National University of Singapore

MW5200 MSC SCIENCE COMMUNICATION PROJECT

Project Report

Strengthening student engagement in the classroom.

Course: Msc (Science Communication)
Faculty of Science
National University of Singapore

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ABSTRACT

The Ministry of Education (MOE) recognizes the importance of student engagement in the classroom. However, keeping students engaged in the classroom is a challenge for many educators these days. Student engagement is a contested concept, theorized in a variety of different ways within academic literature. This project aims to define and understand the concept of student engagement. The purpose of this project was also to find out the usage of engagement-based approaches in the classroom. The survey results in this project indicate that teachers do use these approaches in the classroom but not frequently enough. Usage of engagement-based approaches in the classroom can be increased with changes in attitudes of teachers, sufficient support from schools and changes in modes of assessment.
AKNOWLEDGEMENTS

I would like to thank the following people who have helped me in making this Masters Project interesting and a memorable one:

- Associate Professor Helmer Aslaksen for his guidance and patience. Without his constant assurance and encouragement this would not be possible.
- Colleagues and friends who contributed to the survey in this project.
- My family for all their support and encouragement.
TABLE OF CONTENTS

Abstract .............................................................................................................................i
Acknowledgements ......................................................................................................ii
List of Tables and Figures .............................................................................................v

1. Introduction
   1.1 Background ...........................................................................................................1
   1.2 Scope ....................................................................................................................2

2. Literature Review
   2.1 The Singapore education system ........................................................................3
   2.2 Previous research on engaged learning in Singapore .......................................5
   2.3 Defining student engagement .............................................................................6
   2.4 The importance of student engagement .............................................................9
   2.5 Factors influencing student engagement ...........................................................10
   2.6 Strategies that promote student engagement .....................................................15
   2.7 Measurement of student engagement ...............................................................20

3. Research Methodology
   3.1 Sampling .............................................................................................................23
   3.2 Questionnaire design .........................................................................................23
   3.3 Variables of interest ............................................................................................23

4. Data Analysis
   4.1 Data collection and research response ..............................................................26
   4.2 Demographic profile of respondents ................................................................26
   4.3 Analysis and evaluation of data ........................................................................27
5. Lesson Package

5.1 Introduction .................................................................33
5.2 Website ...........................................................................36
5.3 Chapter 3 – Dynamics .......................................................37
5.4 Chapter 18 – D.C. Circuits ...............................................46
5.5 Chapter 22 – Electromagnetic Induction ..............................52

6. Measuring Student Engagement

6.1 Students’ engagement in school survey .............................58
6.2 Walkthrough checklist .....................................................58

7. Conclusion

7.1 Limitations of study .........................................................60
7.2 Conclusion ......................................................................60

8. Recommendation

8.1 Increasing usage of engagement based approaches in the classroom ...............................................62
8.2 Directions for future research ...........................................64

References ...........................................................................65
Appendices .........................................................................A1
LIST OF TABLES

Table 1: Demographics of teachers…………………………………………………………………………26
Table 2: Summary of the first survey results…………………………………………………………27

LIST OF FIGURES

Figure 1: Venn diagram model of student engagement………………………………………8
Figure 2: Pie chart showing average retention rate from different teaching methods………16
Figure 3: Bar chart showing the usage of engagement based approaches by teachers………28
CHAPTER 1

1. INTRODUCTION

1.1 Background

Student engagement in learning is an area of importance for the Singapore Education system. Under the framework of ‘Thinking schools, learning nation’, initiatives such as ‘Teach less, lean more’ and ‘Innovation and enterprise thrust’ have been introduced (MOE, 2004a). These initiatives focus on developing students to survive the challenges in the 21st century’s knowledge-intensive and post-industrial economy.

Educators in today’s media-saturated culture face the daunting task of maintaining students’ interest in the classroom. Furthermore, disengagement has been cited as a major cause of deviant behavior at school, truanting, and low academic achievement (Lamb et al, 2004). Student engagement in school drops considerably as students get older (Anderman and Midgley, 1998). By the time students reach secondary school, lack of interest in schoolwork becomes increasingly apparent in more and more students, and by college, as dropout rates attest, too many students are not sufficiently motivated to succeed in school (Lumsden, 1994).

There are many factors that contribute to students' interest and level of engagement in learning, and teachers have little control over some of these factors (Lumsden, 1994). However, teachers can influence student motivation by using certain practices that increase time spent on tasks (Anderman and Midgley, 1998). There are ways to make assigned work more engaging and more effective for students at all levels (ibid). Students are engaged when they are attracted to their work, persist despite challenges and obstacles, and take delight in accomplishing their work (Schlecty, 1994).

With students awash in games and media that enables interaction, the task of successfully engaging students in the classroom can be a challenging task for teachers. Furthermore, addiction to passive amusements such as watching television, playing video games and roaming the malls diminishes their attention span (Wagner, 1993). Hence today’s classrooms require a very different set of teaching tools and teaching methods in order to ensure minimal disengagement. In order to remain relevant and maintain engagement, today’s classrooms must lean towards a...
student-centered learning approach. Students learn more effectively when they are more actively engaged in their own learning (Wolfe, 2001). Therefore, lessons should have more social engagement, active involvement, interactive learning, competitive play and customized content. In such student-centered lessons, teachers will take on the roles as facilitators of learning (Riggs and Gholar, 2009).

To deal with low levels of student performance, teachers must reflect on the elements that contribute to student engagement. It is also essential for teachers to understand the importance of strengthening engagement in their classrooms to ensure that effective learning happens. When students are engaged, they assume a high level of responsibility in their own learning, retain more content and help improve student-teacher relationship, which will aid in maintaining good classroom management (Riggs and Gholar, 2009). Hence together with students, teachers must view learning and educational success as a blend of content and skill mastery, each dependent upon the other and both relying on students’ engagement in the classroom.

**1.2 Scope**

This project will consist of two interrelated parts. The first part of the project aims to explain the definition of engagement. It will also cover the importance and benefits of student engagement. Other aspects such as examples of teaching approaches that can be used to promote student engagement in the classroom will be discussed. The project will include the findings of a survey that will include questions on the teachers’ usage of engagement based approaches in their classrooms. The survey will also include suggestions by teachers on how schools can assist to increase the usage of such engaging approaches.

The second part will include a teaching package of a few identified topics in the secondary physics syllabus. This package will consist of teaching resources that will ensure engagement and effective learning in the classroom. The topics chosen for the lesson package will be the challenging or less engaging topics based on the opinions of experienced secondary school physics teachers.
CHAPTER 2

2. LITERATURE REVIEW

2.1 The Singapore education system

Singapore underwent a period of decolonization in the 1960s. The main purpose of the education system then was to assist its people in surviving the new economic realities. Schools were built and teachers were trained to increase the literacy levels of the predominantly uneducated population. Hence a robust education which succeeded in raising the basic literacy of the population was developed.

In the 1970s, refinements in curriculum and languages were made to support the existing system. The main focus of education during this era was to equip students with good technical and industrial training, hence nurturing students to be more relevant to the job market. During this period, the significance of the education system was to prepare its people for the labor-intensive economy.

In the 1980s, the education system was condemned as being too uniformed, with no flexibility given to the potentials of students. Therefore, the emphasis was to refine the system to meet the need for different aptitudes of its students. The major policy change during this time was the call for ‘Towards excellence in schools’. It was also during this period that autonomous and independent schools were established and teachers were given more autonomy to accommodate the different learning capabilities of the students.

In the 1990s, the objective was on training students to become more entrepreneurial and innovative. Thus, in response to emerging global trends, the Ministry of Education introduced the ‘Thinking schools, learning nation’ (TSLN) framework in 1997. The mission was to develop a nation of thinking and committed citizens, who will be able to meet the challenges of the future. It focused on developing students into active learners with creativity and critical thinking skills.

The 21st century saw the introduction of initiatives such as the ‘Teach less, learn more’ (TLLM) and ‘Innovation and Enterprise thrust’. There was also a call for “a need to re-examine
the fundamentals of teaching and learning, teaching for understanding and not just to pass exams but to engage both the hearts and minds of the students” (MOE, 2004a). In response to this call, the Ministry of Education distributed a toolkit for engaged learning and teaching in the classroom. This toolkit, which was known as, the ‘Principles of engaged learning’ (PETALS) was distributed to all schools in 2005. These initiatives were aimed at developing students to survive in the knowledge-based and post-industrial economy (Teo, 2001). In order to do so, students need to be adaptive, flexible and creative. Therefore, student engagement in the classroom is essential to develop these skills.

2.1.1 Teach less, learn more

The ‘Teach less, learn more’ (TLLM) initiative placed greater emphasis on moving away from textbook learning to the methodology of learning content. Its main objective was to engage learners and prepare them for life, rather than for tests and examinations. The TLLM’s framework posited students at the centre taking into account their diverse needs, abilities, backgrounds and aspirations. Teachers were encouraged to get to know their students better and schools were encouraged to customize the curriculum to engage the learners better. Furthermore, teachers had to be able to apply different teaching approaches and use a wider range of assessment modes.

2.1.2 MOE framework on engagement in learning (PETALS)

‘Principles of engaged learning’ (PETALS) was a toolkit for engaged learning and teaching in the classroom. It dealt with the principles for engaged learning and furnished teachers with the crucial components of engaged learning. It also created a common platform and a shared language for teachers to discuss about engaged learning. PETALS helped to enhance the capacity of teachers, building their skills and knowledge in the domains of pedagogy, instruction and curriculum.
2.2 Previous research on engaged learning in Singapore

Most studies in the Singapore context ventured to explain the concept of engaged learning by providing definitions and suggesting frameworks for it. These studies have also contextualized engaged learning in recent notions of meaningful learning, authenticity of learning, self-regulatory learning and initiating strategies such as those in problem-based learning.

The study by Hung, Cheah, Hu and Cheung (2004), proposed that the engaged learning approach should begin with the design of an anchoring problem and the process of problem-solving should be authentic. They also stated that the engaged learning framework differs from traditional learning in that learners indulge in self-regulatory behaviors and that personal and collaborative knowledge construction are the fundamentals for authentic and engaged learning.

In another study, Tan, Hung and Cheung (2004) suggested engaged learning strategies with e-learning technology. In this study they proposed a working model and example.

In the study by Teo, Chai, Hung and Quek (2004), a definition on engaged learning that is relevant to the Singapore context was proposed. Indicators of engaged learning were also proposed. Their study discussed how Singapore is embracing engaged learning in the second IT Masterplan and the role of IT in bringing about engaged learning. They also proposed a framework, a teacher's perspective on how educators can implement engaged learning in schools.

In another study by Foong (2004), a collection of exemplary practices that were carried out by the mathematics department in sixty schools in Singapore were presented. The study also stated that these practices helped teachers, students and parents meet the needs of a more engaging and relevant curriculum.

It is the hope that this study, which investigates the usage of engagement based approaches in the classrooms and teachers’ perspectives on how schools can assist to increase the usage of such engaging approaches, will add to the existing knowledge of student engagement in the Singapore context. Furthermore, I personally am a teacher in a neighborhood school and engagement in the classroom has been an on-going problem for most teachers in my school.
Therefore, I hope this project’s findings will help to improve the level of classroom engagement in not just the school I am teaching in but also all other schools.

2.3 Defining student engagement

There is general agreement that student engagement produces positive outcomes and has been identified as a desirable trait in schools. However, there is little consensus among students and educators how to define it. Most definitions of student engagement include a psychological and behavioral component. Student engagement is used to depict student willingness to participate in routine school activities, such as attending classes, submitting required work and following teachers’ instructions in class (Chapman, 2003). It overlaps with, but is not the same as, student motivation (Sharan et al., 1999). Student engagement developed as an academic concept during the 1970s and 1980s, with many early constructs emphasizing on student participation (Smyth, 1980). Other primarily one-dimensional models emerged soon after. These models focused on the psychological or cognitive dimensions of engagement (Miller et al., 1996).

Student engagement is not a one-dimensional construct (Fredericks et al., 2004). It has many components (Newmann, 1989). Conceptually, student engagement involves both student’s behavior at school and their psychological or emotional attachment to school. It refers not only to the events taking place within the classroom, but also to those that occur outside the classroom (Fin, 1993). The multi-dimensional definition of engagement focuses on the cognitive, behavioral and affective indicators of student engagement (Skinner and Belmont, 1993).

Cognitive engagement

Cognitive engagement is thought to prevail when students expend mental effort necessary to comprehend complex ideas and master difficult skills (Fredericks et al., 2004). Examples:

- Flexibility in problem solving, preference for hard work, investment in learning beyond just behavioral engagement, mental effort and desire to master a task.
Behavioral engagement

Behavioral engagement is student participation in academic, social and extracurricular activities (Fredericks et al., 2004).

Examples:
- Positive conduct: Consists of behaviors that illustrate effort, persistence, concentration, attention, asking questions, contributing to class discussion, following rules, studying, completing homework and participating in school-related activities.
- Absence of disruptive conduct: Not skipping school and not getting into trouble.

Affective engagement

Affective engagement represents attitudes or feelings about the pursuit of learning (Skinner and Belmont, 1993). Students who are affectively engaged at school hold positive attitudes towards academic activities (ibid).

Examples:
- Affective reactions in the classroom, attitudes towards school and teachers, identification with school and feelings of belong and appreciation of success in school.

All three categories represent essential dimensions of engagement (Fredricks at al., 2004). These categories are non-hierarchical, with each being equally important to student engagement (ibid).

However, there are other multidimensional classifications of student engagement. One such classification, divides engagement into cognitive, behavioral, academic and psychological (Anderson et al., 2004). In this classification academic engagement is used to specify time spent on the learning activity as opposed to general behavioral engagement, where students may be participating in nonacademic pursuits (ibid). The psychological engagement in this model is similar to the affective engagement stated in the previous model.

There are also hierarchical models of engagement, viewing certain types of engagement as more important than others. For example, there is a hierarchical model consisting of procedural and substantive engagement (Nystrand and Gamoran, 1991). Procedural engagement correlates to behavioral engagement, arising when students complete class activities and homework (ibid). Substantive engagement describes aspects of psychological and cognitive
engagement (ibid). It exists when students commit to academic study (ibid). In this model, substantive engagement is considered more beneficial for students than procedural engagement as it correlates more strongly with student learning (ibid). This model also states that cognitive engagement is strongly linked to learning, while behavioral and psychological engagement may be necessary to facilitate it (ibid). Therefore, hierarchically, cognitive engagement is the most important kind of engagement (ibid).

From a personal perspective, student engagement involves students in authentic tasks; they are self-directed in their learning and are engaged in constructing their own meaning and problem solving (McDonough, 2000). The lesson becomes a participatory gathering of facts instead of dispensation of facts (ibid). Therefore, the teacher takes on the role of a guide in such lessons (ibid). Students, who are engaged, show sustained behavioral involvement in learning activities, accompanied by a positive emotional tone. These positive emotions include enthusiasm, optimism, curiosity and interest. This definition encompasses the aspects of cognitive, behavioral and affective engagement. In this study the term student engagement is also used interchangeably with engaged learning.

A classroom filled with enthusiastic, motivated students is great, but it is educationally meaningless if the enthusiasm does not result in learning. Conversely, students who are actively learning but doing so reluctantly and resentfully are not engaged. Hence student engagement can also be described as the product of motivation and active learning (Barkley, 2010). It is the product rather than the sum because it will not occur if either element is missing (ibid). It does not result from one or other alone, but rather is generated in the space that resides in the overlap of motivation and active learning as illustrated in Figure 1(ibid).

Figure 1: Venn diagram model of student engagement
The opposite of engagement is disaffection. Disaffected students are passive; they give up easily, display boredom during learning activities, get depressed, anxious or even angry about their presence in the classroom (Skinner and Belmont, 1993). They can even be rebellious towards teachers and classmates (ibid).

2.4 The importance of student engagement

Student engagement is a way to ameliorate low levels of academic achievement, high levels of student boredom and disaffection (Steinberg et al., 1996). Student engagement in classroom activities also fosters greater gains in students’ academic, emotional, social and behavioral achievement (Klem and Connell, 2004). Besides, high engagement during tasks in the classroom has been a significant predictor of continuing motivation, commitment and overall performance in school (Shernoff and Hoogstra, 2001).

Student engagement is also highly correlated to learning and personal development (Astin, 1993). When students are engaged during their learning in school, a positive attitude towards learning is instilled. Students will enjoy their lessons and appreciate the content taught. During such engaging learning activities, students are motivated and serve as active participants in the creation of knowledge rather than as passive observers. The act of being engaged teaches students other essential skills such as communication and cooperation. These skills enlarge their capacity for continuous learning and personal development. Moreover, engagement in the classroom enables students to, build their confidence about their ability to learn new material (Dev, 1997), earn higher grades, score higher on standardized tests and show better personal adjustment to school (Skinner and Belmont, 1993).

Engaged learners have the potential to constructively impact the school in many ways such as improving performance and attendance, which in turn could positively affect exam grades, league tables and consequently enhance the school’s status. Furthermore, high motivation and engagement in learning have consistently been linked to reduced dropout rates of students (Kushman, 2000).
Student engagement is increasingly seen as an indicator of successful classroom instruction (Kenny and Dumont, 1995). Behaviorally, engagement will be accompanied by low rates of disciplinary problems (Ekstrom et al., 1986) and absenteeism (Hudley, 1995). Teachers are less likely to have classroom management problems when their students are on-task and engaged. Students are more likely to remain on-task and engaged if they are interested in and challenged by their work. While it is not possible or necessary for students to always enjoy their assignments, there are steps teachers can take to retain students’ interest and enthusiasm, thus decreasing behavior problems.

The recent changes in the Singapore educational landscape have caused policy makers and educators to become increasingly concerned about the need to develop students holistically, with an enquiring spirit and a certain zest that carries them through life (Parliamentary Debates Singapore, 2005). Thus students need to be engaged in order to attain this spirit. Furthermore, the new global, fast changing economy requires knowledgeable workers who can synthesize and evaluate new information, think critically and solve problems. Even though attendance is compulsory, establishing a commitment to education is essential if students are to benefit from what schools have to offer and acquire the capabilities they will need to succeed in the current marketplace. Hence it is vital for teachers to craft engaging lessons that will motivate and enhance students’ learning experiences in school.

2.5 Factors influencing student engagement

The earliest influences on a student’s motivation to learn are parents and others at home (Lumsden, 1994). When students enter school, their level of interest and desire to engage in learning are heavily influenced by teachers, administrators, the school environment and their classmates (ibid). Students, who are engaged in the learning bubble, participate in learning activities with enthusiasm, optimism and curiosity. They willingly select tasks that stretch their skills, initiate action when given the opportunity and exert extra concentration in their learning task. Unengaged students, on the other hand, are passive. They do not try hard and are quick to give up when faced with a challenge or setback. There are many influence that come into play when some students decide to consistently engage in school learning while others appear
aimlessly adrift. In this report, individual, classroom and out-of-school influences will be discussed.

2.5.1 Individual influences on student engagement

Features such as competence, autonomy, intrinsic and extrinsic motivation, interest, purpose of task and achievement goals, govern students’ engagement in school and ultimate achievement (Wigfield et al., 1998).

Competence

Students draw their sense of competence from their belief in their ability to do the task at hand. When they believe that they can complete a task successfully, they are more likely to choose to do the task, persist at it and maintain their effort till they achieve their desired outcome (Schunk, 1991). Students’ sense of their own effectiveness at completing a task successfully, also relates to their academic performance (ibid). Therefore, training students to be more efficacious and to believe that they are more efficacious improves their achievement in varied subject areas.

Autonomy

Autonomy and academic achievement are positively associated with one another (Findley and Cooper, 1983). Autonomy support refers to the amount of freedom a student has to determine his or her behavior. Students need for autonomy is promoted when they have latitude in their learning activities, feel they are in control and their school activities connect to their interests. It is essential to foster the sense of autonomy in students in the absences of external rewards, controls and pressures (Skinner and Belmont, 1993).

Intrinsic and extrinsic motivation

Student motivation refers to a student’s willingness, need, desire and compulsion to participate in and be successful in the learning process (Bomica et al., 1997). Student motivation is often divided into two categories, namely, extrinsic and intrinsic motivation. When students’ motivation is intrinsic, they engage in activities out of curiosity, interest, enjoyment, or in order to achieve their own intellectual and personal goal (Dev, 1997). In such situations, students are immersed in the activity and will be excited by the challenging nature of an activity (ibid).
When students’ motivation is extrinsic, they engage in activities for reasons such as receiving a reward, pleasing parents, or being with friends. The use of extrinsic rewards to motivate students is a common practice in many schools. External rewards can undermine students’ autonomy and intrinsic motivation (Ryan and Stiller, 1991). Students who are more intrinsically than extrinsically motivated fare better (Brooks et al., 1998). However, extrinsic motivation can spark a student’s interest in exploring a topic further, thus setting the stage for intrinsic motivation.

Interest

Characteristics of academic tasks such as personal relevance, novelty, an appropriate activity level and comprehensibility, attracts a student’s interest towards the task (Wigfield et al., 1998). Deep level learning such as recalling of main ideas, coherence of recall, responding to deeper comprehension questions and representation of meaning, has a stronger relationship with interest (ibid).

Purposes of the task

Students may participate in an academic task for attainment value or utility value (Eccles et al., 1983). Students achieve attainment value when they place personal importance on doing well or want the opportunity to demonstrate their competence. Utility value has to do with the usefulness of an activity to a current or future goal. A task can have a positive value because it smoothes the way to something a student wants in the future. Furthermore students’ attitudes about their capabilities and their interpretation of success and failure will affect their willingness to engage themselves in learning (Anderman and Midgley, 1998). Expectations and values are significant predictors of a student’s achievement and their enrollment decisions for various subjects (Eccles et al., 1983).

Achievement goals

Students’ achievement goals define and direct their performance and learning. Most students exhibit ego-involved goals and task-involved goals (Nicholls et al., 1990). The ego-involved goals motivate students to do well primarily to outperform others (ibid). Students with these goals are likely to engage in tasks that they know they can do (ibid). Task-involved goals focus students on mastering learning tasks to increase their competence (ibid). Students with
these goals will choose challenging tasks and are more concerned with their own progress than with outperforming others (ibid). There are some students who display the work avoidance goals (Nicholls et al., 1989). These students may decide not to engage in a task because of its high personal cost (ibid).

Individual influences such as competence beliefs, intrinsic motivation and achievement goals are interrelated. Students, who believe that they are competent, are intrinsically motivated and direct their energies toward specific learning goals (Wigfield et al., 1998). They show greater persistence, choose more challenging activities and are more engaged in a variety of different activities. These individual influences on student engagement actually decline across the school years (Skinner and Belmont, 1993). This decline in student engagement stems from adolescents having new experiences that open up new interests and reduce the dominant influence of school (Baumert, 1995). This decline could also be due to changes in instructional variables such as clarity of presentation, classroom monitoring, teachers’ supportive behavior, cognitively stimulating experiences, self-concept of the teacher and achievement pressure (Wigfield et al., 1997).

2.5.2 Classroom influences on students’ engagement

Students’ individual characteristics are not the only influence on their learning engagement and performance (Wigfield et al., 1998). Motivation and learning are social activities, and students derive much of their academic motivation from the social organization of classrooms and other settings for learning.

Influence of teacher behavior

Student engagement in learning is most influenced by classroom practices (Wang et al., 1993). Activities such as maximizing learning time, setting high expectations, providing ample time for teachers and student interaction, tailoring instructions to student needs, involving students in setting their own learning goals and engaging them in group learning activities, affect students’ daily engagement in learning (ibid). The teacher’s ability to structure the classroom is the strongest predictor of student engagement (Skinner and Belmont, 1993).
Teachers’ positive involvement with students is a major predictor of student engagement (Skinner and Belmont, 1993). When teachers who are highly involved with their students, display behaviors such as holding clear expectations and responding helpfully to student needs, students are happier, more enthusiastic in class, try harder to achieve and are more persistent in their school work. Student satisfaction, personal growth and achievement can be at their peak when the teacher’s warmth and supportiveness are accompanied by efficient organization, an emphasis on academics and focused goal-orientated lessons (Moos, 1979). Therefore, the amount of autonomy and appropriate structure students experience predicts their motivation and engagement in learning (Skinner and Belmont, 1993).

However, students who are too dependent on their teachers are less likely to be positively motivated (Wigfield et al., 1998). Similarly, teachers who are overly controlling and do not provide an adequate amount of autonomy support undermine students’ sense of autonomy, intrinsic motivation and engagement (ibid). Students’ motivation will also suffer if their ideas about appropriate motivational strategies do not mesh with their teachers’ ideas and practices (Thorkildsen et al., 1994).

**Influence of peers on student engagement**

In addition to the need for well-structured learning environments and close teacher relationships, students are able to focus more of their attention to learning if their peers support and like them (Battistich et al., 1995). Students’ sense of belonging is positively associated with their expectations for success, value of schoolwork and achievement (Goodenow, 1993). Additionally, students feel that doing learning activities together with their peers offers more fun than studying alone. This perception of learning being fun adds a new dimension to students’ motivation (Stevens and Slavin, 1995).

**2.5.3 Out-of-school influences on student engagement**

Students spend about one-fourth of their time in school and three-fourths of their time outside school. Hence a student’s use of out-of-school time has a dramatic impact on their engagement in learning. Participating in structured activities has the most positive effect on student engagement (Jordan and Nettles, 1999). While hanging out with friends has the most
negative effect on student engagement (ibid). When students spend the bulk of their time after-
school in structured, community-based enrichment activities or with their families, they have
greater opportunity to interact with positive adult role models. They also have more opportunity
to interact with peers who share similar aspirations and can inspire them to do well in school.

Thus, student engagement in learning is influenced by students’ perception of their
intellectual abilities, interests and goals. Moreover, positive relationships with teachers, family
members and peers are also vital in supporting and motivating student engagement and
achievement. In addition to these influences, there are many other complex and interrelated
factors that influence student engagement in learning.

2.6 Strategies that promote student engagement

Teachers’ ability to structure the classroom is the strongest predictor of student
engagement (Skinner and Belmont, 1993). The central element of classroom learning is the
design of tasks and learning activities (Ames, 1992). Students’ perceptions of tasks and activities
not only influence how they approach learning but also have important consequences for how
they use available time (Good, 1983). Embedded in tasks is information students use to make
judgments about their ability, willingness to apply effortful strategies and their feelings of
satisfaction.

Tasks that involve variety and diversity are more likely to foster willingness in students
to put forth effort and become actively engaged in learning (Nicholls, 1989). Moreover, students
are more likely to approach and engage in learning in a manner consistent with a mastery goal
when they are focused on developing an understanding of the content, improving their skills, or
gaining new skills and when task presentations emphasize personal relevance and
meaningfulness of the content (Lepper and Hodell, 1989).

Teachers should design tasks that have factors such as challenge, interest and perceived
control (Lepper and Hodell, 1989). Tasks that offer personal challenge give students a sense of
control over either the process or product and tap students’ interest over time (ibid). Furthermore,
students’ beliefs that they can accomplish a task with reasonable effort and their willingness to
apply the effort can be enhanced when tasks are defined in terms of specific and short-term goals (Schunk, 1989). As students make these judgments about tasks, they are also involved in meta-cognitive appraisals about the utility of planning, organizing and monitoring strategies (Corno and Rohrkemper, 1985). The application of these self-regulatory skills is dependent on whether students feel enabled to manage their own learning (Paris and Winograd, 1990).

Students retain more content and learn more effectively when they are actively engaged in their own learning (Wolfe, 2001). This is shown in figure 2 (Sousa, 2006). Students will retain more if they are using multiple senses to process information and are given opportunity at regular intervals to participate in a variety of rehearsal activities that will help them to make sense of the information (ibid).

![Pie chart showing average retention rate from different teaching methods.](attachment:image.png)

When students are focused on the task or on skill improvement and value the learning, they are likely to feel empowered in their pursuits (Paris and Winograd, 1990) to exhibit active engagement (Brophy, 1987). In addition, students will also feel satisfied with school learning (Nicholls et al., 1985). Student engagement in the classroom is shaped by the structure of the task, how the tasks are delivered by the teacher and how it interacts with other students in the classroom (Ames, 1991). Therefore, it is essential for teachers to design relevant, authentic and collaborative activities that will enhance student engagement.
2.6.1 Examples of engagement based approaches

In this report, engagement based approaches such as classroom discussions, group activities, demonstrations, student experimentations, field trips, outdoor lessons, simulations, applets and videos will be discussed in detail. When these approaches are used to deliver appropriate concepts, student engagement in the classroom is enhanced.

Classroom discussions

Classroom discussions can be either in the form of whole class discussions or small group discussions. Whole class discussions are characterized by substantive questions, open ended questions and student talk extensions, where the teacher uses a range of strategies to open up the discussion (e.g., wait time, holding back on evaluation, extension or re-directional moves) (Barkley, 2010). The teacher may record student contributions on the whiteboard. During these whole class discussions or small group discussions, the teacher can interject and form connections between comments, ideas and re-direct them.

Students will stay focused in the content in order to contribute to the discussion (ibid). The structure of small-group discussions provides even shy and diffident students with a platform to practice their voice. The structure for whole class discussions allow students to see how their own opinions and those of others can change as understanding deepens (ibid). Furthermore, group discussions help to develop communication proficiency of students. However, it is important for teachers to guide students to contribute effectively to the discussions.

Group activities

There are various types of group activities that teachers can use to engage students in their learning. Within group activities, individuals seek outcomes that are beneficial to themselves and to all other group members (Smith et al., 1991). Furthermore, students work together to maximize their own and each others’ learning (ibid). Group activities such as learning stations and gallery walks, engage students by requiring them to move around the room and interact with learning materials in an active way as they examine, question, exchange ideas with peers, respond to prompts and formulate their own thoughts and commentary (Barkley, 2010).
For a lesson with the learning stations approach, students will move through the various stations in groups of 3 – 4 students. These stations will have exhibits in the form of posters, applets, simulations, websites, videos or even demonstration set-ups. Students will also have a worksheet that gives directions and questions about each station. Preparing the exhibits and setting up these stations can be time-consuming and labor-intensive. However, the payoff in terms of student engagement for such activities can be substantial (Brookfield and Preskill, 2005). Well-designed exhibits can help students make connections between theory and practice, understand principles and concepts at a deeper level, and be an interesting and enjoyable change of pace (ibid). Furthermore, once developed, the exhibits can be used in subsequent classes.

The gallery walk approach is flexible and has many benefits (Brookfield and Preskill, 2005). It can be used to present prior learning or answer questions and reflect upon the answers given by other groups. Student teams will move from one poster to another, synthesizing and recapping important concepts. This approach encourages students to confidently converse and write the concepts learnt, rather than just hearing it from the teacher. In addition, a variety of cognitive skills involving analysis, evaluation and synthesis are also addressed through the usage of this approach (ibid). Both approaches will require the teacher to explain the directions clearly and keep a close watch on the time spent on each exhibit.

**Demonstrations**

Demonstrations can be used to introduce a topic or teach concepts within a topic. These visual representations arouse curiosity, stimulate ideas and focus students when introducing a topic. They can also be used to support inquiry-based learning by requiring students to be actively engaged during demonstrations. During the demonstration, teachers can prompt questions to students about the physical principles on display. Ideally demonstrations clearly illustrate the principle and are dramatic enough to excite and engage students in their learning (Heckert, 2008).

**Student experiments**

Student experiments can be conducted during practical sessions in the science laboratory or in the classroom during hands-on exercises. Experiments allow students to interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or...
performing experiments (Dodge, 2005). As a result, they will be able to remember concepts and knowledge discovered on their own (Bruner, 1967). Discovery learning is an inquiry-based, constructivist learning theory. This theory believes that it is best for learners to discover facts and relationships for themselves (ibid). Student experiments allow items to be seen, touched, handled and passed between students. This engages students by helping to make abstract ideas or notions real (Dodge, 2005).

Field Trips and outdoor lessons

Field trips and outdoor lessons are learning activities conducted for students outside the usual learning environment. Students are provided with opportunities to explore and discover learning in everyday life. These lessons provide students with a course-related experience that cannot be replicated in the classroom. Going to physical locations such as research laboratories, medical facilities, museums, exhibitions, environmental centers, or sites with unique geological or botanical characteristics help students understand the value and meaning of what they are learning in the classroom (Barkley, 2010). Furthermore, they get to see how this knowledge can be applied in different and novel situations. Going out of school can also be a refreshing change of pace and provide an opportunity for students to bond together as a learning community (ibid).

Simulation and applets

In physics, we represent information about a physical system in many different ways: using words, equations, graphs, diagrams and etc. Many students have difficulties creating these representations and understanding the abstract concepts. They treat equations as a way to calculate a variable or determine a solution to an equation (Christian and Belloni, 2001). However, physical equations have deeper meanings. They represent relationships between various observations and measurements. Simulations and applets allow students to vary parameters and see the effects of these variations. This helps in powerfully enriching a student’s view of an equation (ibid).

Computer simulations and applets can be immensely valuable tools when it comes to bridging the gap between teaching and the students’ conceptual understanding of physical concepts (Gokhale, 1996). Simulations can also act as an effective means of stimulating curiosity in students. Furthermore, students learn much more and stay engaged when they
themselves are in control (Wiema et al., 2007). Therefore, having simulations and applets that students can use to explore a phenomenon on their own can produce more effective learning experiences (Christian and Belloni, 2001).

**Videos**

The use of multimedia (such as film, instructional television and video) helps to enhance the learning experiences of students (Marshall, 2002). Videos help to develop students’ problem solving skills (Bryant et al., 1998). Furthermore, videos have the ability to engage the learner, activate emotional states, initiate interest in a topic and allow absorption and processing of information (Marshall, 2002). The traditional teaching methods (such as lecture and textbook) appeal to learners who lean towards a linguistic approach (ibid). However, teaching methods that include the use of multimedia will reach more students and provide opportunities for development and learning (ibid).

**2.7 Measurement of student engagement**

The most common way to measure student engagement is through information reported by the students themselves. Other methods include checklists and rating scales completed by teachers through observations and conversations with students during class activities. There can also be external observers who conduct classroom walkthroughs to measure student engagement. These observers may be school administrators, instructional coaches or teacher peers.

**Measurement of behavioral engagement**

Behavioral engagement is usually measured by teacher ratings, self-report surveys and observations (Finn et al., 1995). These include a variety of indicators of conduct, work involvement and participation (ibid). Indicators pertaining to conduct measures include positive behaviors such as completing homework, complying with school rules at classroom and school levels (ibid). Other scales measure negative behaviors such as frequency of absences, tardiness, fighting or getting into trouble and interfering in other students’ work (ibid). Work- related behaviors can be assessed with scales which include effort, attention and persistence (ibid). There are other scales that focus on students’ participatory behaviors (ibid). Participation at the
Observation techniques are also used to measure behavioral engagement (Stipek, 2002). Observers can rate students’ engagement by using scales ranging from off-task to deeply involved, where behaviors include student attentiveness, doing the assigned work and showing enthusiasm (ibid). However, observational measures provide limited information on the quality of effort, participation or thinking (Peterson et al, 1984).

Behavioral engagement can also be measured through focus group discussions and case studies (Chapman, 2003). When focus group discussions are restricted to a small group of students, detailed descriptive accounts of engagement can be collected. Case studies allow questions of student engagement to be addressed inductively by recording details on students’ interactions with peers within the classrooms (ibid). These accounts can include the behavior of peers, direct antecedents to the target students’ behaviors (e.g., teacher directions), the students’ response and the observed consequences of that response (e.g., reactions from teachers or peers) (ibid).

**Measurement of cognitive engagement**

The measures of cognitive engagement which centre on the psychological investment in learning are limited. The measures of cognitive engagement include survey items about flexibility in problem-solving, preference for hard work, independent work styles and ways of coping with perceived failure (Connell and Wellborn, 1991). Some of the measures are related to intrinsic motivation. The psychological investment in learning can be assessed by rating the quality of instructional discourse in the context of substantive and procedural engagement in classrooms (Gamoran and Nystrand, 1992). Substantive engagement measures the frequency of high level evaluation and authentic questions (ibid). Whilst procedural engagement measures students’ attempt to complete task requirements which last only as long as the task itself (ibid).

Cognitive engagement can also be measured through students’ self-regulation (Pintrich and De Groot, 1990). In self-regulation, the strategy used in self-report questionnaires measures, meta-cognitive, volitional effort control and cognition (ibid). Strategies used include how students set goals, plan, organize study efforts, monitor and modify cognition (ibid). These
strategies are distinguished between deep and surface strategies (Miller et al., 1996). Deep strategies include attention, persistence, relating new knowledge and monitoring comprehension (ibid). Surface strategies include effort and avoidant strategies (ibid).

Cognitive engagement can also be assessed using observational techniques. The indicators of cognitive engagement include self-monitoring, exchanging ideas, giving directions and justifying answers (Helme and Clarke, 2001). Items relating to the cognitive aspects of engagement often ask students to report on factors such as their attention versus distraction during class, the mental effort they expend on these tasks (e.g., to integrate new concepts with previous knowledge), and task persistence (e.g., their reaction to perceived failure to comprehend the course material) (Chapman, 2003).

**Measurement of affective engagement**

Affective engagement is measured through self-report surveys, which include items about emotions related to school, schoolwork, student-teacher relationship and values (e.g., How useful students think the content they are learning would be to them in the future) (Stipek, 2002). These survey questions measuring affective engagement typically ask students to rate their interest in and emotional reactions to learning tasks, the desire to learn more about particular topics and feelings of simulation or excitement in beginning new projects (Chapman, 2003).
CHAPTER 3

3. RESEARCH METHODOLOGY

3.1 Sampling

There were two surveys conducted for this project. The first survey was sent via email to 12 secondary school physics teachers. The respondents were given a week to reply their inputs. For the second survey, 60 teachers from secondary schools were approached. Teachers were provided with web links to the survey. The survey form had a note to explain its purpose. The respondents were given a month to complete and submit their responses online. All participants responded to the survey electronically.

3.2 Questionnaire Design

The first survey consists of 1 question asking teachers to list 5 topics that students find challenging or not engaging. The second survey (Appendix A1) was developed to find out teachers’ usage of engagement based approaches in their classrooms and their suggestions on how schools can assist to increase the usage of such approaches. There were 2 parts to the second survey. The first part was for all subject teachers and the second part was for teachers teaching physics only. Questions in the second part of the survey were specific to the 5 topics identified as challenging or not engaging in the first survey. The survey included 4 structured (check-boxes) and 17 open-ended questions.

3.3 Variables of Interest

This section will discuss the variables that the second survey questions are grouped under with reference to Appendix A1.

3.3.1 Demographics

Questions 1, 2 and 3 are concerned with the personal data of the respondents.
3.3.2 Usage of engaging approaches

Questions 4 and 5 were created to find out teachers’ usage of engagement based approaches in their classrooms.

3.3.3 Suggestions by teachers

Question 6 was developed to find out teachers’ suggestions on how schools can assist to increase the usage of engaging approaches.

3.3.4 Kinematics

Questions 7, 8 and 9 were developed to identify the concepts in the topic on Kinematics that students find challenging to comprehend. These questions were also created to find out the approaches teachers use and would have liked to use to teach these concepts.

3.3.5 Forces

Questions 10, 11 and 12 were developed to identify the concepts in the topic on Forces that students find challenging to comprehend. These questions were also created to find out the approaches teachers use and would have liked to use to teach these concepts.

3.3.6 D.C. Circuits

Questions 13, 14 and 15 were developed to identify the concepts in the topic on D.C. Circuits that students find challenging to comprehend. These questions were also created to find out the approaches teachers use and would have liked to use to teach these concepts.
3.3.7 Magnetism

Questions 16, 17 and 18 were developed to identify the concepts in the topic on Magnetism that students find challenging to comprehend. These questions were also created to find out the approaches teachers use and would have liked to use to teach these concepts.

3.3.8 Electromagnetic Induction

Questions 19, 20 and 21 were developed to identify the concepts in the topic on Electromagnetic Induction that students find challenging to comprehend. These questions were also created to find out the approaches teachers use and would have liked to use to teach these concepts.
CHAPTER 4

4. DATA ANALYSIS

4.1 Data collection and research response

For the first survey, out of the 12 teachers approached, 8 replied with their responses. The first survey yielded a response rate of 67%. For the second survey, out of 60 teachers approached, 41 of them completed and returned the surveys (Appendix A2). This survey thus yielded a response rate of 68%, which is relatively reasonable.

4.2 Demographic profile of respondents

With reference to Figure 1, 2 and 3 of Appendix A2, of the 41 teachers, 68% were females, 95% were aged 40 and below and 78% had 10 or less years of teaching experience. 63% of them were science teachers.

<table>
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<table>
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<th>31 - 40</th>
<th>Above 40</th>
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<td>%</td>
<td>No.</td>
</tr>
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<td>0</td>
<td>23</td>
<td>56</td>
<td>16</td>
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<table>
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<th>5 - 10</th>
<th>11 - 20</th>
<th>More than 20</th>
</tr>
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<tbody>
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<td>No.</td>
<td>%</td>
<td>No.</td>
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<td>51</td>
<td>11</td>
<td>27</td>
<td>8</td>
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<th>Science</th>
<th>Others</th>
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<tbody>
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<td>No.</td>
</tr>
<tr>
<td>26</td>
<td>63</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 1: Demographics of teachers
4.3 Analysis and evaluation of data

With reference to Appendix A2, the following sub points will explore the responses to questions for each variable of interest that was mentioned in Chapter 3.

4.3.1 Results of the first survey

In the first survey, each teacher was required to list 5 topics that students find challenging or less engaging. 88% of the teachers surveyed stated Electromagnetic Induction and 71% of them stated D.C. Circuits and Forces in their list of topics that students find challenging or less engaging. Hence these three topics were chosen for the lesson package.

<table>
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<td>88</td>
</tr>
<tr>
<td>D.C. Circuits</td>
<td>5</td>
<td>71</td>
</tr>
<tr>
<td>Forces</td>
<td>5</td>
<td>71</td>
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<td>Kinematics</td>
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</tr>
<tr>
<td>Magnetism</td>
<td>1</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 2: Summary of the first survey results.
4.3.2 Usage of engaging approaches

Questions 5 and 6 were created to find out teachers’ usage of engagement based approaches in their classrooms and reasons for not using these approaches. Usage of each engaging approach is analyzed in the following sub points.

Figure 3: Bar chart showing the usage of engaging approaches by teachers.

**Group discussions**

54% of the teachers use group discussions in their classrooms. However, its frequency of usage in the classroom was low. 61% of teachers, who use group discussions, only use it once a month.

**Demonstrations**

44% of the teachers use demonstrations to teach content. 33% of them use demonstrations once a month. Majority of the others had responses such as ‘rarely’ and ‘every one in four lessons’. Survey results for Question 5 showed that demonstrations were not frequently utilized to teach content in the classroom.

**Student experiments**

44% of the teachers use student experiments in their lessons. 61% of these teachers use student experiments either once a week or once every two weeks during practical lessons.
Although usage of this approach is high, most teachers conduct these practical lessons with the objective of preparing students for the school-based Science Practical Assessment (SPA). Hence these practical activities are designed to assess students’ practical skills rather than engage students.

**Field trips and outdoor lessons**

Only 17% of the teachers use field trips and outdoor lessons. However, even these teachers said that they do not use this approach often.

**Group activities**

46% of the teachers use group activities in their lessons. 21% of these use this approach only once a month. 16% of them rarely use group activities in their lessons. Hence, it can be concluded that teachers seldom use group activities to keep their students engaged in their learning.

**Simulation and applets**

Only 24% of the teachers use simulations and applets to engage their students in lessons. 40% of them use this approach only once a month, while others had responses such as ‘once every four lessons’, ‘Twice a term’ and ‘one to two times a year’. Therefore, it can be concluded that simulations and applets are not used frequently in the classrooms.

**Videos**

76% of the teachers use videos in their teaching. The survey results show a good spread of teachers who frequently use and seldom use videos to engage students in their lessons.

**Others**

34% of the teachers use other approaches such as jokes, comics and stories to engage students in the classroom. These teachers include these strategies whenever possible.

2 teachers stated in the survey that they do not use engaging approaches in their lessons. Their reasons for not using them were shortage of time in the syllabus, lack of time to plan lessons with such approaches and lack of available resources. They also feared not being able to manage the classes due to large class size and having distracted students.
Out of the 41 teachers surveyed, 31 of them use videos to engage students in their learning. The high usage of videos might be because there are numerous educational videos readily available online. Furthermore, most of these videos are short and hence easy to include in the lesson plan. However, frequent usage of videos in teaching can prove to be disadvantageous as students are not actively participating in their learning. Therefore, videos have to be supplemented with a dynamic activity that will ensure students stay engaged in the lesson.

In conclusion, the survey results for Questions 5 and 6 show that although teachers use these engaging approaches in their classrooms, they do not use these approaches frequently enough. Teachers might not have used these approaches as frequently due to the lack of time to complete the syllabus and lack of available engaging teaching resources. Another possibility might be due to fear of not being able to manage their class because of large class size, disruptive students and passive students who refuse to contribute to the discussions.

4.3.3 Suggestions by teachers

For Question 7, teachers were asked for suggestions on the kinds of support they would like their schools to provide, in order to conduct more engaging approaches during their lessons. 44% of the teachers stated that they would like to have more ready-to-use teaching resources. Others requested for better IT equipments and support, smaller class sizes and co-teaching of classes.

4.3.4 Kinematics

For the topic on Kinematics, teachers stated that students find the concept on ‘acceleration of free fall’ and ‘interpretation of graphs’ challenging and less engaging. Most teachers use approaches such as simulations and applets, practical sessions and videos to teach these concepts. In response to Question 10, teachers stated that they would have liked to use approaches such as data-logging, self-discovery activities, group activities and inquiry based lessons to teach these concepts.
4.3.5 Forces

For the topic on Forces, teachers stated that students find concepts on ‘balanced forces’, ‘Newton’s second law’ and ‘action-reaction forces’ challenging and less engaging. Majority of the teachers use approaches such as hands-on experiments and drill and practice to teach these concepts. Most of them would have liked to use simulations and group activities to teach these concepts.

4.3.6 D.C. Circuits

For the topic on D.C. Circuits, teachers stated that students find concepts on ‘the relationship of voltage, current and resistance in series and parallel circuits’ and ‘calculation of the combined resistance in complex circuits’ challenging and less engaging. Most teachers would use approaches such as hands-on experiments and drill and practice to teach these concepts. In response to Question 16, they stated that they would have liked to use analogies, self-discovery activities, applets, group work and discussions to teach these concepts.

4.3.7 Magnetism

For the topic on Magnetism, teachers stated that students find the concept on Fleming’s left hand rule and drawing of magnetic field patterns around magnets challenging and less engaging. Teachers stated that they use student experiments, practice worksheets and explanations with examples to teach these concepts. However, they would have liked to teach these concepts using applets where students can explore the variations in magnetic field patterns around and between various magnets.

4.3.8 Electromagnetic Induction

For the topic on Electromagnetic Induction, teachers stated that students find concepts on Faraday’s and Lenz laws and A.C. generators challenging and less engaging. Most teachers use student experiments and lectures supplemented with presentation slides to teach these concepts. In response to Question 22, teachers stated that they would have liked to use approaches such as
showing of physical models of the A.C. generator, interactive experiments and simulations, self discovery activities, group activities and inquiry based activities to teach these concepts.

The results show that teachers are not using engaging approaches to deliver the content frequently enough. It is evident from the suggestions by teachers that providing with more ready-to-use teaching resources would help to increase the usage of engagement based approaches in classrooms. Teachers would find it beneficial if schools have an easily accessible platform for sharing these resources. Therefore, a teaching package of the three topics identified in the first survey was created in this project. This package will consist of teaching resources that will ensure engagement and effective learning in the classroom. To make it easily accessible to teachers, these teaching resources were uploaded on a Google site.
CHAPTER 5

5. LESSON PACKAGE

5.1 Introduction

In the first survey conducted, teachers had identified five chapters that students find challenging and less engaging. The topics identified were; Kinematics, Dynamics, D.C. Circuits, Magnetism and Electromagnetic Induction. The lesson package in this project consists of teaching resources for the topics on Dynamics, D.C. Circuits and Electromagnetic Induction. Most of the teachers surveyed had identified these three topics in their list of challenging and less engaging topics. The teaching resources for these three topics consists of; self-prepared slides, topic information for teachers, activity tasks and quizzes for selected topics.

There is no single tip, technique or strategy that offers a blueprint for student engagement. Approaches that work for one student might not work for another. Yet some approaches and activities do engage students better than others. The lessons were designed with the aim of encouraging students to explore their current beliefs, introduce them to new ideas and create activities that encourage students to re-evaluate, re-define and apply their understanding to situations in and outside school. These lessons have clearly stated objectives, facilitate the use of higher-order thinking skills, allow for different learning styles, encourage collaborative and cooperative learning and encourage students to construct their own knowledge.

The average human’s working memory can handle between five and nine items of information at once (Sousa, 2006). Humans can process an item for ten to twenty minutes before mental fatigue or boredom occurs and attention drifts (ibid). Hence lessons were planned, where possible, smaller and simpler components were chunked together, presentations were broken up into sections interspersed with other kinds of activities such as discussions, group activities and practice.
5.1.1 Self-prepared slides

A large percentage of students are visual learners (Riggs and Gholar, 2009). Hence visual presentations are effective tools for content delivery (ibid). Furthermore, when lessons are supplemented with visual presentations such as presentation slides, students are processing both verbal and visual information (Barkley, 2010). This increases retention of content (ibid). Therefore, presentation slides were prepared for the three topics (Appendices C1, C1 and E1).

The presentation slides show the sequence of lessons and activities for the topics. In addition, instructions for the various planned activities were included for the teacher’s reference. The slides for each topic have the learning objectives clearly stated. It is essential for students to know what they are expected to learn in the topic. This helps students to focus their time and energy on doing things that result in active learning (Barkley, 2010). These slides were also designed to keep students engaged as they contain only key points and graphics.

5.1.2 Topic information for teachers

All three topics in the lesson package have topic information sheets for the teacher’s reference (Appendices C2, D2 and E2). These topic information sheets contain essential information such as pre-requisite knowledge of students, specific instructional objectives of the topic, new concepts and terms they will be learning, common misconceptions students might have, challenging concepts identified in the survey conducted and teaching resources prepared for the topic. Two of the topics require students to complete tasks prior to the start of the topic. Hence the descriptions of these tasks are clearly stated in these information sheets.

These information sheets were prepared with the aim of equipping teachers with necessary information prior to teaching the topic. When teachers are well-informed of the various aspects of a topic, they tend to be confident. Students are more likely to engage in a class if the teacher displays attributes such as energy, enthusiasm, passion, optimism and confidence (Barkley, 2010). This information also allows teachers to plan and design lessons that cater better to their students’ needs, leading to student engagement and effective learning.
5.1.3 Activities

There are proposed activities for each topic in the lesson package. Each activity was designed to teach a complex concept or chunks of similar concepts. These activities were designed using the various engagement based approaches. The goal of each activity is to address a holistic approach to teaching and learning. These activities will help students to improve their cognitive skills (literacy and critical thinking) and enhance their affective (emotional) development. During these activities, teachers take on the role of guides, facilitating learning whilst learners take charge of their own learning. Learning is therefore transformed into the acquisition of knowledge. Each activity will be discussed in detail in the following sections.

A few of the proposed activities in this lesson package involves student experimentation. Traditionally teachers conduct student experimentation in the school laboratory and use activities found in the practical work books. These practical activities are designed to prepare students for the school-based Science Practical Assessment. These practical activities aim at improving the following four practical skills;
Skill 1 – Using and organizing techniques, apparatus and materials.
Skill 2 – Observing, measuring and recording.
Skill 3 – Handling experimental observations and data
Skill 4 – Planning investigations

However, student experiment activities proposed in this lesson package aim at increasing student motivation, engagement and understanding. Most of the experiments are simple and help make the concepts relevant to students. Furthermore, these proposed student experiment activities can be conducted in classrooms, outdoors or in special rooms.
5.2 Website

[Website address: https://sites.google.com/site/engageyourselves/ or http://tinyurl.com/engaging-activities]

Technology offers a powerful array of tools to help share resources between teachers and promote a classroom community (Barkley, 2010). In the 21st century, most teachers and students own or at least have access to a computer. For instance, all classrooms in the previous school I used to teach in have a computer installed for teachers to use during their lessons. Hence it would be most convenient to share resources between teachers using a website. Teaching resources in this lesson package are presented on a website (Appendix B).

Teachers can access these teaching resources anytime, even at home, to prepare for their lessons. They can easily modify the slides and activity sheets to cater to their own students’ needs and developmental levels. Teachers can also access these resources in the classrooms prior to their lessons. They do not need to go through the hassle of saving a copy or printing hard copies of these resources. Furthermore, teachers would need to type out the whole resource if they were to modify it. Teachers can also share their ideas and suggestions or feedback on the resources through the ‘contact me’ link found on the website.

Another aim of presenting the lesson package on a website is to use it as a platform to conduct online lessons for my own students. Students can access the presentation slides, quizzes and pre-lesson tasks in the comfort of their own homes. Curriculum time can be saved with students attempting these quizzes and tasks as homework. Furthermore, students can recap concepts they had covered in class by re-viewing the slides and demonstration videos on the website. Students can also experiment with the applets and simulations they had played with in class. They can also ask or provide feedback on the content taught through the ‘contact me’ link available on the website. Therefore, presenting the lesson package on a website is definitely much more advantageous than sharing hard copies of teaching resources.
5.3 Chapter 3- Dynamics

The concept of forces can be abstract to some students. Students very often have difficulty visualizing forces and get confused with the various concepts. Many have misconceptions of this topic. These misconceptions can be replaced with new concepts through demonstrations, applets, analogies and other teaching approaches. Teaching approaches suggested in this lesson package will engage students and enable easy understanding of the concepts. At the end of the topic, it is also essential for the teachers to re-evaluate the students’ understanding. This can be done by posing conceptual questions. In the lesson package, the topic has been separated into four main concepts. The smaller and similar objectives were put together. The topic begins with Newton’s first law and Inertia, Newton’s second law, Newton’s third law and ends with Friction. Newton’s first law and inertia are taught together. From the survey conducted, teachers had stated that the following concepts are challenging and less engaging:

- Understanding the term ‘no net force’ and balanced forces (Activity 1 and slides 15-17)
- Newton’s second law, F= ma (Activity 3)
- Newton’s third law (Analogy (slide 41), teacher demonstration (slide 43) and Activity 4).

The lesson package resources for this topic include;
1. Self-made slides (Appendix C1)
2. Pre and post lesson Quizzes (Appendix C3)
3. Activity sheet 1- Newton’s first law (Appendix C4)
4. Activity sheet 2 – Inertia (Appendix C5)
5. Activity sheet 3- Newton’s second law (Appendix C6)
6. Activity sheet 4- Newton’s third law (Appendix C7)
   - Post activity quiz (Appendix C7.1)
   - Analogy explanation instructions for teachers (Appendix C7.2)
   - Moving laser demonstration information for teachers (Appendix C7.3)
7. Activity sheet 5- Friction (Appendix C8)
5.3.1 Pre-lesson assignment

Traditionally, not all teachers will mention the history of scientists involved in the formulation of the concepts during teaching and learning of the topic. Due to time constraint in the curriculum, most teachers will not assign students any pre-lesson assignments. In this lesson package, a pre-lesson assignment is suggested for this topic. For this pre-lesson assignment, students are required to research on the story behind Newton’s laws and about what Aristotle, Galileo and Newton stated about forces. A few students will be selected to present their findings to their fellow classmates on the first lesson of the topic.

Knowing the history of scientists prior to learning the topic will motivate and encourage students to learn the new concepts. Furthermore, knowing how the various concepts came about will develop an emotional connection to the components. This will help to permanently store the concepts (Barkley, 2010). Students will be motivated to complete this assignment to prevent embarrassment when picked to share findings with fellow classmates. From this learning task, students’ research skills and communication proficiency are developed.

5.3.2 Pre and post lesson quizzes

Quizzes are administered to evaluate students’ understanding of concepts that have been taught, ensure students keep up with the teaching pace and to better prepare students for exams (Casas, 2011). It is a common practice for teachers to conduct quizzes after teaching main concepts or the whole topic. This traditional practice also allows teachers to assess effectiveness of teaching approaches used. Many students come into the classroom with misconceptions in certain topics. Teachers will only learn about their misconceptions as the topic materials are covered. Hence teachers are not able to plan their teaching activities according to students’ needs. For the topic on Dynamics, pre and post lesson quizzes are suggested in this lesson package (Appendix C3).
Pre-lesson quiz

Before the start of the topic, students are required to attempt an online pre-lesson quiz. Teachers could also conduct the quiz in class. This quiz will help teachers identify students’ misconceptions and plan appropriate teaching approaches to correct them. Furthermore, when teachers develop teaching resources according their students’ developmental needs, lessons will be more engaging and appropriate for students. Teachers will be able to emphasize on certain misconceptions and include specific teaching approaches to replace them with the correct concepts. Pre-lesson quizzes are also used to promote learning by instigating students’ curiosity about the topic.

Post-lesson quiz

At the end of the topic, students will have to complete a post-lesson quiz. This quiz has the same conceptual questions as the pre-lesson quiz. However, this post-lesson quiz will be graded. Grading the quiz will motivate students to prepare for it by reading and practicing concepts taught. Using the same questions for both quizzes will help teachers to re-evaluate students’ understanding and effectiveness of teaching methods used to handle students’ misconceptions of the topic.

5.3.3 Newton’s first law (Activity 1) and inertia (Activity 2)

Newton’s first law (Activity 1)

Newton’s first law is a concept which many daily life experiences can be easily related to. When real life experiences are linked with concepts, students will be able to retain the information better (Barkley, 2010). Traditionally, teachers will introduce this concept with a slide presentation and state a few real life experiences where Newton’s first law is observed. Teachers will conduct practical sessions for students after going through the concepts in class. Most teachers will use the practical activities found in the practical workbooks. These practical activities are conducted with the objective to recap and apply concepts that have been taught. Hence students lack the opportunity to experiment and construct these concepts on their own.

In Activity 1 (Appendix C4) of this topic, students will experiment with objects from their daily life, outside the usual environment of the classroom or science laboratory. A
refreshing change in the learning environment will induce excitement in students, promoting engagement in the learning activity. Furthermore, the use of familiar objects in the activity will help relate the concept and activity to their daily life, making it relevant to them. The questions in this activity will guide students towards constructing the concept of Newton’s first law. During this activity, the teacher can walk around and further guide students towards the correct concept by probing them with more questions. Teachers can also pose other situations to clear the misconceptions students have on the concept of ‘no net force’.

After completing this activity outdoors, students will return back to class and contribute their ideas to their classmates. The teacher takes on the role of a facilitator, collating ideas and guiding them to the correct concepts. This activity will be followed by Activity 2 which will introduce the term Inertia. It is recommended that both concepts are taught together to prevent confusion that they are two entirely different concepts.

**Inertia (Activity 2)**

Activity 1 lays the basic ideas necessary for Activity 2. When teaching this topic, teachers usually show video demonstrations that would illustrate the concept of Inertia. Videos are definitely more engaging than the traditional presentation slides. However, when videos are used to teach a concept, students are not given the opportunity to explore, experiment and participate in active learning. In this lesson package, Activity 2 (Appendix C5) has three components. Students are required to answer questions in their activity sheets as they participate in the various components of Activity 2.

**Component 1- Video demonstration**

The first component is a video demonstration which displays the concept of Inertia. Video demonstrations allow students to concentrate on processing both verbal and visual information. When students use multiple processing modes, retention of concepts increases (Barkley, 2010). Questions in the activity sheet will promote critical thinking and scaffold their ideas towards Newton’s first law.

**Component 2- Teacher demonstration**

The second part consists of a teacher demonstration. Students will be given the opportunity to try out the demonstration on their own as well. When demonstrations are
conducted by teachers or fellow classmates, there is a sense of excitement and suspense that will keep students engaged. Application of learnt concepts to principles demonstrated will help students retain information better (Barkley, 2010).

**Components 3- Applets**

In the remaining part, students will have to answer questions in their activity sheet after viewing two applets that demonstrate the concept of Inertia. These applets demonstrate the consequences of Inertia in a real life scenario. They help to make the concept of Inertia relevant to students’ daily life. Students learn more effectively when the content is personally relevant to them (Riggs and Gholar, 2009).

Therefore in Activity 2, students will have to apply Newton’s first law to various situations. This will help students become familiar with the concept and help in its retention. An average human being can process information for ten to twenty minutes before mental fatigue or boredom occurs and attention drifts (Sousa, 2006). Hence introducing variations in teaching approaches within a lesson will help to keep students attentive and engaged.

**5.3.4 Newton’s second law (Activity 3)**

Newton’s second law was identified in the survey as one of the concepts that students find challenging or less engaging. Challenging topics can be better handled by students when engaging teaching approaches such as student experimentation are used in content delivery. Student experimentation encourages questioning of the observed events, promotes cause and effect thinking, and reduces dependence upon authority (Haury and Rillero, 1994). Furthermore, student experimentation will help students remember the material better, feel a sense of accomplishment when the task is completed and be able to transfer that experience easier to other learning situations (ibid).

**Comparison of a traditional practical worksheet and Activity 3**

Most commonly teachers would allocate at least one lesson per week to conduct practical sessions in the school laboratory. These practical sessions would be conducted after concepts have been taught. Most of these practical activities from practical workbooks have very complex
experimental set-ups. For instance a practical activity (Appendix C6.1), adapted from the practical workbook my previous school uses, requires students to spend a lot of time on setting up the experiment and recording values for analysis and construction of the concept. Traditionally teachers conduct practical sessions with the objective of preparing students for the school-based Science Practical Assessment (SPA). Hence practical activities from these practical workbooks are designed to assess students’ practical skills. These practical activities need to be modified before they are used for students to explore and construct concepts on their own.

Activity 3 (Appendix C6) of this topic was designed to be conducted in the classroom. It is short, simple, allows students to experiment and construct the concept of Newton’s second law before the teacher teaches it. The experimental set-up for Activity 3 is simple and consists of familiar objects that students can easily relate to. They are required to answer questions that would guide them to the correct concept. When sufficient support to succeed in a learning task is provided, students will stay engaged and motivated. They will have to perform this activity in groups of three. Working in groups will provide them with additional support, helping them improve interaction and communication skills. Therefore in Activity 3, students develop their critical thinking skills and discover scientific concepts by participating in active learning. Self discovered concepts are better retained by students (Barkley, 2010).

5.3.5 Newton’s third law

Many students have the misconception that action and reaction forces act on the same body. There are others who have difficulties identifying correct pairs of action-reaction forces. Therefore to ease understanding of Newton’s third law the following teaching approaches are suggested in this lesson package.

- A bridging analogy to help students visualize and understand the concept.
- A demonstration to further convince students.
- An activity where students will apply the concept of Newton’s third law to design their own demonstration.
- A post activity quiz where students will have to answer questions, applying Newton’s third law.
Teachers will usually teach Newton’s third law using the lecture approach supplemented with presentation slides. The practical workbooks do not have any activities that will give students the opportunity to explore and apply Newton’s third law. Hence most teachers will not conduct practical sessions for this concept. However, when students are handling abstract concepts such as Newton’s third law, they need assistance to support them as they move from not knowing to becoming independent and competent. Teaching abstract concepts using multiple teaching strategies would provide sufficient time for students to review the information, comprehend and apply the concept to related situations (Sousa, 2006).

**Analogy**

Analogies can be useful tools when they are able to form a bridge from otherwise abstract ideas to a concept that students already understand. They promote mental imaging by the learner. The Newton’s 3rd law analogy (Appendix C7.2) used in this lesson will assist understanding by provoking the learners’ imagination. The teacher demonstrates and explains the analogy using connecting situations (book on foam, book on thin board), eventually leading to the target situation (book on table). This would help students understand and identify the pairs of forces involved when a book is placed on the table.

**Demonstration**

Demonstrations clearly illustrate the principle and are dramatic enough to excite students about learning physics (Heckert, 2008). The moving laser beam demonstration (Appendix 7.3), suggested in this lesson package, will help to further convince students that action-reaction forces do exists. The teacher will set-up the experiment and chooses a student to kick against the other side of the wall. As the student kicks, the laser light will move on this side of the wall. This demonstration clearly shows students that action-reaction forces do exist.

**Activity 4**

Activity 4 (Appendix C7) in this topic will give students the opportunity to apply concepts on Newton’s third law to design their own demonstrations. Students will be able to relate that the rocket works on the same principle that launches the balloon. It will also help to clear the misconception that a solid surface is needed for a reaction force to act on as students
will be able to see that the balloon propels through air due to the reaction force, in the absence of any solid surface. Students will be challenged to synthesize and be creative as they design their own experiments. Furthermore, this activity can help students deepen their knowledge and understanding of the concept as they discuss, design and modify their demonstrations. The teacher could also allow students to compete on whose balloon is able to propel the furthest from the point of release. They can also be allowed to modify their demonstration designs to achieve further distances. Adding these fun and competitive elements to the activity will help to motivate and engage students.

**Post activity quiz**

Traditionally teachers will conduct tests for students after teaching a few concepts or at the end of the topic. In this lesson package, a post activity quiz (Appendix C7.1) is suggested. Students are required to attempt the quiz online, after they have completed the activity in class. Having a quiz after completing a challenging concept such as Newton’s third law, will allow students to receive immediate feedback, any misunderstandings can be quickly corrected and their valid concepts are reinforced. This also helps the teacher assess student learning. Having students to attempt the quiz online at home will save curriculum time, allowing the teacher more time to cover other concepts in the syllabus.

**5.3.6 Effects of friction (Activity 5)**

Friction is a topic that students are introduced to in lower secondary science. Traditionally most teachers will merely go through the concepts on Friction supplemented with presentation slides. Teachers will usually do a simple recap on this portion of the topic due to the lack of curriculum time.

In this lesson package, a dynamic and exciting gallery walk activity is suggested, for students to recap and relearn concepts of Friction. Students, in groups of five, are required to create posters that illustrate their understanding of key concepts of Friction. While students are creating their posters, teachers can walk around prompting groups that have difficulties recalling certain concepts. During their walkabouts, teachers can also check and correct the accuracy of information presented in the posters. After creating the posters, students would be re-grouped and participate in a gallery walk. They will have to explain and answer questions when their
group arrives at their poster. At the end of the gallery walk, students are required to vote for the best poster online. The group members with the winning poster will be awarded with additional points in their Continual Assessment grades. This element of competition will add excitement and fun to the activity. It will also increase motivation for students to actively participate in the activity.

Benefits of Activity 5

This activity engages students on multiple levels. Students must (1) do an initial plan (such as a mind map of Friction concepts, they recall); (2) be creative as they generate possible ways to represent and display their idea; (3) evaluate possibilities and choose their best display design; (4) construct the poster with appropriate contents and chosen design; (5) reflect upon what they have learned so that they are able to summarize, synthesize and share their learning with fellow classmates.

This activity helps students deepen their knowledge and understanding as they view and discuss the exhibits with their peers. Furthermore, this activity allows the teacher to move away from an authoritarian role. The students take control of their own learning. The teacher is merely a facilitator guiding students throughout the activity. When students take ownership of their own learning, they stay motivated and engaged during the activity (Barkley, 2010)
5.4 Chapter 18 - D.C. Circuits

The topic on D.C. Circuits requires students to visualize circuits and apply various concepts. Students must have the ability to reduce a complex network of resistors to a simple equivalent circuit that would enable them to do further calculations. They also need to be able to identify if a circuit is either series or parallel. From the survey conducted, teachers had stated that the following concepts are challenging and less engaging:

- Concepts on the relationship of the voltage, current and resistance in series and parallel circuits. (Activity sheet 1)
- Calculating combined resistance in complex circuits. (Activity sheet 2 and learning stations activity)
- The concept that the combined resistance in a parallel circuit is lesser than the resistance of the individual resistor with the lowest resistance. (Activity sheet 2 and learning stations activity)

The lesson package resources for this topic include:

1. Self-prepared presentation slides (Appendix D1)
2. Activity sheet 1- Recap Circuit Basics (Appendix D3)
3. Activity sheet 2- Series and Parallel Circuits (Appendix D4)
4. Learning stations package (Appendix D5);
   - Instructions page (Appendix D5.1)
   - Station 1- Voltage relationships (Appendix D5.2)
   - Station 2- Voltage and current relationships (Appendix D5.3)
   - Station 3- Parallel circuits (Appendix D5.4)
   - Station 4- Combined circuits (Appendix D5.5)
5.4.1 Activity 1- Recap circuit basics

This topic requires the application of many concepts from the previous topic on Current electricity. Traditionally, teachers will begin the topic by plunging straight into new concepts. Most teachers will merely state the prior concepts during teaching of this topic. By doing so, teachers are not giving students the opportunity to activate their prior knowledge on their own. When students retrieve prior knowledge by participating in activities, it helps them to connect new ideas and information to already known concepts and principles (Barkley, 2010).

Activity 1 (Appendix D3) makes use of an applet to activate students’ prior knowledge. Introducing the topic with an activity instead of a lecture would stimulate students’ interest and motivation, ensuring student engagement (Barkley, 2010). In this activity, students are required to build series and parallel circuits using the applet. They will then have to draw their circuits and answer questions found in their activity sheets. Through constant exposure to videos and computer games, using applets to recap on their prior knowledge would appeal to students much more than a teacher’s lecture. Furthermore, the applet-based activity would help to stimulate students’ curiosity and allow them to take control of their own learning. When students are allowed to explore and retrieve prior knowledge, they stay engaged during the activity and retention of the knowledge dramatically increases (Christian and Belloni 2001).

Design of Activity sheet 1

Goals of the task are clearly stated on the activity sheet. Hence students are informed on what they are expected to achieve from this activity. When students are well informed of activity or lesson goals, they stay focused on the task and participate actively in their learning (Barkley, 2010). The activity sheet also has step-by-step instructions for students to follow throughout the activity. This allows students to stay engaged in the activity, without getting confused or lost. When students get confused or discouraged that they will not be able to complete the activity, they lose their willingness to learn and become disengaged (Brophy, 2004). The questions in Activity 1 are phrased to prompt students’ activation of prior concepts. When learners foreground their prior knowledge, they will be better able to interpret and assign meaning to new information. There are few questions in this activity that allow students to construct new
concepts from this topic. (Appendix D3, Part 1: Q8 and Q9, Part 2: Q6). These questions will help learners bridge their prior knowledge to new information.

### 5.4.2 Activity 2 - Series and parallel circuits

At the end of this topic, students are required to have a good understanding of voltage, current and resistance in a series and parallel circuit. These concepts are essential for them to simplify complex circuits and solve related problems. Traditionally teachers will teach these concepts using the lecture approach supplemented with presentation slides. After teaching a few concepts, they will conduct practical sessions in the science laboratory. Most teachers will use practical worksheets from the school’s practical workbook. These practical sessions are designed with the intention of allowing students to recap and practice concepts they had learnt. Most practical workbooks have limited number of experiments for each topic. For example, the topic on D.C. Circuits, has only one experiment (Appendix D5) for students to explore (Chew, 2007). Some of these experiments do not provide enough scaffolding for complex circuit concepts while others do not pose any challenge for students. Either of the extremes can lead to disengagement (McKeachie, 1994). Students must be working at their optimal challenge level to be engaged (ibid).

**Comparison of a traditional practical worksheet and Activity 2**

The experiment from the practical workbook (Appendix D4.1), used in my previous school, provide students with scaffolding by requiring them to answer questions. These questions will assist understanding of the concept on calculating the combined resistance in a series circuit. However, it fails to provide scaffolding to help students understand the complex concept on calculating the combined resistance in a parallel or combined circuit. This concept was identified as challenging and less engaging from the survey conducted. Such challenging concepts should be broken down into simpler portions or students should be provided with examples, clues or prompts to help them engage in and succeed at the complex learning task. When learning tasks are extremely challenging and minimal support is provided by teachers, students’ willingness to try can be destroyed (Barkley, 2010).

In Activity 2 (Appendix D4), students will prove the concepts introduced, by building their own circuits and making measurements using the circuit components provided. As the
lesson progresses, the teacher will probe students with inquiring questions. The questions require students to apply their critical thinking skills to construct new concepts. These questions also provide the scaffolding that students need to construct these concepts. During active learning tasks such as these, students’ curiosity is aroused, their ideas are stimulated and they stay engaged. They also remember better when they carry out experiments and discover concepts on their own (Bruner, 1967). After students experiment with various circuits, they will have to contribute their results and ideas during the class discussion. The teacher will record students’ answers on the whiteboard. During the class discussion, the teacher will interject and form connections between experiment results, ideas and re-direct them. In order to contribute to the class discussion, students will stay focused on the experimentation tasks. The teaching approach used in Activity 2, requires students to process both verbal (class discussion and teacher’s prompts) and visual information (experimentation, presentation slides). Usage of multiple processing modes will increase students’ retention drastically (Sousa, 2006).

5.4.3 Learning stations package

Summarizing concepts learnt at the end of a lesson or topic is a common practice for most teachers. It is essential as it helps to maintain continuity within a topic, emphasizes areas of importance and ensures student understanding. Traditionally, teachers will summarize concepts taught with class discussions. Some teachers will merely state the important teaching points of the lesson or topic. After the summary, teachers will hand out practice questions for students to work on.

When such teaching approaches are used to summarize the content, most students sit passively and concentrate primarily on processing verbal information. Some students might get bored and disengage themselves from the lesson. Students need to dynamically participate in the learning activity to ensure effective retention of concepts (Sousa, 2006). Summarizing of concepts is done at the end of the lesson when most students’ have difficulty maintaining attention. Hence class discussions will only have a few students exchanging information, while majority remain quiet. Teachers might find it challenging to involve all students in the discussion. It will be effective to summarize a lesson or topic with a dynamic activity such as learning stations.
The learning stations activity is a group activity, which will give students the opportunity to move around the room, have fun and learn. Students stay engaged when an activity includes physical movement (Barkley, 2010). They will work in groups of four to five for this activity. A group activity is an important way to promote community as students have to work together to achieve a common goal (ibid). In each group, students are assigned roles such as time keeper, leader, worksheet filler and materials in-charge. Assigning roles to students will ensure everyone contributes during the activity. Furthermore, they will be motivated as they feel important in the group. This will help to improve group interactions as well. There are four stations in this activity. This activity will be carried out in an hour. Students will spend ten minutes in each station. The remaining twenty minutes is allocated for students to get to the lesson location, teacher to introduce and instruct the activity and most importantly, sum up the lesson.

Design of learning stations

In the various stations, students will have to recall and apply concepts they have learnt. When they recall and apply the appropriate concept to solve a problem, they retain the knowledge better (Barkley, 2010). Students will receive an instruction sheet (Appendix D5.1) to guide them through this activity. In the first station (Appendix D5.2), students will observe and analyze voltage relationships by experimenting with an applet and circuit components provided. In the second station (Appendix D5.3), students will analyze voltage and current relationships using an applet. In the third station (Appendix D5.4), students will deepen their understanding on parallel circuits with the help of an applet. In the final station (Appendix D5.5), students will explore the applet and circuit components to build on their understanding of combined circuits. Completing all four stations will give students the opportunity to explore, recall and practice concepts that were introduced in this topic. In this activity, students are engaged in active learning as they interact with learning materials, question, recall, exchange ideas with group mates and apply concepts learnt.

5.4.4 Electric circuit design challenge

This Electric Circuit Design Challenge (Appendix D6) is an additional enrichment activity that teachers can choose to use. This activity can be used to recap concepts in this topic or to check students’ understanding before moving onto the next topic. This challenge must be
conducted in a venue with computers and lab equipments prepared for each pair of students. Students will be given 45 minutes to 60 minutes to complete this challenge. During this activity the teacher takes on the role of a facilitator, prompting students who face difficulties getting started.

Students are required to design a working circuit with a few listed requirements. In order to do so, they must apply concepts they have learnt in this chapter. This challenge instigates students' thinking and creativity. The idea of conducting this activity in the form of a competition helps to engage students. Furthermore, including competitive elements in activities can add excitement and fun to classroom activities (Brophy, 2004). Awarding additional marks for their Continual Assessment, adds motivation for students.
5.5 Chapter 22- Electromagnetic Induction

The topic on Electromagnetic Induction is an abstract concept that is difficult to fully grasp due to the non-intuitive notion that electricity can induce magnetism and vice versa. Most students have difficulties understanding the principles of Electromagnetic Induction. Therefore, the focus of resources created will be on concrete examples to convince students on validity of the phenomenon.

The activities crafted, in this lesson package, promote excitement, a sense of curiosity and engagement in the classroom. The teacher acts merely as a guide throughout the various activities. Through instigation of curiosity and constructive questioning, students are guided towards crucial concepts in this topic. In this lesson package the topic has been separated into three parts. The first section is on principles of Electromagnetic Induction. It is then followed by the section on A.C. generators and ending off with the section on transformers. From the survey conducted, teachers had stated that the following concepts are challenging and less engaging;

- A changing magnetic field can induce an Electromagnetic Force (E.M.F) in a circuit (Activity 1).
- A.C Generator (Activity 3).

The lesson package resources for this topic include;
5. Self-prepared presentation slides (Appendix E1)
6. Activity sheet 1- Inducing E.M.F and directions (Appendix E3)
7. Activity sheet 2- Factors affecting size of induced E.M.F (Appendix E4)
8. Activity sheet 3- A.C. generators (Appendix E5)
9. Activity sheet 4- Transformers (Appendix E6)
10. Check-out quiz (Appendix E7)
5.5.1 Pre-lesson assignment

Teachers seldom spend time furnishing students with details of scientists behind the concepts. Most teachers have the mindset that since it is not going to be tested, it is not essential for students to know. Furthermore, constraints in curriculum time make it impossible for teachers to spend much time on historical information that would help to develop students’ interest in the topic. However, it is essential for teachers to understand that this initial interest in the topic will help to motivate and encourage students to learn new concepts. Hence it is beneficial for teachers to allocate time in the curriculum to trigger students’ curiosity and interest in the topic.

In this lesson package, a simple pre-lesson assignment is suggested for this topic. For this pre-lesson assignment, students are required to research briefly on Faraday’s history. On the first lesson of this topic, volunteers will share information with fellow classmates while the teacher notes a few important points on the board. This activity can be carried out as a short class discussion with the teacher prompting questions and with students contributing the appropriate research information.

As mentioned in the topic on Dynamics, knowing a bit more on the person behind Faraday’s law will help students develop an emotional connection to the concepts. This will help them retain the concepts better (Barkley, 2010). To prevent embarrassment when picked to contribute findings during the class discussion motivates students to complete this assignment. From this learning task, students’ research skills and communication proficiency are developed.

5.5.2 Principles of Electromagnetic Induction (Activity 1 and 2)

In the survey conducted, teachers had stated that students have difficulties understanding the concept that a changing magnetic field can induce an E.M.F in a circuit. Students will be able to comprehend and retain such challenging concepts when they are given opportunity to explore and construct information on their own. Challenging concepts can discourage and disengage students when they have difficulty comprehending or keeping up during lessons (Barkley, 2010). Hence it is essential for teachers to plan appropriate engaging activities and provide sufficient scaffolding to assist in complex learning tasks. Traditionally teachers would deliver this concept
with presentation slides, conduct practical activities after the concept is taught and conduct class tests to gauge students’ understanding.

**Inducing an E.M.F and direction of induced E.M.F (Activity 1)**

In Activity 1 (Appendix E3), students will work in groups of four to five members to explore an applet to construct concepts of Electromagnetic Induction on their own. As they explore the applet, they are required to answer questions in their activity sheet. After completing this activity, students will present their answers to fellow classmates.

**Design of Activity 1**

It is important for teachers to allocate appropriate group sizes for successful cooperative learning activities. If a group is assigned too many members, there may be a few uninvolved and passive participants. The most efficient group size for attaining a goal is four to six members (Cohen, 1994). In this activity with each group having four to five members, a class of forty students should have eight to ten groups formed. Smaller groups make monitoring of group performance more difficult, because the number of times the teacher can interact with each group is reduced accordingly (Borich, 2011). But larger groups generally argue more, reach consensus after more discussion, have more difficulty sharing limited materials and take longer to complete the assigned tasks (ibid).

Activity 1 makes use of the self-directed learning approach that actively engages students in the learning process to acquire higher-order thinking skills. As students explore the applet and observe changes in the circuit, they construct their own understanding and meaning. Furthermore, through this activity students will have to reason, solve problems and think critically about the content. Students these days are constantly exposed to videos and computer games. Hence usage of an applet would appeal and engage students in this activity. Furthermore, using the applet for students to explore the concept of Electromagnetic Induction can produce a more effective and enjoyable learning experience.

The questions in Activity 1 help to guide students towards understanding the concept of Electromagnetic Induction. They provide students with sufficient scaffolding as they explore the applet and construct concepts on their own. The activity sheet also provides students with clear
instructions to guide them to succeed in the learning task. After completing the activity, students will participate in their own learning by contributing to an answer and dialogue session initiated by the teacher. The teacher keeps the dialogue session going by prompting questions that would guide students towards the correct concept. This dialogue session will also help teachers assess students’ understanding.

Factors affecting the size of the induced E.M.F (Activity 2)

In Activity 2(Appendix E4), students will work in the same groups of four to five members to experiment and explore with laboratory items to discover factors that affect the size of an induced E.M.F. As they explore their experimental set-ups, they are required to answer questions in their activity sheet. After completing this activity, students will present their answers to fellow classmates.

Design of Activity 2

The design and benefits of Activity 2 are similar to that of Activity 1. However, students are required to construct concepts and ideas through student experimentation instead of exploring an applet. This variation was introduced to keep students excited and engaged in the learning activity. Furthermore, student experimentation uses handheld items to arouse curiosity and stimulate ideas in students.

5.5.3 A.C. Generators (Activity 3)

Many students have difficulties understanding the components and principle of operation of a simple A.C. generator. This was also confirmed in the survey conducted for this project. Most teachers use the drill and practice strategy to handle concepts that students find challenging. The drill and practice strategy does not guarantee that information will be remembered in such a way that it can be located, identified and retrieved accurately in future. Students need to make an emotional connection to the information, make sense of it, and find meaning and personal relevance in the topic for effective retention (Anderson et al., 2001).

Activity 3 (Appendix E) makes use of multiple teaching approaches to teach the components and principle of operation of a simple A.C. generator. Activity 3 requires students to
use multiple senses to process information. In part 1 of Activity 3, students are required to make their own simple A.C. generators following instructions given in a video demonstration. After they make their own generators, they are required to answer questions in their activity sheet. In part 2 and 3 of the activity, students will have to answer questions as the teachers goes through the presentation slides.

In part 1, making their own A.C. generators will help to familiarize students with the various components of a simple A.C. generator. Assembling the various parts will get students familiar with the mechanisms involved in an A.C. generator. Furthermore, handling and making these generators will help students make connections with concepts of Electromagnetic Induction. The questions in Activity sheet 1 will require students to recap and apply the principles of Electromagnetic Induction that they learnt in the initial portion of this topic. When students are given adequate time and practice to reprocess and apply learnt concepts, new learning is moved from short-term to long-term memory (Anderson et al., 2001). Part 2 and part 3 of Activity sheet 3 allow students to predict the answers by applying concepts introduced to them in the slide presentation. This helps students transfer learning into practice. The curiosity of finding out if the accuracy of their predictions will help keep students engaged in the learning.

5.5.4 Transformers (Activity 4)

This topic ends with the final concept on Transformers. Most teachers do not spend much time on this portion of the topic as in the exams, only the application of related formula and calculations are commonly tested. Teachers will usually present concepts of Transformers in presentation slides followed by worksheets that would require students to apply the formula. Activity 4 (Appendix E6) is conducted after the concepts of Transformers are taught. Students will work in pairs to experiment and participate in active learning. As they explore and experiment, they are required to answer questions in their activity sheet.

Design of Activity 4

Working in pairs will give students the confidence of support and ensure both students stay engaged in the activity. The experiments and questions designed in Activity 4 will require students to reprocess and apply knowledge learnt from the slide presentation. They will also
help to visually convince students of the functions and principles involved in transformers. As students experiment and answer, they will have to transfer principles learnt to new situations. Therefore, this activity can serve as a bridge between learning and practice.

5.5.5 Check-out quiz

At the end of the topic, students will have to complete an online check-out quiz. This quiz will be attempted by students after curriculum time. Having students to do it at home will save teachers’ curriculum time. Furthermore, teachers can assess the quiz answers and do a post test analysis on the next lesson. As students these days are constantly exposed to the internet and computer games, having to do a quiz online will be more engaging for them.

This check-out quiz will help teachers assess students’ understanding of the topic. Since students receive immediate feedback, any misunderstandings are quickly corrected just as their valid concepts are reinforced. Finally, it can reduce student anxiety about the kinds of questions that will be in major exams and point to areas that warrant further study.
6. MEASURING STUDENT ENGAGEMENT

6.1 Students’ engagement in school survey

Student engagement in school can be measured with student surveys. The questions can be designed to measure the three types of engagement; behavioral, cognitive and affective. The divisions of engagement merely aids in understanding that ‘engagement’ as a whole is a multi-dimensional construct. Consequently, these components are expected to be highly correlated to each other, but relate differently to student outcomes such as achievements and attendance. Students’ feedback will help teachers plan activities in school and design lessons that are engaging. An example of a students’ engagement survey (Appendix F1) was designed and included in this project.

6.2 Walkthrough checklist

Student engagement in the classroom or a specific lesson can be measured by classroom walkthroughs. Classroom walkthroughs are specific, short observations in classrooms. These may be done by school administrators, instructional coaches, teachers or teacher peers. Classroom walkthroughs are not a traditional supervisory evaluation of the teachers but instead it is more focused on how well students are engaged in the lesson. As teachers or other officials conduct classroom walkthroughs, they can use the checklist to rate the level of student engagement in each of the categories. A walkthrough checklist is included in this project (Appendix F2).

The first part is based on direct observation of students and includes these criteria;

- Positive body language- Students exhibit body postures that indicate listening and attention to the teacher or other students. Teachers can look out for indicators such as eye contact, head position, leaning forward or backward and position of arms.
- Consistent focus- Students are focused on the learning activity with minimum disruptions. Teachers can consider these questions regarding student behavior during the entire
observation: Are students focused on the learning experience? Does their attention waiver because of lack of interest, lack of knowledge or frustration?

- Verbal participation- Students express thoughtful ideas and answers. They ask questions that are relevant or appropriate to learning. Student participation is not passive; it involves sharing options and reflecting on complex problems.

- Student confidence- Students exhibit confidence to initiate and complete a task with limited coaching and can actively participate in team-based work.

- Fun and excitement- Students exhibit interest and enthusiasm.

The second part requires a conversation with the students to gather details about the degree to which they are engaged in the learning experience. These criteria include;

- Individual attention- Students feel comfortable in seeking help and asking questions.

- Clarity of learning- Students can describe the purpose of the lesson or topic.

- Meaningfulness of work- Students find the work interesting, challenging and connected to learning.

- Rigorous thinking- Students work on complex problems, create original solutions and reflect on the quality of their work.

- Performance orientation- Students understand what quality work is and how it will be assessed. They also can describe the criteria by which their work will be evaluated.
CHAPTER 7

7. CONCLUSION

7.1 Limitations of study

There are a few limitations in this study. Firstly, this study relied on self-reported data, which is ideal for studying teachers’ subjective experiences but vulnerable to errors including problems with memory, hasty completion and exaggeration. Secondly, teachers might have been dishonest in the survey by stating that they use the engaging approaches in their classrooms when they actually did not. Thirdly, this study did not directly examine students’ perspectives on which teaching approach engages them in their learning. Finally, this study did not take into account students’ developmental levels, educational histories, specific learning skills and expectations for success. All of these individual factors are undoubtedly important when selecting teaching approaches to engage students in their learning.

7.2 Conclusion

The Ministry of education (MOE) recognized the need to transform learning from quantity to quality—‘more quality and less quantity’ in education. Therefore, MOE launched the initiative ‘Teach less, learn more’ (TLLM). The TLLM initiative placed greater emphasis on engaged learning, discovery through experiences and the building of character through innovative and effective teaching strategies. With such an initiative already in place, it is important for teachers to incorporate engagement based approaches into their lessons. To support schools in the area of engaged learning, MOE developed and distributed the PETALS toolkits. However, schools have not been using these toolkits effectively. There are many teachers like myself, who have never seen the toolkit. Furthermore, there have not been sufficient training and monitoring of the usage of the PETALS toolkit.

Evidence suggests that teachers do use these approaches in their teaching but not regularly enough. The survey results also suggest that although teachers know the importance of the various engaging approaches, they seldom use them in their teaching. The underutilization of engaging approaches is due to the lack of time to complete the syllabus and shortage of available engaging teaching resources. In order to effectively engage students in their learning, students’
perspectives on what teaching approaches engage them should be examined. Teachers should use at least two or more engaging approaches in every lesson to ensure students are engaged in the classroom.

To produce a transformation that policy makers and researchers advocate, teachers have to recognize that changes in personal attitudes and beliefs are inevitable. They have to believe that engaging students is their responsibility. Teachers should be more willing to learn new skills and change their teaching style to include engaging approaches in their lessons. Schools can provide assistance through technical support, introducing co-teaching systems to tail end classes and scheduling sessions for teachers to share or discuss how different approaches can be used to engage students effectively in their learning.

While policy changes may have the right intentions, to really create engaging learning experiences for students, both schools and teachers must take proactive steps. This will ensure that the implementation of an engaged learning paradigm and the transformation of learning from quantity to quality will not prove to be mere elusive goals.
CHAPTER 8

8. RECOMMENDATIONS

8.1 Increasing the usage of engagement based approaches in the classroom.

Teachers’ attitudes and beliefs must change

Teachers must understand that encouraging students to engage themselves in their class work is seldom enough. They have to take responsibility to engage the students, as opposed to them expecting students to come to class naturally and automatically engaged. Teachers traditionally depend very much on textbooks that are written according to the subject syllabus. This relieves them of the selection and planning process needed in crafting of engaging learning tasks. In order to strengthen student engagement in the classroom, teachers have to learn new skills that will help them to develop, polish and enhance their natural inclination to motivate and engage students. Furthermore, teachers have to overcome the fear of working outside their comfort zone, in terms of incorporating systematic strategies that facilitate student engagement in their lessons.

Teachers will be more willing to change when they are informed of the positive outcomes that other teachers experience from engagement based lessons. These experiences can be brought about through professional development courses or teachers’ sharing sessions. Teachers have direct control and can make changes instantaneously to improve student engagement in the classroom. Therefore, it is essential for teachers to change their attitudes and beliefs towards the usage of engaging approaches in their lessons.

Schools must provide sufficient support

The best way to promote high levels of student engagement is to develop and maintain a school-wide initiative that is dedicated to creating a culture of student engagement. When schools provide teachers with sufficient support, they will be encouraged to include more engaging approaches in their lessons. Schools can promote the sharing of engagement based lessons between teachers by providing easily accessible sharing platforms. Teachers need to be provided with adequate IT equipments and support to conduct engaging lessons.

Smaller class sizes increase the teachers’ ability to monitor student behavior and learning, allows more immediate and individualized re-teaching and the usage of a variety of engagement
based approaches to meet learners’ needs (O’Connell and Smith, 2000). When class sizes are smaller, there are more opportunities for students to engage in active interaction with teachers, hence improving classroom engagement (Blatchford et al., 2008). Increasing classroom engagement with smaller class sizes is proven to be most effective for underachieving secondary students (ibid). Therefore, it would be beneficial for schools to divide tail end classes and introduce the system of co-teaching to reduce the student to teacher ratio. In addition, to increase student engagement in schools, teachers have to be provided with ample opportunities for professional development and sharing to learn from other teachers’ effective engagement approaches. Staff development, combined with staff ownership and recognition, is critical to developing and maintaining a culture of effective student engagement.

**Changes in modes of assessment**

Many teachers are teaching content with the objective of preparing students for tests and examinations. This is because beyond the classroom, other major assessments that contribute to students advancing from one level to the next are based on content knowledge written in examination papers. However with the introduction of initiatives such as ‘Teach less, learn more’, the education system is progressing towards teaching better, to engage learners and prepare them for life. Therefore, it would be advantageous to supplement traditional modes of assessment with different forms of assessment. Teachers can practice ‘Assessment for Learning’ where teaching and learning is expected to be interactive. Through student interaction, teachers would be able to assess students’ learning and adapt their lessons to meet the needs of the students. Introducing changes in the modes of assessment will help to change the focus of teaching to engagement.
8.2 Directions for future research

This study focused only on the teachers’ perspectives of classroom engagement. Therefore, future studies on classroom engagement through the students’ perspectives can be undertaken to contribute to the body of knowledge currently available in the field of engagement in the classroom. Students’ perspectives on what engages them in their own learning will help teachers plan effective engaging lessons. Future research on students’ perspectives on classroom engagement can be focused primarily on underachieving students. This will help many teachers cope with the discipline problems they currently face with underachieving students.

Another area for future research could be more longitudinal studies on engagement from primary to secondary and post secondary institutions. This research could determine how behavioral, cognitive and affective engagements develop. It would be interesting to discover which types of engagement are more likely to be displayed during early or later years in school and how the different types of engagement changes over time.
REFERENCES


APPENDICES
Survey of Student Engagement

Dear teachers,

Hope you could please spend some time to fill up this survey. It will aid in my final project for my masters course. Thank you very much.

Regards,
Ganeshini

(Link for survey online: http://tinyurl.com/surveySE)

1. Gender
   - □ Male
   - □ Female

2. Age
   - □ Below 20 years old
   - □ 20 – 30 years old
   - □ 31 – 40 years old
   - □ Above 40 years old

3. Teaching experience
   - □ Less than 5 years
   - □ 5 – 10 years
   - □ 11 – 20 years
   - □ More than 20 years

4. State your teaching subjects.
5. Select the engaging approaches that you use in your lessons. For each of the item you selected, state the frequency of usage in terms of lessons.

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Frequency of usage in terms of lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ None</td>
<td></td>
</tr>
<tr>
<td>☐ Group discussions</td>
<td></td>
</tr>
<tr>
<td>☐ Demonstrations</td>
<td></td>
</tr>
<tr>
<td>☐ Student experiments</td>
<td></td>
</tr>
<tr>
<td>☐ Field trips and outdoor lessons</td>
<td></td>
</tr>
<tr>
<td>☐ Group activities</td>
<td></td>
</tr>
<tr>
<td>☐ Simulations and applets</td>
<td></td>
</tr>
<tr>
<td>☐ Videos</td>
<td></td>
</tr>
<tr>
<td>☐ Others</td>
<td></td>
</tr>
<tr>
<td>( state other activities you use in the blank space below)</td>
<td></td>
</tr>
</tbody>
</table>

6. If you selected none for question 4, list reasons for not using engaging approaches in your lessons?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
7. What are the kinds of support you would like your school to provide, in order to conduct more engaging approaches during your lessons?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

The following questions are specific to the topics identified as challenging for students or not engaging.

8. For the topic on kinematics, list a few concepts that students find challenging to comprehend.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

9. List approaches you use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

10. List approaches you would have liked to use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
11. For the topic on forces, list a few concepts that students find challenging to comprehend.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

12. List approaches you use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

13. List approaches you would have liked to use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

14. For the topic on DC circuits, list a few concepts that students find challenging to comprehend.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

15. List approaches you use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
16. List approaches you would have liked to use to teach these concepts.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

17. For the topic on magnetism, list a few concepts that students find challenging to comprehend.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

18. List approaches you use to teach these concepts.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

19. List approaches you would have liked to use to teach these concepts.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

20. For the topic on electromagnetic induction, list a few concepts that students find challenging to comprehend.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
21. List approaches you use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

22. List approaches you would have liked to use to teach these concepts.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

End of survey
Survey of Student Engagement: Summary of responses

PART 1: For all teachers

Q1. Gender

![Bar chart showing the gender proportions of survey respondents.](chart)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>13</td>
<td>32%</td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>68%</td>
</tr>
</tbody>
</table>

People may select more than one checkbox, so percentages may add up to more than 100%.

Q2. Age

![Bar chart showing the age proportions of survey respondents.](chart)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 20 years old</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>20 - 30 years old</td>
<td>23</td>
<td>56%</td>
</tr>
<tr>
<td>31 - 40 years old</td>
<td>16</td>
<td>39%</td>
</tr>
<tr>
<td>Above 40 years old</td>
<td>2</td>
<td>5%</td>
</tr>
</tbody>
</table>

People may select more than one checkbox, so percentages may add up to more than 100%.

Q3. Teaching experience

![Bar chart showing the teaching experience proportions of survey respondents.](chart)

<table>
<thead>
<tr>
<th>Experience</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5 years</td>
<td>21</td>
<td>51%</td>
</tr>
<tr>
<td>5 - 10 years</td>
<td>11</td>
<td>27%</td>
</tr>
<tr>
<td>11 - 20 years</td>
<td>8</td>
<td>20%</td>
</tr>
<tr>
<td>More than 20 years</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

People may select more than one checkbox, so percentages may add up to more than 100%.
Q4. State your teaching subjects

Physics (4), Chemistry (10), Biology (5), Lower secondary science (9), NT science (4), Mathematics (12), Computer applications (2), English (4), English Literature (1), Mother tongue (2), Home Economics (3).

Science teachers: 26

Other subject teachers: 15

Q5. Part 1: State the engaging approaches that you use in your lessons.

Figure 4: Bar chart showing the proportions of engaging approaches used by the survey respondents.

Q5. Part 2: For each of the item you selected, state the frequency of usage in terms of lessons.

Group discussions: Alternate lessons, Once a day, Approximately 1 in 4 lessons, Once a week (2), Try to include for 50% of the lessons, 1 to 2 times a week, 3 times a week, At least once in 2 weeks, About once a month (11), Atleast twice a term.

Demonstrations: Occasionally, Rarely (3), Every 1 in 4 lessons (2), Try to include 20% of the lessons, Once a week (2), Twice a week, 3 times a week, Once every 2 to 3 weeks, Once a month (6), Once per term.

Student experiments: Atleast once in 2 weeks for practical sessions (4), As often as I can, Once a week for practical lessons (7), Once a month (2), Once every 4 lessons, At least 1 per topic (2), Rarely,
Field trips and outdoor lessons: Twice a year, When necessary, Once per term or semester, Not very often.

Group activities: Rarely (3), Weekly (2), Once in 2 weeks, 1 in every 4 lessons, Once a month (4), 2 to 3 times a month, 1 to 2 times a month, Atleast once per topic, Once in 4 topics.

Simulations and applets: Depends on the topic, Once every 4 lessons, Atleast once a week, Once a month (4), Twice a term, 1 to 2 times a year.

Videos: When necessary, Atleast one per lesson, Once every 2 lessons (2), Once every 4 lessons, Once in 8 lessons, Once a week (4), Once every 2 weeks (2), Once every 2 to 3 weeks (2), , Once a month (7), 1 to 2 times a month (2).

Others: Jokes, comics and stories- When possible.

Q6. If you selected none for the question above list reasons for not using engaging approaches in your lessons.

Catching up with the syllabus and these approaches are not always suitable for the topics, Students become too distracted when there are group discussions or activities and the teacher cannot meet the lesson objectives, Lack of time to plan good lessons for students, Lack of time in the syllabus and I teach a lot of secondary 4 classes, so there is a constant rush for the syllabus, There is a lack of time and resources available, Class sizes must be small for group activities.

Q7. What are the kinds of support you would like your school to provide, in order to conduct more engaging approaches during your lessons?

More platforms between teachers to share and learn engaging activities that are subject specific (4), More available ready to use teaching resources (18), More funds to purchase useful teaching resources (3), Smaller class sizes to better manage students (7), More manpower such as a teacher aid attached to teachers or co-teaching classes (7), Better IT equipments such as visualisers, projector and laptops, other equipments such as boards and stationary, and IT support (8), More conducive classrooms that are friendly to activity based lessons (5), More time in the syllabus (2).
PART 2: Only applicable for teachers teaching physics.

Q8. For the topic on kinematics, list a few concepts that students find challenging to comprehend.

The concept of when an object falls, acceleration remains constant (4), Interpretation of graphs (2).

Q9. List approaches you use to teach these concepts.

Simulations and applets showing velocity/speed-time graphs (4), Help students relate with real-life examples, Drill and practice until they remember, Show them the graphical, Practical sessions (3), videos (2).

Q10. List approaches you would have liked to use to teach these concepts.

Student experiments, Data logging, Self-discovery methods, More available applets, group and hands-on activities, Inquiry based lessons.

Q11. For the topic on Forces, list a few concepts that students find challenging to comprehend.

Concepts on ‘no net force’ and balanced forces (2), Newton’s second law (2), Identifying and understanding action-reaction pairs (3).

Q12. List approaches you use to teach these concepts.

Simulations and applets, Drill and practice (3), Practical sessions (2), Slide presentations, Pictorial representations.

Q13. List approaches you would have liked to use to teach these concepts.

Student experiments, Simulations, More group activities as it can be difficult to manage the students.

Q14. For the topic on D.C Circuits, list a few concepts that students find challenging to comprehend.

Relationship of voltage, current and resistance in the circuit (2), Parallel circuit has the same potential difference, Calculating the effective resistance in a combination circuit (4), Combined resistance in a parallel circuit is lesser than the individual resistance, When multiple concepts are tested together.
Q15. **List approaches you use to teach these concepts.**

Hands-on experiments (3), Simulations and applets, Drill and practice (2), Draw diagrams to show how the current splits and the measurement of the voltmeter if it is places at different parts of the wires, lecture, Presentation slides.

Q16. **List approaches you would have liked to use to teach these concepts.**

Use water circuit analogy, Self-discovery method, More applets, Group work, Discussions, Research.

Q17. **For the topic on Magnetism, list a few concepts that students find challenging to comprehend.**

Drawing magnetic field patterns around a bar magnet and between the poles of 2 magnets, Fleming’s left hand rule.

Q18. **List approaches you use to teach these concepts.**

Student experimentation, Practice, worksheets and examples can be shown by the teacher.

Q19. **List approaches you would have liked to use to teach these concepts.**

Use applets for students to explore the variations in magnetic field patterns.

Q20. **For the topic on Electromagnetic Induction, list a few concepts that students find challenging to comprehend.**

Faraday’s and Lenz’s laws (4), A.C. generator (3).

Q21. **List approaches you use to teach these concepts.**

Student experiments (2), Applets and simulations, Lecture with slides (2), Worksheets, Demonstrations and animations, Videos, Discussions.

Q22. **List approaches you would have liked to use to teach these concepts.**

Show students a physical model of the A.C. generator, Interactive experiments or simulations, Allow students to discover the laws themselves- usually there isn’t enough time and resources to do so, Group activities, More student experiments, Inquiry based lessons.
Appendix B

Side bar links:
1. Feedback and question form.
2. Topics- Dynamics, D.C., Circuits and Electromagnetic Induction.
4. Other resources

Main column:
1. Pre-lesson assignment details for students to complete before the topic is taught.
2. Announcements or updates that the teacher would like to inform students

Google site links: https://sites.google.com/site/engagemyourelves/
or http://tinyurl.com/engaging-activities
At the end of this topic you should be able to:
1) Describe ways in which a force may change the motion of an object.
2) State and explain Newton’s Laws
3) Recall Resultant force = mass \times acceleration (F=ma).
4) Use $F = ma$ to solve new related problems.
5) Explain the effects of friction on the motion of a body.

Dynamics Vs Kinematics
- Kinematics deals with the motion of the body without looking at what causes the motion of the body (displacement, velocity and acceleration)
- In dynamics, we look at what causes motion.
Ideas about Force

A force is a Push OR Pull

The teacher can mention some of the definitions provided by students in the pre-lesson quiz.

Names the types of forces you experience

1) Contact force
2) Weight
3) Friction
4) Tension
5) Resistance
6) Electric force
7) Magnetic force

Class discussion: What are the types of forces you experience?
Teacher writes responses on the board.

What are effects of forces on motion?

1) A force can cause a stationary object to start moving.

Class discussion: What the effects of forces? Teacher can help students recall with a simple demonstration using a toy car. Teacher writes responses on the board.
EFFECTS OF FORCES ON MOTION

2) A force can cause a moving object to increase speed (accelerate).

Demonstration: Teacher can help students recall with a simple demonstration by walking, jogging and running in the classroom. Teacher writes responses on the board.

3) A force can cause a moving object to decrease speed (decelerate).

Demonstration: Teacher can help students recall with a simple demonstration by rolling and kicking a football. Teacher writes responses on the board.

4) A force can cause a moving object to change its direction of motion.

Demonstration: Teacher can help students recall with a simple demonstration by kicking a rolling football in a different direction. Teacher writes responses on the board.
Pre-lesson assignment: Research on the scientists who worked on the laws of motion.

Teacher shows video (1) to students.

Class discussion: Teacher probes students with questions shown on the slide.
Refer to activity sheet 1. After the activity, students will share the answers with the class. Teacher introduces Newton’s 1st Law.
Newton’s First Law of motion
An object moving at constant speed will remain moving at constant speed.

Balanced forces on the aircraft - It moves at constant velocity and at constant height.

No net force

‘No net force’ does not mean that there is no force acting on the body.

It is just that all the forces are balanced.

Newton’s First Law of motion
This law is also known as the Law of Inertia.

Activity 2 - Let’s watch and apply!!!

Table cloth trick: [http://www.youtube.com/watch?v=zWeKRMh3kT8](http://www.youtube.com/watch?v=zWeKRMh3kT8)

Falling eggs: [http://www.youtube.com/watch?v=STQRUzahH2M](http://www.youtube.com/watch?v=STQRUzahH2M)

Refer to activity sheet 2. Video of the table cloth trick is shown to the students. **Demonstration:** Teacher demonstrates the falling eggs trick. Invite students to try out as well.
The inertia of an object is its reluctance to move when it is at rest or to slow down or stop when it is moving.

That is, it is its reluctance to change its state of rest or motion.

Inertia is measured by mass. The more massive an object, the more inertia it has, hence, the larger the force is required to change its motion. Conversely ...

Examples of Inertia in everyday life:
- Drive safely!
- Why did this happen?
- What must the man do to avoid the scenario shown on below?

Refer to Q6-8 in Activity sheet 2.
Slide 22

Examples of Inertia in everyday life

- Why did this happen?
- What must the man do to avoid the scenario shown above?

Slide 23

Just for laughs!!!

HEY, EINSTEIN, HOW ABOUT CONVINCING SOME OF THAT MASS INTO ENERGY AND GETTING OUT OF BED?

A study of inertia, a physics student of me!

Slide 24

Balanced Vs unbalanced forces

A force can be represented by its magnitude and direction.

3 N
**Slide 25**

Balanced Vs unbalanced forces

Resultant Force / Net Force

\[
\begin{align*}
5 \text{ N} & \quad 10 \text{ N} \\
\text{Resultant Force / Net Force} & = 10 - 5 \\
& = 5 \text{ N (Right)}
\end{align*}
\]

**Slide 26**

Balanced Vs unbalanced forces

- What will happen if the two forces are not along the same line?
- We will discuss this later!!

**Slide 27**

Tug-of-war

- Which direction will the red flag move?
- Right.
When forces are balanced, there will be NO resultant force.

5 N 5 N

Balanced Vs unbalanced forces

Which direction will the red flag move?

It will not move.

When forces are Not balanced, there will be a resultant force.

5 N 10 N

Resultant Force / Net Force = 5 N (Right)
Newton’s 2nd Law of motion
An object will only \textit{accelerate} when a Resultant force acts on it.

What is the resultant force?

Newton’s 2nd Law of motion
It will accelerate \textit{in the direction of the resultant force}.

What is the resultant force?

Activity 3
Play and learn

\begin{itemize}
  \item Drawing conclusions about the relationship between force, mass and acceleration.
\end{itemize}

Refer to activity sheet 3.
Group work (4 students per group)
Let’s share the conclusions we have made!

- A constant force produces a constant acceleration.
- Increasing the force will increase the acceleration.
- Acceleration is in the same direction as the resultant force.
- Increasing the mass requires a larger force to achieve the same acceleration.

Each group is to send a representative to present their conclusions. Teacher will guide students towards the correct conclusions. Teacher will probe students with questions, to derive the correct relationship between force, mass and acceleration.

Newton’s 2nd Law of motion

Formula to calculate Resultant Force

\[ \text{Resultant Force} = \text{mass} \times \text{acceleration} \]

\[ F = ma \]

Unit: Newton (N)

- \( m \) is the mass of the object
- Unit: Kilogram (kg)

- \( a \) is the acceleration of the object
- Unit: Meters per second per second (m/s²)

Resultant \text{ FORCE} = 0 N
Slide 37

Resultant FORCE ≠ 0 N

- Forces are Unbalanced
- There is an acceleration
  - The acceleration depends directly upon the "net force"
  - The acceleration depends inversely upon the object's mass.

Slide 38

Newton's 3rd Law of motion

For every action, there is an equal and opposite reaction, and these forces act on mutually opposite bodies.

Slide 39

Newton's 3rd Law of motion

- It tells us that Actions and Reaction are equal in magnitude but opposite in direction.
- Occur in pairs and act on different bodies.
Slide 40

Class discussion:
Students are to discuss with their partners and identify. First pair with the correct answer will get a sweet treat from the teacher. (Motivational factor)

Slide 41

Teacher demonstrates and verbally explains the analogy to ease understanding.

Slide 42

NEWTON’S 3RD LAW OF MOTION
Examples of Actions and Reaction
Action: I push the wall with a 10 N force.
Reaction: The wall pushes me with a 10 N force in opposite direction.
Slide 43

**Demonstration:** Teacher to set up apparatus as shown above and demonstrate to the class.

- Not convinced???
  - Volunteer to vent his frustrations on the wall!!!
  - Can you see the laser light moving? Why?
  - Convinced that the wall exerts an equal and opposite force?

Slide 44

**Activity 4 – Designing your own demonstration.**

- Let's see whose balloon rocket is able to travel the farthest.
- Work in groups of 5 and you have 25 mins to create your design.
- Share your conclusions on how does the rocket work.

Refer to activity sheet 4
Students can view teacher’s demonstration video and attempt the quiz as homework! (Googlesite)

Slide 45

**Friction**

What causes Friction?

It is caused by surface irregularities between two surface.

- Surface irregularities catch up and resist motion
Friction always acts in **opposite direction** to the motion of the object.

---

**Gallery walk**

- Follow the instructions given.
- Have fun learning from each other!

---

Refer to activity sheet 5
The teacher will have to vet the information of the posters as she walks around during the creations.

---

Students are required to visit the Google site to complete a post-lesson quiz.

---

**THE END!!**

**THANK YOU.**

Please visit my googlesite to try the post-lesson quiz.

[https://sites.google.com/site/engageyourselves/](https://sites.google.com/site/engageyourselves/)
Chapter 3: Dynamics

Level: Secondary 3 Express

Pre-requisite Knowledge

Students should be able to:
1. Know the physical quantities of mass and weight and their SI units.
2. Differentiate between scalar and vector quantities.
3. Recall concepts of kinematics such as displacement, velocity and acceleration.
4. Add two vectors using the graphical method.

Specific Instructional Objectives

By the end of the topic, students should be able to:
1. Describe the effect of balanced and unbalanced forces on a body.
2. Describe the ways in which a force may change the motion of a body.
3. Identify forces acting on an object and draw free body diagram(s) representing the forces acting on the object (at most 2D).
4. Solve problems for a static point mass under the action of 3 forces for 2-dimensional cases.
5. Recall and apply the relationship resultant force = mass x acceleration to new situations or to solve related problems.
6. Explain the effects of friction on the motion of a body.

New Concepts and terms

- Inertia
- Balanced and unbalanced force

Common Misconceptions

- Forces are required for motion with constant velocity.
- All objects eventually stop moving when the force is removed.
- Action-reaction forces act on the same body.
- Friction can't act in the direction of motion.
- Once an object is moving, heavier objects push more than lighter ones.
## Teaching strategies to address some of these misconceptions

<table>
<thead>
<tr>
<th>Misconception</th>
<th>Teaching strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is no reaction force when an object is not moving. (Eg a book on the table)</td>
<td><strong>Bridging analogy</strong>&lt;br&gt; Show students the analogies that will enable them to imagine the action-reaction forces when a book is on the table.</td>
</tr>
</tbody>
</table>

![Figure 6 – Analogy for action – reaction pair forces](image)

**Demonstration**<br>The teacher can set up the experiment shown below. A student can be chosen to kick against the wall which will cause the laser light to move. Through this demonstration, students will be able to see clearly that action-reaction forces exist.

![Figure 7 - of the experimental set-up.](image)

| Heavier objects fall faster that lighter objects | **Demonstration**<br>The teacher can show a short demonstration of dropping a paper and a scissors. Students will respond that the scissors fell faster than the paper. Crush the paper and drop it with the scissors. Students will be able to see that the ball of paper and scissors both reached the ground at the same time. |
Objects will follow a certain path by forces, and will continue along that path, even after the forces are removed.  

**Group activity**

Students can be asked to conduct the experiment of spinning a ball on a string counterclockwise, so that it rolls in a circular path. They are then to cut the string and sketch the path the ball takes after the string is cut. They can try this experiment in groups, in the school court yard.

After the experiment, the teacher can start a class discussion and address the misconception. The teacher can also state that the results obtained might not be perfect as there is friction between the ball and the ground.

---

### Challenging concepts

- Understanding the term ‘no net force’ and balanced forces (Activity 1 and slides 15-17).
- Newton’s second law $F=ma$ (Activity 3)
- Action and reaction forces
  - (Analogy (slide 41), teacher demonstration (slide 43) and Activity 4).

### Lesson Package Resources

- Self-prepared presentation slides
- Activity sheet 1 - Newton’s 1st law
- Activity sheet 2 - Inertia
- Activity sheet 3 - Newton’s 2nd law
- Activity sheet 4 - Newton’s 3rd law
- Activity sheet 5 - Friction
- Analogy explanation instructions for teachers
- Moving laser (Newton’s 3rd law) demonstration information for teachers
- Check-out and check in Quiz

### Pre-Lesson preparation

- Students would have been given the task to research on the story behind Newton’s laws, prior to this topic. They are to find out more about what Aristotle, Galileo and Newton stated about forces.
- They are to share what they have read up with their fellow classmates.
- Volunteers will present their information to the class whilst the teacher notes a few important points on the board.
Dear students,
Let's re-visit our pre-lesson Quiz. With all the concepts of forces mastered, you should find this easy!
You will be graded this time around. For each correct answer you will be awarded 2 marks.
Good Luck.

* Required

**Name** *

**Class** *

**Date** *

**Define the word force in your own words.** *

**What are some examples of forces?** *

**How will you measure, how large a force is?** *
2 bowling balls, of equal size and unequal mass (one weighs 8 lbs, the other 16 lbs), are hanging from strings. The strings are cut simultaneously. Compare the velocities of the 2 balls as they fall towards the ground.

Friction can act in the direction of motion. *
True

Congrats! You have completed the Quiz.
You are now ready to move on to the next chapter.
Dynamics - Activity Sheet 1
Aim: To understand Newton’s 1st law and inertia.

Location: In an open space outside the classroom (eg basketball court)
Groups of 5
Aim: To understand Newton’s 1st law and inertia.

Materials needed:
Skateboard
Basketball
Rod
Plank (height reaching the top of the skateboard tires)
Piece of chalk
Metre rule
Blue tack

Experiment 1:
1. Place the basketball on the skateboard.
2. Mark on the ground, the position of the ball.
3. Pull the skateboard away from the ball. Do it fast and parallel to the ground.

What happens to the ball?
**Experiment 2:**
1. Place the rod on the skateboard.
2. Place the plank 1 m away from the skateboard.
3. Secure the plank on the ground with a piece of blue tack.
4. Push the skateboard (together with the rod) towards the plank (Ensure that nobody is in the direction of the push).

What happens to the rod when the skateboard is suddenly stopped by the plank?

End of activity 1! Let’s head back in.
Dynamics - Activity Sheet 2
Aim: To understand and apply inertia concepts to examples.
Work with your partner.

Video demonstration 1: **Table cloth trick**
Address: [http://www.youtube.com/watch?v=zWeKRMh3kT8](http://www.youtube.com/watch?v=zWeKRMh3kT8)

1. What happens to the things on the table as the table cloth was pulled away?

______________________________________________________________________________

______________________________________________________________________________

2. Why do you think this happened? Explain applying Newton’s 1\textsuperscript{st} law.

______________________________________________________________________________

______________________________________________________________________________

Teacher demonstration 2: **Falling Eggs**
Address: [http://www.youtube.com/watch?v=STQRUzalH2M](http://www.youtube.com/watch?v=STQRUzalH2M)

3. What happened to the egg as the plate was pushed away?

______________________________________________________________________________

______________________________________________________________________________

4. Why do you think this happened? Explain applying Newton’s 1\textsuperscript{st} law.

______________________________________________________________________________

______________________________________________________________________________

5. List a few examples of inertia you might experience in your everyday lives.

______________________________________________________________________________

______________________________________________________________________________
Applet 1:

6. What do you observe happening to the driver?

______________________________________________________________________________

7. Why did that happen (Use Newton’s 1st law to explain)?

______________________________________________________________________________

8. What must the driver do to avoid the scenario shown on applet 1?

______________________________________________________________________________

Applet 2:

9. Why did that happen (Use Newton’s 1st law to explain)?

______________________________________________________________________________

10. What must the driver do to avoid the scenario shown on applet 2?

______________________________________________________________________________

Congrats you have completed the activity!
**Dynamics - Activity Sheet 3**

**Aim:** Draw conclusions on the relationship between force, mass and acceleration.
In groups of 4.

**Materials required:**
Long thin rubber band
Fairly large toy truck
Materials with mass - eg books, stones, sane or other small but heavy objects.

**Part 1: Relationship between force and acceleration.**

**Instructions**

1. Cut the rubber band and tie one end to the truck as shown above.
2. Place the truck on a smooth surface like a ceramic floor.
3. Let go of the truck and try to keep the rubber band at the same extended length as far as possible.

Is the truck accelerating?

________________________________________________________________________________

4. Repeat the experiment by stretching the rubber band even more than before.
5. Again keep the length of the rubber band constant.

Has the acceleration of the truck changed from before?

________________________________________________________________________________
Part 2: Relationship between force, mass and acceleration.

6. Pile some books, stones, sand or other small but heavy objects in the truck as shown above.
7. Repeat steps 3 and 4.

Do you notice any differences when each of these items are added to the mass of the truck?

______________________________________________________________________________

What is your conclusion about the relationship between force, mass and acceleration?

______________________________________________________________________________

Let’s share our conclusions!


**EXPERIMENT 6**

**Forces on a Moving Object**

**Aim**
To investigate the motion of a cart with variable mass acted on by a fixed force

**Objectives**
- deduce how the acceleration of an object is related to the forces acting on it.
- appreciate how scientific relations can be verified experimentally using data capture techniques.
- be proficient in handling data logging devices.
- analyse and manipulate data captured from data loggers e.g. plotting related graphs, calculating gradients and comparing with accepted values.

**Apparatus**
- data logger
- cart (with variable load)
- track for cart to move
- electronic balance
- smart pulley (photogate with wheel)

**Procedure**

1. Set up the experiment as shown. The smart pulley is basically a combination of a pulley and a photogate. As the wheel of the pulley rotates, the blades block the light beam at the photogate. The data logger records the change in the photogate signal with time and uses it to calculate the position, velocity and acceleration of the cart. The force sensor measures the tension in the string pulling the cart.

2. Connect the smart pulley to the data logger. Choose smart pulley as the sensor for one channel and force sensor for another channel to collect the data using the software provided.

3. Check that the track is horizontal. Mount the smart pulley at one end of track. Tie the string from the cart over the pulley to the hanging mass \(m'\). Check that the mass is a short distance (≈ 10 cm) from the ground when the cart just reaches the pulley.

4. Measure the mass, \(M\), of the cart using the balance. Place a hanging mass of 20 g to act as the external force.

5. Place a load, \(m\), of 200 g on the cart. Start taking recordings on the data logger and release the cart with load towards the pulley. Take note of the force reading \(T\) from the force sensor.

6. Repeat Step 5 with different values of load \(m\). Adjust the hanging mass \(m'\) such that the force reading, \(T\), is constant before taking recordings from the photogate.
7. Using the software provided with the data logging equipment, display the graphs of position, velocity and acceleration of the cart against time. Fill in the table below.

**Tabulation**

Mass of cart, \( M = \) _________ kg

Force acting on the cart, \( T = \) _________ N

<table>
<thead>
<tr>
<th>Total mass, ((M + m)/kg)</th>
<th>Acceleration, (a/m\ s^{-2})</th>
<th>Theoretical value for acceleration, (\frac{T}{M + m}/m\ s^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**Conclusion**

**Reflection**

- The experimental values may not be in agreement with the corresponding values calculated theoretically due to the presence of friction.

- It is important that the cart move freely on the track and the effect of friction minimised. The track must be level so that the motion of the cart is due only to the force applied. The string should be parallel to the track and aligned with the cart and pulley.

**Challenge Yourself**

- Modify the above experiment to investigate the change in acceleration of an object due to a different applied force.

- Think of how you can measure the acceleration of the loaded cart using a motion sensor.
Dynamics - Activity Sheet 4
Activity: Designing your own demonstration
Aim: Apply Newton’s 3rd law related examples.
Groups of 5

Have you ever thought about how the rocket works?

Instructions:
Materials given: 4 long party balloons, 4 round balloons, Nylon fishing line, 2 retort stands, metre rule, 1 scissors, masking tape, 5 straws.

1. Using the materials given, you are to design a demonstration to explain the science behind how the rocket works to your classmates. You are not expected to use all the materials given.

2. You can use any available space within the school court yard.

3. You are to complete the task in 25 minutes.
Bonus: If your balloon travels the furthest, you are in for a sweet treat!

How does the rocket work?
Dynamics - Activity Sheet 5
Aim: To recall and present the effects of friction in your daily life.
Location: Special room (larger than a classroom)

Instructions

Creation of information poster
- Work in groups of 5.
- Within each group, number yourselves from 1 to 5.
- You will be given markers, mahjong papers and blue tack.
- Use these materials to create a poster which states the positive and negative effects of friction in your daily life.
- Information presented on the poster can be done in any creative way you might think of.
- Once completed, choose a suitable location and pin up your poster using the blue tacks provided.

Delivery of information
- Once you have completed your poster, follow the teacher’s instructions and regroup according to your assigned numbers. Example: All the number 1s will regroup together.
- There will be approximately 8 members in your new group. There should be 5 new groups altogether.
- You will then take a gallery walk around the special room.
- Each group will choose a poster to start with and move in a clockwise direction.
- The original member of that poster has to present the information to the rest of his/her new group members.
- Give your group members time to ask questions.

Grading
- At the end of today, you are required to vote for the best poster.
- Visit my Google site- [https://sites.google.com/site/engageyourselves/](https://sites.google.com/site/engageyourselves/)

- Click on the link ‘3.5 - Friction’ and follow the instructions stated on that page.
- The winning group will receive additional points for their Continual Assessment grades.

Have Fun!
Chapter 18

D.C. Circuits

Objectives:

- Draw circuit diagrams with power sources (cell or battery), switches, lamps, resistors (fixed or variable), fuses, ammeter and voltmeters, bells, light-dependent resistors, thermistors and light-emitting diodes.

- State that the current at every point in a series circuit is the same.

- Apply the principle of current in a series circuit to new situations or to solved related problems.
Slide 4

Objectives:

- State that the potential difference across the separate branches of a parallel circuit is the same.
- Apply the principle of potential difference in a parallel circuit to new situations or to solved related problems.

Slide 5

Recap Lower Sec Work

Activity 1 - Recap basics on series and parallel circuits

- Complete this activity with your partner.
- Follow the instructions given in activity sheet 1.
- Have fun building your circuits.

Refer to activity sheet 1.

Slide 6

Work as we learn!

- Each pair is given a basket of wires, light bulbs, switches, resistors, voltmeters and ammeters.
- Build your circuits as we go along in the lesson.
- Check if the concepts are true for your circuits.

Students will have to build the circuits shown in the slides to prove the concepts are true!

Class discussion as students play and learn.

Students record their observations and readings on their activity sheet 2 as well. This serves as notes for them to look back on and keeps them focused during the lesson.
Slide 7

**Series Circuit**

Current in Series Circuit
- Current flowing through a series circuit is the same.

\[ I_1 = I_2 = I_3 = I_4 \]

Teacher gives students time to build the above shown circuit. Place light bulbs at the positions of the blue boxes in the diagram above. Direct students to connect the ammeter at the various positions in the circuit to test if the current is the same.

**Class discussion (Teacher records students’ responses on the board):**
- Is the current the same at the various points?
- How many paths do the electrons take in this circuit?

---

Slide 8

**Series Circuit**

Potential Difference in Series Circuit
- The sum of potential difference is equal to the potential difference of the whole circuit (e.m.f.).

\[ V = V_1 + V_2 + V_3 \]

Place the voltmeter across the light bulbs to measure the voltage at the various positions of the circuit. Voltmeter across: Light bulb 1, Light bulb 2, Light bulb 3 and battery.

**Class discussion (Teacher records students’ responses on the board):**
- What are your observations on the voltage readings?
- What do you get when you add the voltage readings together?
- What can you conclude about the current and voltage through a series circuit?
Students are to replace the light bulbs with resistors of the same resistance. Measure the current and voltage at the various positions.

**Class discussion:**
Using the formula, V=IR, calculate the resistance and check if it tallies with the resistance of the resistor. Calculate the combined resistance of the circuit.

Teacher allows students time to build the above shown circuit. Place light bulbs at the positions of the blue boxes in the diagram above. Direct students to connect the ammeter at the various positions in the circuit. Ammeter reading at: Before Bulb 1, Before Bulb 2, Before Bulb 3, After the battery, Before the battery.

**Class discussion (Teacher records students’ responses on the board):**
Record the current at the various positions. Do they add up to give I? How many paths do the electrons take in this circuit?
Slide 11

**Parallel Circuit**

**Potential Difference in Parallel Circuit**
- The potential difference across two points in a parallel circuit is equal to the potential difference across each branch in a parallel circuit.

\[ V = V_1 = V_2 = V_3 \]

Place the voltmeter across the light bulbs to measure the voltage at the various positions of the circuit.
Voltsmeter across: Light bulb 1, Light bulb 2, Light bulb 3 and battery

**Class discussion (Teacher records students’ responses on the board):**
What are your observations on the voltage readings?
What can you conclude about the current and voltage through a parallel circuit?

Slide 12

**Parallel Circuit**

**Resistance in Parallel Circuit**

\[ \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \]

Students are to replace the light bulbs with resistors of the same resistance. Measure the current and voltage at the various positions.

**Class discussion:**
Using the formula, \( V=IR \), calculate the resistance and check if it tallies with the resistance of the resistor.
Calculate the effective resistance of the circuit using the formula for effective resistance in a parallel circuit.
Recap the reason for why the resistances in parallel do not add up like those in series. This is because they have a different current in each resistor.
QUIZ TIME

- If you were an architect, deciding on how to arrange the light bulbs in a building,
- Would you connect 5 light bulbs in series or parallel?
- State reasons for it.

QUIZ TIME (Answers)

- Connect the light bulbs in parallel.

QUIZ TIME (Answers)

- **Reason 1**: In a parallel circuit, when one light bulb is faulty, the current can take other path, hence the other bulbs will still be lit. However in a series circuit, when one bulb is faulty, it will open the whole circuit, hence current cannot flow through.
Slide 16

**QUIZ TIME (Answers)**

- **Reason 2**: In a parallel circuit, the effective resistance is lower than the bulbs connected in series. Hence, the light bulb in the parallel circuit are brighter than bulbs in series circuit.

Slide 17

**Sum things up!**

- **Learning stations!**
  - Let's move around, play and have fun learning!
  - Work in groups of 5.
  - Follow instructions in the learning stations booklet.
  - Listen to the time cues given by the teacher and your group member.

Refer to Learning Stations Package.

Slide 18

**THE END!**
Chap 18: D.C. Circuits

Level: Secondary 4 Express

Key Concepts:
1. Drawing of circuits diagrams with common components, e.g. power sources, switches, lamps and resistors.
2. Characteristics of current and voltage in series and parallel circuits.

Prerequisite Knowledge:
1. Students have been taught the topic on Current Electricity.
2. Students are familiar with terms such as resistance, current, voltage and potential difference.
3. Students have the knowledge of connecting voltmeters and ammeters in a circuit.
4. Ohm’s Law has been introduced to the students.
5. Calculation of resistors in series.

Specific Instructional Objectives:
At the end of the lesson, students should be able to:
1. Identify series or parallel circuits.
2. Draw simple series or parallel circuit diagrams.
3. State that current at every point in a series circuit is the same.
4. State that potential difference of a series circuit is equal to the potential difference across the whole circuit, e.g. the source.
5. Calculate the effective resistance and draw an equivalent circuit for simple series circuits.

Common Misconceptions

- Voltage flows through a circuit.
- Charges move by themselves.
- Current is the same thing as voltage.
- There is no current between the terminals of a battery.
- A circuit does not have form a closed loop for current to flow.
- Current gets "used up" as it flows through a circuit.
- The resistance of a parallel combination is larger than the largest resistance.
- Current is an excess charge.
- Charges that flow in circuit are from the battery.
- The bigger the battery, the more voltage.
Challenging concepts

- Concepts on the relationship of the voltage, current and resistance in series and parallel circuits. (Activity sheet 1)
- Calculating combined resistance in a complex circuit. (Activity sheet 2 and learning stations activity)
- The concept that the combined resistance in a parallel circuit is lesser than the resistance of the individual resistor with the lowest resistance. (Activity sheet 2 and learning stations activity)

Lesson Package Resources

1. Self-prepared presentation slides
2. Activity sheet 1- Recap Circuit Basics
3. Activity sheet 2- Series and Parallel Circuits
4. Learning stations package;
   - Instructions page
   - Station 1-Voltage relationships
   - Station 2- Voltage and current relationships
   - Station 3- Parallel circuits
   - Station 4- Combined circuits
D.C. Circuits - Activity Sheet 1
Aim: Build and draw simple series and parallel circuits.

Instructions:
1. Click on the application that says **Activity 1- Series and Parallel circuits.** (From the destop)

You have the raw materials to create a circuit. Take a moment to look over the site and find all the different materials to build a circuit. To build a circuit, you will need several wires, a light bulb, a voltage source, a voltmeter, and a non-contact ammeter. Play around with the application to get familiar on how to grab and manipulate these tools. Click the reset button.

Part 1: Series circuit
2. Build a **simple series circuit.**

Build a simple series circuit that consists of 6 pieces of wires, 1 light bulb and 1 battery (voltage soure).

3. To complete the circuit, ensure that the red circles at the end of each component must overlap with each other. Please note the light bulb also has 2 circles.
4. Your circuit is complete when the light comes on and the blue dots begin moving.

Draw a diagram of your circuit.

What do you think the blue dots represent?
5. Use the tools at the right-hand side bar to get a voltmeter and a non-contact ammeter.

6. Place the voltmeter near the battery. Put the red tab at one end of the battery and the black tab at the other end.

   What is the voltage reading?

   ________________________________________________________________

7. Place the ammeter over the wire.

   What is the reading shown on the ammeter?

   ________________________________________________________________

   What can you conclude about the circuit?

   ________________________________________________________________

8. Right-click on the battery to play with the resistance and voltage of the battery. Record your observations on how this changes the readings on the voltmeter and ammeter (in the table below).

<table>
<thead>
<tr>
<th>Changes made with resistance of the battery</th>
<th>Changes made with the voltage of the battery</th>
<th>Voltmeter readings</th>
<th>Ammeter readings</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

9. Click on the advanced tab and alter the resistivity of the wire. Record your the changes in the voltmeter and ammeter readings.

   ________________________________________________________________

Once completed, let your teacher check your working series circuit.

Click on the reset button to begin working on a parallel circuit.
**Part 2: Parallel circuit**

1. Build a parallel circuit.

Parallel circuits provide more than one path for electrons to flow. Build a parallel circuit that consists of 10 pieces of wires, 2 light bulbs and 1 battery (voltage source).

2. Your circuit is complete when both light bulbs work and the blue dots begin moving.

Draw a diagram of your circuit.

3. Use the tools at the right-hand side bar to get a voltmeter and a non-contact ammeter.

4. Place the voltmeter near the battery. Put the red tab at one end of the battery and the black tab at the other end.

   What is the voltage reading?

   __________________________________________________________

5. Place the ammeter over the wires.

   What is the reading shown on the ammeter?

   __________________________________________________________

   How does this compare with your observation in the series circuit? Is this surprising? Why or Why not?

   __________________________________________________________
6. Right-click on the battery to play with the resistance and voltage of the battery. Record your observations on how this changes the readings on the voltmeter and ammeter (in the table below).

<table>
<thead>
<tr>
<th>Changes made with resistance of the battery</th>
<th>Changes made with the voltage of the battery</th>
<th>Voltmeter readings</th>
<th>Ammeter readings</th>
</tr>
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</tbody>
</table>

7. Right click on one of the wires connected to a light bulb. Remove the wire. What do you observe?

___________________________________________________________________________
___________________________________________________________________________

8. Does this affect the voltage or current readings? If so, how does it affect?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

9. Replace the wire. Now remove one the wires touching the voltage source. What happens?

___________________________________________________________________________
___________________________________________________________________________

10. What is the difference between removing the first wire and the second? Why is this significant?

___________________________________________________________________________
___________________________________________________________________________

End of activity 1!
D.C. Circuits - Activity Sheet 2
Aim: Understand the differences in the voltage, current and resistance in a series and parallel circuit.

Part 1: Series Circuit
   Is the current the same at the various points?

   
   How many paths do the electrons take in this circuit?

   

2. Voltage in a Series circuit.
   Voltmeter across: Light bulb 1, Light bulb 2, Light bulb 3 and battery
   What are your observations on the voltage readings?

   
   What do you get when you add the voltage readings together?

   
   What can you conclude about the current and voltage through a series circuit?

   

3. Resistance in a Series circuit
   Using the formula, V=IR, calculate the resistance and check if it tallies with the resistance of the resistor. Show your working here.

   
   Calculate the combined resistance of the circuit. Show your working here.

   

Part 2: Parallel Circuit

4. Current in a Parallel Circuit
   Ammeter reading at: Before Bulb 1, Before Bulb 2, Before Bulb 3, After the battery, Before the battery.
   Record the current at the various positions. Do they add up to give I?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
   How many paths do the electrons take in this circuit?
   ____________________________________________________________

5. Voltage in a Parallel Circuit.
   Voltmeter across: Light bulb 1, Light bulb 2, Light bulb 3 and battery
   What are your observations on the voltage readings?
   ____________________________________________________________
   What can you conclude about the current and voltage through a parallel circuit?
   ____________________________________________________________

6. Resistance in a Parallel Circuit.
   Using the formula, V=IR, calculate the resistance and check if it tallies with the resistance of the resistor. Show your working here.
   ____________________________________________________________
Calculate the effective resistance of the circuit using the formula for effective resistance in a parallel circuit.
EXPERIMENT 23

Combined Resistance

Aim
To derive the combined resistance formula for a series arrangement of resistors.

Apparatus
- ammeter (0–1.5 A or 0–3 A)
- accumulator (2 V)
- switch
- resistors of values \( r_1 \), \( r_2 \), and \( r_3 \)
- voltmeter (0–3 V)
- connecting wires

Objective
You are to:
- connect a complete electrical circuit, in particular the voltmeter and ammeter.
- show understanding that the voltmeter and ammeter will cause some disturbance to the voltage and current values.
- appreciate how a scientific relation can be derived experimentally.

Procedure
1. Connect the accumulator \( \varepsilon \), ammeter, resistors of values \( r_1 \), \( r_2 \), and \( r_3 \), and the switch in series, as shown in Figure 23.1.

2. Connect the voltmeter in parallel with the resistor of value \( r_1 \) (i.e., across terminals \( w \) and \( x \)). Record the voltmeter reading \( V_1 \).

3. Record the voltmeter readings \( V_2 \), \( V_3 \) and \( V \) when the voltmeter is connected across terminals \( x \) and \( y \), \( y \) and \( z \), and \( w \) and \( z \) respectively.

4. Record the ammeter reading \( I \) (Since the resistors are in series, the same current flows through them).
5. Calculate the values of resistance \( r_1, r_2, r_3 \) where \( r_1 = \frac{V_1}{I}, r_2 = \frac{V_2}{I} \) and \( r_3 = \frac{V_3}{I} \).

### Readings

<table>
<thead>
<tr>
<th>Voltmeter connected across terminals</th>
<th>Voltmeter readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>wx</td>
<td>( V_1 = )</td>
</tr>
<tr>
<td>xy</td>
<td>( V_2 = )</td>
</tr>
<tr>
<td>yz</td>
<td>( V_3 = )</td>
</tr>
<tr>
<td>wz</td>
<td>( V = )</td>
</tr>
</tbody>
</table>

\[ I = \]

### Calculations

Resistance \( r_1 \) across terminals \( w \) and \( x = \) \( \) \( \Omega \)

Resistance \( r_2 \) across terminals \( x \) and \( y = \) \( \) \( \Omega \)

Resistance \( r_3 \) across terminals \( y \) and \( z = \) \( \) \( \Omega \)

### Questions

1. From your values of \( V \) and \( I \), calculate the combined resistance across \( w \) and \( z \).

2. Draw the equivalent circuit of the one in Figure 23.1 using only one resistor with the combined resistance of \( r_1, r_2 \) and \( r_3 \). Include other essential electrical components required.
3. Hence, derive an equation relating the combined resistance to the individual resistances of the three resistors.

Reflection

- What assumptions have been made about the ammeter and voltmeter?

- To avoid introducing resistance to the circuit, ensure that there are no loose contacts e.g. when connecting and reconnecting the voltmeter.

Challenge Yourself

- Modify the experiment to verify the combined resistance formula for a parallel arrangement of resistors.
Dear students,

You are about to begin a wonderful experience of having fun whilst playing. You will work in your 5 member groups to answer the questions in the station activity sheets. You will be given 40 minutes to complete the 4 fun and exciting learning stations. You are to spend 10 minutes in each station. Have fun!

**Instructions:**

1. Follow the instructions in your booklet for each station.
2. Assign the following roles to members in your group;
   - Time keeper x2 (Keeps track of the 10 minutes for each station)
   - Leader
   - Worksheet filler
   - Materials in-charge
3. Follow the sequence of stations informed to you by your teacher or the sequence in which your worksheets are arranged.
4. Please close or reset the applications before you move on to the next station.
5. Strictly keep to the allocated 10 minutes to ensure smooth flow of the lesson.
You are given 10 minutes for this station
Aim: Observing voltage relationships
Using the batteries, masking tape and voltmeter given in the basket, try the following:

Label three batteries 1, 2 and 3 with masking tape. Measure the voltage of each separately and record the real voltage in the table below. Then hold the batteries end to end as below to measure voltage for combinations.

<table>
<thead>
<tr>
<th>Battery</th>
<th>Voltage (V) Real</th>
<th>Voltage (V) Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1+2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1+2+3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Describe the relationship between the number of batteries and the voltage and explain what you think might be happening.

___________________________________________________________________________

Click on the application: Circuit Construction Kit (from the desktop) to do the same procedure.

2. How does the real world data differ from the simulation?

___________________________________________________________________________

3. Explain what might cause the differences.

___________________________________________________________________________

You have completed this station. Move on to the next station and try the activity!
Station 2

You are given 10 minutes for this station.

Aim: Using voltage in a series circuit.

Click on the application: Circuit Construction Kit (from the desktop). Build the circuits with a battery of 12 volts as shown below. Record bulb brightness with descriptive language.

<table>
<thead>
<tr>
<th>Figure 1</th>
<th>Figure 2</th>
</tr>
</thead>
</table>

![Circuit Diagrams]

<table>
<thead>
<tr>
<th>(# of bulbs</th>
<th>Battery voltage (v)</th>
<th>Current into battery (A)</th>
<th>Brightness of bulbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Summarize the relationships you observed and explain what you think is happening.

______________________________________________________________________________
**Aim: Observing voltage and current relationships**

Using the materials given in the basket set up the circuit as shown below.

```
  V
 /   /
 |   |
  |   |
  A
```

<table>
<thead>
<tr>
<th>Battery voltage (v)</th>
<th>Current into battery (A)</th>
<th>Calculate resistance using ( V=IR )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. What would happen to the ammeter readings if the number of batteries were reduced? (If you are unsure, try it out with the materials in the basket.)

______________________________________________________________________________
______________________________________________________________________________

You have completed this station. Move on to the next station and try the activity!
Station 3

You are given 10 minutes for this station.

Aim: Understand Parallel circuits

Click on the application: Circuit Construction Kit (from the desktop). Build the circuit as shown in figure 1. Take readings in different places as shown in figure 2 by moving the meters. Record your values in the table shown below. Calculate total resistance using ohm’s Law (V=IR) for the last column.

<table>
<thead>
<tr>
<th>Resistor number</th>
<th>Measured R(Ω)</th>
<th>Voltage (V)</th>
<th>Current(A)</th>
<th>Calculated R(Ω) (powered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Not measurable</td>
<td>V_T reading</td>
<td>A_T reading</td>
<td>R_T=V_T/I_T</td>
</tr>
</tbody>
</table>

1. How is the total resistance related to the individual resistances?
Hey guys! Congrats you have completed this station early. If you have enough time before your 10 minutes is over, you can attempt this question for bonus points.

**Bonus Question:**

Imagine you and your friend are running through the neighborhood like electrons flowing through a circuit. Write stories that would serve as analogies for a parallel versus series circuits.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

You have completed this station. Move on to the next station and try the activity!
You are given 10 minutes for this station.

**Aim:** Build circuits from schematic drawings and provide reasoning to explain the measurements in circuits.

**Instructions:**

1. Open the application: Circuit Construction Kit (from the desktop).
2. Drag 3 resistors onto the work area. Right-click on each to make the resistances different from one another. Record the individual resistances in the table below.
3. Build the circuit as shown in figure 1, with the various tools given in the application.
4. Complete the table with measurements of the voltage across each resistor and the power supply.
5. Measure and record the current through each resistor and the total current form the power supply.
6. Show all your workings clearly in the table provided below.

![Figure 1](image)
<table>
<thead>
<tr>
<th>Resistor</th>
<th>Individual resistances (Ω)</th>
<th>Current (A)</th>
<th>Voltage (V)</th>
<th>Resistance in the circuit (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><em>(Theoretical)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You have completed this station. Move on to the next station and try the activity!
Instructions:

- You are to complete this challenge with your partner.
- You can use the Circuit construction kit application to build and check your circuits.
- The final submission must be an actual circuit, built using the given components.
- Electrical components required for this challenge is in the lab baskets provided.
- Your circuit submitted must be working. If it fails to do so, you are out of the competition.
- Your score depends on the highest level you complete.

Levels:

1) Make a light bulb light brightly using 4 batteries.
2) Add an on/off switch.
3) Make 3 light bulbs light brightly with all 3 with the same brightness (same amount of current, Amperes).
4) Have a switch that turns on/off 2 of the 3 light bulbs.
5) Have a switch that turns on/off all 3 light bulbs.
6) Make a circuit with one main on/off switch that will turn on/off all 3 light bulbs, each with a different brightness. Use an Ammeter to check for the different currents.
7) Change the circuit so that 1 switch will turn on/off all the light bulbs and a second switch will change the lights from all being the same brightness to all being different brightnesses.

The team with the first and best submission will be entitled to 3 additional points. These points will be added to your Continual Assessment Scores. Both members in a team will receive the same score.

Have Fun!
We can produce a current by moving a conductor in a magnetic field!!!

Who is he?
What did he discover?
When?

• Students would have been given the task to research briefly on Faraday’s history prior to this lesson.
• They are to share what they have read up with their fellow classmates.
• Volunteers will present their information to the class whilst the teacher notes a few important points on the board.

Rationale:
• Introduction to famous scientists will help cultivate their liking for science.
• Add on to their knowledge
• Creates the excitement for what is going to be taught in the chapter.

http://scienceworld.wolfram.com/biography/Faraday.html
Slide 3

**Electricity**

- Where does electricity come from?
- How do we get our electrical appliances in our homes and schools to work?

Slide 4

**How do we produce electrical energy?**

- The hydroelectric dam

- Grand Coulee Dam in USA
- Do you recognize this place?
- Hydroelectric power in Marina Barrage

Slide 5

**The Generator**

- Device in power plants that transforms mechanical energy into electrical energy.
- This generator produces alternating current which is then transported to our homes.
Slide 6

**Electricity in Singapore**

- Oil and Gas-power plants (e.g. Senoko, Tuas)
- Why are other forms of electrical energy production not feasible in Singapore?

Can anyone tell me the location of the Senoko power plant

Slide 7

**Learning outcomes**

- **Electromagnetic Induction (Part 1)**
  - E.m.f is induced due to changing magnetic field.
  - Factors affecting the induced e.m.f.
  - The direction of the induced current.

- **The a.c. generator (Part 2)**
  - How it works.

Slide 8

**Learning Outcomes**

- **The transformer (Part 3)**
  - Structure and how it is used for voltage transformations.
  - Apply two new equations to solve related problems
  - Describe energy loss and advantages of high voltage transmissions.
Aim: To understand the principles of electromagnetic induction. Through this activity students will explore and construct the principles of electromagnetic induction. The teacher acts as a guide and leads them to the concepts.

Part 1: Inducing an e.m.f.

- A changing magnetic field or the cutting of magnetic lines of force inside the coil can induce an e.m.f and hence a current, in a circuit.

This method of producing electricity is called electromagnetic induction.
Slide 12

Part 2: Direction of Induced E.M.F.

- When the N pole of the magnet moves towards the coil, the induced current makes end A of the coil a North pole (Repulsion).
- The induced current opposes the change producing it.

---

Slide 13

Part 2: Direction of Induced E.M.F.

- When the N pole of the magnet is moved away from the coil, the direction of the induced current is reversed, making end A a South pole (Attraction).
- The motion of the magnet is again opposed.

---

Slide 14

Lenz Law

- The direction of the induced current is such that its magnetic effect always opposes that change producing it.
Lenz’s Law

- Energy is conserved. (Conservation of energy)
  - Mechanical (kinetic + potential) energy of the work done against opposing force of the moving magnet is converted into electrical energy.

Fleming’s right-hand rule

- Determines the direction of the induced current.
- Label your first 3 fingers in your right hand.
  - Thumb – F (Motion or force)
  - First finger – B (Magnetic field)
  - Second finger – I (Induced current)

Students can try out a few questions from the textbook, to get themselves familiar with determining the direction of the induced current.

Factors affecting the magnitude of induced e.m.f. (Activity 2)

- Follow the instructions in activity sheet 2 and carry out the experiment.
- Discuss with your partners and answer the questions.

Aim: To understand the factors affecting the size of E.M.F induced. Once again the concepts are introduced through this student-centered activity.
Slide 18

Factors affecting size of induced e.m.f.
(Summing up activity 2)

- Speed at which the magnet moves in and out of the coil.
- Strength of the magnet.
- Number of turns in the coil.

Slide 19

Faraday’s law of electromagnetic induction

- The electromotive force (e.m.f.) generated in a conductor (usually copper) is directly proportional to the rate of change of magnetic field.

Slide 20

Motor

- Do remember what a motor does?
- It uses electrical energy to rotate the coil to provide mechanical energy.

A.C. Generator

- Opposite functions to a motor
- A device that uses mechanical energy to rotate the coil to produce electrical energy.
- Structurally similar to a motor.
Slide 21

A.C. Generator–components

- Consists of a coil between the poles of a permanent magnet.
- The ends of the coil are connected to a pair of slip-rings in contact with carbon brushes.
- The slip-rings ensure that when the coil is rotated, the same end of the coil is constantly in contact with the same carbon brush.


Slide 22

Making our very own A.C. generator. (Activity 3)

http://www.youtube.com/watch?v=k7Sz8oT8ou0

- Follow the instructions in the demonstration video to create your own simple A.C. generator.
- Answer the questions in Activity sheet 3 (part 1).

Aim: To understand the components and principles of an A.C generator. Students will have fun making their own A.C generator and at the same time understand the components and principles.

Slide 23

Principle of your A.C. Generator

- When the magnets rotate, the magnetic field changes, inducing a current in the coil which lights up the light bulb.

Principle of the simple A.C. Generator

- When the coil rotates, the magnetic flux is cut by the coil and an alternating current is induced in the coil.

Refer to Activity sheet 3
Using Fleming’s right hand rule, the current flows from A to B and C to D.

After the coil rotates through 180°, the current flows from B to A and D to C.

The direction of the current induced is reversed and hence explains the alternating current / e.m.f induced in the coil.

The e.m.f induced is:
- alternating because the current induced in the coil is alternating.
- maximum (peak e.m.f) when the plane is parallel to the magnetic field.
- zero when the coil is perpendicular (horizontal) to the magnetic field.
Let’s think about it!

- Increasing the speed of rotation of the coil.

- Both the frequency of the alternating current and the rate of cutting of the magnetic lines of force will be doubled. (Maximum output also doubled)

---

- Increasing the number of turns in the coil.

- Frequency of output is the same but the output voltage is doubled.

---

- Using stronger magnets.

- Frequency of output is the same but the output voltage is doubled.

Refer to Activity sheet 3
Slide 30

Transformers

- What do we use or do if we wish to run a 12V train set from the 240V mains or change 2000V to 400000V for transmission in a power cable?
  - A transformer can be used.
  - Transformers are used in record players, radios, computers etc.

Slide 31

- A transformer consists of two coils with different number of turns each – the primary coil and the secondary coil.
- Wound on opposite sides of a soft iron core.
- An alternating current supply is applied to the primary coil.
- The secondary coil is connected to a small lamp.

Slide 32

How does it work?

- The ac. supply applied in to the primary coil will create a continually changing magnetic field in the iron core.
- Which then induces a current in the secondary coil, lighting up the lamp.
**Slide 33**

**Principle of transformers**

- **Step-up transformer** - more turns in the secondary coil than in the primary coil.
  - This makes its voltage.

- **Step-down transformer** - more turns in the primary coil than in the secondary coil.
  - This decreases the voltage.

<table>
<thead>
<tr>
<th>Secondary output voltage ($V_S$)</th>
<th>Number of turns in secondary coil ($N_S$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary input voltage ($V_P$)</td>
<td>Number of turns in primary coil ($N_P$)</td>
</tr>
</tbody>
</table>

$N_S \over N_P$ is called the **turns ratio**

---

**Slide 34**

**Show and tell!!! (Activity 4)**

- Working in pairs, follow the instructions given in activity sheet 4.
- Record your observations in your worksheets.
- Time to share and compare your observations with your classmates!!

---

**Slide 35**

**Transmission of Electrical Energy**

- Electrical power generated in a power station is transmitted over long distances to consumers using cables.

- Transmission cables have resistance and energy can be lost as:
  - Heat in the coils due to resistance of the wire.
  - Heat of the core due to induced current in it. (Can be reduced by making the core out of insulated soft iron in laminated strips.)

---

Aim: To understand the principles and purpose of the transformer.

Through the show and tell component, students get the opportunity to present and compare their observations with their classmates. This helps to create the learning from peer atmosphere in the classroom.
Students are required to visit the Google site and attempt a check-out quiz.

Please visit my googlesite to try the check-out quiz.

https://sites.google.com/site/engageyourselves/
Chap 22: Electromagnetic Induction

Level: Secondary 4 Express

Pre-requisite Knowledge

Students should be able to:
- To describe conventional current direction in a simple circuit, including using dots and crosses in three-dimensional space.
- Draw the pattern of the magnetic field due to currents in straight wires and in solenoids.
- State the effect on the magnetic field of changing the magnitude and/or direction of the current.
- Describe experiments to show the forces on a current-carrying conductor in a magnetic field.
- Apply Fleming’s left-hand rule.
- Demonstrate how a d.c. motor works.

Specific Instructional Objectives

By the end of the topic, students should be able to:

a. Deduce from experiments showing electromagnetic induction, such as a magnet entering a solenoid:
   (i) that a changing magnetic field can induce an E.M.F. in a circuit
   (ii) that the direction of the induced E.M.F. opposes the change producing it
   (iii) the different factors affecting the magnitude of an induced E.M.F.

b. Describe the principle of operation of a simple a.c. generator (rotating coil or rotating magnet) and the use of slip rings (where needed)

c. Sketch a graph of voltage output against time for a simple A.C. generator.

d. Describe the structure and principle of operation of a simple iron-cored transformer as used for voltage transformations.

e. Recall and apply the equations $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ and $V_pI_p = V_sI_s$ for an ideal transformer to new situations or to solve related problems.

f. Describe the energy loss in cables and deduce the advantages of high voltage transmission.

New Concepts and terms

- Induced current – Electrical current created in a closed circuit due to a changing magnetic field.
- Induced E.M.F – Electromotive force created in a circuit (closed or open) due to a changing magnetic field.
- Transformer – An electrical device used to change the voltage of an alternating current.
**Common Misconceptions**

- Generating electricity requires no work.
- When generating electricity, only the magnet can move.
- Voltage can only be induced in a closed circuit.
- Magnetic flux, rather than change of magnetic flux, causes an induced E.M.F.
- Water in dams causes electricity.

**Challenging concepts**

- A changing magnetic field can induce an E.M.F in a circuit (Activity 1).
- A.C Generator (Activity 3).

**Lesson Package Resources**

1. Self-prepared presentation slides
2. Activity sheet 1- Inducing E.M.F and directions, applet
3. Activity sheet 2- Factors affecting size of induced E.M.F
4. Activity sheet 3- A.C. generators, video demonstration
5. Activity sheet 4- Transformers
6. Check- out quiz

**Pre-Lesson preparation**

- Students would have been given the task to research briefly on Faraday’s history prior to this topic.
- They are to share what they have read up with their fellow classmates.
- Volunteers will present their information to the class whilst the teacher notes a few important points on the board.
Activity Sheet 1
Aim: To understand the principles of electromagnetic induction.
Part 1: Induce an electromotive force in a coil.
Instructions
1. For this activity, you will be working in groups of 4 to 5.
2. Pick a laptop nearest to your work station.
3. Click on the applet – Activity 1 (Inducing E.M.F and directions). If you are unable to find the link, ask for help from the teacher.

Let’s get started!
4. Click on the option, Bar magnet on the top of the page.
5. On the right hand side, check on the show field and show compass boxes.

Draw the magnetic field lines of the bar magnet.

6. Click on the option, Pickup coil on the top of the page.
7. On the right hand side, click on the light bulb icon under the heading indicator.
8. Drag the bar magnet into the coil.
What do you observe happens to the light bulb?

______________________________________________________________________________
______________________________________________________________________________

What is induced for the light bulb to light up?

______________________________________________________________________________

What happens to the magnetic field when the magnet is dragged into the coil?

______________________________________________________________________________


9. Hold the bar magnet stationary inside the coil. Write down what you observe and why.

______________________________________________________________________________
10. Try steps 8 and 9 a few times. Hence what can we conclude about electromagnetic induction from these observations? Discuss and write down your group’s opinions.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Move on to part 2!
Part 2: Direction of Induced E.M.F.

11. On the right hand side, click on the voltmeter icon under the heading indicator.
12. Check the show electrons box (bottom right hand side).
13. Ensure that the N pole of the bar magnet is pointed towards the coil. To change the polarity facing the coil, click on the tab Flip polarity.
14. Drag the N pole of the bar magnet into the coil. Observe the deflection of the pointer on the voltmeter. Is the deflection to the left or right?

______________________________________________________________________________

15. Hold the magnet stationary inside the coil. Does the voltmeter show a deflection?

______________________________________________________________________________

16. Move the N pole of the magnet out of the coil. Observe the deflection on the voltmeter. In which direction is the deflection?

______________________________________________________________________________

17. Click on the tab Flip polarity (S pole pointing towards the coil) and repeat steps 11 and 13. Note the direction of the deflections on the voltmeter.

What is the direction of the deflection on the voltmeter when the S pole enters into the coil?

______________________________________________________________________________

What is the direction of the deflection on the voltmeter when the S pole moves out of the coil?

______________________________________________________________________________

18. Leave the magnet stationary and drag the coil toward the magnet. Is there any deflection?

______________________________________________________________________________

What can you conclude about the direction of the induced E.M.F, relative to the direction of the change producing it (direction of magnet).

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Fantastic! You have completed the activity.
**Activity Sheet 2**

Aim: To understand the factors affecting the size of the induced E.M.F.

**Instructions**

1. Check if your basket has these items.
   - Center-zero galvanometer
   - Copper wire
   - 3 Bar magnets

2. Connect a copper wire coil (of about 10 turns) to the centre-zero galvanometer as shown below.

3. Plunge the N pole of a bar magnet into the coil. Observe the angle of deflection of the pointer on the galvanometer.

4. Repeat step 2, this time moving the magnet at a faster speed. Was the angle of deflection smaller or larger than that obtained in step 2.

___________________________________________________________________________

Hence how does the speed at which the magnet moves in and out of the coil affect the amount of current induced?

___________________________________________________________________________

5. Bind three bar magnets together with the N poles at the same end. Move this stronger magnet into the coil. Was the angle of deflection smaller or larger than that obtained in step 2.

___________________________________________________________________________

Hence how does the strength of the magnet affect the amount of current induced in the coil?
6. Increase the number of turns of the coil to 20. Move a single bar magnet into the coil. Was the angle of deflection smaller or larger than that obtained in step 2.

___________________________________________________________________________

Hence how does the number of coils affect the amount of current induced in the coil?

___________________________________________________________________________

From your observations, state the factors that affect the size of the induced current.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

Congratulations! You have completed the activity.
Activity Sheet 3  
Aim: To understand the components and principles of an A.C. Generator.  
Part 1: A.C. Generators.  
Follow the instructions in the demonstration video to create your own simple A.C. generator.  
http://www.youtube.com/watch?v=k7Sz8oT8ou0  

1. As the magnets rotate, what do you observe happens to the light bulb?  
______________________________________________________________________________  
______________________________________________________________________________  

2. What is induced for the light bulb to light up?  
______________________________________________________________________________  
______________________________________________________________________________  

3. Explain in your own words, how current is induced and what does it cause?  
______________________________________________________________________________  
______________________________________________________________________________  

Part 2: Directions of induced current in the coil.  
4. Using Fleming’s right hand rule, determine the direction of current flow in the coil.  
______________________________________________________________________________  
______________________________________________________________________________  

5. After the coil rotates through 180°, state the direction of current flow.  
______________________________________________________________________________  

Move on to part 3!
Part 3: Voltage output of an A.C. Generator.

6. Knowing that the current produced is an alternating current, how do you think the graph of induced E.M.F against time for a simple A.C. generator would look like?

7. How do you think the graph of induced E.M.F against time would look like if the speed of rotation of the coil is increased?

8. How do you think the graph of induced E.M.F against time would look like if the number of turns in the coil is increased?
9. How do you think the graph of induced E.M.F against time would look like if stringer magnets are used?

End of Activity 3!!!
Activity Sheet 4
Aim: To understand the principles and purpose of the transformer.

Resources required:
Two iron C Cores, 2 one metre lengths of insulated wire, a 1.5V cell, a clip, a variable resistor and a 0 - 100μA meter.

Instructions:
1. Set up the apparatus as shown in the diagram. There should be 10 turns on each coil (primary and secondary). Connect one coil to a light bulb.

What happens to the light bulb when the other coil is connected to the 1.5V cell?

______________________________________________________________________________

What happens to the light bulb when the other coil has a steady current flowing in it?

______________________________________________________________________________

What happens to the light bulb when the other coil is disconnected?

______________________________________________________________________________
2. Replace the 1.5V cell with a 1V A.C supply. The other coil remains connected to a light bulb.  
What happens to the light bulb?

______________________________________________________________________________

3. Now try reducing the number of turns on the secondary coil.  
What happens to the light bulb?

______________________________________________________________________________

4. Try reducing the number of turns on the primary coil.  
What happens to the light bulb?

______________________________________________________________________________

Describe and explain what happens if the C cores are slightly separated.

______________________________________________________________________________

______________________________________________________________________________

End of activity!
Dear students,
you are required to complete the following quiz before you move on to the next chapter. Good Luck!!!

* Required

Name *

Class *

Date *

Why is iron preferred to steel for use as the core of an electromagnet? *

- Iron is easy to magnetise and demagnetise.
- Steel is easy to magnetise and demagnetise.
- Iron is cheaper than steel.

What happens when a bicycle dynamo is connected across a moving coil voltmeter and turned slowly? *

- The pointer of the meter swings backwards and forwards randomly.
- A steady reading shows on the voltmeter.
- The pointer of the meter swings backwards and forwards in time with the rotation.

What do the brushes do in the A.C. generator? *

- Support the coil.
- Take the current in and out of the coil.
- Clean the generator.
How would you increase the voltage output of a generator? *
- Rotate the coil faster.
- Have fewer turns of wire in the coil.
- Rotate the coil more slowly.

A transformer is connected to a 240V a.c. supply to light up a 3W 6.0V lamp. What is the turn ratio of the transformer? *
- 1/2
- 1/40
- 2

A transformer with a primary coil of 1200 turns and a secondary coil of 120 turns has 240V connected to its primary coil. What is the output voltage? *
- 2400V
- 24V
- 5V

Which statement about a step-down transformer is true? *
- The output voltage is lower than the input voltage.
- The output power is greater than the input power.
- The output current is lower than the input current.

Why is electricity transmitted across the country at high voltage and low current? *
- It was generated at that voltage.
- To reduce energy loss in transmission.
- We use electricity at high voltage.

Congrats! You can now move on to the next chapter.
## Behavioral Engagement

**Tick your choice**

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How often have you thought of dropping out of school?</td>
<td>□</td>
<td>□</td>
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</tr>
<tr>
<td>2. When I am in class, I just pretend I am working.</td>
<td>□</td>
<td>□</td>
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</tr>
<tr>
<td>3. I follow the school rules.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>4. I get in trouble in school.</td>
<td>□</td>
<td>□</td>
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</tr>
<tr>
<td>5. I skip classes during school.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>6. I skip the entire school day.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>7. I try to stay home from school.</td>
<td>□</td>
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</tr>
</tbody>
</table>
**Cognitive Engagement**

Circle your choice

8. How important do you think an education is?  
   - Very
   - Not at all

9. How important do you think it is to get good grades?  
   - Very
   - Not at all

10. How important do you think the content you are learning in school is going to be in the future?  
    - Very
    - Not at all

11. How important do you think it is to have a good job or career after finishing school?  
    - Very
    - Not at all

12. I am getting a good education at my school.  
    - Yes
    - No

13. I want to go to college.  
    - Yes
    - No

Tick your choice

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
</table>

14. Most of my classes are boring.  

15. I learn a lot from my classes.  

16. I am interested in the work I get to do in my classes.  

17. When I revise my work, I ask myself questions to make sure I understand what it is about.  

18. I study at home even when I don’t have a test.  

19. I talk with people outside of school about what I am learning in class.  

20. I check my school work for mistakes.  

21. If I don’t know or remember a concept, I do something to figure it out, like look it up my textbook or notes.  

22. If I don’t understand what I read, I go back and read it over again.  

23. I try my best at school.  

24. I get good grades in school.
Affective Engagement

25. My first impression of school was…

26. My first impression of school was…

27. My first impression of school was…

28. I am happy to be at my school.

29. The teachers at my school treat students fairly.

30. I like most of my teachers in school.

31. The discipline at my school is fair.

32. Most of my teachers care about how I am doing.

33. Most of my teachers know the subject matter well.

34. There is an adult at school whom I can talk my problems to.

35. I respect most of my teachers.

36. Most of my teachers understand me.

37. I feel excited by the work in school.

38. My classroom is a fun place to be.

39. I enjoy the work I do in class.

40. I feel I can go to my teachers with the things that I need to talk about.
Student Engagement Walkthrough Checklist

Observations

<table>
<thead>
<tr>
<th></th>
<th>Very High</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Very Low</th>
</tr>
</thead>
</table>

**Positive Body Language** □ □ □ □ □
Students exhibit body postures that indicate they are paying attention to the teacher and/or other students.

**Consistent Focus** □ □ □ □ □
All students are focused on the learning activity with minimum disruptions.

**Verbal Participation** □ □ □ □ □
Students express thoughtful ideas, reflective answers and questions relevant or appropriate to learning.

**Student Confidence** □ □ □ □ □
Students exhibit confidence, can initiate and complete a task with limited coaching. They can work in a group.

**Fun and Excitement** □ □ □ □ □
Students exhibit interest, enthusiasm and can use positive humor.
Perceptions

<table>
<thead>
<tr>
<th></th>
<th>Very High</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Very Low</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Attention</strong></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Students feel comfortable seeking help and asking questions.</td>
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</tr>
<tr>
<td>Question to ask: What do you so in this class if you need extra help?</td>
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</tr>
<tr>
<td><strong>Clarity of Learning</strong></td>
<td>□</td>
<td>□</td>
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</tr>
<tr>
<td>Students can describe the purpose of the lesson or unit. This is not the same as being able to describe the activity being done during class.</td>
<td></td>
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<tr>
<td>Questions to ask: What are you working on? What are you learning from this work?</td>
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<td></td>
</tr>
<tr>
<td><strong>Meaningfulness of Work</strong></td>
<td>□</td>
<td>□</td>
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<tr>
<td>Students find the work interesting, challenging and related to learning.</td>
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<tr>
<td>Questions to ask: What are you learning? Do you find this interesting? Do you know why you are learning this?</td>
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<tr>
<td><strong>Rigorous Thinking</strong></td>
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</tr>
<tr>
<td>Students work on complex problems, create original solutions and reflect on the quality of their work.</td>
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<tr>
<td>Questions to ask: How challenging is this work? In what ways do you have the opportunity to be creative?</td>
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</tr>
<tr>
<td><strong>Performance Orientation</strong></td>
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<td>□</td>
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<tr>
<td>Students understand what quality work is and how it will be assessed. They also can describe the criteria by which their work will be evaluated.</td>
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<tr>
<td>Questions to ask: How do you know you have done good work? What are some elements of quality work?</td>
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</tr>
<tr>
<td><strong>Overall Level of Student Engagement</strong></td>
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</tr>
</tbody>
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F2-2