Baytiyeh and Naja (2016) further added that in its core, the flipped learning model is rooted in the self-learning of students as well as their engagement in the classroom. In that regard, they emphasised the inclusion of student perspectives in their work, and an understanding of their views to develop effective engagement and out-of-class content that is appealing. In order for one to transition from the traditional model of teaching to a more active learning model, it therefore becomes paramount to understand the current learning climate. The higher education system within South Africa consists of its own challenges as a result of direct and indirect factors like policies, economic standing of student households, etc. explored in the subsequent section.

The flipping learning model cannot be highly appreciated if ICT is not incorporated into it. The following highlight the advantages ICT has brought to the flipped classroom which has made learning easier (Turan and Göktaş, 2018):

- There is support for distance learning.
- It makes modern ways of teaching easier.
- It supports teamwork.
- There is a chance to submit an assignment and instantaneous evaluation can be made.
- Further access to additional materials.
- There is ease in bringing up to date study materials or information.
- Teachers could be absent.

- More opportunities for communication and consultations (with the application of discussion tools).
- There is high motivation and stimulation for students.
- Dynamism and attractiveness of the on-line study materials.

Despite the assiduous importance of ICT to the flipping classroom, there are some drawbacks that can be encountered:

- It requires a lot of time for preparation and development and hence, it might be time-consuming.
- Lack of personal interaction or contact.
- It is expensive for students to get access to the on-line courses from outside.
- Sometimes there might be vagueness of feedback.
- Challenges of technology.

4.2 Current Learning Climate

Active learning is observed as a method intended to equip students with the necessary skills and problem-solving attributes that allow them to thrive in the working environment. Not only that, but it also improves the learning experience in higher education and the academic performance of students (Prevalla & Uzunboylu, 2019). Hence, for active learning, a well-designed classroom activity that is created to bring a strong connection or bond between the teachers/lecturers and students helps them handle their interaction of input and output during the learning process. This design is dependent on a task-based teaching technique, judicious preparations of classroom tasks, types of teaching curriculum, and with diverse classroom activities. These are all intended to motivate the student attentiveness and assimilation, and positively conclude the learning process in the oral classroom. All these are initiated to help the teachers and the students to make adequate accomplishments for their tasks without any hindrances (Osagie, Wesselink, Runhaar, & Mulder, 2018).

There is a set of peculiar qualities which are generally known as the 21st century skills (general capabilities or soft skills) by the educational sector. These skills are regarded by the employer as employability skills, and they comprise collaboration, problem unraveling, innovation, and creativity. These skills are not only needed by employer but also various individuals who are determined to create their own establishments/businesses/companies (Prevalla & Uzunboylu, 2019). Sikhwari, et al., (2015) covered some of the factors that are affecting the academic perfromance on South African universities which should be considered when in and around the transition process from the traditional model. These factors ranged from lecturer attributes, assessment and feedback, language competence as well as academic challenges.

One vital factor which is affecting student learning is the classroom environment. There is high efficiency for a student to learn when support and a positive learning environment is available. The environment where the students can be cheered to confront challenges, feel trusted and can take tasks, ask questions, and feel a sense of belonging. This type of climate allows for important conspicuous feedback and learning goals, relevant content, prospects to innovate strategies and skills to aid student's success (Cole, Lennon, & Weber, 2019). Well known factors that impend a constructive environment for student learning include, problems that students carry from their homes, absence of enthusiasm among students and many more. These factors cannot be controlled, unless there are some strategies to proffer solutions to the negative effects. This is achievable only if the power of emotions can be harnessed, then effective learning can be achieved together (Cole, Lennon, & Weber, 2019).

It has been studied that stress has a huge negative influence on cognitive functioning (Cole, Lennon, & Weber, 2019). Although, negative events prevail over the efficacy of positive events. Owning to this, there is a need for lecturers to prepare themselves with a tool-set of strategies that protect students against these negativities through the provision of practices to neutralize the negative. In that manner, students can be helped to avoid getting trapped in a negative circle, since negative emotions always impede learning via lessening students' focus and their capacity to comprehend diverse viewpoints and proffer solutions to problems (Lamb, Creutzig, Callaghan, & Minx, 2019).

4.2.1 Class Management

The term class management refers to the systems applied to coordinate physical structure, instructions, classroom activities, and other features so as to make the use of actual time for learning more productive and enthusiastic, and to curtail behavioural disruptions and problems (Herman, Reinke, Dong, & Bradshaw, 2020).

Classroom management is always a challenge for a starter (lecturer or teacher). For a veteran teacher or lecturer who has gained experience on how to relate and please the students to guide them in learning is quite different from a beginning teacher who is expected to maintain a similar level of class management. Often there are concerns about teasing the students to behave and how to discipline students when needed. This method is conservative, similar to an officiating official shouting foul on a player in a game. The lecturer must be able to create soothing strategies that can aid a conducive and positive environment for impact in addition to a strategic scheme that creates a high level of activities coupled with conspicuous instructional segments (Burden, 2020).

Classroom management is mostly dependent on teachers/lecturers with activities and action/behaviour that are majorly designed to enhance student consideration and cooperation in the classroom, either virtual or physical (Burden, 2020). A university must accept some responsibilities to promote class management, some of the responsibilities are extension worker, counselor, evaluator, guider, curriculum engineer, innovator/researcher, disciplinarian, organizer of co-curricular activities, custodian, management etc. The mode of training is specifically associated with the scope of the course in the classrooms. The lecturers are seen to be the large basic contributor in carrying out most of the educational modification at the foundation level. The teaching-learning system is influenced by educational capacities, the commitment of the lecturers, abilities and capacities of instructing etc., (Cain, 2019).

Classrooms environment (either virtual or physical) should be protected and also be a fascinating environment to provide the important scholarstic, together with passionate and social assistance to students. The method of managing classrooms influence the goal attainment of students. The management, structures and facilities of classrooms gives a diverse measure of motivation (Egeberg & McConney, 2018). Due to the various theories about the management of classroom, lecturers are much more interested in student's achievement and classroom management (Saifi, Hussain, Salamat, & Bakht, 2018). Several factors influence classroom management (virtual and physical) at various level of studies, namely:

- Lack of facilities.
- Low attendance of students.
- Lack of time management.
- Electricity availability.
- Non-availability of internet.
- Less fascinating classroom.
- Poor communicating system.
- Lack of latest technologies.
- Personal favoritism/conflict.
- Lack of orientation discussions to inspire students (Cain, 2019).

In classroom management there should be quarterly/yearly upgrade of information or the manner in which studies are carried. Similar content of topic or schemes should not be taught for one year without a revision or an upgrade in the information, due to changes in technology. The method of teaching in the current year might be quite different compared to the previous year. Hence, quarterly or yearly revision should be done on classroom activities. Activities such as module content, mode of lecturing, assigning duties to students, feedback mechanism, evaluation of marks, workspace for student (either physical/virtual), discussion forum, class grades, assignments, quizzes, class progress, course tools all require quarterly or yearly revision (Egeberg & McConney, 2018).

4.2.2 Module Content

This section was classiffied by students in the work done by Sikhwari, et al., (2015) as either interesting or uninteresting largely due to the nature in which the content is structured. According to the work of Sikhwari, et al., (2015) students classified lectures as interesting or uninteresting largely due to the nature in which the content of the module was presented by the lecturer. Interesting models were attributed with challenging content that stimulated problem-solving capacity and a sufficiently provided practical component that provoked thoughts on its real-world application. The uninteresting modules were said to contain a bulk of theory whose application was unclear with few practical components. A case study by Nyamupangedengu, (2017) summarised that students' lack of interest also stems from content (notes or slides) that contains insufficient information, that is not clear or structured in manner that is not coherent with prescribed textbooks. Furthermore, most university libraries have textbooks that are too old with content that has since been deemed outdated. Bagarukayo and Kalema (2015) advocated for an increased adoption of a variety of e-learning activities as it affords students' access to appropriate content because the current process of just uploading slides is insufficient.

4.2.3 Assessments and Feedback

Classroom assessment and feedback have developed to be an integral part of any education system. Class assessment is a phenomenon where teachers or students collate, interpret/deduce, analyzing students' weaknesses and strengths, assigning grades, and assessing student development toward meeting preferred altitudes of ability (Grieve, Moffitt, & Padgett, 2019). Few of these schemes are formative, especially, assessing the development to assist student education, while the rest are summative, such as attesting the accomplishment after a report session. Learning is crucial even for summative classroom evaluation since the main aim of education is for students to be impacted. (Grieve, Moffitt, & Padgett, 2019). Classroom evaluation systems make use of diverse types of schemes, such as informal observations, classroom dialogue (discussion forum), classroom quizzes and tests, outcome from computer-based education programs, short and long-term student presentation evaluation, peer and self-estimation. In addition, classroom assessment relates education targets to efficient assessment methods that lecturers applied in their classrooms to improve and observe student learning (Carless & Boud, 2018).

Grieve et al., (2019) understood that a well-structured classroom assessment is used by students as well as teachers to examine their learning goals and get feedback if the students are in agreement with the learning goals. This enables the lecturers/teachers to make quick

alterations in instructions and also to the learning practices should the students not be aligning with the learning goals.

The issue within this section is less on the quality and standard of assessments (test, assignments, practicals, etc) and more to do with the poor feedback from lecturers to students. There are many instances where students would write consecutive tests without receiving feedback on the first or have marks issues without their test answer sheets being returned, and in more cases, test answer sheets are marked incorrect with no comment (Sikhwari, et al., 2015). This creates a culture where students are uncertain of their errors and how exactly to go about fixing them, especially when most of the students fail on a specific topic and are not given clarity on what was wrong with the answers they gave. This negatively impacts the student's engagement and leads to lack of interest in attendance as "they feel like there is no point in listening if you're not corrected either way". Nyamupangedengu (2017) gave the lecturer perspective wherein, some of the issues were attributed to the workload resulting from the high volumes of students. Furthermore, continuously rotating hired help which is delegated work (tutors, etc), means the variable quality of work and students assistance, creating more problems than solving them.

4.2.4 Lecture Attributes

The lecturer is ultimately responsible for the learning atmosphere in the classroom and creating a platform for free engagement with students. Unfortunately, the majority are seemingly failing in that regard. In most cases, they present whatever slides they have prepared without use of any audio-visual component at a hasty pace in an attempt to cover the module content. This occurs at the cost of students' engagement and learning as most students lose focus and interest as soon they no longer follow slides content (Sikhwari, et al., 2015). Case studies by Nyamupangedengu (2017) found that there were students in their second or third year of study who had never interacted in classes or ever consulted with lectures. One such student, 'Ngoni', in the case study states:

> "Like, I haven't talked for two years in science, so like, everybody got the chance to say something about genetics, so if you didn't understand then there will be a platform to show that you don't understand and then the misconception you have will be corrected".

The responses/reactions of students to instructions, information, submission of assignments, quizzes mostly dependents on the lecturers. If effective communication and proper clarity of instructions/information is deficient in a classroom, the outcome of the students' results and responses to task will not be encouraging. Hence with respect to this,

the lecturers must be well equipped on how to effectively communicate and carry the students along so that the atmosphere in the classroom can be conducive for the students to study and be eager to give responses/answers to tasks and assignments (Oh, Park, & Ye, 2020).

4.2.5 Students Academic Difficulties

Language competence is a challenge encountered with the diverse student demographic wherein English is not the majority native tongue. This presents a scenario where students never engage in class as they feel they will not be as articulate as their peers. Some struggling students respond to certain questions in their native tongue or get penalised in tests for language mistakes without feedback on how to phrase correctly in the future (Sikhwari, et al., 2015). Some students struggle with time management as a result of poor communication skills. Lack of personal laptops forces them to rely on the school's saturated electronic resources, plus they struggle with their ability to distribute time accordingly with multiple tasks. Students are faced with with chalenges in the use of modern facilities such as computers and other electronic gadgets because they lack the proper background to the use of these gadgets and hence these challenges may retard their learning process. (Bagarukayo & Kalema, 2015; Nyamupangedengu, 2017).

4.3 The Active Learning Climate

The current active learning climate can be segmented into categories, namely flipped learning and blended leaning. Blended learning is defined as a more thoughtful integration of both online and face-to-face learning as opposed to the inverted form observed in flipped learning. Gren (2020) best described blended learning as an efficient and effective method to enhance meaningful learning experiences while exposing the values of traditional higher education. This section on active learning is sub-sectioned into the evolution of active learning, the lecturer's perspectives as well as the students' perspectives.

4.3.1 Evolution of Active Learning

The early predominant implementation years (2012-2014) saw a large application of flipped learning in school STEM subjects. Ardies, et al., (2015) indicated that the nature of data capturing processes then from over 20 schools lead to inconclusive results when comparing practices and testing performace. However, they observed a gender disparage based on the nature of the activites, citing that female students in contrast to their male counterparts preferred more collaborative activities over competitive ones. Sanchez-Carmora, et al. (2017), in their work with gamification of their Computer Science program encountered that

“feelings of unfairness” when rewarding quantity over quality of work were apparent, intensified bythe competitive approach used. Though they configured the maximum level of their leader board to be more attainable to all students, they observed a reduction in participation by the poorer performing students.

Clark, et al. (2016) performed a “school wide” study of flipped learning in the engineering faculty where they observed the highest engagement with more practical aspects. It was favoured by the structure of flip with the use of teaching assistants circulating the classroom to offer guidance where needed. Their data analysis indicated a significant improvement in students’ academic performance and high proficiency of module content. The observation was a lower usage of online material and videos by 1st year students and a mild resistance from final year students with 2nd-3rd year students being more receptive. This indicated the necessity of starting active learning early on, and educating 1st year students on the benefits and intention of flipped learning along with usage of these methods as they have no previous experience. Along with Xiaobin Le (2015) they discovered that the evolution of interactivity and active learning progresses along the academic year and thus flipped learning may require time for full implementation.

A review by Karabulut-Ilgu, et al. (2018) of 2013-2015 publications indicated that, when comparing flipped learning to the traditional approach, a higher number of authors reported the flip approach as being more effective. A low number of some authors mentioned there was no difference in results with the two approaches, and very few authors reported the flipped approach as being less effective. One takeaway from the review was an observation of increased class attendance as a result of the engagement. This is significant as studies such as those by Motsima (2020) indicated with statistical significance that students who attend classes were more likely to perform better than their non-attending counterparts. Outside the scope of performance, the common observation in Karabulut-Ilgu, et al. (2018) was a development of professional skills such as life-long learning (through independent study), critical thinking, learner autonomy and interpersonal skills.

Work by Akçayır and Akçayır (2018) and Rathner & Schier (2020) reported high-performance levels of students as a result of developing a comprehensive and engaging online content and ensuring student access to the content. This emphasises the necessity of developing a strong Content Management System (CMS) and Learning Management System (LMS) so as to regulate the quality of content and monitor the students’ use of it. An LMS is a system like Blackboard, for the administration, tracking, and delivery of educational course content while the CMS stores, manages, and distributes all content, including video, etc. as observed in Figure 3.

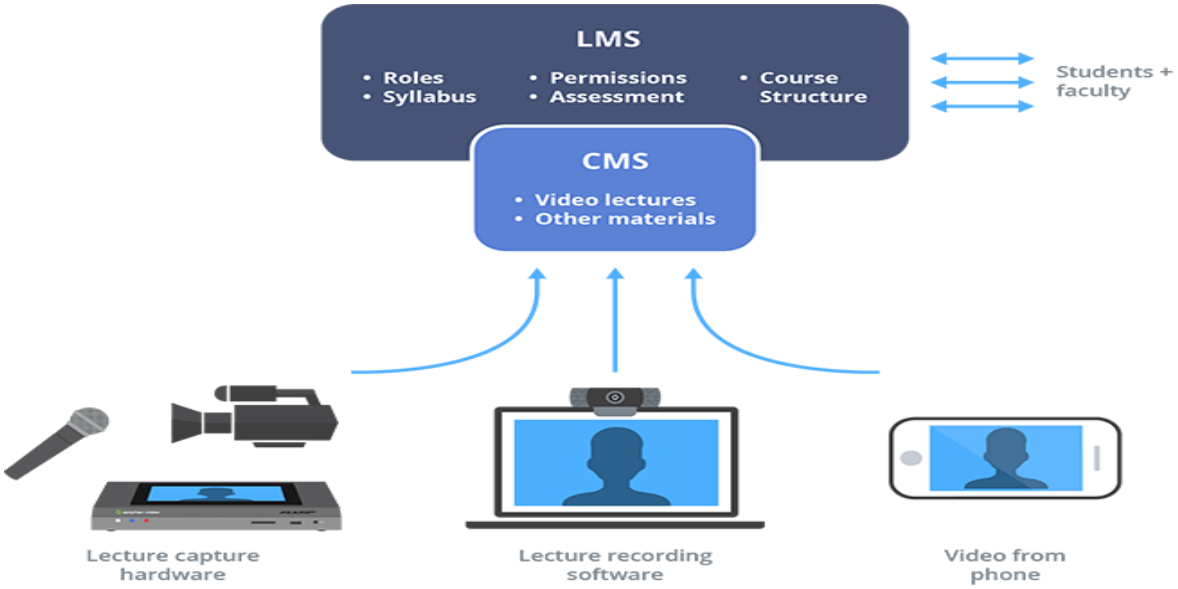


Figure 3. CMS and LMS platform interaction for flipped learning (Chernova, 2019).

Khan and Ibrahim (2017) performed a long-term blended study wherein it was observed that an 81% success rate was attained with 57% attaining better grades compared to the traditional approach with 60% success rate and 32% of good grades. This blended approach was done using post-tests, videos and surveys on an online platform. The benefit for students is that they can access the material any time and review content they did not fully grasp. Overall, the collective literature and trends observed are in favour of flipped learning when applied correctly.

The challenges around correct application have been observed to arise from a lack of collaboration between subject specialists, pedagogical experts and learning technologists. Without comprehensive analysis of the course content and intended flip strategies the active learning presents more challenges than benefits. Clark, et al. (2016) reiterated this, as most of the lecturers concluded that not all topics or courses were well-suited for flipped learning. Gren (2020) saw the equiping of new teaching skills within this growing pedagogical aproach as an important factor for successful implementation.

The effects of flipped learning over the blended form is an increased number of students with career skills necessary in the work environment. Carnevale & Smith (2013) wrote that skills required by employers within the 21st century span from communication, deductive reasoning coupled with problem-solving, to behavioral and continuous learning. Beyleveld, et al. (2019) expanded that these skills are not only applicable in a carreer but they are necessary as life skills. The authors alluded to the students attaining skills for adaptability and fexibility with social and intercultural skills as well as leadership skills, productivity in their work, being self-driven, having initiative and accountability. Active learning is observed as a bridge between skills developed in educational institutions and skills required by

employers in the workspace. Ito and Kawazoe (2015) also highlighted that active learning enhances skills such as “ student ability to discover” which is a requirement in the Japanese industry.

4.3.2 Lecture perceptions of Active learning

Some lecturers have the notion that flipped learning requires more time which impacts on their ability to cover the course content. Furthermore, to make an effort in that direction would increase the workload to an even greater extent as they would have to contend with creating content that is good enough to prepare students for year-end exams (Bhat, et al., 2020). In hindsight, Nyamupangedengu, (2017) observed in more instances, with traditional learning, lecturers prioritize their time to covering content while neglecting students to comprehend learning the content on their own. Whereas, flipped learning offers lecturers the flexibility in the delivery of course content, along with the freedom of examining the objectives of the course and designing class activities accordingly.

Karabulut-Ilgu, et al. (2018) pointed to a lack of creativity in creating engaging content that would result in students finding the videos boring and lengthy. As some case studies found, under those circumstances, the student would rather skip the video and read through slides. The challenge here is students coming to classes unprepared and thus it defeats the purpose of in-class activities as one would spend more time educating than on activities. Another hurdle that lecturers perceive as stated by Rathner and Schier (2020) are the university policies around attendance which frame the student perception of what is important. Some universities have optional attendance policies that are a major impediment as the flipped model is reliant on in-person activities and learning.

Aside from the hurldes that lecturers face when approaching the flipped learning path, the majority of lecturers are observed to be enthusiastic about it. This can be attributed to the benefits observed within the students that exit this learning method. Xiaobin Le (2015) phrased it that most lecturers see it as the next revolution in engineering education.

4.3.3 Studenst Perceptions on Active Learning

Beyleveld, et al. (2019) pointed out that students were found to attend lectures more in a traditional setting where lecturers were passionate and brought subjects to life, had a high degree of engagement and clearly structured content that was easy to follow. Active learning covers these areas while encouraging students to take responsibility for what they have learnt through assessments that enhance self-efficacy and motivation. Nyamupangedengu (2017) reported that even in traditional learning, students showed self-

efficacy and understood that their learning was their own resposibility. For instance, a student would complain and require lecture slides prior to classes so as to ask questions on things they could not understand. Furthermore, they appeared to do best and prefer lecturers that engage with them, “rather than lecturers who talk at them”.

Students find that the new approach of using videos is more beneficial as they can rewatch when a concept is not understood. Bhat et al. (2020) argued that the length of said videos possessed a challenge to students and some would lose focus and had to rewatch them again. According to Bhat et al. (2020) another factor was the style of content delivery in which a student was quoated saying: “some lecturers are just boring and slow and some are way too fast without using any examples”. Karabulut-Ilgu et al. (2018) observed that chunking the videos into segments within a topic offered a greater acceptance among students and lecturers. They also found in the process that students complained about connectivity speeds, which was then improved campus wide.

Beyleveldet al. (2019) as well as Rathner and Schier (2020) noted that students were in support of flipped learning as it promoted deep learning that nurtured and enhanced their problem-solving skills. They cite that students were afforded time to reflect on the information learned and discovered so as to move it from their short-term memory to their long-term memory. This is one of the reasons to which the greater success with the pedagogical approach is attributed. According to Xiaobin Le (2015) students favor the flexibility that comes with the learning process and the ease in following the content as opposed to long lectures. In addition, they supported in-class sessions as they are able to ask questions as they arise and attain help, as opposed to solving problems alone.

Karabulut-Ilgu et al. (2018) found that students lacking in organisational and metacognitive skills were the more vocal resistance as they struggled with flipped learning. Xiaobin Le (2015) reported that such students often felt like they were being forced to teach themselves the new material, with some stating that the material in most higher education subjects were new to them and they would prefer having a lecturer teach them as “*this is not a way to learn engineering*” (referring to the flipped learning model).

4.4 Suggested Classroom Activities

Sheshikala et al. (2020) performed a study in which the authors reiterated that the majority of students preferred cooperative as opposed to competetive activities. They indicated that group competitive tasks are accepted better than an individual task. The following are some of the different types of activities that can be used in a class setup.

- **Role play**: altering ones behaviour to conciously adopt and act out an assigned role for the purpose of classroom activity.
- **Stump your partner**: students need to use the information they have learnt and discussed thus far to formulate a question for their partner.
- **Group problem solving**: combining students of varying numbers and present them with a project or problem they need to solve analytically.
- **Concept test**: A mutiple choice test which puts in place a combination of all wrong answers so as to measure the attentiveness of the students.
- **Think-pair share**: combining students to discuss through sharing ideas, solve a problem or answer questions on assigned material to be read before the class.

Discussions amongst student pairs was observed to help in clarifying what they may not have understood. However, this presented a noise challenge which can be solved by the use of a teaching assistant or by carefully considering the use of props that will reduce cross-communication (Sheshikala et al. (2020)).

4.4.1 Role Play

In the classroom environment, role-playing is achieved by outlining a specific situation that would occur in their professional environment or workspace which they would then be tasked with solving. In this, the student is expected to use the theoretical information that they have learned and apply it to the situation that has been given to them. Cobo et al. (2011) pointed out that some of the benefits and drawback of using roleplay in engineering after a two-year study:

- It develops professional competencies in communication, adaptability to changing scenarios, problem solving and conflict resolution.
- It bridges the gap between academia and the real-world scenarios experienced in the workplace, which has made it a useful tool in non-STEM fields of study like a business.
- The outcome is heavily reliant on the knowledge the students possess, otherwise, it becomes fruitless and more of an entertainment task.
- It may cause disorder and consume time because the lecturer loses control of what is learnt and omits certain theoretical aspects.

Suobere and Eniekenemi (2017) applied this to a mechanical engineering group and found that it increased the pass average from 58% (control group) to 79% for that given module.

4.4.2 Stump Your Partner

This activity is best conducted in small groups where each group would have to formulate a question for one of the other groups, that they have an answer to that is based on the topic being discussed. It increases collaboration and competition as one team attempts to develop a question for the other team. This shifts from the lecturer to students as they discuss with their peers. The benefits and drawback of this method are:

- It promotes collaboration and improves the communication skills of students while pointing out their gaps in knowledge.
- It allows the lecturer to observe gaps and know which points need further instruction for the students.
- The results will depend on the knowledge of the students and on their level of preparation prior to the class.

Rathner and Schier (2020) performed a “stump your lecturer” activity which afterward allows the students to raise questions to their instructor. Their observation was that it offered students the opportunity to ask questions on the content they found conceptually intricate. The authors found that it maintained high class attendance as students could still remain in their comfort zone and be engaged with their instructor.

4.4.3 Concept Test

These are small tests issued to students after content has been covered to ensure that concepts are well understood. These may come in the form of multiple-choice tests, class exercises or quizzes. Peuker et al. (2013) applied multiple-choice tests over four engineering disciplines and observed the student’s performance in them, the result being the response tests were not far apart with 80% and 76% respectively. Their observation was that students were able to display a better understanding of concepts. The benefits and drawbacks observed:

- Students are better prepared and encouraged to go over material/content covered in class to prepare for quizzes.
- Concept tests highlight gaps in knowledge so the instructor can revisit certain concepts that students found to be intricate.
- These are short assessment that do not consume much time and allow for other activities in the classroom to take place.

Xiaobin Le (2015) found that applying quizzes alone to a classroom had a significant impact but works better when coupled with more activities and used as a measure for understanding.

4.4.4 Think Pair Share

This strategy to active learning is a cooperative one where students are given a problem or asked to reflect on the material read. Here they are given 2 minutes to think on the problem individually while the class is devoid of any movements. They are then paired and given 5 minutes with which to discuss before the instructor asks them what conclusions have been drawn. Bewoor and Kulkarni (2018) applied this to a quality control module within the mechanical engineering graduate programme. Their surveys indicated that 99-100% of students found the think-pair-share strategy motivated them to learn more, while the process of problem-solving allowed them to have a better grasp on concepts. They indicated that it

explored different approaches to solving a problem and helps the student better articulate complex tasks. The benefits and drawbacks are:

- The task promotes deep learning in students as it exposes flaws and misconceptions they have on the module content.
- Teaches students how to work together and share ideas towards a common goal.
- Promotes self-learning as students desire to be well prepared for the discussions.
- Effective results can only be achieved based on the knowledge of the students.

4.5 Learning and Teaching Theories

Learning theories refer to how students process and absorb the knowledge that was received during learning. Environmental, reasoning and emotional impacts and also previous experience, partake in how a world view or understanding is assimilated or altered. There are various theories that characterize learning (Martens, Meeuwissen, Dolmans, Bovill, & Könings, 2019). Behaviorists perceive learning as a part of advocating and conditioning a scheme of targets and rewards in education. Lecturers who imbibed cognitive theory consider that the description of learning as a change in behavior is too constricted, and only educate the learner rather than their environment, specifically the difficulties of human recollection. People who support constructivism consider that a student's capacity to be educated depends mostly on prior experience and understanding, and the achievement of knowledge has to be separately designed practices of construction. Transformative learning theory emphasizes the frequent important alteration needed in a student's worldview and experiences. Geographical learning theory emphasizes on the prospects that environment and circumstances form/shape the learning practice (Hajian, 2019).

Outside the scheme of educational psychology, practices to openly discern the working of the brain during the learning process, such as functional magnetic resonance and event-related potential are applied in educational neuroscience. The jurisdiction where education is regarded as the correlation between dozens of diverse functional parts in the brain with their strengths and weaknesses in some specific students has likewise been stipulated, but practical examination has discovered the theory to be unproven (Kamel-ElSayed & Loftus, 2018)

4.5.1 Types of Learning and Conditioning

Klein (2018) stated the following classification of learning and conditioning required in education

- Social learning theory: this is where examination of activity is followed by modelling.
- Classical conditioning: this is where an activity develops an impulse to a precursor stimulus.

- Operant conditioning: this is where precursor stimuli is emanating from the outcomes that follow the performance through compensation or a chastisement.

Matthews et al. (2019) examined that if dogs accompany the delivery of food with the ringing of a bell or a white lab coat, they produce saliva, even if there is no vision or smell of food. This type of learning is also considered by classical conditioning, even if it is in humans or in dogs. Operant conditioning supports this performance with compensation or a punishment (Matthews et al., 2019). A compensation increases the possibility of the student's performance while a punishment declines this performance. Social learning theory examines performance which is followed by modeling. These learning theories give the foundation of applied behavior analysis, whose application applies examined experiences, replacement performance strategies, functional analysis and a support of change performance. (Duchesne & McMaugh, 2018).

Behaviorists see the educating process as a change in performance and this inconsequently organizes the environment to cause preferred reactions via such devices as competency-based education, behavioral objectives, and skill training and development. Educational views such as direct instruction, early intensive performance intervention, behavioral intervention and direct instruction have developed from this model (Clark, 2018).

4.5.2 Transfer of Learning

The transfer of learning is the knowledge that a student learnt from school and then carries it to circumstances not similar from that specific time and that specific setting. In educational psychology, 'transfer' was included among the main phenomena examined. One description of why transfer does not happen frequently is because it entails deep structure and surface structure. The surface structure is the approach where a problem is outlined, while the deep structure is the model for the solution. For instance, when a mathematics problem alters its circumstances from asking what are the expenses incurred to reseed a lawn to how much it costs to varnish a table, these questions have a varying surface structure, but the model for getting the answers are similar. Although, several people are more impacted by the surface structure, in actual fact the surface structure is unnecessary (McInerney & Green-Thompson, 2020).

Outlining transfer and searching its fundamental mechanism is a challenging task. Scholars are still searching to comprehend the problems that students face when they try to disseminate their knowledge from one perspective to the other. Most of the primitive suggestions about the transfer are majorly established on the idea that impacting students via instruction, practice and guidance in a specific context can aid them to achieve proficiency of a

specific task of a domain and this proficiency is all that is required to apply the knowledge in practice. Although the new constructivist theories of learning do not undervalue the role of practice and instruction, they see learning as a complete, or the integrative process in which students are dynamically involved in the process of their learning but they acquire proper feedback, instruction, opportunities and guidance via social involvement and interaction in correct experiences. Thus, learning is not just defined in regards to the cognitive processes that individuals are involved-in, it is about how people develop in this change and process. Nevertheless, there is more concern about it by people because they consider it to give thorough knowledge on how to solve the problem. Therefore, this hinders their understanding of the deep structural problem. Although if someone makes an effort to focus on the deep structure, 'transfer' may still not be possible because of the obscurity of the deep structure. Thus, surface structure gets in the line of students' capacity to view the deep structure of the problem and transfer the knowledge and ideas they have acquired to bring up a solution to any challenging situation (Bozkurt, 2019).

The present learning pedagogies center on transferring knowledge, free of the background that provides its definition. Because of this, students frequently find it hard to convey this stand-alone information into other facets of their learning. Students require more than abstract theories and independent knowledge; hence the need to be enlightened in learning that is equipped in the perspective of real activity and culture. The reviewer of situated cognition would debate that by demeaning independent information, the transfer of knowledge across background becomes difficult. Therefore there must be stability between allocating knowledge alongside holding the deep structure of a material and the understanding of the way the information arrives to be understood (O'Leary, 2020). Some critics have disputed that the transfer rarely happens. They consider that students alter what they acquired into the modern situation. These critics further state that transfer is too large of an inactive notion. They opined that students, alternatively alter their knowledge in an active approach. Students rarely convey knowledge from the classroom, but they build the knowledge in a manner that they can comprehend the knowledge themselves, and in the process of doing so, some of the knowledge may be lost or misinterpreted. The students alter the information they have acquired to make it best fitting to the varying setting that they apply the knowledge in. This change process can happen when a learner senses elation to apply the knowledge, although if the student finds the transformation not important, it is difficult that the knowledge will ever transform and thus the student may not be a beneficiary of the information (Shawa, 2020).

4.5.3 Benefits and Methods of the Transfer of Learning

Various situations impact the transfer of learning in the classroom. These situations comprise the attributes of the learner, attributes of the task, attributes of the social setting of the activity, attributes of the organization. The attributes of the task comprise practicing through problem-based learning, through simulations and skills and knowledge for executing modern plans. The peak aim of the undistinguishable theory of transfer has been to enhance learner's application of knowledge via giving the same tasks in the same contexts (with united features and elements), albeit this theory was disapproved some years ago. When it was practically designated that the capacity of organizing general principles (for instance, the principle of water refraction) was more efficient than the existence of the same tasks in the transfer of training, it was observed that other conditions such as individual variation via the habit of authenticating a judgment or the capability to simplify a standard for oneself extremely inclined the amount of knowledge and skills transfer.

The attributes of learners comprise their capacity to partake in group discussions and in written discussions, ability to reproduce previous experiences, practice skills. All these unique attributes add to a student's capacity to apply transfer of learning. Learning transfer in the classroom is aided by structural techniques, and these strategies include bridging and hugging (Alibali & Nathan, 2018). Hugging applies the method of simulating an action to persuade reflexive learning. For instance, the hugging approach is when a student displays teaching a message. This example persuades analytical thinking that employs the student and aids them to comprehend what they are learning, which is one of the aims of transfer of learning. Bridging is when instruction inspires critical discerning abstractly by aiding to recognize relations between ideas and to evaluate those relations. An example is when a lecturer permits the student to evaluate their previous results and the approach in which the results were achieved. This includes the number of study techniques and study time. These are some of the concepts necessary for fruitful bridging and hugging practices. There are varying levels of importance of transfer of learning in the classroom. One of the major importance is the capacity to promptly learn a modern task. Thus, this possesses actual applications such as speech and language processing. Transfer of learning is also very important in educating students to apply developed cognitive thinking by using their experience knowledge to modern situations (Hajian, 2019).

4.5.4 Teaching Theory

Teaching activities align with a process. It is understood that activities applied in teaching practices are done through curriculums that have a specific framework. As a result of this, students possess the ability to accomplish more, although they cannot progress due to the

incomplete content embedded in the curriculums. From this perception, brain-based learning states that practices that impact individual and brain differences should be noted while organizing learning environments and educational aims. It is feasible via organizing in a submissive manner, the learning environments in the brain so that the brain can comprehend efforts productively and effectively. Learning can be enhanced by a way of organizing environments possessing stimuli that sustain the brain and the standard of learning and removing the issues that influence the brain in a bad way (Von Esch & Kavanagh, 2018).

Some of the behaviors and activities that can be proposed for teaching in environments are:

- a conducive atmosphere that gives students/learners the confidence and courage should be organized
- students/learners should be given the chance to concentrate on various subject parts
- brain accommodating evaluation techniques should be applied
- students/learners should not be given a high condition to meet
- group cooperation and activities should be encouraged and incorporated in the teaching curriculum
- enticements and rewards for learners/students are applied to encourage excellence
- standards for classroom performance are high.

Learning entails both unconscious and conscious processes. Humans learn more than what we comprehend consciously. This condition is a pointer that the unconscious process operates often. Some amount of stimuli retrieved from around drives into the brain and is linked into interaction without the awareness of the learners. Information coming into the brain impacts decision and motivation. For instance, if a student is not aware of a teacher's character while learning Mathematics, he may end up disliking the teaching or maths. It is noted that if verbal communication is backed by body language such as eye contact, gestures, and mimes, these may all contribute to learning secondarily and will be efficient in attracting the students' audience. In teaching practice, work should be arranged in such a way that the learners' experiences are increased and they are being given a chance to make intelligence out of their experiences maximally. An environment where the teaching materials are valuable and significant for students then will make them be lively in the learning process (Maybee, Bruce, Lupton, & Pang, 2019).

McInerney & Green-Thompson (2020) stated that learning can be improved by challenge and subdued by threat. Brain's working declines when there is anxiety or fear. On the opposite, the will of learning of a human's brain enhances to maximum when the brain is put to work properly (captivated to produce an effort). The main purpose of the decline in the working of the brain is as a result of desperateness. Hence, the sensing part is closed down, and flexibility declines, spontaneity ceases, whereas routine and primitive performance

emerge. Circumstances such as stress, anxiety and fear inhibit the interaction at the anticipated stage between brain parts. Inconsequent, the excellence of learning is impacted negatively in this condition. However, the teaching condition which inspires, gives positive instructions and inspirations to the learner is very vital in learning.

4.5.5 Teaching strategies

Von Esch & Kavanagh (2018) proposed that for a brain-based learning, the prescription of different strategies for effective teaching was essential. Some of these strategies are stated below:

- note taking and summarizing
- active learning
- group learning
- ensuring awareness, supporting individual and cooperate works
- high level of organization
- assignments, quizzes with instant feedback
- asking questions

The application of teachers' overall performance management strategies to help to enhance the efficacy of classroom activities and organizing the disruptive behavior have huge signs of usefulness in impacting students.

4.6 The Importance of Assessments in Students Learning Process and Success

The importance of assessment in students' learning process cannot be fully understood if its importance to lecturers is not firstly elaborated. Assessment in learning is both useful for the teacher's and student's success. For a teacher, the assessment gives an evaluation of their impact on students' learning and helps them to also see which of their mode of teaching is quite efficient to the students' learning (Klein, 2018).

Assessment is a fundamental measure for instruction, as it defines or determines whether aims or objectives of learning are being accomplished. Assessment influences actions about curriculum, instructional requirements, placement, grades, and promotion/advancement, and in some circumstances funding. Assessment stimulates students/teachers to ask or think about difficult questions. As for the teachers: are they imparting what is right? 'Is there a more efficient method to teach the students, hence enhancing better learning? Are students learning what they should learn? These questions must and should be answered by lecturers to see if their learning is and has been efficient' (Tosuncuoglu, 2018).

Student assessment provides instructors a way to measure the efficacy of their teaching via the linking of students' performance to certain learning standards. In consequence, lecturers/instructors are able to allocate efficient teaching decisions and revise inefficient ones in their pedagogy. Student assessment cannot be achieved if there are no instructors/lecturers/a self-evaluating machine which are needed to determine or measure the efficiency of their learning by associating their performance or results to a particular learning standard (Black & Wiliam, 2018).

Requesting students to exhibit their understanding of the subject matter is important to their learning development. Hence it is paramount to estimate if the educational principles and goals are being achieved. Without assessment, students cannot know their strengths and weaknesses. They will be ignorant of their performance about where to improve and what to continue to do, in order to bring the desired/preferred outcome. Today's students are required to understand not only arithmetic skills and basic reading, but also skills and knowledge that will give them capacity to confront the world that is constantly changing. They must be equipped with the ability to reason analytically in proffering solutions to real-life problems and challenges. Knowledge and skills needed by students require modern learning goals, and these goals alter the relationship between instruction and assessment. Thus, lecturers require to take a conscious effort in making clear decisions about the necessity of assessment and the content that is being assessed (Tosuncuoglu, 2018).

Hayes, Christie, Mills, & Lingard (2020) proposed that the nitty-gritty of assessment works at best when the following questions are answered in relation to specific goals;
When it gives diagnostic feedback to teachers, such as:

- What the student's wants?
- What is required to be taught?
- What are the students' behaviour foundation?
- What is the student's knowledge foundation?

When it helps lecturers set principles, such as:

- What conduct exhibits knowledge?
- What conduct exhibits understanding?
- What conduct exhibits mastery?

When it helps lecturers to determine the progress of the student, such as:

- What teaching or learning practices/methods are most efficient?
- How are the student performing?
- What modifications or alterations to teachings/learning are required to assist the student?

When it helps the student to see his progress, such as

- What have the students acquired?

- Can the student demonstrate the knowledge that has been acquired in a real-life situation?
- How well able the students can carry-out the new skills they were taught in class-room in other projects?

When it provides self-evaluation to student, hence to motivate his/her performance, such as:

- At the moment that I know how I am doing; how can I improve?
- Currently that I am in control of my learning, how am I doing?
- What other thing would I be interested to study?

When it gives self-evaluation for lecturers, such as:

- What can be done better for the students?
- What is working best and not working effectively for the students?
- In what other way should the students be directed next?

4.6.1 Forms and Importance of Assessment to Student

There are normally two forms of student assessment. Which are summative assessment and formative assessment (Menéndez, Napa, Moreira, & Zambrano, 2019).

Summative assessment: This is an assessment that is employed at the final stage of the course of study. Its main aim is to give an evaluation that 'adds up' student performance. In nature, summative assessment is broad and is deeply engulfed with learning outcomes. Although summative assessment is mostly beneficial to give information about the outlines of students attainment, it does so without giving a chance for students to mirror on and exhibit growth in specified areas for development and also does not give opportunity for the lecturers to change teaching schemes/approaches during the learning and the teaching process. Summative assessment for instance comprises the comprehensive end of the year papers or exams.

Formative assessment entails the estimation of student learning/studying over the period. Its optimum aim is to evaluate the level of accomplishment of students so as to improve students' learning during the teaching and learning period. This is through analyzing students' outcomes via formative assessment and distributing the results with them, hence, the instructors/lecturers assist the students to recognize their 'strengths and weaknesses' and to mirror what is required of them to be improved on throughout their concluding studies. Formative assessment entails course work-where feedback is received by the students to recognize and reflect their weaknesses, strengths and other instructions to adhere to for

future tests/quizzes/assignments. Moreover, formative assessment involves the discussions/dialog between instructors and students, and final-unit analyses that give chances for students to recognize necessary areas for development and growth for themselves. It is paramount to identify that summative and formative assessments do not specify the method but only the purpose of assessment (Norcini et al., 2018).

Heritage Margaret (2018) of the Assessment and Accountability Comprehensive Center, gives a schematic diagram (Figure 4) indicating how different assessments influence students. It shows how assessments that are taken away from students' regular interaction have less effect on students' learning progressions.

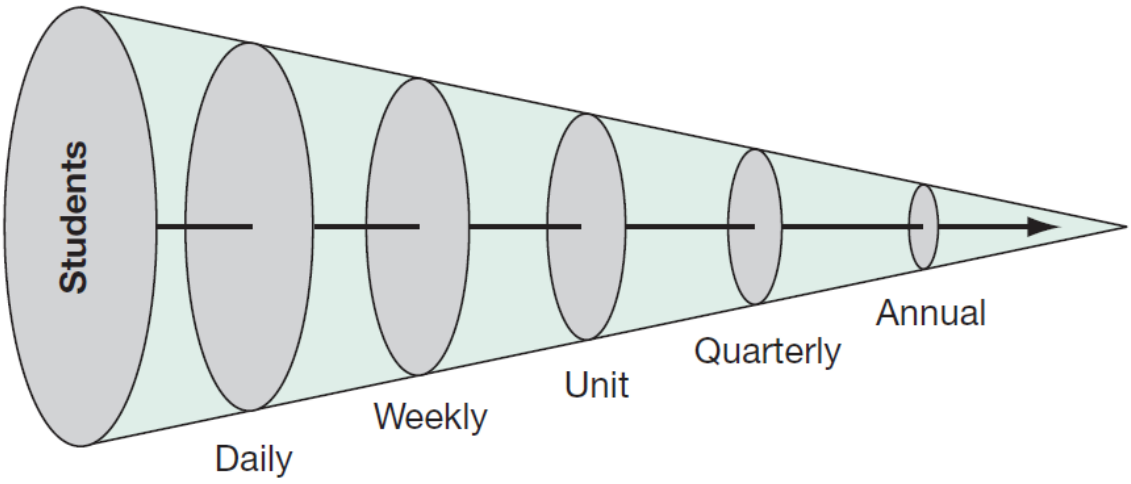


Figure 4. How various assessments affect students (Heritage Margaret, 2018).

4.6.2 Different Methods of Assessment

Black & Wiliam (2018) stated that the following are the common methods of assessment which have been observed to be vital tools for student learning and success

- Self-assessment: The aim of introducing self-assessment in a period of learning is to make students develop their judgment. The student is anticipated to evaluate both the process and outcome of their studies. However, the assessment of the outcome is mostly done by the lecturer/instructor. The introduction of student assessment in the classroom inspires students to assess their work and the procedures that led them to the final results. In addition, self-assessment promotes a sense of belonging to one's studies and can lead to higher student investment. It provides students a platform to acquire some problem solving, and critical thinking skills.
- Peer assessment: Peer assessment is a category of collaborative learning technique, in which the evaluation of students' work is done by their peers. Similarly, as with self-assessment, peer assessment provides ownership of learning to learners and concentrates them on the procedure of learning.
- Instructor or Lecturer assessment: As consequences of the instructor/lecturer's experiences, they are able to analyze/assess the works of students/learners following the scheme and curriculum of a certain standard of learning.

Figure 5 shows how the different activities through which formative assessment is executed can be conceptualised as containing a map of five key strategies (Figure 5). Strategy 2, Figure 5, indicates the challenging job of the lecturer/teacher in putting together and handling several tactics to serve these strategies. Strategy 4 and 5 shows the importance of engage the students in group discussions, peer-assessment, and the formative use of such methods in the marking of written work, including outcomes of tests (Black & Wiliam, 2018). In summary, the form of formative assessment has stood out as a platform for students to recognize their 'strengths and weaknesses' and to mirror what is required of them to be improved throughout their learning. Moreover, the different methods of assessment as stated above also contributed to the students' success in learning.

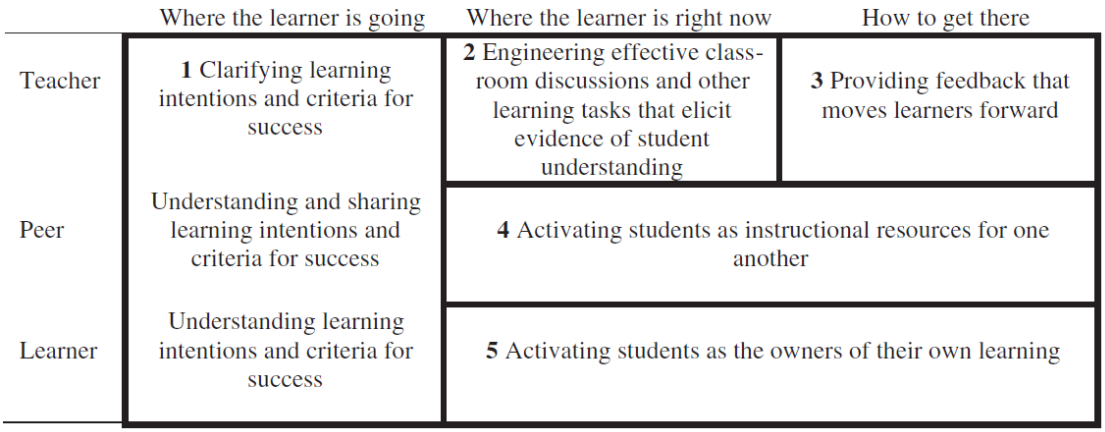


Figure 5. Key strategies in lecturer/teacher assessment (Black & Wiliam, 2018).

One of the foremost aims of education is to help students employ acquired knowledge in different ways and in varied settings. However, this expected "transfer" does not always occur and, therefore, the acquired knowledge cannot be flexibly employed in different contexts. One way to reduce this problem is to understand how transfer occurs and what learning conditions can improve this process. The current work in this thesis provides a study into the impact of class activities on engineering students' success, a way to explore the most effective method to optimize knowledge acquisition and transfer. It is envisaged that this study will enhace the learning process of students at the Tshwane University of Technology. Learning theories state that learning transfer is a multi-dimensional process that occurs at any stage of learning. The study approach employed in this work will access the effectiveness of class activities on the learning process of students, and if it has a positive impact on the success rate.

5 Research Methods

In this research methodology section, I report on the steps that were followed to assess the impact of class activities on engineering students' success. Sections 5.1 to 5.3 gives the relevant research methodology literature. The research methodology literature given in sections 5.1 to 5.3 explains the choice of methods that are then employed in this work, that is, the way the research approach, data collection and data analysis are carried out as detailed in sections 5.5.

5.1 Research approach and methods

Research conducted within the STEM education is aimed at the discovery of truth that involves a combination of reasoning and experiences. The uniqueness of an individual's experiences of the same encountered stimulus prompts a case by case research. In determining an appropriate combination of teaching methods to improve student performance, educational researchers either use the qualitative or quantitative approach. Though existing in different spectrums, both approaches are aimed at identifying and resolving educational problems (Eyisi, 2016). Bresciani, Gardner, & Hickmott, (2011) best describe the two spectrums, with the qualitative approach being describes as

> "detailed description of situations, events, people, interactions, and observed behaviours, the use of direct quotations from people about their experiences, attitudes, beliefs and thoughts".

The quantitative approach on the other hand is described as "distinguished by an emphasis on numbers, measurements, experimental design and statistical analysis".

The current focus on student performance applies a quantitative assessment method through tests and quizzes due to the academic assessment structure in institutions. Arguments can be made on both sides for the appropriateness of either qualitative or quantitative approaches to social/education research. However, it is agreed that the two are incompatible due to their unique manner of data collection and its analysis (Harrison, Birks, Franklin, & Mills, 2017). The advantages of the quantitative approach are (i) the application of statistical data as a time saving tool that also reduces the effort of interpreting or describing results, (ii) the data collection and analysis allows for generalisations, that is, interaction made with one group can be generalised for other groups as the findings are not considered as coincidental, (iii) The replicability of the research approach, that is, it follows a clear guideline and objectives which can be repeated in another setting to yield the same results, (iv) the use of a control of study group which allows for teaching the same content with the

use of multiple teaching approaches, (v) allowing “researcher detachment” approach, removing any bias of the researcher associated with the data collection or analysis (Eyisi, 2016).

The disadvantages of the quantitative approach are (i) the “researcher detachment” approach separates the participant-researcher dynamic which deprives the researcher of an in-depth understanding, (ii) the linearity and non-flexibility of the approach deprives participants from contributing to the study through their input because the researcher is in the “driver’s seat”, (iii) the structured nature of the approach does not encourage or require the use of imaginative, creative and critical thinking as the collected data is used to support or reject predetermined paradigms. These disadvantages make the approach an effective tool for studying that which is known as opposed to seeking the unknown and revamping that which is known (Eyisi, 2016).

The framework applied to this body of work is that of a case study in nature, allowing for a quantitative analysis of student performance with various measures implemented. The approach satisfies the student performance objective through analysis of multiple students; whose behaviour cannot be manipulated, thereby creating suitable grounds for a case study approach. Though deductive, induction and abductive research logics are applicable to this case study, Rashid, Ammar Rashid, Warraich, Sabir and Waseem, (2019) builds a rationale for abductive reasoning. The rationale applied to this context, primarily serves the research objective by understanding the value cocreation in students as it occurs. Secondly, by empirically elaborating the cocreation process, and thirdly, by considering limitations of empirical studies and their interpritive stance. The value cocreation is observed through the improving students that perform better and have overall better outcomes after their studies due to better knowledge retention.

There are a number of case study types that are applicable to a given problem which are further covoluted by refferal and use of case studies as a methodology and method. Baxter and Jack, (2010) describes a number of case study types, namely, explanatory, descriptive, multiple-case studies, intrinsic, instrumental and collective type case study. This work is best described by a mutiple-case study approach which is briefly defined by exploring the difference between and within cases in an attempt to replicate findings. These explored cases (methods) include, for this work, applying concept tests, think-pair and share method (problem-based learning), class exercises and quizzes as well as student tutor interactions. Mills & Birks, (2014) defines methodology as the lens with which the researcher observes and makes decisions about the study, while methods are procedures and techniques applied within the study. Despite the numerous variation in approaches to case study

research, there are characteristics or commmonalities between them. The methodology within this work can therefore be described as applying a combination of quantitative approach and abductive research logic to a mutiple-case type case study. The methods are descibed in detail in the 'Research Methods' section.

5.2 Data Collection Process

The research methods used are structured to work with a central idea of assessing improvements in student performance through increasing engagement and self-learning. The collection of data is archived through a quantitative assessment of the students in their natural class setting. The different research methods proposed for this use a combination of traditional indicators of achievement as a base for data collection, namely, results of class tests and major tests. Additionally, other non-traditional indicators through concept tests and problem-based learning are applied. The traditional assessments have been used as a systematic method of assessing the behavioural changes associated with effective learning and teaching activities. It serves as a tool for collecting data on cognitive, psychomotor, and effective achievement of students while simultaneously differentiating their level of proficiency (Talib, Alomary, & Alwadi, 2018).

Some opposing views have emerged citing that traditional assessment yields results too slowly to guide instructional changes within the classroom and that it has been outpaced by adopted students' learning methods. This argument is due to the influx of technology in education and workspaces that has led to one of the workforce requirements being a proficiency in technology (Bennett, 2002; Wind, Alerndar, Lingle, Moore, & Asilkalkan, 2019; Kartal, Dunya, Diefes-Dux, & Zawojewski, 2016). Kartal, et al., (2016) proposed a pre and post examination test using traditional methods with a mathematical modelling of real-world problems approach to assessment. The results indicated no correlation between test results and solving/modelling complex situation, indicating that performance on a test is not a guarantee of success in the workspace. Though both arguments have merit, traditional assessments remain a standardised method for data collection method that yields statistical data that is interpretable and extrapolative. The lack of correlation observed above can be attributed to an uneven distribution between the complete content delivered and the number of concepts grasped by individual students. This prompted the use of methods which yield timely results to guide instructors on student understanding such as concept tests (Eberly Center, 2021).

Concept tests are constructed using a small number of multiple-choice questions, one to five, on the content of the lecture given. The primary purpose of these tests for instructors

is to attain a snapshot of the entire class' understanding, not just of individual students. Wind et al., (2019) noted the ease of use asssociated with multiple-choice questions and also pointed out a common criticism of providing limited data regarding students' ability to conceptualise complex questions. The note also included the possibility of structuring questions to give insight into the students' conceptualisation. Mahzari, Kambal, Mohammed, Alshahrani, and Al wadi, (2020) attributed the critisim to poorly written mutiple-choice questions, citing the difficulty and time consuming aspect of creating well structured tests for higher levels of knowledge. A further advantage of this approach was the ability to include a wide body of knowledge into a single test.

The last data collection method embraced through tutorials and the think-pair share method is problem-based learning. This student centered pedagogy which is in line with the central idea of this work, presents real world problems that promote and improve student learning as opposed to presenting conventional concepts. Joshi, Desai, & Tewari, (2020) noted benefits of the approach with regards to improvements in cognitive ability, critical thinking abililty, problem solving skills along with overall student performance. The collected data is applicable to quantitative studies but allow for qualitative analysis of students' behaviour while spotlighting the teachers' involvement. Barrett, (2017) elaborated on the open ended nature of the approach that allows the lecturers and tutors to gain appropiate data on students' understanding and the relative ease of applicability to various fields of study.

5.3 Data analysis

Analysis of quantitative data tends to use a lot of statistical tools, given that the majority of it is numerical in nature. Through identifying variable levels of data an analysis can be achieved either to describe, compare or make predictions. Greene, (2020) defines descriptive analysis as the use of central tendencies and dispersions around it, as well as distribution of responses. Comparative analysis consists of ensuring the sample demographic that mimics the underlying population, checks for differences on a measure of groups or individuals within a dataset. A predictive analysis summarises the relationship between measures and the effective ability to make predictions based on the measures. For traditional assessment, the varying nature of mutiple-choice questions influences the learning process of students and requires a separate analysis to ensure it is done correctly. Mehta, Banode, & Adwal, (2016) cited data analysis tools used in a number of studies, namely, difficulty index (DIF I) which is also denoted by P-value or FV (facility value), Discrimination Index (DI), and a Distractor Efficiency (DE).

The difficulty index is a measure of the percentage of items in which the students found the least and/or most difficulty. The discrimination index measures an item's ablility to distinguish low scoring and high scoring students. The distractor efficiency measures an item's success or failure (less than 5% selecting it) in distracting students from the correct answer. These tools help the facilitator construct a well balanced and effective mutiple-choice question. While the effects of the problem-based learning can be analysed through traditional means of perfomance in minor and major assessments, this cannot be done through questionnaires. Gerritsen-van Leeuwenkamp, Joosten-ten Brinke, and Kester, (2018) noted the importance of student questionnaires surrounding assessment and teaching practices as they are stakeholders that can provide valuable feedback. The authors' extensive work on measuring students' expectations and perceptions of assessment quality resulted in a six factor-structure after the validation process. The structure for capturing includes (i) the effect assessment has on learning, (ii) the fairness of assessments, (iii) the condition used within the assessment, (iv) how test scores are interpreted, (v) the authenticity of the assessment, and (vi) the credibility of the assessment. These two, Student Expectations of Assessment Quality Questionnaire (SEAQQ) and the Students' Perceptions of Assessment Quality Questionnaire (SPAQQ) methods developed from the six factor-structure were able to yeild a sufficient degree of reliability of $\alpha = 0.76$ and $\alpha = 0.94$.

5.4 Background of the module

The module in this study is Mineral Processing: Chemical Principles (MNP20XT). This is a 1st-year module offered in the first semester and runs for a period of six months. The module has 14 credits and students are not able to do higher-level modules that require a pass in this module, so success is of paramount importance to students. The success in this module for students is currently very poor at 55% in the academic year 2019. As a new development in this module, new teaching and learning methods were introduced to encourage active learning. The new class activities introduced in the year 2020 that were not used in the module before (in 2019) were: think-pair and share, concept test, class quiz and tutor taking register for all students who consult during a tutorial.

In the academic year 2020, the students wrote four class tests and three semester tests. The difference between a class test and a semester test is that a class test carries a low weight towards the student final mark. Also, the content tested in an individual class test is lower, while in a semester test the contribution towards the student final mark is higher and the test content and mark in the test will be much higher compared to a class test. For

example, a class test can have a total of 25 marks while a semester test can have 40 marks per test or more.

5.5 Teaching methods and Data Collection

5.5.1 Application of concepts tests

In a typical class setup where students are taught the course material as per the study guide, the students were given a topic (Unit 1) for the day and taught using a PowerPoint presentation. Concepts were taught to students without using the think pair and share method as done in the previous year (2019). The students wrote an assessment following the completion of a study unit as per TUT practice. The assessment was a class test. The student performance after writing the class test was analysed using the grading format in Table 2 from A-F. All students who got between a particular mark range as indicated in Table 2 were grouped together to determine the performance of students per symbol.

Table 2. Symbol and marks obtained by students.

Symbol	Marks obtained
A	75-100
B	70-74
C	60-69
D	50-59
F	0-49

After the conclusion of marking of class test 1, the teaching plan progressed into the next phase in which students were taught the concepts that follow as per the study guide (Unit 2). However, in this study unit, during class sessions that lasted for almost three weeks, students were given a concept test at the end of each session. This enables me as the lecturer to verify their knowledge level and be prepared for the next level. The concept test also enabled students to be aware of their understanding.

Using the concept tests results in the following week I reinforced areas that the students struggled with as reflected in the concept test outcome. Afterwards, we continued with the study unit, and as done in the previous week the class was concluded with a concept test. The same procedure was followed in the third week, finalising the study unit. Once the study unit was concluded, it was immediately followed by a class test (class test 2) administered to the students. Analysis of the student's success in class tests 2 was done using the same procedure followed in class tests 1.

Students' achievement in class test 1 and class test 2 will be compared to assess the impact of introducing the concepts tests on student success. The steps of the methods implemented in the course are shown in Figure 6.

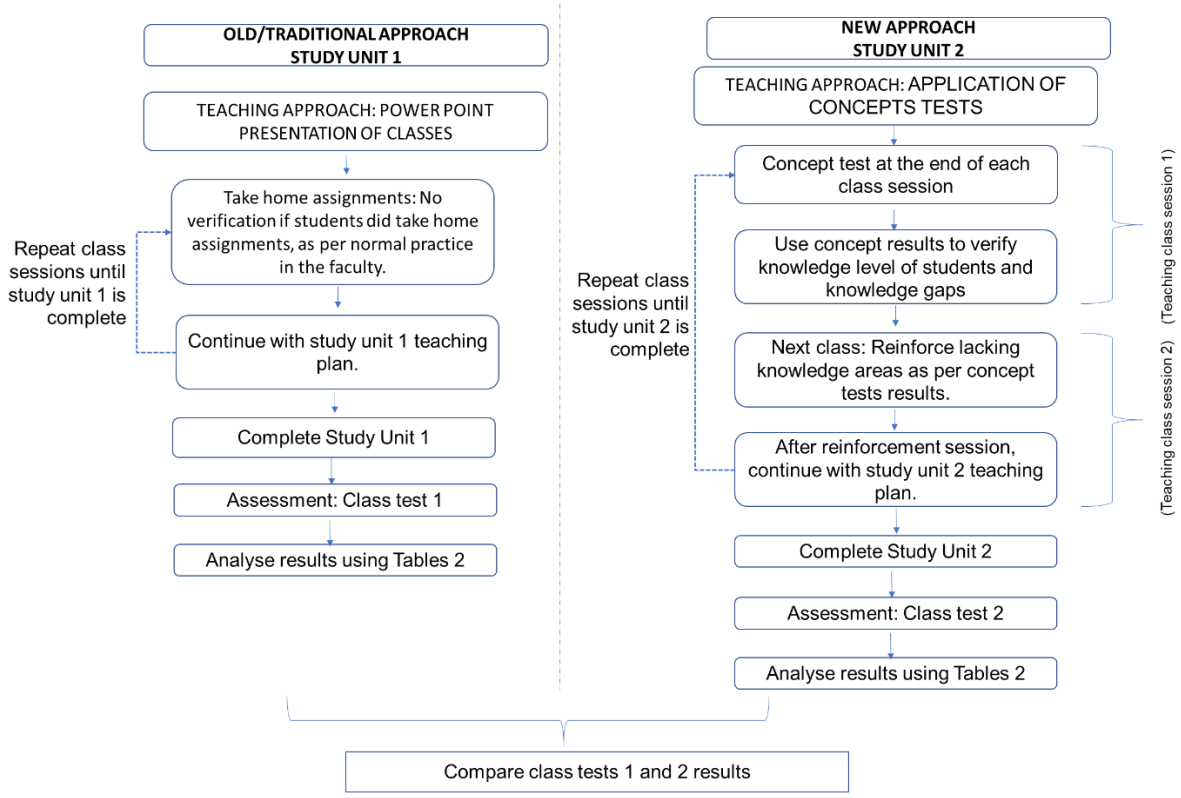


Figure 6. Steps employed in the course using the traditional teaching approach and application of the concept tests method.

5.5.2 Application of think-pair and share method

Unit 3 was taught using the traditional approach of using a PowerPoint slide without engaging students in class. However, at the end of the session students would be informed which exercises (take home assignments) in the prescribed textbook they should do at home for practice purposes. However, there was no follow-up if students did these take-home problems. Once study unit 3 was finalised students wrote a semester test 1. The analysis of the student's success followed the same procedure as done in section 5.2.1.

A new study unit 4 was then introduced. However, in study unit 4, the teaching approach was changed in which the think-pair and share method was used halfway through the class and again 15 mins before the class ended. A full class session was 90 minutes.

The think-pair and share approach involved giving problems to students during the class session which followed the following steps:

(1) A student thinks individually about how they will solve the problem or answer to a question; and
(2) share ideas with two classmates.

The time distribution for individual work was 4 mins and for sharing ideas with classmates was 5 mins. The problems that were given to students was prepared in advance before the class and I ensured that they align with the study unit objectives. This approach was done for 3 weeks of students' contact sessions which means that students had 6 sessions of think-pair and share in total. This was followed by semester test 2.

Analysis of the students' success in semester test 2 was done using the same procedure as section 5.2.1. Students' achievement in semester test 1 and semester test 2 was compared to establish the impact of introducing the think-pair and share methods on student success. The steps of the methods implemented in the course are shown in Figure 7 which presents the traditional teaching approach and the application of the think-pair and share method.

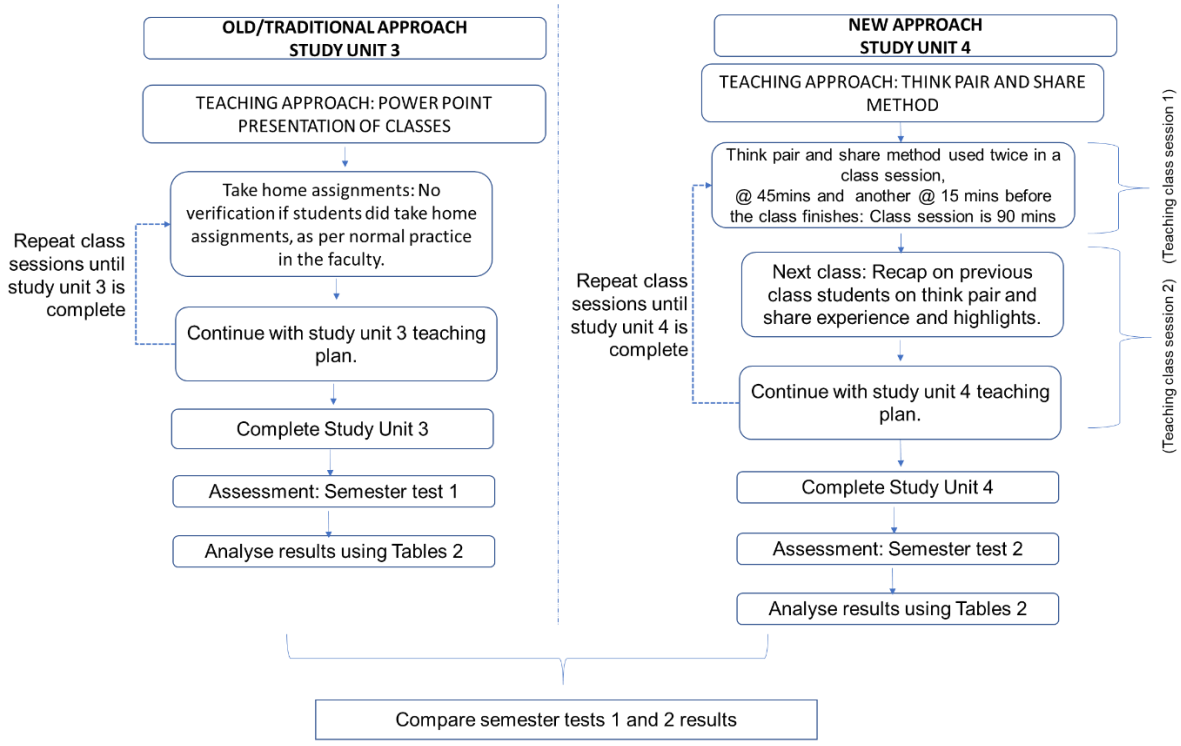


Figure 7. Steps employed in the course using the traditional teaching approach and the application of the think pair and share method.

5.5.3 Application of Class Exercises and Quizzes

In the previous year (2019), students were taught in class and given home assignments; however, there was no follow-up on whether students did this home assignment or not. In the year 2020 for study unit 5, students were given in-class exercises and quizzes that students were expected to do in class. Tutors were available in class and students were informed if they needed any assistance, they could raise their hands for the tutor to assist them. Using tutors in class is reported in section 5.2.4.

The class exercises were given to students 20 mins before the class finished. Students were asked to do these exercises and quizzes in class before the session for the day ended and were asked to submit the completed work. All submissions were recorded against each student´s name. However, students were made aware that these in-class exercises and quizzes would not count for marks, but were for students to test their understanding. At the conclusion of study unit 5 after 3 weeks, the students wrote semester test 3. The performance of students who submitted all class exercises and quizzes was compared to the students who submitted 50% - 0% of class exercises and quizzes. The comparison was made using the class grade scale shown in Table 2. The methodology followed to assess the effectiveness of class exercises and quizzes is shown in Figure 8.

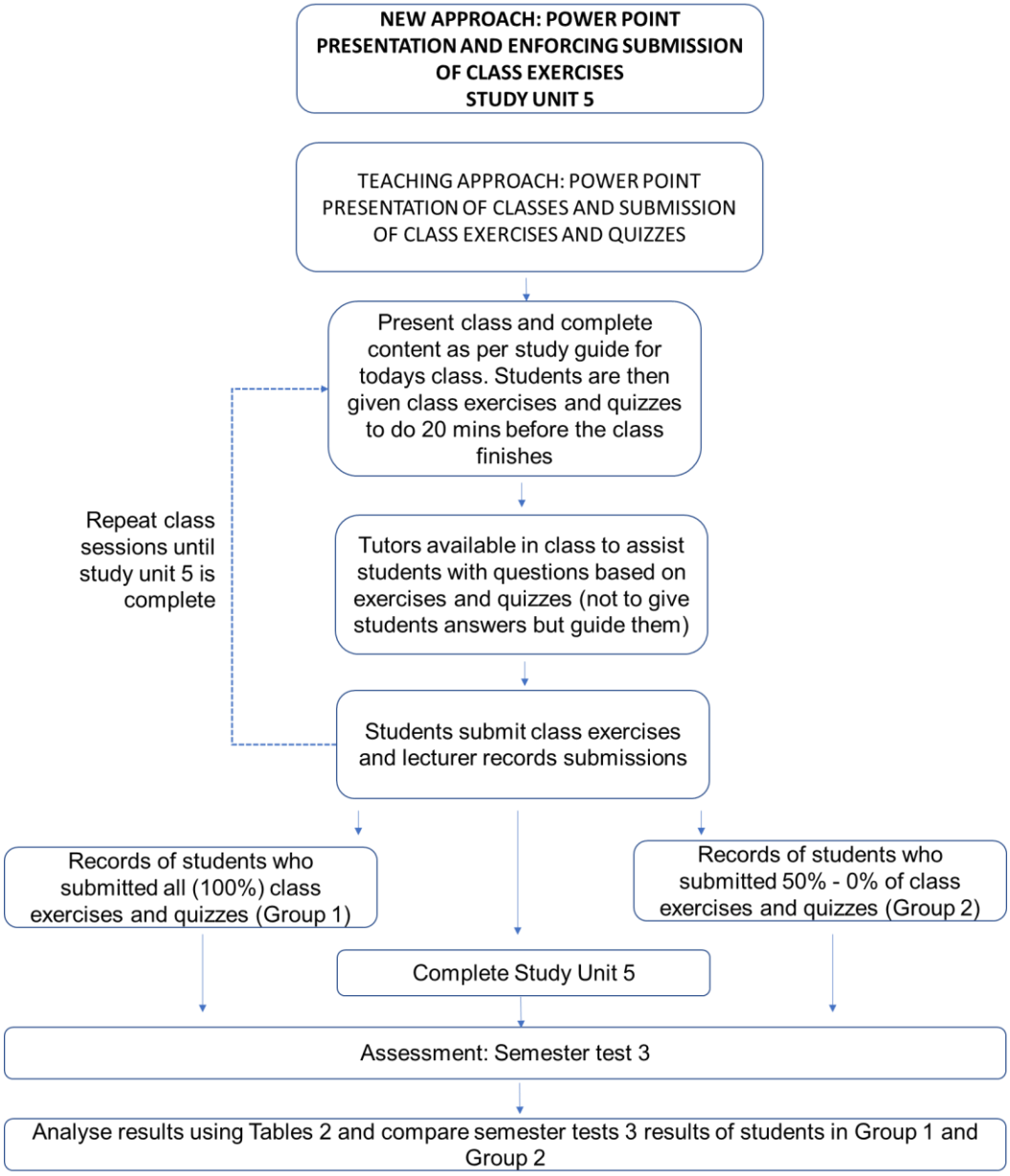


Figure 8. Methodology for submitting class exercises and quizzes to improve student's genitive success.

5.5.4 Keeping Record of Students and Tutor Interaction During Tutorials Sessions

As already highlighted in section 5.2.3 during study Unit 5, tutors were made available in the class which was not done in the year 2019. However, an additional step during study unit 6 was taken. This was ensuring that as tutors assisted students, they recorded the names of students who requested assistance during class. During study unit 6, the class was divided in half, 45 mins for teaching and 45 minutes for students to consult with tutors and seek assistance with the given class exercises. This was not done before in 2019 and was also not done in the teaching of Unit 5.

At the conclusion of study Unit 6 after 3 weeks, the students wrote class test 3. The performance of students who consulted with the tutor (as per recorded names) was compared to that of the students who never consulted with the tutor (as per records). The comparison was done using the class grade scale shown in Table 2. Figure 9 shows the schematic flow which was followed to determine the influence of students and tutor interaction during tutorial sessions.

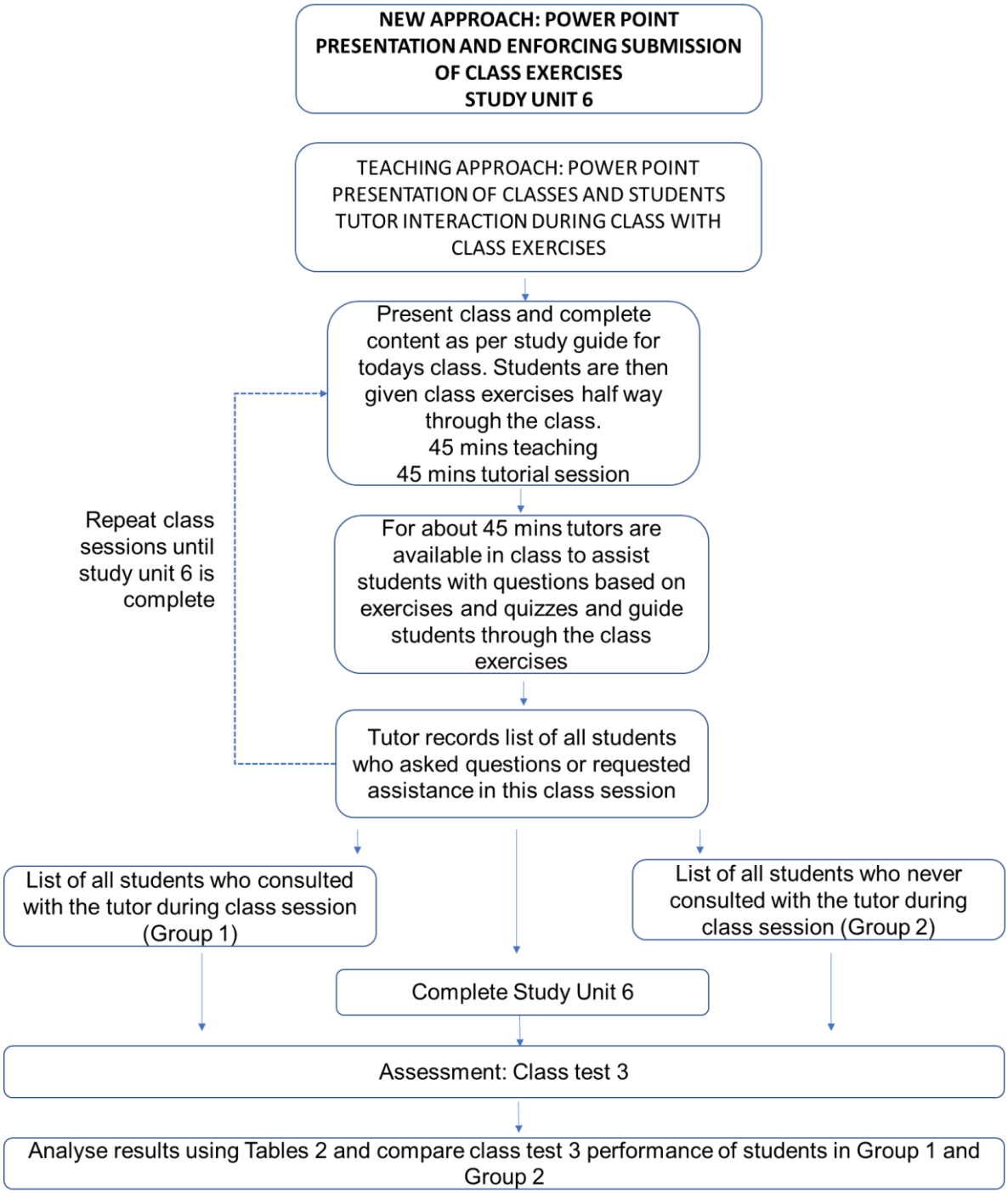


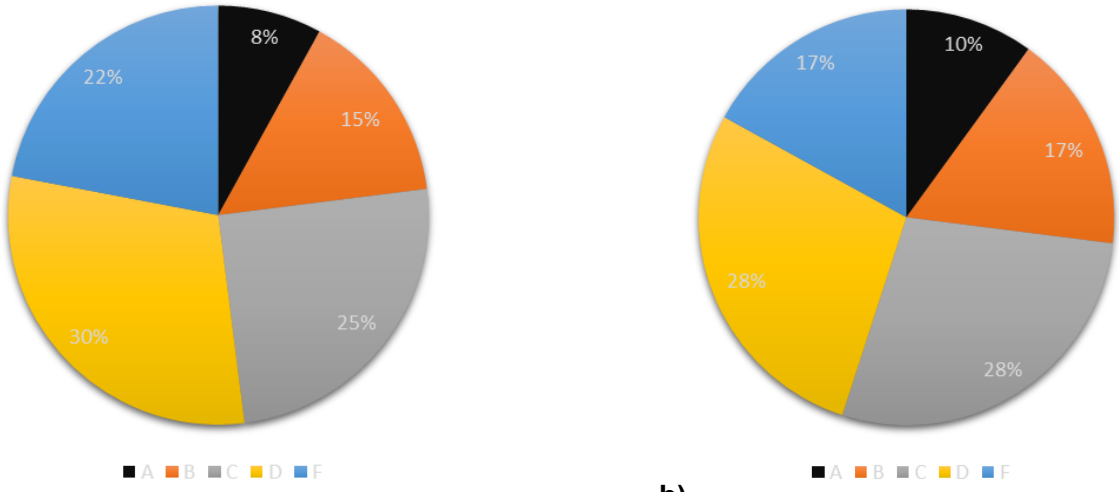
Figure 9. Shows the schematic flow which was followed to determine the influence of students and tutor interaction during tutorial sessions.

6 Results and Discussion

The results are based on the outcomes and observations of the Metallurgical Engineering module MNP20XT.

6.1 Influence of Concepts Tests on Students Class Tests Success

When comparing students' performance after applying concept tests after class sessions, the percentage of failures dropped from 22% to 17% (Figure 10). The percentage of students who achieved symbols A-C (passes) increased from 48% to 55% with an even distribution across the symbols. This indicates that though significantly effective, as a standalone activity in the classroom it is not sufficient to achieve the desired outcome. As Sheshikala et al. (2020) describe, it is a method to test how much of the concepts they were able to understand from the content being taught. It is best used when combined with other collaborative activities in class like the think-pair share, groups solving problems, where students engage together and then get individually tested to assess their understanding of the taught concept. In the case of MNP20XT, this collaborative method was applied after traditional lectures, which meant that student engagement was low and served only as an additional assessment, hence the low impact as illustrated in Figure 10.

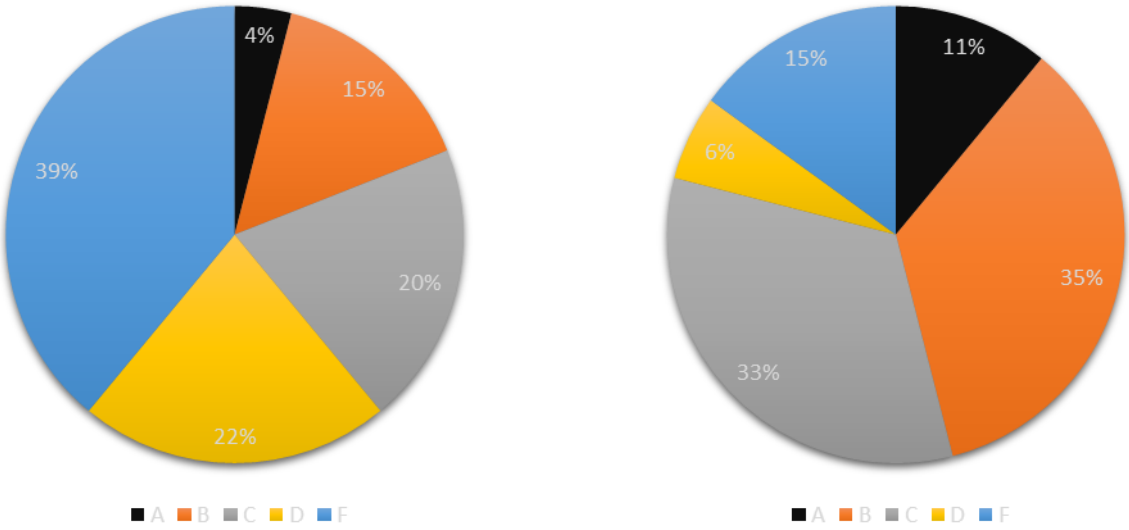


a) **b)**

Figure 10. Class test performance of students for (a) before introduction of Concept test in Class Tests 1 and b) after introduction of Concept Test in Class Tests 2 (All student participated). Black – symbol A, Orange – symbol B, Grey – symbol C, Yellow – symbol D and Blue – symbol F. Symbols A to D are successes and F is failure.

6.2 Influence of Think-Pair Share Method on Students´ Semester Test Success.

The semester test failure percentage saw a drop from 39% to 15% after applying the think-pair share method in class (Figure 11). The total number of students achieving A-C symbols increased from 39% to 79% with the number of students achieving high marks [A] increasing from 4% to 11%. This method is considered quite impactful on student learning in that students could think on concepts they were taught and apply them while achieving real-time feedback from the lecturer. Considering that these major tests combine a larger majority of the module content, the increase in the percentage of high-performing students indicates a much better understanding and correct implementation of concepts. This is supported by Beyleveld et al. (2019) and Rathner & Schier (2020) who indicate that the strategy favoured deep learning that allowed students to better solve problems. Moreover, it encouraged students to continually go through the material so that they are better prepared for the discussion, thus , promoting a culture of self learning.



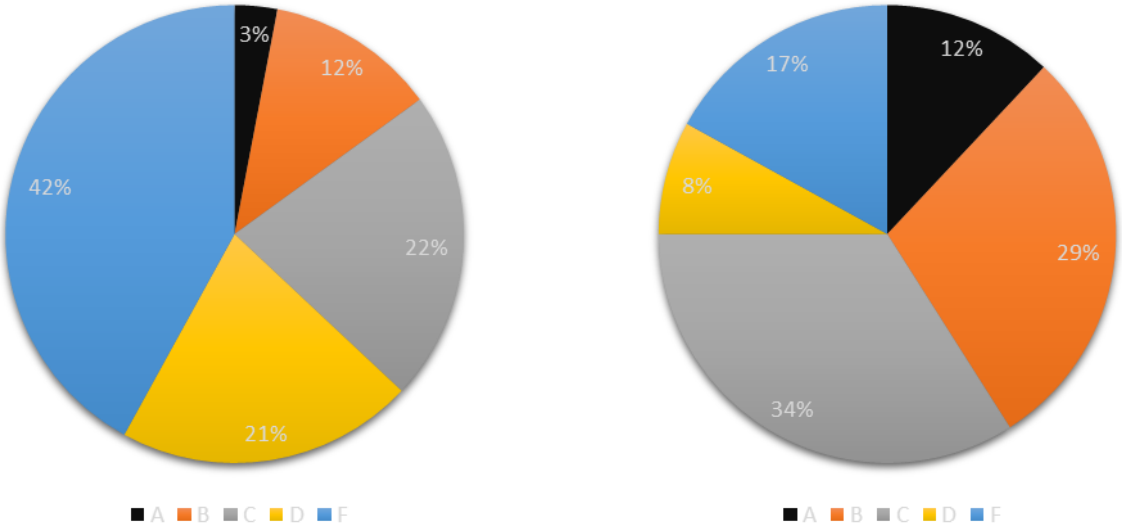
a) **b)**

Figure 11. Semester test performance of students for (a) before introduction of think-pair and share method in semester test 1, and b) after before introduction of think-pair and share method in semester test 2. Black – symbol A, Orange – symbol B, Grey – symbol C, Yellow – symbol D and Blue – symbol F. Symbols A to D are successes and F is failure.

6.3 Influence of Class Exercises and Quizzes on Students´ Semester Test Success

Another observation was an improvement in student performance in major tests after the implementation of class exercises and quizzes. As observed in Figure 12 the failure percentage dropped from 42% to 17% along with statistics of low performing students [D] that dropped from 21% to 8%. The higher-performing students achieving symbols A-C increased from 37% to 75%, which is a great increase in performance over tutorials and

concept tests. The reason for this is that unlike tutorials where students are taught to solve specific problems, with class exercises, the instructor is present and engages with the students to address their gaps in knowledge. This also increases students´ engagement as they work together to solve these exercises, and this has been proven to improve performance. Quizzes are applied after these sessions to measure the extent of understanding for each individual student so that all may participate in the exercises to gain a better understanding.



a) **b)**

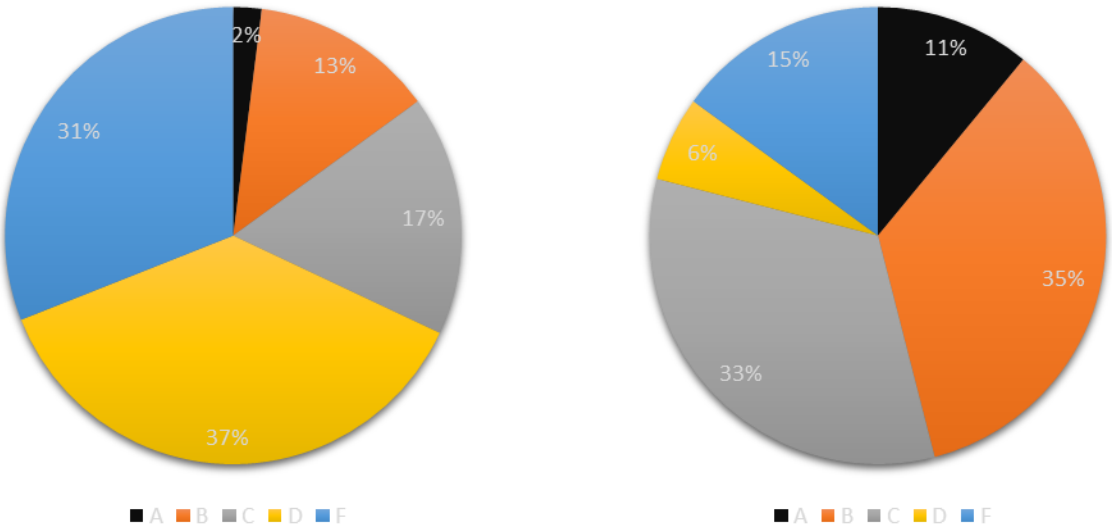
Figure 12. Semester test 3 performance of students for (a) students who did not submit, and (b) students who submitted class exercise or quiz. Black – symbol A, Orange – symbol B, Grey – symbol C, Yellow – symbol D and Blue – symbol F. Symbols A to D are successes and F is failure.

6.4 Effect of Students' and Tutor Interaction During Tutorial Sessions on Student Class Tests Performance

When comparing the student performance after implementing tutorials as observed in Figure 13, the failure percentage [F] in the class test for students who consulted with the tutors dropped by 16%, compared to that of students who did not consult who had a failure percentage of 31%. Students that achieved symbols A-C saw an increase from 32% to 79% after consulting. This is attributed to the tutorials being a problem-solving exercise that follows the traditional form of teaching where students are spoken to instead of engaged with (Nyamupangedengu, 2017).

As the content becomes more conceptually difficult, students consult with tutors, which as observed in Figure 13(a) does not suffice to ensure student success. In my experience this is because tutors tend to help the students understand how a specific question from the

tutorial is answered instead of bridging the knowledge gap these students have with respect to the syllabus. Thus, a better method would be to engage with them during the actual teaching process to plug these gaps in knowledge



a) **b)**

Figure 13. Class test 3 performance of students who consulted during tutorials in class a) consulted with the tutor, and b) did not consult with the tutor, as shown in the tutor's class record. Black – symbol A, Orange – symbol B, Grey – symbol C, Yellow – symbol D and Blue – symbol F. Symbols A to D are successes and F is failure.

Overall, classroom activities that promote collaboration between students and engagement with the instructor are observed to be more effective than the traditional form of teaching. The challenges with applying these approaches were observed to be an increase in the workload for the instructor, that is, the number of scripts that have to be marked increases. This observation is supported by Nyamupangedengu (2017). Students do prefer timely responses to their outcomes. This means that test answer sheets for students would have to be marked and returned to students before the next assessment is made so that they can see their performance and how much more effort to put in. This is where structuring the exercises in a manner that is easier to grade becomes critical to reduce the workload. Additionally, questions that require wording are substituted for multiple-choice questions to reduce bias when teaching assistants are used in the marking of students´ test answer sheets. This is because a large enough percentage of students struggle with their English grammar/and sentence construction.

7 Conclusions

This work has indicated the importance of class activities for engineering students' success. The new class activities introduced in the year 2020 that were not used in the module before (in 2019) were: concept test, think-pair and share, class quiz and tutor taking register for all students who consult during a tutorial.

Using the think-pair approach the percentage of failures dropped from 22% to 17%, while the percentage of students who achieved symbols A-C increased from 48% to 55%. This method indicated a positive change in terms of student success. However, the change was not significant when comparing the results achieved using the other methods. This is especially true for the think-pair and share method which achieved a drop in failures from 39% to 15% after it was implemented. The total number of students achieving A-C symbols increased from 39% to 79% which was very significant.

In this work it has been found out that for better students' success to be achieved the concept test, think-pair and share, class quiz and tutor taking register for all students who consult during a tutorial, all these approaches, will have to be used concurrently in class. Collaboration amongst students was also seen to play a role in students' success as some students were more comfortable learning from each other.

This work has demonstrated that the success of students in an engineering module can be increased by incorporating the aforementioned class activities. The success in this module for students in the 2020 academic year was 83% compared to the 2019 success rate of 55%. This finding is important for the Faculty of Engineering and Built Environments at TUT. Since the success rate has been a major concern being the lowest in the University, this work provides a solution to increase students´ success rate which will positively affect the finances of the faculty and more importantly students completing their studies.

The methodology demonstrated in this work can be employed by other lecturers and academic managers to increase the success in other engineering modules which in turn will be beneficial. This work has also demonstrated the importance of tutors in class sessions which should encourage the faculty and/or University management to set aside additional funds for hiring tutors.

8 Further Development Work

The activities described in this work will need to be employed concurrently in another engineering module to evaluate its full impact. The responsible lecturer will need to be allocated an appropriate number of tutors to ensure that these activities are employed effectively, and the required data is collected.

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