A STUDY OF COMBINING ACTIVE LEARNING TECHNIQUES WITHIN PROBLEM BASED LEARNING WHEN TEACHING MEDICAL STUDENTS IN A SMALL GROUP ENVIRONMENT.

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Abstract

Background

In recent times there has been a clamour against 'spoon feeding' (1) in medical education, something that has coincided with a drive to encourage medical students to participate in self-directed learning (SDL). This is all well and good; however an important variable should not be overlooked. The environment in which we are placing medical students is by no means a perfect arena for learning. The ward environment has changed dramatically since the introduction of the European Working Time Directive (2) (EWTD). The firm based structure, which supported undergraduates so well, is no longer present. The combinations of shift-working and ward-based teams have resulted in a transient workforce. Consequently there can be a lack of continuity in care for patients throughout their hospital stay. From personal experience, I have witnessed the adverse effects this environment has on educational opportunities for medical students. There is a new breed of junior doctors known as Clinical Teaching Fellows (CTFs) - doctors who are specifically devoted to teaching medical students. CTFs are a fantastic resource and provide an opportunity to bridge the gap between classrooms and clinical environments.

Objectives

This dissertation will look at incorporating active learning methodologies into Small Group Teaching (SGT), and to determine if this can help prepare clinical medical students for life on the wards. This preparation will entail equipping students with core knowledge that is readily retrievable. The term I have applied to this process is (PBL-SGT)-Fusion, as I have taken elements from traditional Problem Based Learning (PBL) and Small Group Teaching (SGT) when developing this style. (PBL-SGT)-Fusion can help prepare students for life in a challenging learning environment in order to maximise their learning opportunities. The primary objective of this study was to determine

if implementing active learning techniques would translate into improved student performance on a 'Post-test' paper. The initial cohort included Clinical Phase 3 (CP3) students. A secondary objective was looking at whether this kind of teaching could also be implemented with Clinical Phase 1 (CP1) students. Across both objectives, I wanted to ensure I developed a teaching process that was both psychometrically sound yet still enjoyed by the students. The overarching research questions therefore are as follows:-

1. 'Can a new teaching methodology incorporating active learning techniques be successfully developed and delivered?'
2. 'Does this translate into increased student performance in a written exam?'
3. 'Can the same method be used to deliver CP3 material to CP1 students?'

Methods

This study was performed as part of the Trauma & Orthopaedic teaching delivered to University of Nottingham Medical Students on placement at Lincoln County Hospital. A convenience sampling method (3) was used to enroll CP3 students to the study. Students were on the Musculoskeletal Diseases & Disorders (MDD) block for 8 weeks per rotation, with a maximum of 10 students per group. Due to this set up, SGT was always going to be a heavily utilised teaching methodology. The SGT environment is well suited to the (PBL-SGT)-Fusion approach as it permits incorporation of constructivist (4) approaches to learning. Students were exposed to active learning techniques including mind mapping the case and group Case Based Discussion (CBD). A total of 35 students (15 CP1 and 20 CP3) participated in this study.

A 'Pre-test' paper was given to students at the start of sessions to introduce the subject material. This also allowed for the activation of prior knowledge whilst identifying weaknesses and deficiencies in students' understanding. On completion, the 'Pre-test' papers were handed in and reviewed by the teacher to rapidly identify the baseline level of knowledge within the group, and adjust session difficulty accordingly. Following tutor review, the tutor facilitated a group CBD between the students. This took the salient elements of the case and summarised the group discussion on to a mind map. Finally, towards the end of their placement six weeks later, students sat a 'Post-test' paper covering all the cases under examination conditions. It is worth noting students were not allowed to keep the 'Pre- or Post-' test papers, and that they were unaware the same cases would be used in the 'Post-test' scenario. The reasons for distributing the 'Post-test' paper are three fold; to assess the impact of the teaching intervention and its effect on learning, to allow students to consolidate their knowledge via recall under examination conditions, and finally, to enable the teacher to check students are not leaving the placement with gaps in their knowledge or understanding.

I used a mix of descriptive and inferential statistics to analyze the data obtained in this study. The psychometric properties of items have been calculated including item difficulty and the reliability of test scores.

Results

This study was universally well received by students of all ability and stage. Many of whom would like more teaching in this style elsewhere in their medical curriculum. CP1 students found the process enjoyable and were able to comprehend and retain material traditionally taught at CP3 level. Interestingly there was no significant difference between performances of Undergraduate (UG) students on 'Pre-test' papers when compared to Graduate Entry Medical (GEM) students. One might expect GEM students to out-perform their UG colleagues, given their experience doing PBL on the GEM course, this was not the case. These findings for UG and GEM students were replicated in the 'Post-test' paper, in that there was no significant difference between their results. CP3 students generally outperformed their CP1 colleagues. However, a particularly interesting result is the CP1 students scoring a higher median mark on their 'Post-test' paper than CP3 students achieved on their 'Pre-test' papers.

Discussion

Given the current climate (5) within the NHS, a typical ward environment is far from an optimal setting for teaching. As medical educators, the temptation can be to increase classroom based teaching to compensate, however, I would argue we need to develop innovative ways of using time with students in the classroom to maximise their learning opportunities in clinical environments. We must be mindful of the environment we are preparing students to enter and learn in, as there is often a conflict between service provision and training. (PBL-SGT)-Fusion is an example of how innovative approaches can improve student engagement and attainment. Kirkpatrick's model has been applied when evaluating this curriculum intervention, for which the combined use of constructivist learning theory (6, 7) and implementation of active learning techniques have been central to its creation.

Conclusion

It is worth bearing in mind this innovative teaching technique so far has only been implemented by one teacher at one site with 35 students. Nevertheless, this study has proved that the introduction of active learning methodologies within SGT is both enjoyed by students and translates into improved performance in written examinations. (PBL-SGT)-Fusion has an advantage over traditional teaching methods, as active learning methodology is engrained throughout the educational process. Anecdotally students have reported a desire to alter their approach to learning having been introduced to such techniques.

An argument could be made for introducing this type of teaching earlier in students' clinical phases, then building on it by incorporating simulation. I have termed this approach 'Theory, Simulation, Practise' (TSP) and is introduced in 'Chapter 7.0) Recommendations & Suggestions for Future Research.' The idea behind the TSP approach is creating environments where students' learning maps with their curriculum, in a way we are actively preparing them for life as junior doctors. I believe this will lead to increased levels of engagement and satisfaction.

Chapter 1.0) Introduction

1.1.0) UK Undergraduate Medical Education

1.1.1) The Current State of Play

Undergraduate medical education within the United Kingdom is currently in a state of flux. With the introduction of nine thousand pound per annum tuition fees, there has been an attitudinal shift among students. A 'consumer' mentality to higher education is becoming more prevalent (8), as students are becoming increasingly responsible for a greater proportion of their training costs. Students can now find themselves taking loans and leaving medical school with around £100,000 of debt. The cost of training a doctor in the UK, over 10 years of studying and initial training (9), is in excess of £600,000 per undergraduate student. There are certainly challenges to meet the demand of higher expectation given university funding does not increase. Whilst higher education funding has implications for all subjects, Medicine, where graduates have patients' lives in their hands, is clearly a special case worthy of focused attention. In this dissertation I will discuss and evaluate the delivery, development and implementation, of a new hybrid teaching and learning style. I have termed this style (PBL-SGT)-Fusion, as it draws on elements from both traditional Problem Based Learning (PBL) and Small Group Teaching (SGT). I have been keen to implement a clinically contextualised problem solving basis to this teaching as such an approach will be of most use to students once they graduate and start practicing medicine (10).

1.1.2) Historical Perspective

The introduction of the European Working Time Directive (EWTD) resulted in several unintentional repercussions with respect to undergraduate education (2). The loss of a firm based structure has inadvertently led to the dismantling of an adequate mechanism to deliver an 'apprenticeship' model of teaching.

The first Wednesday in August has become colloquially known as 'The Killing Season', (11, 12) largely because all junior doctors become a grade more senior overnight. Front page headlines, regarding numerous healthcare scandals (5, 13-15), have seen the medical profession coming under increasing public scrutiny. Questions are also being asked about the adequacy of newly qualified medical graduates when it comes to having the skills and attributes required to undertake foundation training (16, 17). There is currently no standardised process through which final year medical students become foundation doctors. Given the potential for newly qualified foundation doctors to move away from the area in which they trained, this poses a patient safety issue (16-18). This may change in time, especially given the General Medical Council's (GMC) aspiration to introduce a national licensing exam before 2020.

Debate surrounding undergraduate medical education is not a new phenomenon. Over 35 years ago, undergraduate medical curricula were criticised for encouraging the passive acquisition of facts rather than promoting curiosity and exploration (19). The current debate in medical education is concerning the extent medical schools are preparing newly qualified graduates for life as foundation doctors (16, 17). This has been brought sharply into focus recently. If current GMC proposals for medical students to leave medical school with full, as opposed to provisional, registration becomes implemented this focus will only increase. It could also result in wide ranging overhauls in curricula, to ensure medical graduates are ready for the rigours of life as foundation trainees.

Just over 10 years ago, when considering undergraduate medical curricula, Burge (20) posed the question 'Are students being trained to meet future service needs?' This has subsequently been addressed with two major overhauls in postgraduate training, namely 'Modernising Medical Careers' and 'Shape of Training' (21, 22). Greenaway's proposals in the 'Shape of Training' review call for a broader based generic training, with the intention being trainees are able to manage the vast majority of conditions without specialist referral. Should these proposals become implemented within postgraduate medical training; change within the undergraduate arena will also be required. Currently students can be encouraged to learn material in compartmentalised blocks. This is inherently risky when it comes to wanting to produce holistic doctors with a broader knowledge base to their training (22). Without specific integrated teaching students may not fully appreciate how subject material links together. As medical educationalists I believe we must be aware of the potential situations students will face as doctors. Teaching in an integrated way using clinical cases means students will be in a better situation when it comes to applying their knowledge to clinical scenarios. Failure to teach in such a manner is, in my opinion, a wasted opportunity to further the medical profession. Furthermore, poor quality medical education may pose a patient safety risk further down the line.

1.1.3) The Rise of Clinical Teaching Fellows

The role of a Clinical Teaching Fellow (CTF) is relatively new and rapidly expanding (23). CTF posts did not widely exist when I was a medical student between 2004 and 2009. In all honesty the post has probably come into existence as a result of the 'ST3 bottleneck' (24). The growth in teaching fellow numbers represents a fantastic opportunity to provide the apprentice type teaching and training that has been lacking in recent years following the introduction of EWTD legislation (2).

1.2.0) My Role as a Clinical Teaching Fellow

As a CTF, I am in a privileged position to teach and train the next generation of junior doctors. I have used this as an opportunity to develop a curriculum of cases where students are encouraged to take a holistic approach to patients and the care they receive. On the whole this process has been positively received by students.

1.2.1) What is (PBL-SGT)-Fusion?

(PBL-SGT)-Fusion is the new teaching style I have developed. Key tenets of the (PBL-SGT)-Fusion process are 'Problem Based Learning' (PBL) and 'Small Group Teaching' (SGT). Encouraging active learning within these learning environments is vital for the acquisition and retention of knowledge (25). A recent meta-analysis of 225 studies (26) demonstrated failure rates on science related undergraduate degree courses, were significantly lower when active learning methodologies were utilised. It was also demonstrated students on traditional lecture based courses are 1.5 times more likely to fail than students on courses with active learning.

Before describing the (PBL-SGT)-Fusion process in 'Chapter 3.0) Methodology' I have considered the origins of PBL and SGT and how they relate to this new teaching style. My educational philosophy is included and relevant educational theory discussed.

1.2.2) Problem Based Learning (PBL) – Origins & Relevance to (PBL-SGT)-Fusion

The earliest origins (27) of PBL, as we know it today, can be traced back to 1920s France. Celestin Freinet, a primary school teacher returning from WWI, found himself in a predicament. The toils of war meant he was no longer able to deliver teaching in the traditional style, which invariably involved shouting at students - doing so would leave him terribly breathless. Out of circumstance a new teaching style was born!

In the last quarter of a century, PBL has been described as the most significant innovation (28) pertaining to professional education. It has also proved to be among the most divisive (29-31). The use of PBL in medical education is widely acknowledged as having its origins (32) at McMaster Medical School in the 1960s.

Before I started delivering and designing teaching, I was keen to interview students, having had minimal PBL exposure as an undergraduate. Opinion seemed to be polarised, possibly due to personal learning style, the way PBL was implemented, or a combination of both. These are all factors I have considered when preparing (PBL-SGT)-Fusion sessions. A common theme amongst both proponents and protagonists was the key role PBL facilitators play. Traditionally, an expert is not required to fill the facilitator role, however, the majority of students I spoke to felt a knowledgeable facilitator was essential. Another common theme was the potential for PBL sessions to go 'off tangent'. Skilled facilitators can quickly identify this and move discussion back on track. This requires a high level of skill and being able to resist jumping in and teaching.

I feel discussing case studies within the group is vital for maximising student learning as such this forms a significant part of (PBL-SGT)-Fusion. By having knowledgeable facilitators, discuss cases in which they have been intimately involved in delivering care, means there is a fantastic opportunity for students to benefit from rich discussion pertaining to the case. The (PBL-SGT)-Fusion format was devised following interviewing 19 students to determine their experience of PBL and SGT. The common themes from student interviews can be found summarised in Table 1).

Table 1) Summary of Positive & Negative Experiences of Students Prior Teaching

Positive Factors	**Negative Factors**
Basic building upon previous knowledge	Demoralising teaching
Clinical focus	Didactic - read from slide
Constructive feedback	Difficulties getting access to patients on wards
Interactive / friendly / encouraged to participate	Lack of interaction
Personalised to individual learning needs	Lack of structure of the teaching session
Put on spot but not humiliated	Lack of testing our knowledge
Low student : teacher ratio	Small group teaching essentially being lecture format
Tailored to learning objectives	Taught at the wrong level / not related to objectives
Well prepared / good structure	Teaching by humiliation

This table shows the themes from initial discussions I had with students while designing the (PBL-SGT)-Fusion process and cases.

1.2.3) Small Group Teaching (SGT) – Origins & Relevance to (PBL-SGT)-Fusion

It has been hypothesized that Socrates and his 'dialogues' were amongst the earliest examples of SGT (33). Research seminars held in Germany throughout the 1700s and tutorials held at Oxford University throughout 1800s have both contributed to the development of this method (34). Around the world SGT is a popular method of teaching in higher education, no doubt due to its flexible nature (35). Here in the UK the famous 'Oxbridge tutorials' are of particular significance within the literature (36).

SGT provides a unique opportunity to tailor teaching to the needs of individual students. This is a massive advantage over more traditional styles. It can however be resource intensive and often under-utilised. When I interviewed my first batch of students in August 2013, their views were aligned with these points. I was particularly surprised by the number of times SGT sessions were essentially delivered as a didactic lecture to a handful of people. This is unfortunate as when delivered appropriately, SGT can be responsible for great improvements in students' knowledge. A low student to teacher ratio with opportunities to test prior knowledge and check understanding are all important elements (35) that can contribute to successful SGT. From these discussions I came to the conclusion it is potentially quite difficult to test prior knowledge of all individuals in a group when delivering SGT in the traditional manner. This may explain the tendency for teachers to revert to delivering a mini-lecture in this environment. (PBL-SGT)-Fusion has been designed to revolve around the aspects that make PBL and SGT successful, whilst also incorporating active learning techniques.

1.3.0) (PBL-SGT)-Fusion

In this section I will summarise my educational philosophy as this was integral to the creation of (PBL-SGT)-Fusion. I will also consider medical student mentality, learning techniques currently utilised, GMC requirements of curriculum design and key educational theories central to the process.

1.3.1) My Educational Philosophy

I firmly believe high quality medical education is vital for shaping the future of our profession. I experienced a wide range of teaching styles as an undergraduate. Teaching by humiliation is thankfully less prevalent nowadays. I can also certainly remember inspirational teachers who provided the spark to stimulate further study. I aim to provide an inclusive environment to facilitate discussion of cases within the group. There is no such thing as 'a stupid question' and I am keen to emphasise this to all students. These principles have been implemented into the curriculum and are reinforced each time the material is delivered.

Within the teaching sessions, I am keen to encourage medical students' participation in active learning. A recent meta-analysis has clearly shown (26) that active learning is strongly beneficial when it comes to the retention and recall of knowledge; this will be of great benefit when training a new generation of junior doctors. The one caveat is ensuring students are aware of when the material they have learnt previously is out of date.

I have incorporated a range of active learning techniques into (PBL-SGT)-Fusion. These are summarised, with examples of how I apply them, in Table 2). Clearly content and delivery are inextricably linked. This is something I have looked to capitalise upon as (PBL-SGT)-Fusion has evolved, matching the most appropriate method of delivery to material covered. Students thrive on

high quality formative assessment (37). This is incorporated throughout the (PBL-SGT)-Fusion process and is discussed in 'Chapter 3.0) Methodology'.

1.3.2) Student Mentality

Traditionally medical education has been structured around a lecture based programme delivered by an authoritative faculty. It has been suggested (25) this provides an 'individualistic competitive' environment; something at odds with the co-operative multidisciplinary approach required for patient centered care. I find this an interesting dichotomy. It has long been acknowledged the inherent academic ability of medical students can compensate for inadequacies in course design, delivery and approaches to teaching (20). I have been struck by how many medical students progress having adopted a passive rote learning approach to their studies. I can empathise with them and on reflection these were the same techniques, perpetuated from GCSEs and A-levels, I used at medical school. As medical knowledge is vast and constantly expanding, it becomes difficult to grapple with the scope of subject matter when adopting such approaches. Superficial rote learning can result in large areas where there is a knowledge deficit, and in turn becomes a potential risk to patient safety. To counteract this, we must encourage students to learn in a more efficient and effective manner to cover more material, hence expanding breadth and depth of their knowledge. With patients' lives soon to be in new junior doctors' hands, as medical educators, we owe it to all involved to equip students with the skills, knowledge and attitudes required to fulfil the role of Tomorrows' Doctors (38).

Table 2) Summary of Active Learning Techniques Used in (PBL-SGT)-Fusion

Activation of prior knowledge
Identification of gaps in knowledge
Group discussion
Mind mapping
Thinking in pairs & sharing with the class

1.3.3) Curriculum Design – Content & Delivery

Two key considerations when designing any curricula are content and delivery (39). Content relating to medical degrees can vary between institutions. Although all courses lead to the same end point (provisional registration with the GMC) various teaching methods are employed to achieve this. These include PBL, SGT, traditional courses (pre-clinical and clinical) and Mixed Methods (MM). As far as possible, delivery should take into account different learning styles (40). An important thing I have come to appreciate is an efficient method of delivery, does not necessarily translate into an effective learning process. Although lecturing is incredibly efficient in terms of resources required, it tends towards a more passive learning style; this something shown to have a negative effect on examination performance (26). Thinking about content and delivery has been central to both creating and delivering (PBL-SGT)-Fusion.

1.3.4) Relevance of Educational Theory to (PBL-SGT)-Fusion Curriculum Design

When designing (PBL-SGT)-Fusion I was keen to incorporate key principles that are essential for day one FY1 doctors. I feel the accrual of such vital knowledge should not be left to opportunistic learning in clinical environments, as can currently be the case. Vygotsky, Wood and Kolb have greatly influenced this process. Definitions of their theories are outlined in 1.4.0) along with an explanation of how they are used within the (PBL-SGT)-Fusion process.

Constructivism is a collection of epistemological theories (6) concerned with integrating new into existing knowledge. The (PBL-SGT)-Fusion process is aligned with constructivist and experiential principles (41, 42) and utilises the best aspects of different teaching modalities.

I am acutely aware of how important it is to cater for Maslow's hierarchy of needs when creating a successful environment for teaching and learning. Table 3) gives examples of how (PBL-SGT)-Fusion has been designed to fulfil Maslow's hierarchy of needs. In 1.4.0) I discuss how relevant educational theory has been applied to (PBL-SGT)-Fusion. I hope through combining the most relevant learning theory and styles, I can provide an excellent educational framework around which to prepare clinical medical students for life as FY1 doctors.

Table 3) How Maslow's Hierarchy of Needs is Achieved in (PBL-SGT)-Fusion

Needs	Examples
Self-actualization	• Group discussions are structured but allow spontaneity. • Creative element to discussion with anecdotal cases. • Problem solving is actively encouraged with the 'Pre-test' paper, when students are working individually. • When 'rote' learning is required for certain facts I highlight this. • All other times I am keen to teach and encourage a deeper understanding of cases. • Also hypothetical discussion surrounding how they would feel dealing with certain situations e.g. discussing do not resuscitate status with patients.
Self-esteem	• I screen all the answers once the 'Pre-test' papers are collected. • For students who are less confident speaking to the group I specifically ask them to give their answers. (Which I have already checked as being correct). • This no doubt encourages the students and helps build confidence in their own ability and presenting skills. • Also students are allowed to research the topic once the 'Pre-test' paper is finished. They can then discuss this in the group CBD and builds confidence.
Social Love, Acceptance & Belonging	• To foster a sense of belonging within the group I try to keep group composition fairly constant. • I also foster a jovial competitive spirit between groups. • This is useful to ensure all groups get through the same material over the same timeframe. • I have only needed to alter group dynamics on one occasion. This was when three particularly immature students were having a negative influence on the rest of the group.
Safety & shelter – with order & structure	• The point about my only asking less confident students when I know they have an appreciation of the correct answer also contributes to a feeling of safety within these sessions. • I think it is important students are neither intimidated nor bullied, otherwise they would avoid attending. Attendance has been 100% for these sessions. • The format of delivering these sessions has been evolving. I now provide written instructions in addition to the verbal introduction to the course. • I have also started issuing stopwatches to students. Not only do they help provide accurate timing data but they also help maintain order. As one of the ground rules of the sessions is that everyone remains silent until everyone has finished. (A bleep of a stopwatch signifies this.) • The only other ground rule is that there is no such thing as a silly or stupid question. I feel this is particularly important to state considering I am trialing a new method of teaching which depends on group interaction.
Physical & Psychological	• In terms of meeting these needs I am always mindful of ensuring adequate breaks between cases. • I also always deliver this teaching in the largest seminar room.

1.4.0) Educational Theory & Definitions

In this section I will discuss how the educational theories proposed by Vygotsky, Wood and Kolb have influenced how students are taught via the (PBL-SGT)-Fusion process. Each of the theories is introduced below, with reference made to how they are relevant to my teaching - aspects that are particularly relevant have been *italicised*. The remainder of this section covers the differences between active and passive learning whilst introducing retrieval practice and mind mapping.

1.4.1) Vygotsky's 'Zone of Proximal Development' (ZPD)

"The distance between *actual developmental level* as determined by *independent problem solving* and the level of *potential development* as determined through *problem solving* under *adult guidance,* or *in collaboration with more capable peers*." (43)

1.4.2) Wood et al's 'Scaffolding'

"Those *elements* of a task that are *initially beyond the learner's capacity* removed, thus *permitting* concentration upon and *completion* of only those *elements* that are *within learner's range of competence*." (44)

1.4.3) Kolb's 'Experiential Learning Theory'

"Learning from experience; the *process* of *making meaning* from *direct experience*." (41)

1.4.4) Differences Between Active & Passive Learning Techniques

From my experience of teaching medical students, the most common learning styles I have encountered students using would be passive ones. I have found this to be particularly true among undergraduate students reading their first degree. Due to medical students' inherently intelligent nature there is the potential to continue with inefficient learning strategies, yet still progress through the course. The danger behind this approach, given the ever increasing body of medical knowledge, is there will become a point where students are no longer successful in employing passive learning

styles and will subsequently fail examinations. I was keen to incorporate as many active learning strategies into (PBL-SGT)-Fusion as possible. Michael and Modell (45) suggest case based learning, collaborative learning and inquiry based learning as useful active learning techniques. These methods are all included in (PBL-SGT)-Fusion.

1.4.5) Retrieval Practice & Mind Mapping

Karpicke (46) suggested retrieval practice as a useful methodology. This formed the educational theory behind the 'Post-test' element of the (PBL-SGT)-Fusion process. Mind mapping has also been included as a way of capturing the group CBD. The intention of this was to make the discussion relevant to the pre-existing knowledge of the group, thus tailoring each session to students' individual learning requirements.

1.4.6) Relevance & Application of Key Theories to (PBL-SGT)-Fusion

For each of the definitions in 1.4.0) I have *italicised* what I believe to be key concepts when these theories are applied in a medical education setting. This is further explored in Table 4) where I have detailed which elements of the (PBL-SGT)-Fusion teaching process relate to these theories.

The 'Pre-test' and group CBD format permits students to move through the 'Zone of Proximal Development' as described by Vygotsky. Making students sit the 'Pre-test' individually places them in a situation where they have to consider what they would do from a patient management point of view. Giving students immediate feedback starts them off on the journey of using cases to learn by experiential learning. Another benefit of the group learning environment is that students may experience less distress while discovering the limits of their knowledge from seeing others in the same situation.

I find scaffolding in medical education an interesting concept. From personal experience of tutoring over 150 students I have found there is definitely the potential for students to become overwhelmed when starting clinical work. Students may adopt various maladaptive coping strategies (47) attempting to mitigate exposure to stress. Such techniques sadly include avoidance of clinical situations wherever possible! There are many situations where medical students can feel marginalised. Wards are busy clinical environments. Students need to attend with not only a grasp of basic medical knowledge, but also an ability to apply that in real life practical situations. (PBL-SGT)-Fusion provides students with clinical situations they will be expected to handle and therefore introduces the concept of how to utilise wards as educational environments.

If maladaptive coping strategies are allowed to progress unchecked, it can either leave students paralysed by fear in finals examinations or unable to cope as FY1 doctors. I have found scaffolding useful to create structured clinical scenarios students can work through and discuss as a group. Students have reported feeling better prepared for ward-life and identifying learning opportunities following participation in (PBL-SGT)-Fusion. The acquisition of knowledge and the 'hidden curriculum' I impart from discussing additional anecdotal cases is helpful in getting students to this standard. This should bode well for their final examinations and life as FY1s. In the future I plan to look at students' examination results and see if there is a correlation with exam performance.

An important component of (PBL-SGT)-Fusion involves the introduction of simulating a clinical scenario via a paper case study. This is further elaborated upon in 'Chapter 3.0) Methodology' and 'Chapter 7.0) Discussion'.

Table 4) Application of ZPD, Scaffolding & Experiential Learning to (PBL-SGT)-Fusion

Learning Theory	Examples of Application
Zone of Proximal Development	Students interactions with cases and the amount they get correct highlights their 'Actual developmental level' though independent problem solving. Looking at the case as a whole illustrates the standard required of a competent 'Day 1 FY1'. Students then have chance to collaborate with 'More capable peers' to bridge the gap between actual and potential developmental level.
Scaffolding	Cases become sequentially more difficult, both as a collection of cases and within each individual case. Students are encouraged to recognise areas where they are competent and then further build around this core knowledge. Students learn how to break down complex clinical cases into areas they feel competent in and those they are not. This is similar to clinical practice when we are dealing with the unknown. By highlighting these key areas students need not worry about parts they do not know as it is highlighted as area for development.
Experiential Learning	All questions are based on real life case studies. I have then modified elements of the case to make it suitable for a medical student audience working towards becoming an FY1. Learning by working through these paper cases aids pattern recognition and helps students create schemata that can be accessed and utilized at a later date when faced with similar cases.

1.5) Multimodal Delivery & Non-Medical Analogies

Consider a fire safety talk. It may be considered efficient to deliver a lecture in a didactic fashion as this is quick and easy. In the vast majority of cases, where a fire does not occur, this will be 'ok'. However consider the situation where there *was a fire* and people suffered serious morbidity or even mortality. At this point greater emphasis may be placed on whether the material needed to avoid such fate, was presented in an appropriate manner. When it comes to catering for differing learning styles multi-modal delivery (48, 49) of content is vital for the successful dissemination and reinforcement of information. Since undertaking a Masters in Medical Education, I have taken a great interest in the ways core knowledge is delivered; a prime example is the safety briefing when getting on an aircraft. Sound, video, laminated sheets and an air stewardess all provide alternative means of delivering, essentially, the same information. I have applied the same logic to (PBL-SGT)-Fusion. As part of the Mid Staffordshire enquiry, Sir Robert Francis stated if the airline industry were run in the same way as the NHS, planes would be 'dropping out of the sky every single day'. I took great interest in his analogy given my desire to improve the NHS through medical education.

1.6) Research Questions

The overarching questions of this research are 'Can a new teaching methodology incorporating active learning techniques be successfully developed and delivered?' and 'Does this translate into increased student performance in a written examination?' This will be evaluated through analysis of both student feedback and comparison of 'Pre-test' and 'Post-test' marks. Initial evidence and reaction during the study indicated this was a positively received intervention. It would therefore have been unethical to teach another CP3/CP1 group with a more traditional format in the search of a true 'control group'. Once the methodology was finalised, a secondary research

question was 'Can CP1 students be taught CP3 material successfully using this methodology without being overwhelmed?'

Chapter 2.0) Literature Review

2.1) Introduction

The purpose of this literature review is to inform the design of the educational intervention used in this study. I was interested in developing a new style of teaching that involved active learning as a core component. I was keen to draw on the positive elements of existing styles, namely PBL and SGT, whilst avoiding the negative aspects of these teaching modalities. During my literature search, I identified publications exploring the use of these methods in medical education. Through identification of common themes, I hope to learn valuable lessons from such publications that I can incorporate into the study design. In addition to the history and origins of PBL and SGT, as previously outlined, this literature review will provide a sufficient evidence base to guide the intervention I would like to implement. A topic I am particularly interested in is looking at how these teaching styles are applied to achieving optimal learning environments. The literature searches were performed in conjunction with reading key papers from the teaching and learning, in addition to assessment modules, on the Medical Education Masters course. References were reviewed and relevant papers looked at to form part of a snowballing technique. These papers are referenced throughout this dissertation.

All search terms were entered in two different search engines (Google Scholar and PubMed). The 3 main areas of interest were "Problem Based Learning in Medical Education", "Small Group Teaching in Medical Education" and "Active Learning in Medical Education". In section 2.2, I have discussed how these searches were performed, and how the papers of interest were selected and applied to the (PBL-SGT)-Fusion process. All searches were confined to the English language. All relevant and freely available papers were reviewed, with abstracts reviewed if the paper was not available. If the abstract of any unavailable papers was deemed relevant, efforts were made to obtain the full text through the University of Nottingham Medical School Library.

2.2) Problem Based Learning in Medical Education

The initial search term 'problem based learning in medical education' yielded 683 results. Removal of patents and citations reduced this to 597. Papers were sorted by relevance. The first 15 pages of search results were reviewed, paying particular attention for summary articles, systematic reviews and meta-analyses. After 15 pages, the subject of papers became inappropriate for the purposes of this study. All titles and abstracts were reviewed, with full papers sought for those deemed relevant. In total, 5 key papers contributed from this search.

Jun Jin's recent systematic review in 2014 (50) looked at the impact of educational technology on PBL curricula. Of a possible 470 studies, the 28 that were selected for analysis covered a range of specialties including Medicine, Dentistry and Speech & Language Therapy. This review highlighted several factors contributing to a positive learning experience for students. These included 'authentic clinical cases' and an environment which provides a platform to elicit 'articulation, collaboration and reflection'. The generally positive effect of educational technologies in PBL was also noted; this subsequently influenced the choice of presentation technology utilized for (PBL-SGT)-Fusion, and is discussed in greater detail in 'Chapter 3.0 Methodology'. Students have commented on the high quality of clinical cases and excellent learning environment, both of which are discussed more in 'Chapter 5.0 Discussion'.

When PBL was originally introduced at McMaster Medical School, there was a fundamental desire to 'move away from a block structure' where content was 'rammed down the throats of students' and information invariably not retained (51). There was also an emphasis on encouraging active learning to facilitate the retention of facts. Over the past 30 years, since the introduction of PBL, it could be argued the focus on active learning has been lost with more of a shift towards Student Directed Learning (SDL) (52). As PBL groups often disperse, with students working on

elements of the problem in isolation, are we inadvertently encouraging students to compartmentalise knowledge? Rather than learning in an integrated way, students are potentially also able to persist with ineffective learning strategies.

It is widely acknowledged PBL traditionally involves the use of a facilitator rather than a teacher (53), however there are conflicting views about the effectiveness of this approach. Barrows (54) stated PBL tutors must facilitate students' thinking and reasoning skills in order to promote problem solving, whereas Maudsley specified (55) that the success of PBL sessions is dependent on the effectiveness of the teacher. There is quite a difference between these views.

These varying viewpoints caused me to consider how (PBL-SGT)-Fusion sessions would run in terms of student-teacher interactions. Feedback from my GEM students, who had previously participated in PBL, indicated their experience was vastly improved when facilitators could also step into the teaching role as required. The facilitator must resist the temptation to lecture in a small group setting, and requires the skills and judgment to ensure they do not prevent learning by discovery.

Another traditional element of PBL includes students determining their own learning objectives (30, 31). Considering I had to cover set learning objectives when delivering the curriculum to CP3 students, I was unable to let students come up with their own learning objectives and incorporate this element of PBL. However, this did enable me to implement a uniform teaching programme which can be delivered to repeated batches of students. This is important to ensure all students get broadly the same experience, and is therefore equitable.

Searching 'problem based learning' and 'medical education' yielded 2764 results, refinements 'Humans' and 'English language' reduced this to 2406 and 2214 respectively. The abstracts for the

first 200 results over 10 pages were reviewed. Of these results, 351 papers had free full text available. Those with a relevant abstract were reviewed in their entirety. Themes from these papers are discussed below. Supplementary searches originating from this included 'flipped classroom' and 'adult learning'.

Lee's 2002 paper (56) 'Monitoring the outcome of Problem Based Learning in Medical Education' reported at least two studies concluding graduates from PBL curricula demonstrated superior 'cooperation and interpersonal skills', (57, 58) and are better equipped for team working (59). These are desirable attributes for medical students and junior doctors to possess. This element of PBL is overwhelmingly positive and will be retained in the (PBL-SGT)-Fusion process.

This search identified several papers (60-64) on learning styles and their relevance to success in learning and practicing medicine. Dunn et al (65) defined the term 'learning style' as 'different and unique ways used by individuals as they prepare to learn and recall information'. As discussed in 'Chapter 1.0 Introduction', the importance of multimodal delivery cannot be underestimated. As such, the (PBL-SGT)-Fusion process involves dissemination of information via various mechanisms. I would like to further modify the (PBL-SGT)-Fusion process to cater for those who prefer experiential learning (41, 66). This will be achieved by adding simulation. The Theory, Simulation, Practise (TSP) approach is introduced in 'Chapter 7.0 Recommendations & Suggestions for Future Research' and will form the basis of extending this work.

An important distinction was made between superficial and deep learners by Gurpinar et al. in their 2013 paper (67) 'Do learning approaches of medical students affect their satisfaction with problem based learning?' A superficial learner is most interested in fulfilling the minimum requirements, therefore exerting the minimal effort required to be successful. This could be a by-product of the numerous exams medical students are expected to take. An aim of (PBL-SGT)-

Fusion is to demonstrate why time invested in deep learning will be beneficial, not only for exams, but in working life as a doctor. This is the main reason a pass mark has not been attributed to these papers. Students are encouraged to attain the highest possible score they are capable of, as all information will be useful when they begin working life.

Lauw et al's paper from 2011 looked at the implementation of a weekly medical quiz as part of test-based medical education (63). They concluded although quizzes may be a useful medical educational tool, in their experience interaction was limited due to low response rates. They hypothesized time constraints and fear of being wrong may be attributable as causes.

Although there is an element of test-based medical education in (PBL-SGT)-Fusion, the presentation of clinical cases that students work through individually and then discuss in a facilitator-led group creates a non-threatening environment. This allows students to identify deficiencies in their knowledge without fear of embarrassment in front of other students. I feel the limitations of test-based education as described by Lauw et al. are surmountable using the (PBL-SGT)-Fusion teaching methodology.

2.3) Small Group Teaching in Medical Education

There is a wealth of literature surrounding SGT but perhaps less so specifically concerning SGT in a medical education setting. My initial Google Scholar search 'small group teaching in medical education' yielded 39 results. Refining this search to 'medical education small group teaching' gave 13 results. The second search provided more relevant papers to this study, but the useful articles from the first search were also considered. All titles, abstracts and free full text articles were reviewed.

As long ago as 1975, Dow et al. (68) indicated whilst SGT was used extensively in medical education, as it has continued to be, in many cases the teacher assumed an authoritarian role and essentially delivered a mini lecture. This common pitfall remains a regular occurrence in medical education establishments across the country. The authors highlighted teachers working in this way failed to recognise and utilise the advantages of working in smaller groups. The major benefit of a lower student to teacher ratio is the opportunity for interaction between all members of the group including, including the tutor. This was considered when designing the (PBL-SGT)-Fusion sessions.

In 2013, Saleh et al. wrote about their experience of qualitatively assessing students' experience of small group teaching at Hawler College of Medicine, Iraq. It was commented upon several times that most teachers tended to deliver SGT as they would a lecture. A suggestion was made teachers should be trained in delivering SGT in order to adapt their teaching methods. This is certainly a consideration should the (PBL-SGT)-Fusion method be delivered at other sites. Another parallel with practice in the UK was the conflict which arose where clinicians were delivering teaching but had pressing clinical matters to attend at the expense of delivering teaching. CTFs (23) with dedicated time allocated for delivering teaching, would be the preferred mechanism for delivering (PBL-SGT)-Fusion.

The PubMed search included the terms 'small group teaching' and 'medical education' which yielded 132 results. All abstracts were reviewed. Of the initial search result, the 31 papers that were available as free full text were reviewed. The vast majority of these were relevant to this research. Something touched upon by Meo in 2013 (69) was the teacher's ability to handle students at both ends of the academic ability spectrum. Although medical students are inherently intelligent, there are numerous situations where ability level ranges. Thinking about this proved useful for developing (PBL-SGT)-Fusion. To ensure the brightest students remain engaged, they can be given the opportunity to teach and explain concepts to their peers (70). This is a well-recognised technique in SGT (35, 71, 72). The benefit of having a facilitator with knowledge of the cases ensures student discussions remain on track, whilst ensuring peer teaching remains relevant and correct.

2.4) Active Learning in Medical Education

The Google Scholar search term 'active learning in medical education' returned 101 results, all of which were reviewed. Although the benefits of active learning were commended, particularly when combining this approach with deep learning, (25, 27, 69, 73, 74) there was nothing similar to the (PBL-SGT)-Fusion process. A refined search of 'active learning' and 'medical education' returned 272 results, of which 87 were freely available as full text. The abstracts of the initial 272 were reviewed as well as the relevant papers freely available.

Active learning forms an integral part of the (PBL-SGT)-Fusion process. The 'Pre-test' methodology is pivotal to achieving this. Gaps in students' knowledge are flagged up at the beginning of each session. The way in which these deficiencies are highlighted within the context of a clinical case immediately shows the relevance of this information to their future role as an FY1 doctor. I have certainly found students pay more attention to the group CBD which follows the 'Pre-test' paper as they are keen to remedy gaps in their knowledge. The pre-existing evidence base

would suggest that, by incorporating active learning methodology into the (PBL-SGT)-Fusion process, we are maximising the potential for medical students to both learn and retain knowledge.

A common shortfall of medical educators is their tendency to deliver complex information in a format not conducive to optimal learning (75). Although cognitive researchers recommend a positive engagement to learning, this is often not achieved from the methods of delivery used by medical educators. From engaging in the literature, it is clear that incorporation of active learning into any teaching methodology is highly beneficial. For instance, student satisfaction levels are reported to be higher, (73) and as a result, they are likely to put increased effort in, which in turn leads to improved retention and recall (73) of knowledge.

2.5.0) Supplementary Searches & Key Terms

2.5.1) Flipped Classroom

The 'Flipped Classroom' concept is something that has recently become popular in educational literature (76, 77). As a teaching methodology, it is a type of blended learning (78). The lack of consensus over the definition of 'blended learning' means it can be hard to research (79). The idea behind a 'Flipped Classroom' approach involves students receiving material prior to their arrival in class. This is beneficial as it means a greater proportion of the teacher-student interaction can be devoted to providing a 'personalized education' (80). Although students do not receive material prior to their arrival at (PBL-SGT)-Fusion sessions, there is an element of 'Flipped Classroom' methodology applied, with the 'Pre-test' paper making the teacher aware of baseline knowledge level within the group. It is then possible to provide a tailored session according to the ability of the group and individual students where appropriate.

For all the virtues of a 'Flipped Classroom' approach, it has recently been argued that any benefits from such techniques are largely due to those of active learning (81). This is worth bearing in mind to ensure the focus remains on the active learning element.

2.5.2) Adult Learning

Given medical students are adult learners, consideration was given to how the learning environment could be made to suit them (82). Everything from room layout, to temperature and breaks were considered. This was also open to discussion as far as possible depending on students individual needs within a group.

There is a wealth of literature available concerning PBL and SGT in both medical and non-medical educational settings (30, 83). PBL has been a component of medical education for over 30 years and has come in and out of vogue. Recent publications have eluded to providing tips on how to best reinvigorate this as a teaching medium (84). These tips have been considered when planning the (PBL-SGT)-Fusion process. It has also been interesting considering, and retaining, the elements that make PBL and SGT particularly suited to adult learners.

Chapter 3.0) Methodology & Study Design

3.1) Introduction

In this chapter I will consider the research methodology and study design surrounding the curriculum intervention I have developed and implemented. This intervention was delivered to University of Nottingham Medical Students on placement at Lincoln County Hospital. There were certain set parameters regarding the number of students, their clinical stage and the time they would be with us in Lincoln. These aspects determined the number and length of cases. Sufficient material was required for students to consider over a two month placement. Convenience sampling was used meaning students who attended Lincoln for their musculoskeletal placement were included. This study was initially designed with CP3 students in mind and the process was piloted with them first. However once the content and delivery was perfected a secondary research question was considered. 'Could this methodology be applied to deliver CP3 material to CP1 students successfully?'

Students on placement with us have set learning objectives. As long as these are covered in sessions the specific teaching methodology varies between sites and is teacher dependent. As a medical student I can remember not necessarily always being prepared in the best way for life on the wards. I certainly found learning by case studies useful, and as a result, this forms a large part of (PBL-SGT)-Fusion teaching. Active learning techniques (75, 85) are vital for long term retention and recall of knowledge. These are the reasons why particular emphasis has been placed on including such techniques in the study design.

3.2) Study Design

Within any group of medical students, ability will vary. This is acknowledged, and a primary objective of (PBL-SGT)-Fusion is to challenge students at both ends of the ability spectrum. This was considered when designing the methodology.

A baseline level of understanding is established with students sitting a 'Pre-test' paper prior to the delivery of any teaching. The intervention termed '(PBL-SGT)-Fusion' is the way in which teaching is delivered. This is discussed further in section 3.7.0) of this chapter. A 'Post-test' is delivered a few weeks later. Students are unaware the 'Post-test' involves revisiting the 'Pre-test' cases combined as one long paper. It is worth noting students are not allowed to keep the original papers. This is to encourage learning via pattern recognition rather than the rote-learning of answers to cases. Clinical reasoning involves making use of past experience through pattern recognition and is an important skill for doctors to possess. It is something that can take many years to develop. (PBL-SGT)-Fusion has been designed as a mechanism by which learning through pattern recognition can be accelerated.

3.3) Sample Size & Sampling Method

Results for 35 students are analysed in this study. This number was determined by marking constraints, but data collection is ongoing. A total of 20 CP3 students participated in the study during their Musculoskeletal Disorders and Diseases (MDD) placement at Lincoln County Hospital, as it formed the basis of teaching I delivered to them. Of the 16 CP1 students that were placed at Lincoln during the study period 15 agreed to participate on a voluntary basis to give a total of 35 participants. The student who dropped out after one session did so because they were not keen on the social element of learning. It is interesting to note 13 of these students have expressed an interest in returning to Lincoln for their CP3 year to participate in a follow up study looking at the long-term retention of knowledge. Convenience sampling (3) a non-probability sampling method was used to recruit participants to the study. They were all students on placement at Lincoln County Hospital I was expected to teach. Ethical approval was not required. Following discussions I was advised given my CTF role this study falls under the remit of curriculum review and service evaluation - both aspects of my job I am contractually obliged to undertake.

3.4) Data Collection

The main instrument used to collect data was the (PBL-SGT)-Fusion question paper. This has been provided in its entirety on the CD Appendix. The content was determined by looking at the CP3 logbook and required learning outcomes for General Medicine, General Surgery and Trauma & Orthopaedics. Although the range of subject matter is fairly broad, cases are taught in an integrated way. I found real life clinical cases through which these objectives could be taught and assessed. Two early iterations of these questions were used on the first 19 students I taught. These results have not been included. Through discussing these preliminary questions with the students I was able to modify and reword questions as required to ensure there was no ambiguity. On finalising

the content, the presentation of the written cases was improved. Questions are presented in a format that displays the maximum mark available and a bullet point list to encourage students to cover distinct points in their answers, rather than saying the same thing in different ways. A total of 16 case studies were written initially equating to 2 cases per week for the CP3 MDD students who were on an 8 week attachment. When the material was delivered to the CP1 students, they managed to sit the first 11 cases in the time available to teach them. There is therefore a complete data set available for the 35 students who have sat both 'Pre- and Post-' test elements of the first 11 cases. It is worth considering the 20 MDD students completed the 'Pre- and Post-' test elements for the whole 16 cases. This was marked and data will be used in future research, however has been excluded from this dissertation.

The second instrument used to collect data on this intervention was a nationally recognised online teaching feedback tool known as an 'Observation of Teaching' form. This was developed by the Royal College of Surgeons and is delivered online through the Intercollegiate Surgical Training Programme website – www.iscp.ac.uk. This form allows participants to rate three domains of the teaching; 'Introduction', 'Presentation', & 'Conclusion' as one of either 'Outstanding', 'Satisfactory' or 'Development required'. This form can also be used to provide free text qualitative responses for the areas above, general strengths of the teaching and areas for improvement. This feedback has been collated and analysed in Tables 6 and 7.

3.5) Marking Process

I recruited volunteers though the Nottingham INSPIRE research programme. This is an initiative to connect those wanting to pursue a career in medical education with those currently conducting research in the field. A total of 13 students expressed an interest. I interviewed all of them to assess their suitability for the role. Essential attributes were a meticulous nature and a willingness to ask me for help if they were unsure. Applicants were asked to demonstrate the last time they performed a task that specifically required paying attention to detail. Of the 13 students 3 students felt the project was not for them. The remaining 10 were invited to training sessions I held to explain the methodology and marking process. Following the training 5 signed up to the project and we formed a close knit team where we worked together marking papers.

A shared marking scheme was developed in addition to my answers. This was to ensure inter-rater reliability was as high as possible. Markers were also asked to score the same page of a case at a time, rather than entire cases. This was to ensure intra-rater reliability was kept as constant as possible. All situations where there was any confusion over an answer were discussed with me and shared with the group. Markers were encouraged to take breaks every 40-45 minutes. Food and drinks were also provided. These steps were implemented in an attempt to mitigate examiner fatigue introducing bias.

3.6) Reliability & Validity of the Test

Before the (PBL-SGT)-Fusion cases were delivered to the first batch of students in the study the content validity was checked by two orthopaedic consultants and one anaesthetic consultant, Mr. Simon West, Mr. Mohammed Maqsood and Dr. Matthew Dolling respectively. To ensure satisfactory content validity, all cases were discussed with these consultants and their feedback

addressed. Item difficulty (Tables 9-19) and Cronbach Alpha (Table 20) for the test are illustrated in 'Chapter 4.0) Results' and discussed in 'Chapter 5.0) Discussion'.

3.7.0) (PBL-SGT)-Fusion - Procedure

In this section I will explain the procedure by which the (PBL-SGT)-Fusion methodology is applied. I will explain the classroom layout, and how the sessions are run. The statistical methods used to evaluate this methodology are also justified.

3.7.1) Classroom Layout

Various iterations of classroom layout were trialed during the development of the (PBL-SGT)-Fusion process. I found the process works best with the layout demonstrated in Figure 1). The seating layout involves a 'U' shaped table which is vital to the discussion element. There is a computer connected to an overhead projector at the front of the room. This computer is pre-loaded with materials for the session and a Bluetooth mouse. The teacher sits at the head of the 'U', but still 'amongst' the students, to facilitate discussion. The teacher is also far away from the overhead projector to prevent the temptation of lecturing to the small group. Behind the teacher is a white board, used for creating the mind map of the group CBD.

Figure 1) Anatomy of a (PBL-SGT)-Fusion Classroom

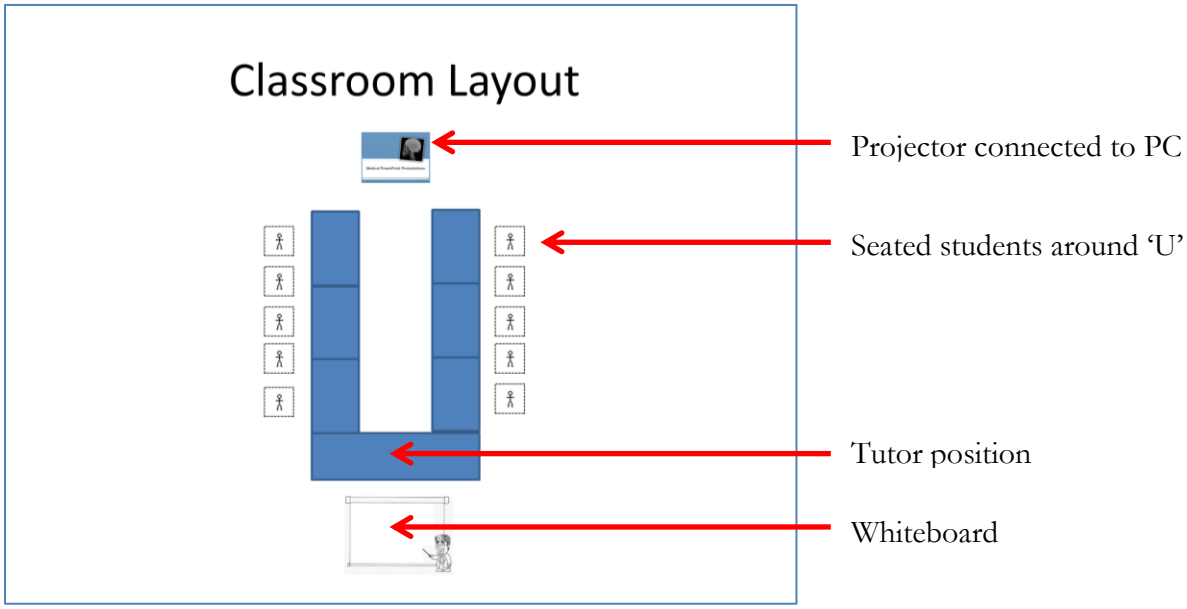


Figure 2) The Dangers of Traditional Small Group Teaching

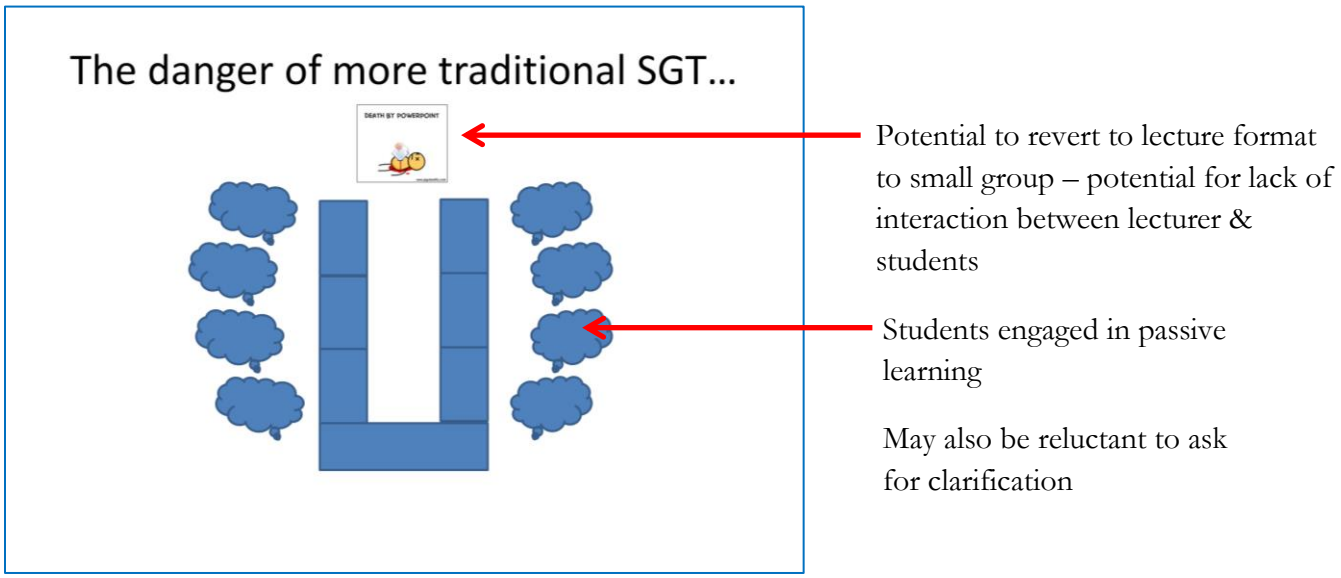
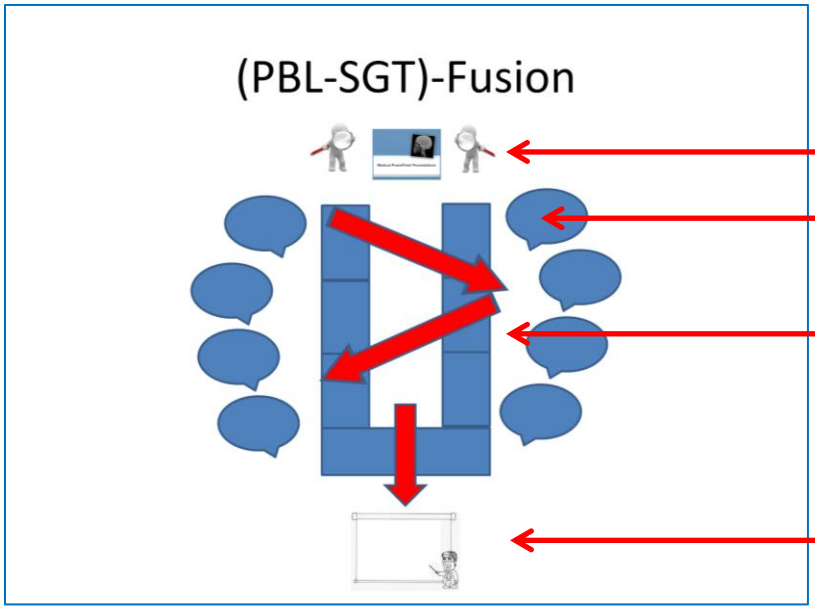


Figure 3) Anatomy of a Group Case Based Discussion in (PBL-SGT)-Fusion



Case displayed & answers revealed sequentially as discussed

Students volunteering answers practise their VIVA technique

Arrows demonstrate discussion about the case

Discussion, common themes and core generic knowledge distilled in to mind map form on whiteboard

Students are encouraged to take notes this way

3.7.2) The (PBL-SGT)-Fusion Process

The (PBL-SGT)-Fusion process can be divided into two distinct parts. These are summarised in Table 5). 'Part I' is delivered 16 times in total, once for each of the 16 clinical cases. The (PBL-SGT)-Fusion process is currently delivered over 5 days. The first 4 days involve the delivery of 4 cases per day. This process is described in 'Part I' in Table 5). 'Part II' is on the final day where the 'Post-test' paper is delivered and reviewed, with students receiving appropriate feedback. Note this describes the process as a whole as it is currently delivered. For the students in this study only the first 11 cases are looked at.

Table 5) Summary of (PBL-SGT)-Fusion Process

'Part I - Days 1-4' (a-c repeated for each case)	'Part II - Day 5'
a) 'Pre-test' paper	a) 'Post-test' paper
b) Tutor review	b) Tutor review
c) Group CBD & mind mapping	c) Corrective feedback as appropriate

This table summarises the (PBL-SGT)-Fusion process. The sub sections of each part are detailed from section 3.7.3) onwards.

3.7.3) 'Pre-test' Paper (Part Ia)

A key part of (PBL-SGT)-Fusion involves the activation of prior knowledge. This is achieved by means of the 'Pre-test' paper. Students are given a real life case study composed of short answer questions. They are required to sit the paper in examination conditions. When they have completed the case they hand their paper in and are allowed to leave. Highlighting areas in which students' knowledge is deficient is a vitally important part of the process. I have found allowing students to identify gaps in their knowledge early in the session is useful for captivating their interest throughout the group CBD. Students are encouraged to look into topics they were unsure of as the rest of the group are finishing.

3.7.4) Tutor Review (Part Ib)

As the 'Pre-test' papers are being handed in the tutor review process begins immediately. This is immensely valuable as it allows the baseline level of knowledge among the group to be gauged. This is useful in allowing the teacher to modify session difficulty accordingly. Areas of excellence can be identified, and such students are encouraged to present their answers in the group CBD. It also allows identification of subject areas that are answered poorly across the board. The range of answers can be shared with the students in the group discussion section. A key part of tutor review is the teacher having a detailed knowledge of the case. Ideally they should have written the case. This means they should be in a position to field any questions and expand on areas as appropriate.

3.7.5) Group Case Based Discussion & Mind Mapping (Part Ic)

The 'Pre-test' paper and tutor review are essential in making the group CBD a positive learning experience. They make the process different from more traditional SGT, which has the danger of potentially descending into a tutor delivering a PowerPoint presentation to a small group. More often than not such an approach means students are left either bored, disengaged or both. This is summarised in Figure 2). I chose a group CBD approach to be integral to the (PBL-SGT)-Fusion process as it fits well with constructivist (4, 7) principles concerning the acquisition of new knowledge.

3.8) Statistical Analysis

In this study a range of statistical measures were used. They included both descriptive and inferential statistics. Descriptive statistics were used for demographic information of participants as well as mean, median and standard deviation of marks obtained on their 'Pre- and Post- test' papers. Boxplots and histograms have been used to display this information in a graphical manner.

Inferential statistics, Mann Whitney U and Wilcoxon Rank Test were also employed to investigate any statistical differences between types of student and their performance on 'Pre- and Post-' test papers. Non parametric tests were used because of the relatively small sample size (n=35) it was considered unlikely data would be normally distributed.

Chapter 4.0) Results

4.1) Introduction

Within this chapter I have presented the results of my (PBL-SGT)-Fusion teaching intervention. There are two sources of results which will be considered. Firstly qualitative data on student opinion via online feedback forms. These are nationally recognised and administered via the Intercollegiate Surgical Curriculum Programme (ISCP) website. The qualitative data obtained from these has been collated and grouped into themes, both positive and negative, as presented in Tables 6 and 7). Quantitative data obtained from these forms is referred to in 'Chapter 5.0) Discussion' and presented in a summary table in Appendix I. The raw feedback forms from students (1-35) are provided in their entirety on the CD appendix.

The second source of data concerns student performance on 'Pre- and Post-' test papers. I will use these results to review the intervention in 'Chapter 5.0) Discussion'. Prior to presenting these results I will provide information concerning the reliability and validity of the test looking at item difficulty and Cronbach Alpha. It is important to consider these factors before planning a wider expansion in the delivery of this style of teaching. Throughout this chapter, to aid the reader when interpreting results, 'Pre-test' and 'Post-test' have been coded red and green respectively.

Table 6) Summary of Common Positive Themes (Students 1-35)

Theme	Material	Process	Facilitator	Students making comments (CP1 Response Students 11-25) (CP3 Response 1-10 & 26-35)	Number of Students
Good clear learning objectives.				1, 2, 3, 7, 8, 9, 10 11, 12, 13, 14, 18, 25 27, 30, 34, & 35	17
Key points summarized & emphasized.					
'Pre-test' an effective way to learn, good teaching method to identify gaps in knowledge.				1, 2, 3, 4, 6, 7, 10 11, 12, 13, 14, 24 28 & 34	14
Group discussion useful, non-threatening, inclusive, relaxed environment & enjoyable.				1, 2, 3, 6, 7, 9, 10 11, 14, 16, 17, 18, 23, 24, 25 26, 29, 30, 31 & 33	17
New interactive style of teaching.				2, 12, & 14	3
Wide range of topics.				2, 4, 6, 7 & 13	5
Knowledgeable / enthusiastic delivery, kept attention of group. Approachable & non-judgmental. (Questions welcomed).				3, 7, 8, 9, 10 11, 12, 13, 15, 17 26, 27, 32, 33 & 35	13
Would have been useful to do more.				3, 6, 11, 15 & 33	5
Logical, structured, systematic delivery of topics.				5, 10 12, 17 27, 28, 29 & 30	8
Key common topics.				6	1
Better format than current MCQ assessments.				6	1
Interesting.				6 & 15	2
Relevant.				6 & 29	2
Good use of technology & resources.				7, 9, 11 & 31	4
Good pacing / timing of sessions.				8, 9, 10 12, 13, 15, 16, 18, 21, 23 29, 30, 31, & 35	14
Guided to answers by being asked questions.				11 & 34	2
Concept of learning via cases in a clinical context.				11, 12, 14, 15, 19 & 25	6
Emphasis on understanding why & pathophysiology.				12	1
Enjoyed.				12, 19 & 25	3
Introduction to mind maps a useful & positive experience.				13, 14, 17, 18, 19, 23, 27 & 28	8
Varying question difficulty.				13	1
Shown how intimidating topics can be broken down and approached with application of logic and previous knowledge.				15	1
Useful to have concentrated at start of the placement.				30 & 31	2

This table shows common positive themes from students' qualitative feedback and CP stage.

Table 7) Summary of Common Negative Themes (Students 1-35)

Theme	Material	Process	Facilitator	Students making comments (CP1 Response Students 11-25) (CP3 Response 1-10 & 26-35)	Number of Students
More handouts.				1 & 11	2
Wasn't emphasized it included more than pure MDD objectives.				2	1
Some papers too long.				2	1
Diagrams would have made the process better.				2	1
Ambiguous questions / vague.				3, 4 & 28	3
Too fast paced.				4	1
Should be able to keep question papers.				4	1
More feedback on performance.				7	1
More patient contact.				8	1
Shorten final exam.				9 & 10	2
Sessions ran over time.				11, 19, 32 & 33	4
Overall conclusion lacking.				12 &13	2
Students would have preferred warning about the topics.				14 & 23	2
Discussion went off topic.				20	1
What to put at the center of the mind map unclear.				21	1
Sessions would be improved if started with a recap of the last session.				24 & 28	2
Would like to keep x-rays.				31 & 34	2

This table shows the common negative themes and whether these were from CP1 or CP3 students.

4.2) Descriptive Statistics

Table 8) Descriptive Statistics of Demographic Data (n=35)

Demographics	Subtype	Frequency	Percent
Course	Undergraduate	24	68.6
	Graduate Entry	11	31.4
	Totals	35	100
Stage	CP1	15	42.9
	CP3	20	57.1
	Totals	35	100
Gender	Female	23	65.7
	Male	12	34.3
	Totals	35	100

This table uses descriptive statistics to illustrate the demographics of students involved in the study. Just fewer than 70% of participants were undergraduates. The intervention was delivered to 20 CP3 students accounting for 57.1% of the total. Females outnumbered males by almost 2:1.

4.3) Item Difficulty Pre & Post Test Cases 1-11

Table 9) Case 1 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C1I1	**0.66**	**0.69**
C1I2	**0.30**	**0.81**
C1I3	**0.50**	**0.79**
C1I4	**0.31**	**0.34**
C1I5	**0.24**	**0.34**
C1I6	**0.32**	**0.35**
C1I7	**0.63**	**0.94**
C1I8	**0.46**	**0.66**
C1I9	**0.02**	**0.39**
C1I10	**0.29**	**0.44**
Average	**0.37**	**0.58**

Case 1 covers osteomyelitis. The item difficulty of C1I9 at 'Pre-test' was 0.02. This meant students found this challenging. This particular question looked at the mechanism causing bony destruction in osteomyelitis and why it is of clinical significance regarding presentation. C1I7 'Pre-test' item difficulty was 0.63; this was a one mark question regarding the most common route of spread. 'Post-test' this increased the most to 0.94. Meaning 94% of students got this information correct.

Table 10) Case 2 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C2I1	**0.50**	**0.56**
C2I2	**0.15**	**0.93**
C2I3	**0.11**	**0.39**
C2I4	**0.14**	**0.60**
C2I5	**0.09**	**0.36**
C2I6	**0.54**	**0.72**
C2I7	**0.19**	**0.42**
C2I8	**0.19**	**0.50**
C2I9	**0.46**	**0.79**
C2I10	**0.16**	**0.49**
C2I11	**0.16**	**0.42**
Average	**0.24**	**0.56**

Case 2 concerns abdominal trauma. C212 saw the most dramatic rise between 'Pre-test' and 'Post-test' item difficulty (0.15 to 0.93). This question was introducing the AMPLE mnemonic used for taking a history in a trauma setting. With the item difficulty increasing so much it would be interesting to see if this translates into clinical practise in a stressful situation.

Table 11) Case 3 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C3I1	**0.62**	**0.67**
C3I2	**0.66**	**0.69**
C3I3	**0.45**	**0.40**
C3I4	**0.40**	**0.41**
C3I5	**0.44**	**0.51**
C3I6	**0.36**	**0.57**
C3I7	**0.50**	**0.57**
C3I8	**0.63**	**0.67**
C3I9	**0.26**	**0.63**
C3I10	**0.60**	**0.77**
C3I11	**0.57**	**0.80**
C3I12	**0.26**	**0.74**
C3I13	**0.05**	**0.47**
Average	**0.44**	**0.61**

Case 3 looks at septic arthritis. A 'Pre-test' item difficulty of 0.05 for C3I13 probably represents the fact this question covers radiological changes of osteomyelitis. In the 'Post-test' this did not increase as much as I would have liked, 0.47, still means more people getting it incorrect than correct. Reflecting back this could be due to be not actually showing radiographs of these changes. This is something I will add to the teaching sessions in future.

Table 12) Case 4 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C4I1	**0.50**	**0.63**
C4I2	**0.25**	**0.35**
C4I3	**0.20**	**0.40**
C4I4	**0.19**	**0.28**
C4I5	**0.23**	**0.69**
C4I6	**0.46**	**0.69**
C4I7	**0.70**	**0.85**
C4I8	**0.46**	**0.31**
C4I9	**0.30**	**0.45**
C4I10	**0.36**	**0.51**
C4I11	**0.46**	**0.66**
C4I12	**0.59**	**0.74**
Average	**0.39**	**0.55**

Case 4 covers acute abdomen. 'Pre-test' for C4I7 is regarding assimilating a summary of the patient's history so far. It is probably too easy given all the information is on the paper. However is there to aid students understanding of the case as a whole.

Table 13) Case 5 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C5I1	**0.22**	**0.40**
C5I2	**0.20**	**0.30**
C5I3	**0.00**	**0.20**
C5I4	**0.34**	**0.61**
C5I5	**0.40**	**0.58**
C5I6	**0.16**	**0.24**
C5I7	**0.09**	**0.69**
C5I8	**0.32**	**0.43**
C5I9	**0.22**	**0.48**
C5I10	**0.13**	**0.33**
C5I11	**0.34**	**0.60**
C5I12	**0.21**	**0.34**
C5I13	**0.26**	**0.37**
C5I14	**0.54**	**0.74**
C5I15	**0.21**	**0.43**
C5I16	**0.11**	**0.40**
Average	**0.23**	**0.45**

Case 5 was definitely challenging and is about compartment syndrome. There were a total of 71 marks on offer and in hindsight is potentially too much for a single case study. This is reflected in the item difficulty not increasing dramatically between 'Pre-test' and 'Post-test' and not getting above 0.5 in the 'Post-test'. I think this was probably a case of too much new complex information and therefore became difficult to retain.

Table 14) Case 6 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C6I1	**0.25**	**0.40**
C6I2	**0.36**	**0.50**
C6I3	**0.73**	**0.79**
C6I4	**0.49**	**0.54**
C6I5	**0.18**	**0.36**
Average	**0.40**	**0.52**

Case 6 covers tension pneumothorax an incredibly important topic and a medical emergency. C6I3 covers the initial emergency management. 73% of students answered correctly. Looking at the rest of the 'Post-test' item difficulties they were all around or below 0.5. Perhaps this is the kind of topic better suited to delivery within a simulation environment to allow for experiential learning.

Table 15) Case 7 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C7I1	**0.23**	**0.89**
C7I2	**0.38**	**0.61**
C7I3	**0.46**	**0.46**
C7I4	**0.80**	**0.86**
C7I5	**0.49**	**0.80**
C7I6	**0.13**	**0.29**
C7I7	**0.29**	**0.51**
C7I8	**0.77**	**0.94**
C7I9	**0.26**	**0.61**
C7I10	**0.21**	**0.57**
C7I11	**0.24**	**0.44**
C7I12	**0.24**	**0.46**
Average	**0.38**	**0.62**

Case 7 looks at rheumatoid arthritis. C7I6 had the lowest item difficulty. C7I10 had the second lowest item difficulty. This was a question looking at a radiograph of the patient's wrist with significant changes as a result of the disease process. In the 'Post-test' the item difficulty more than doubled to 0.57. Radiology is an area of significant concern for medical students, so this was pleasing to see.

Table 16) Case 8 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C8I1	**0.31**	**0.58**
C8I2	**0.41**	**0.56**
C8I3	**0.07**	**0.24**
C8I4	**0.24**	**0.50**
C8I5	**0.04**	**0.50**
C8I6	**0.07**	**0.35**
C8I7	**0.20**	**0.19**
C8I8	**0.32**	**0.51**
C8I9	**0.30**	**0.60**
C8I10	**0.44**	**0.49**
C8I11	**0.34**	**0.49**
C8I12	**0.19**	**0.49**
C8I13	**0.25**	**0.46**
Average	**0.25**	**0.46**

Case 8 relates to ankle fractures. Items 3, 5 and 6 were particularly challenging. This has not been taught to students before in the course so this is expected and reflected in the low item difficulties.

Table 17) Case 9 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C9I1	**0.32**	**0.60**
C9I2	**0.91**	**0.91**
C9I3	**0.26**	**0.50**
C9I4	**0.35**	**0.46**
C9I5	**0.36**	**0.55**
C9I6	**0.38**	**0.62**
C9I7	**0.33**	**0.62**
Average	**0.42**	**0.61**

Case 9 covers carpal tunnel syndrome. C9I2 was answered well across the board, indicating this question was too easy. This was naming the nerve involved. What is interesting about these results is when asked to outline the distribution of nerves involved (C9I3) students found this much harder in both 'Pre-' and to a lesser extent in 'Post-' test papers.

Table 18) Case 10 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C10I1	**0.51**	**0.43**
C10I2	**0.14**	**0.40**
C10I3	**0.11**	**0.27**
C10I4	**0.17**	**0.46**
C10I5	**0.01**	**0.35**
C10I6	**0.34**	**0.63**
C10I7	**0.09**	**0.23**
C10I8	**0.07**	**0.23**
C10I9	**0.29**	**0.41**
Average	**0.19**	**0.38**

Case 10 covers fractured neck of femur and prescribing. C10I1 in this case was on radiology. Strangely 'Post-test' item difficulty decreased this may have been due to a printing issue which meant the fracture was not clearly visible. C10I9 covered prescribing skills. Item difficulty for this in both 'Pre- and Post-' test papers indicates more work would be beneficial in this area.

Table 19) Case 11 Item Difficulty (n=35)

	'Pre-test'	'Post-test'
C11I1	**0.17**	**0.43**
C11I2	**0.43**	**0.74**
C11I3	**0.15**	**0.44**
C11I4	**0.16**	**0.41**
C11I5	**0.51**	**0.67**
C11I6	**0.55**	**0.67**
C11I7	**0.44**	**0.63**
C11I8	**0.23**	**0.31**
C11I9	**0.01**	**0.20**
Average	**0.29**	**0.50**

Case 11 was concerning a patient with soft tissue swelling. C11I1 involved asking students to identify this abnormality on a radiograph. It is interesting to note students on the whole found this difficult on their 'Pre-test' papers.

Although all item difficulties have not been commented upon each case is provided in its entirety on the CD appendix. This is to allow the reader to appreciate the scope of knowledge covered in the (PBL-SGT)-Fusion sessions.

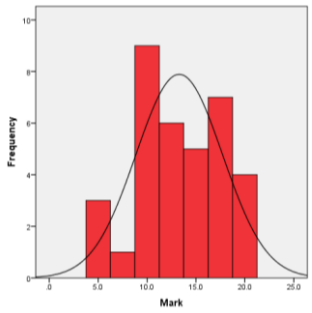
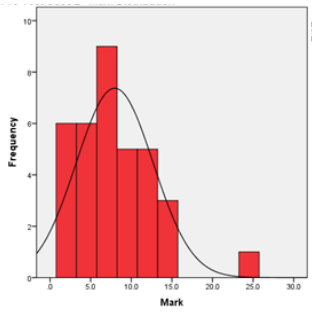
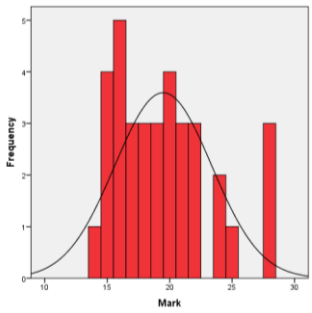
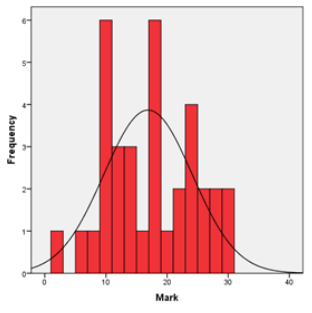
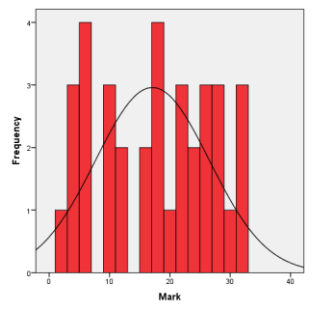
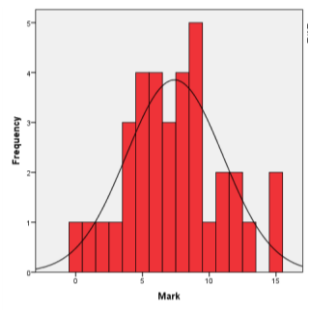
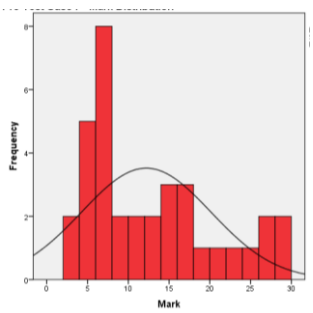
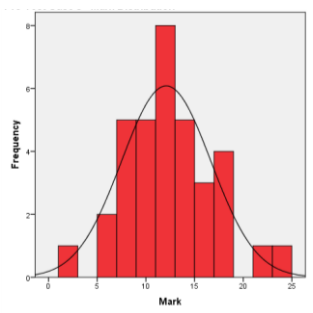
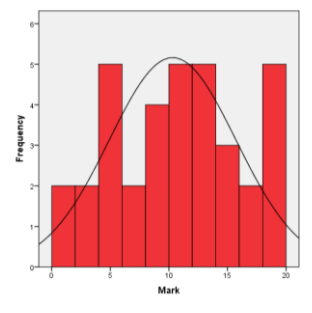
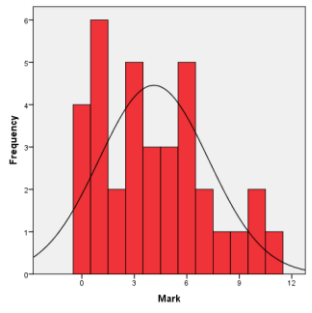
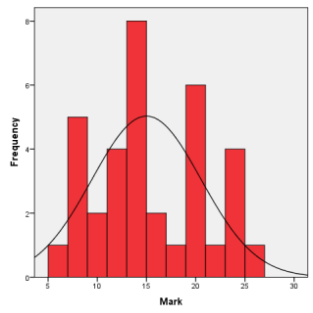
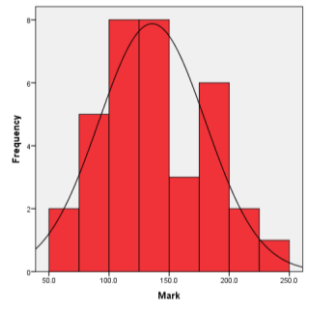
Table 20) Cronbach Alpha for 'Pre-test' & 'Post-test' Cases 1 - 11 (n=35)

Case	Cronbach Alpha (n = 35)	
	'Pre-test'	**'Post-test'**
1	**0.55**	**0.59**
2	**0.71**	**0.80**
3	**0.40**	**0.64**
4	**0.79**	**0.57**
5	**0.85**	**0.87**
6	**0.62**	**0.55**
7	**0.81**	**0.78**
8	**0.64**	**0.85**
9	**0.74**	**0.82**
10	**0.47**	**0.72**
11	**0.34**	**0.73**
Mean	**0.63**	**0.72**

This table details Cronbach Alpha for Cases 1-11 'Pre- and Post-' test.

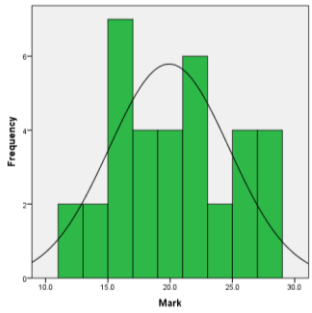
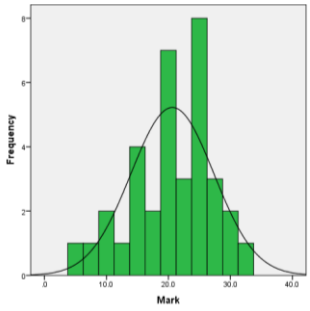
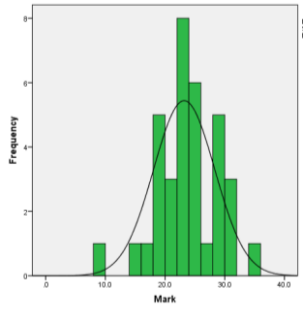
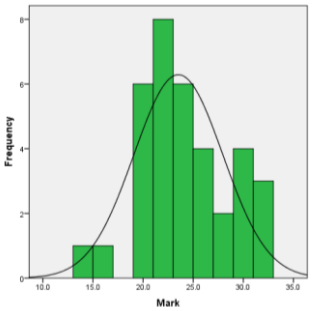
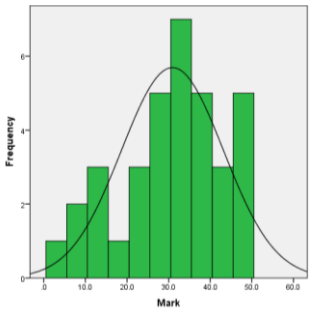
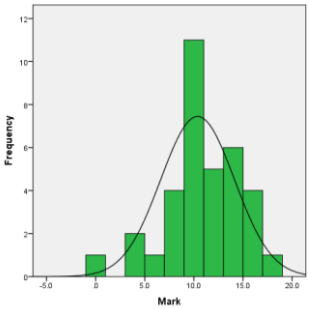
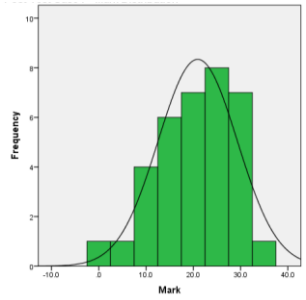
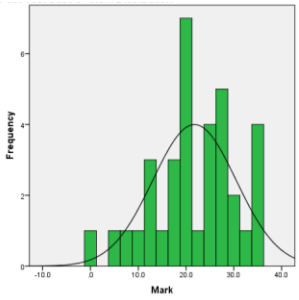
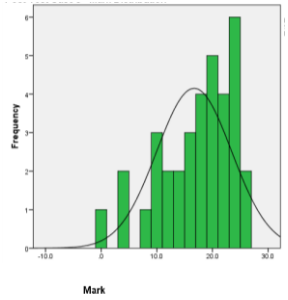
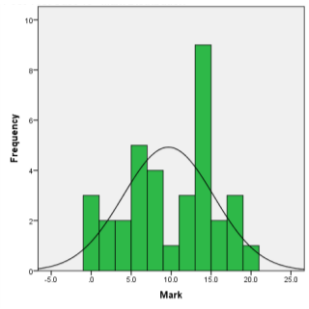
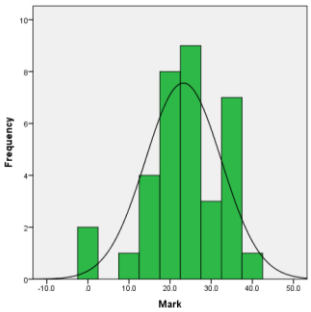
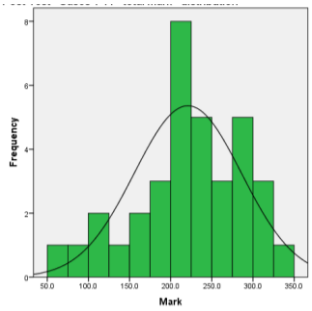
Cronbach's Alpha is a statistical measure of the items internal reliability (86). According to General Medical Council (GMC) guidance (dated 13.02.13) (87), a co-efficient of between 0.6 and 0.8 is good and considered acceptable for assessment.

Graph 1) 'Pre-test' Student Mark Distribution Histograms

Case 1 'Pre-test'			Case 2 'Pre-test'			Case 3 'Pre-test'		
								
SD = 4.423	Mean= 13.29	n = 35	SD = 4.735	Mean= 7.96	n = 35	SD = 19.49	Mean= 3.883	n = 35
Case 4 'Pre-test'			Case 5 'Pre-test'			Case 6 'Pre-test'		
								
SD = 7.218	Mean= 16.89	n = 35	SD = 9.436	Mean= 17.11	n = 35	SD = 3.623	Mean= 7.4	n = 35
Case 7 'Pre-test'			Case 8 'Pre-test'			Case 9 'Pre-test'		
								
SD= 7.933	Mean= 12.2	n = 35	SD= 4.591	Mean= 12.09	n = 35	SD= 5.411	Mean= 10.31	n = 35
Case 10 'Pre-test'			Case 11 'Pre-test'			Cases 1-11 'Pre-test'		
								
SD = 3.132	Mean= 4.11	n = 35	SD= 5.552	Mean= 15	n = 35	SD= 44.312	Mean= 135.84	n = 35

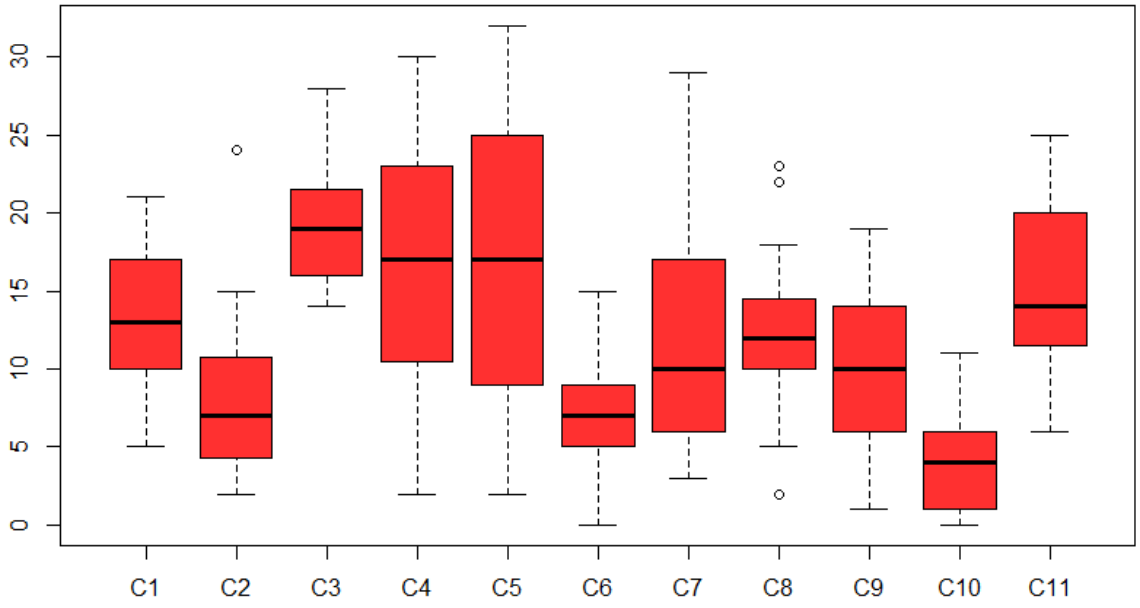
The positive skewness of mark distribution for Case 2 suggests students found this case challenging.

Graph 2) 'Post-test' Student Mark Distribution Histograms

Case 1 'Post-test'			Case 2 'Post-test'			Case 3 'Post-test'		
								
SD = 4.823	Mean= 19.91	n = 35	SD = 6.684	Mean= 20.64	n = 35	SD = 5.132	Mean= 23.2	n = 35
Case 4 'Post-test'			Case 5 'Post-test'			Case 6 'Post-test'		
								
SD = 4.442	Mean= 23.51	n = 35	SD = 12.263	Mean= 30.91	n = 35	SD = 3.75	Mean= 10.37	n = 35
Case 7 'Post-test'			Case 8 'Post-test'			Case 9 'Post-test'		
								
SD= 8.37	Mean= 20.94	n = 35	SD= 8.732	Mean= 21.76	n = 35	SD= 6.728	Mean= 16.71	n = 35
Case 10 'Post-test'			Case 11 'Post-test'			Cases 1-11 'Post-test'		
								
SD = 5.672	Mean= 9.66	n = 35	SD= 9.236	Mean= 23.23	n = 35	SD= 65.117	Mean= 220.86	n = 35

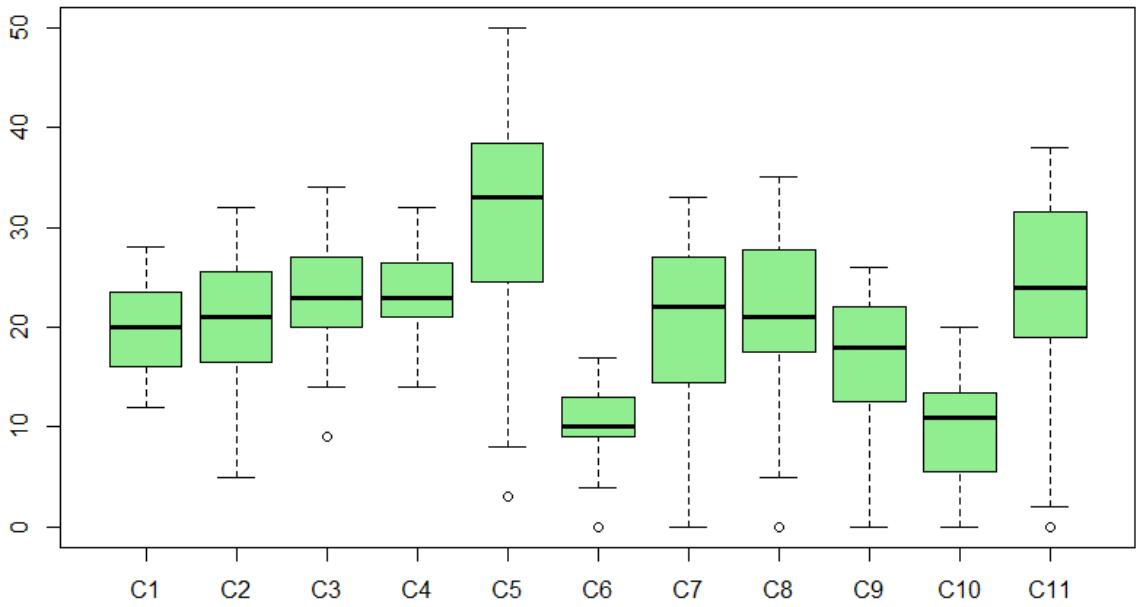
The distribution of total mark for all cases, apart from Case 10, demonstrates negative skewness. Suggesting following the (PBL-SGT)-Fusion intervention students generally scored better on the 'Post-test' paper.

Graph 3) Student Mark Boxplots for Cases 1-11 'Pre-test' (n=35)



The median mark on 'Pre-test' Case 10 was clearly lower than for the rest of the cases.

Graph 4) Student Mark Boxplots for Cases 1-11 'Post-test' (n=35)



Median marks were higher across the board for all cases. Cases 6 and 10 are highlighted as two cases where this improvement was to a lesser extent.

4.4.0) Inferential Statistics

4.4.1) Pre-Test Cases – Mann-Whitney & Boxplot for Student Mark vs. UG / GEM

Table 21) Pre-Test Case 1 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc1	n	Mean Rank	Sum of Ranks
prc1	UG	24	16.58	398.00
	GEM	11	21.09	232.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 1 (prc1) for GEM (Mdn = 15.0) vs UG (Mdn = 11.5) students. MW = 98.000, p = 0.226.

Boxplot

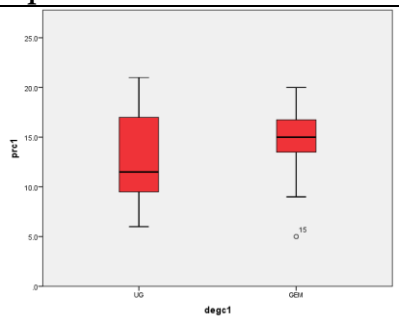


Table 22) Pre-Test Case 2 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc2	n	Mean Rank	Sum of Ranks
prc2	UG	24	18.33	440.00
	GEM	11	17.27	190.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 2 (prc2) for GEM (Mdn = 6.0) vs UG (Mdn = 7.0) students. MW = 124.000, p = 0.776.

Boxplot

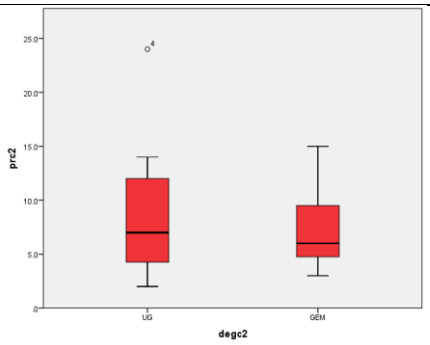


Table 23) Pre-Test Case 3 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc3	n	Mean Rank	Sum of Ranks
prc3	UG	24	18.71	449.00
	GEM	11	16.45	181.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 3 (prc3) for GEM (Mdn = 18.0) vs UG (Mdn = 19.5) students. MW = 115.000, p = 0.544.

Boxplot

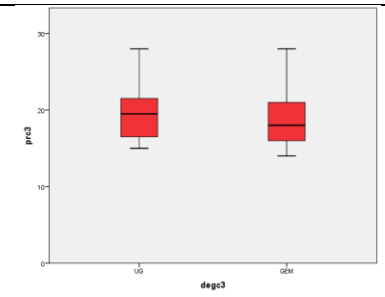


Table 24) Pre-Test Case 4 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney Test

Ranks

	degc4	n	Mean Rank	Sum of Ranks
prc4	UG	24	17.56	421.50
	GEM	11	18.95	208.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 4 (prc4) for GEM (Mdn = 14.0) vs UG (Mdn = 17.0) students. MW = 121.000, p = 0.708.

Boxplot

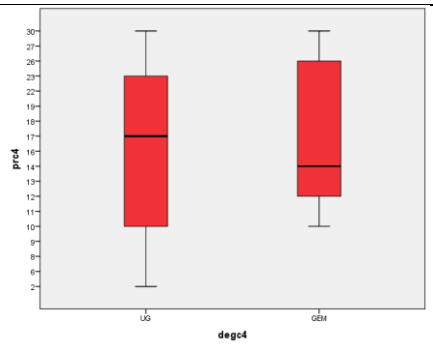


Table 25) Pre-Test Case 5 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc5	n	Mean Rank	Sum of Ranks
prc5	UG	24	15.92	382.00
	GEM	11	22.55	248.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 5 (prc5) for GEM (Mdn = 22.0) vs UG (Mdn = 11.5) students. MW = 82.000, p = 0.075.

Boxplot

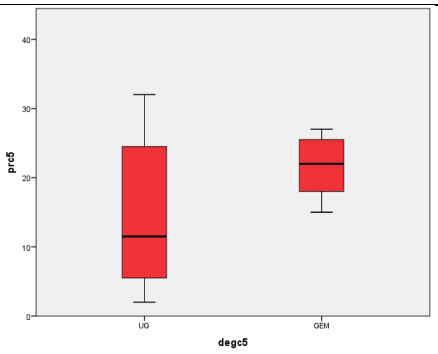


Table 26) Pre-Test Case 6 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc6	n	Mean Rank	Sum of Ranks
prc6	UG	24	16.63	399.00
	GEM	11	21.00	231.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 6 (prc6) for GEM (Mdn = 8.0) vs UG (Mdn = 6.5) students. MW = 99.000, p = 0.239.

Boxplot

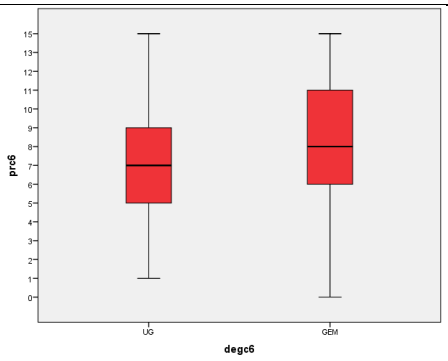


Table 27) Pre-Test Case 7 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc7	n	Mean Rank	Sum of Ranks
prc7	UG	24	16.71	401.00
	GEM	11	20.82	229.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 7 (prc7) for GEM (Mdn = 14.0) vs UG (Mdn = 7.5) students. MW = 101.000, p = 0.269.

Boxplot

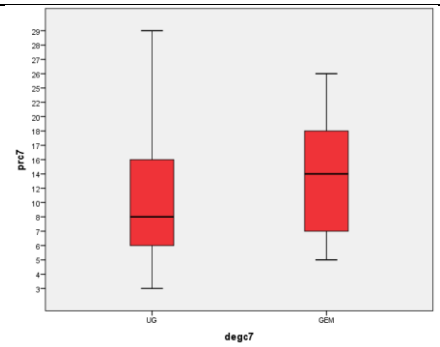


Table 28) Pre-Test Case 8 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc8	n	Mean Rank	Sum of Ranks
prc8	UG	24	17.90	429.50
	GEM	11	18.23	200.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 8 (prc8) for GEM (Mdn = 12.0) vs UG (Mdn = 12.0) students. MW = 129.500, p = 0.929.

Boxplot

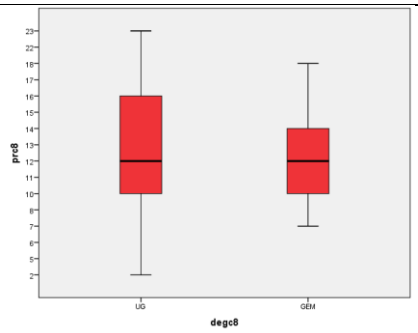


Table 29) Pre-Test Case 9 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc9	n	Mean Rank	Sum of Ranks
prc9	UG	24	16.44	394.50
	GEM	11	21.41	235.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 9 (prc9) for GEM (Mdn = 11.0) vs UG (Mdn = 9.5) students. MW = 94.500, p = 0.182.

Boxplot

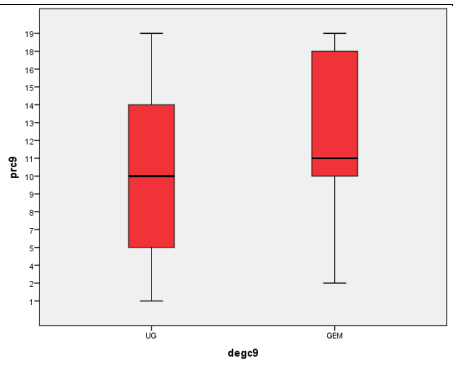


Table 30) Pre-Test Case 10 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc10	n	Mean Rank	Sum of Ranks
prc10	UG	24	16.38	393.00
	GEM	11	21.55	237.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 10 (prc10) for GEM (Mdn = 4.0) vs UG (Mdn = 3.0) students. MW = 93.000, p = 0.163.

Boxplot

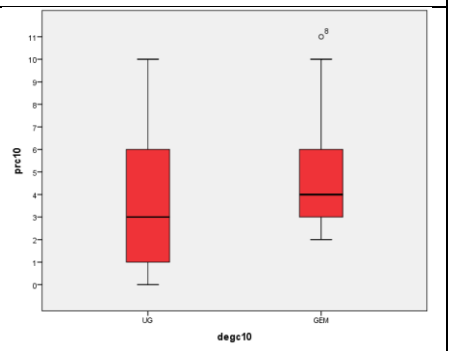


Table 31) Pre-Test Case 11 – Student Mark vs. UG/GEM (n=35)

Mann Whitney Test

Ranks

	degc11	n	Mean Rank	Sum of Ranks
prc11	UG	24	16.58	398.00
	GEM	11	21.09	232.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 11 (prc11) for GEM (Mdn = 19.0) vs UG (Mdn = 13.5) students. MW = 98.000, p = 0.226.

Boxplot

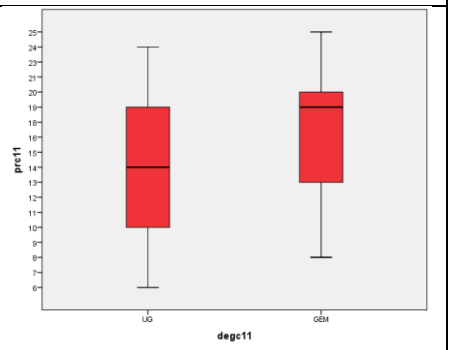


Table 32) Pre-Test Total – Student Mark vs. UG/GEM (n=35)

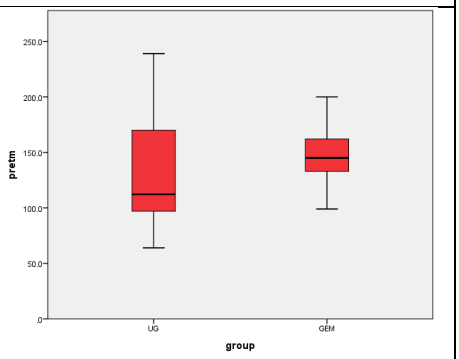
Mann Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
pretm	UG	24	16.44	394.50
	GEM	11	21.41	235.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median total mark on the 'Pre-test' paper (Cases 1-11) for GEM (Mdn = 145.0) vs UG (Mdn = 112.25) students. MW = 94.500, p = 0.183.

Boxplot



4.4.2) Post-Test Cases– Mann-Whitney & Boxplot for Student Mark vs. UG /GEM

Table 33) Post-Test Case 1 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc1	n	Mean Rank	Sum of Ranks
poc1	UG	24	18.02	432.50
	GEM	11	17.95	197.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 1 (poc1) for GEM (Mdn = 20.0) vs UG (Mdn = 20.5) students. MW = 131.500, p = 0.986.

Boxplot

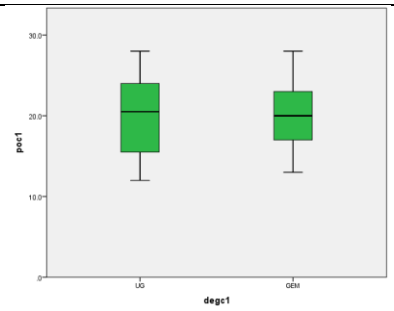


Table 34) Post-Test Case 2 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc2	n	Mean Rank	Sum of Ranks
poc2	UG	24	18.02	432.50
	GEM	11	17.95	197.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 2 (poc2) for GEM (Mdn = 19.0) vs UG (Mdn = 21.5) students. MW = 131.500, p = 0.986.

Boxplot

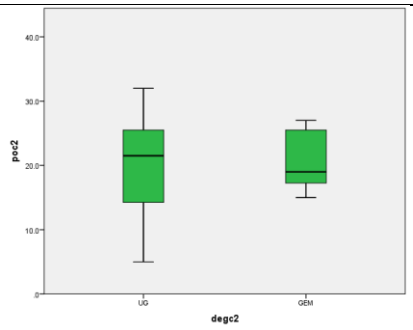


Table 35) Post-Test Case 3 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc3	n	Mean Rank	Sum of Ranks
poc3	UG	24	17.83	428.00
	GEM	11	18.36	202.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 3 (poc3) for GEM (Mdn = 23.0) vs UG (Mdn = 23.5) students. MW = 128.000, p = 0.887.

Boxplot

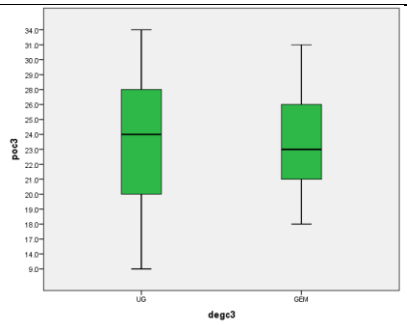


Table 36) Post-Test Case 4 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc4	n	Mean Rank	Sum of Ranks
poc4	UG	24	17.38	417.00
	GEM	11	19.36	213.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 4 (poc4) for GEM (Mdn = 23.0) vs UG (Mdn = 22.5) students. MW = 117.000, p = 0.592.

Boxplot

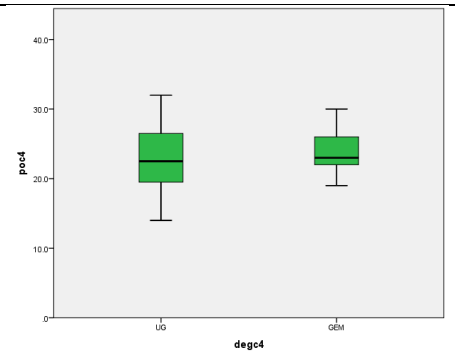


Table 37) Post-Test Case 5 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc5	n	Mean Rank	Sum of Ranks
poc5	UG	24	18.83	452.00
	GEM	11	16.18	178.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 5 (poc5) for GEM (Mdn = 28.0) vs UG (Mdn = 34.5) students. MW = 112.000, p = 0.477.

Boxplot

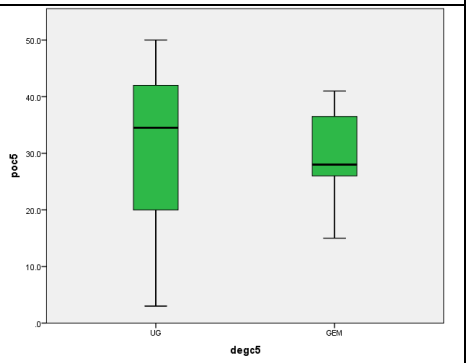


Table 38) Post-Test Case 6 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc6	n	Mean Rank	Sum of Ranks
poc6	UG	24	16.71	401.00
	GEM	11	20.82	229.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 6 (poc6) for GEM (Mdn = 11.0) vs UG (Mdn = 9.0) students. MW = 101.000, p = 0.268.

Boxplot

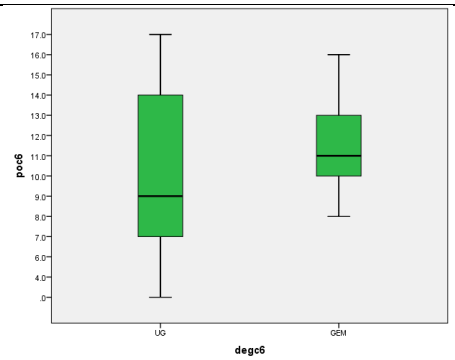


Table 39) Post-Test Case 7 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc7	n	Mean Rank	Sum of Ranks
poc7	UG	24	17.83	428.00
	GEM	11	18.36	202.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 7 (poc7) for GEM (Mdn = 20.0) vs UG (Mdn = 22.0) students. U = 128.000, p = 0.887.

Boxplot

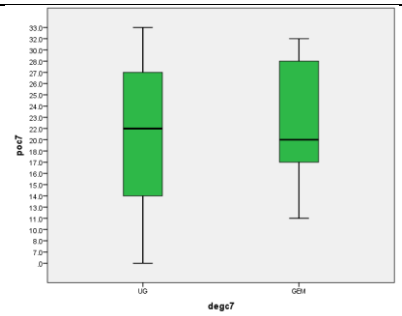


Table 40) Post-Test Case 8 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc8	n	Mean Rank	Sum of Ranks
poc8	UG	24	18.17	436.00
	GEM	11	17.64	194.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 8 (poc8) for GEM (Mdn = 21.0) vs UG (Mdn = 22.0) students. MW = 128.000, p = 0.887.

Boxplot

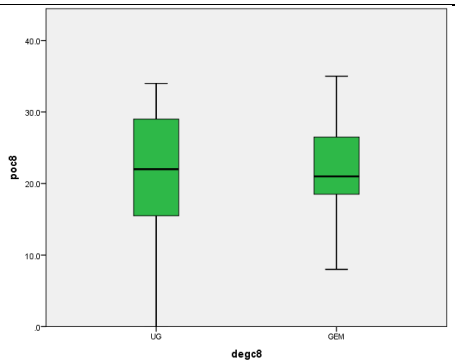


Table 41) Post-Test Case 9 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc9	n	Mean Rank	Sum of Ranks
poc9	UG	24	18.02	432.50
	GEM	11	17.95	197.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 9 (poc9) for GEM (Mdn = 16.0) vs UG (Mdn = 18.5) students. MW = 131.500, p = 0.986.

Boxplot

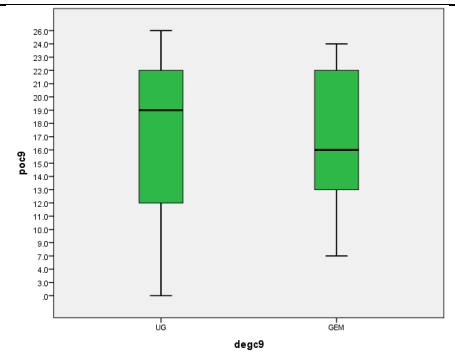


Table 42) Post-Test Case 10 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc10	n	Mean Rank	Sum of Ranks
poc10	UG	24	17.69	424.50
	GEM	11	18.68	205.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 10 (poc10) for GEM (Mdn = 12.0) vs UG (Mdn = 10.0) students. MW = 124.500, p = 0.789.

Boxplot

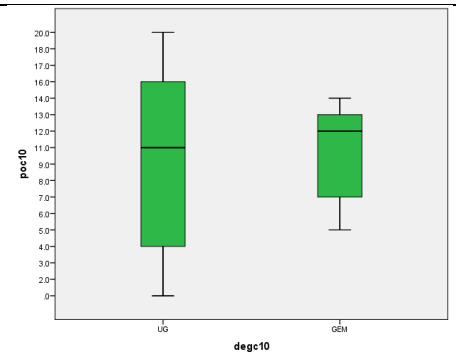


Table 43) Post-Test Case 11 – Student Mark vs. UG/GEM (n=35)

Mann-Whitney

Ranks

	degc11	n	Mean Rank	Sum of Ranks
poc11	UG	24	15.27	366.50
	GEM	11	23.95	263.50
	Total	35		

A Mann-Whitney test indicated GEM students had a statistically significantly higher median on 'Post-test' Case 11 (poc11) (Mdn = 27.0) than UG students (Mdn = 20.0). MW = 66.500, p = 0.020.

Boxplot

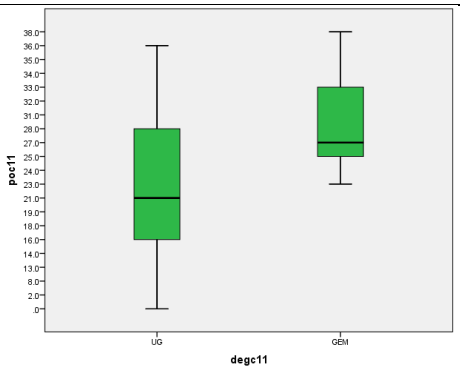


Table 44) Post-Test Total – Student Mark vs. UG/GEM (n=35)

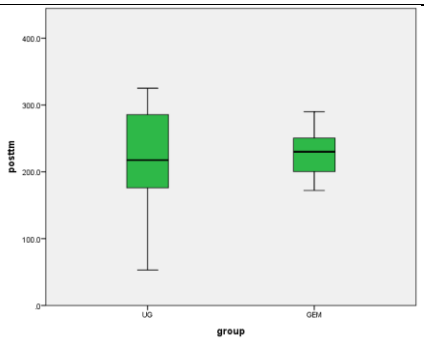
Mann Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
posttm	UG	24	17.83	428.00
	GEM	11	18.36	202.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median total mark on the 'Post-test' paper (Cases 1-11) for GEM (Mdn = 230.0) vs UG (Mdn = 217.5) students. MW = 128.000, p=0.887.

Boxplot



4.4.3) Pre Test Cases – Mann-Whitney & Boxplot for Student Mark vs. CP1/CP3

Table 45) Pre-Test Case 1 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc1	n	Mean Rank	Sum of Ranks
prc1	CP1	15	10.33	155.00
	CP3	20	23.75	475.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 16.3) on 'Pre-test' Case 1 (prc1) than CP1 students (Mdn = 10.0). MW = 35.000, p = 0.000.

Boxplot *

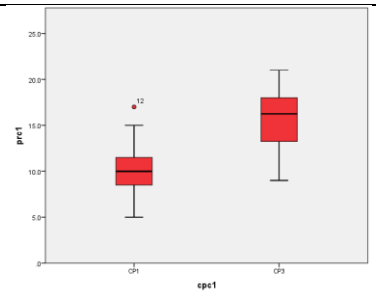


Table 46) Pre-Test Case 2 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc2	n	Mean Rank	Sum of Ranks
prc2	CP1	15	11.10	166.50
	CP3	20	23.18	463.50
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 10.0) on 'Pre-test' Case 2 (prc2) than CP1 students (Mdn = 4.0). MW = 46.500, p = 0.001.

Boxplot *

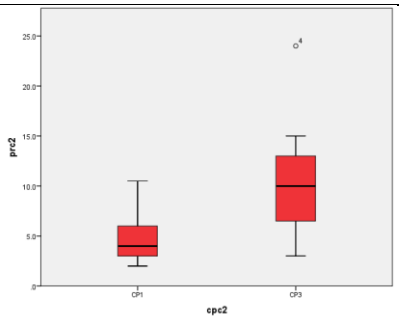


Table 47) Pre-Test Case 3 – Student Mark vs. CP1 / CP3 (n=35)

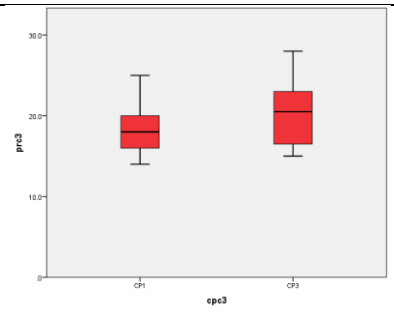
Mann-Whitney

Ranks

	cpc3	n	Mean Rank	Sum of Ranks
prc3	CP1	15	14.90	223.50
	CP3	20	20.33	406.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 3 (prc3) for CP3 (Mdn = 20.5) vs CP1 (Mdn = 18.0) students. MW = 103.500, p = 0.119.

Boxplot



* = Statistically significant result

Table 48) **Pre-Test Case 4** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc4	n	Mean Rank	Sum of Ranks
prc4	CP1	15	11.73	176.00
	CP3	20	22.70	454.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 22.0) on 'Pre-test' Case 4 (prc4) than CP1 students (Mdn = 11.0). MW = 56.000, p = 0.002.

Boxplot *

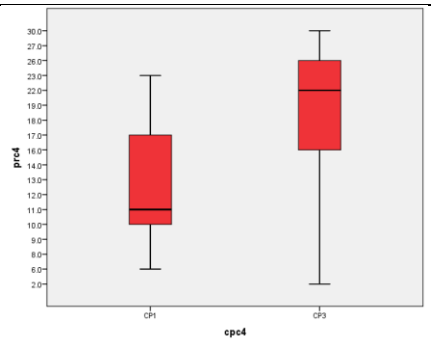


Table 49) **Pre-Test Case 5** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc5	n	Mean Rank	Sum of Ranks
prc5	CP1	15	9.00	135.00
	CP3	20	24.75	495.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 24.5) on 'Pre-test' Case 5 (prc5) than CP1 students (Mdn = 6.0). MW = 15.000, p = 0.000.

Boxplot *

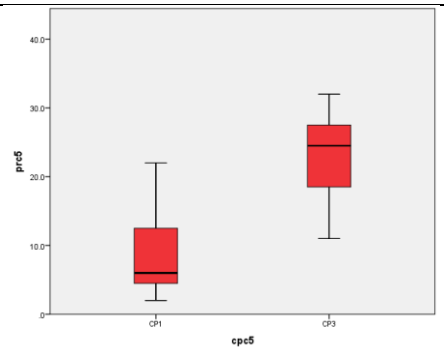


Table 50) **Pre-Test Case 6** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc6	n	Mean Rank	Sum of Ranks
prc6	CP1	15	18.20	273.00
	CP3	20	17.85	357.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 6 (prc6) for CP3 (Mdn = 7.5) vs CP1 (Mdn = 7.0) students. MW = 147.000, p = 0.920.

Boxplot

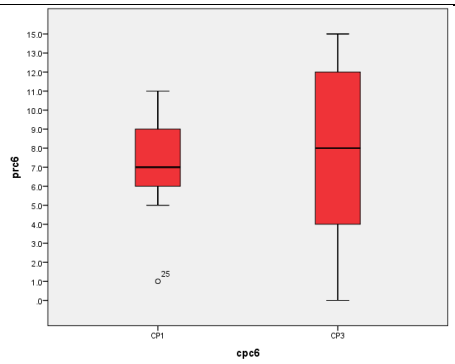


Table 51) **Pre-Test Case 7** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc7	n	Mean Rank	Sum of Ranks
prc7	CP1	15	11.23	168.50
	CP3	20	23.08	461.50
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 15.0) on 'Pre-test' Case 7 (prc7) than CP1 students (Mdn = 6.0). MW = 48.500, p = 0.001.

Boxplot *

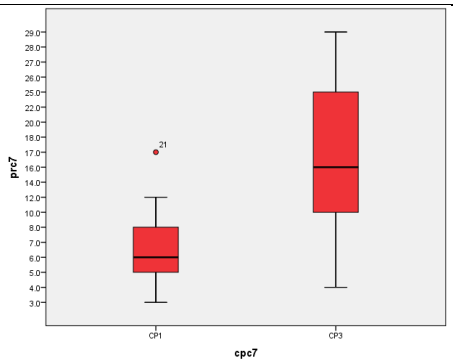


Table 52) **Pre-Test Case 8** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc8	n	Mean Rank	Sum of Ranks
prc8	CP1	15	11.83	177.50
	CP3	20	22.63	452.50
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 13.5) on 'Pre-test' Case 8 (prc8) than CP1 students (Mdn = 10.0). MW = 57.500, p = 0.002.

Boxplot *

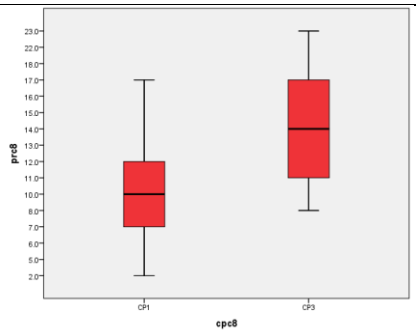


Table 53) **Pre-Test Case 9** – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc9	n	Mean Rank	Sum of Ranks
prc9	CP1	15	12.13	182.00
	CP3	20	22.40	448.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 13.0) on 'Pre-test' Case 9 (prc9) than CP1 students (Mdn = 7.0). MW = 62.000, p = 0.003.

Boxplot *

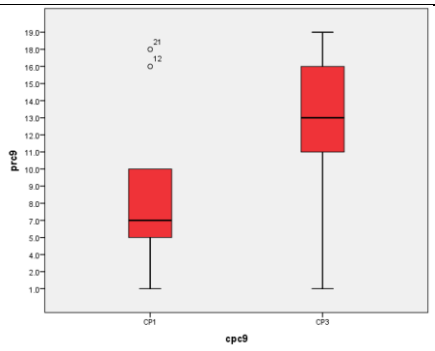


Table 54) Pre-Test Case 10 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc10	n	Mean Rank	Sum of Ranks
prc10	CP1	15	10.70	160.50
	CP3	20	23.48	469.50
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 5.5) on 'Pre-test' Case 10 (prc10) than CP1 students (Mdn = 1.0). MW = 40.500, p = 0.000.

Boxplot *

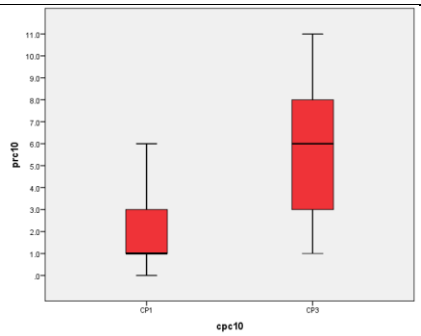


Table 55) Pre-Test Case 11 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc11	n	Mean Rank	Sum of Ranks
prc11	CP1	15	14.50	217.50
	CP3	20	20.63	412.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 11 (prc11) for CP3 (Mdn = 15.0) vs CP1 (Mdn = 13.0) students. MW = 97.500, p = 0.79.

Boxplot

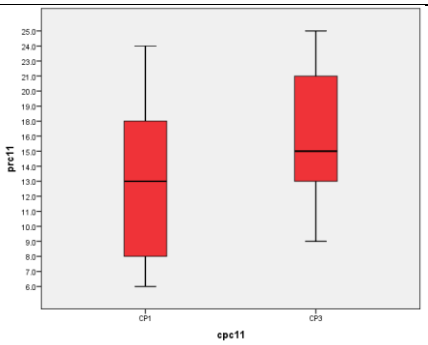


Table 56) Pre-Test Total – Student Mark vs. CP1 / CP3 (n=35)

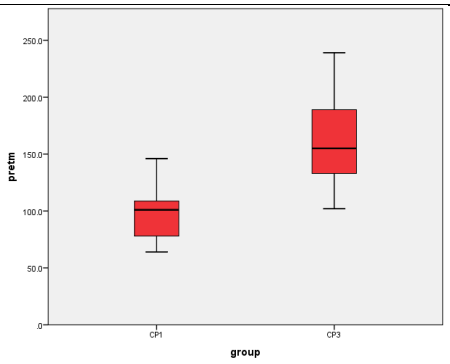
Mann Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
pretm	CP1	15	9.47	142.00
	CP3	20	24.40	488.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 155.00) on the 'Pre-test' paper (Cases 1-11) than CP1 students (Mdn = 101.0). MW = 22.000, p = 0.000.

Boxplot *



4.4.4) Post-Test Cases Mann-Whitney & Boxplot for Student Mark vs. CP1/CP3

Table 57) Post-Test Case 1 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc1	n	Mean Rank	Sum of Ranks
poc1	CP1	15	12.53	188.00
	CP3	20	22.10	442.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 22.0) on 'Post-test' Case 1 (poc1) than CP1 students (Mdn = 16.0). MW = 68.000, p = 0.006.

Boxplot *

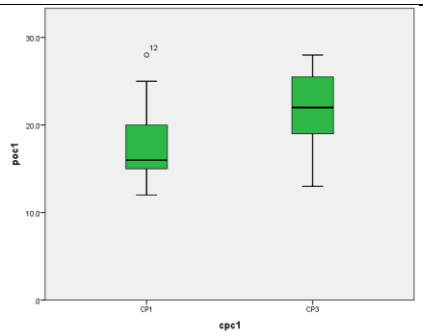


Table 58) Post-Test Case 2 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc2	n	Mean Rank	Sum of Ranks
poc2	CP1	15	12.27	184.00
	CP3	20	22.30	446.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 24.5) on 'Post-test' Case 2 (poc2) than CP1 students (Mdn = 17.0). MW = 64.000, p = 0.004.

Boxplot *

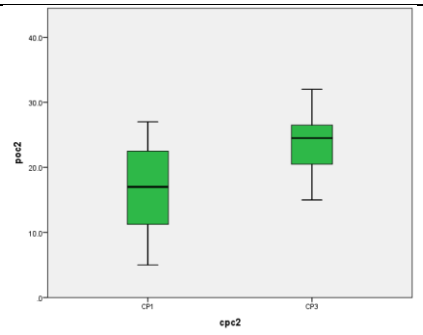


Table 59) Post-Test Case 3 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc3	n	Mean Rank	Sum of Ranks
poc3	CP1	15	12.60	189.00
	CP3	20	22.05	441.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 24.5) on 'Post-test' Case 3 (poc3) than CP1 students (Mdn = 21.0). MW = 69.000, p = 0.007.

Boxplot *

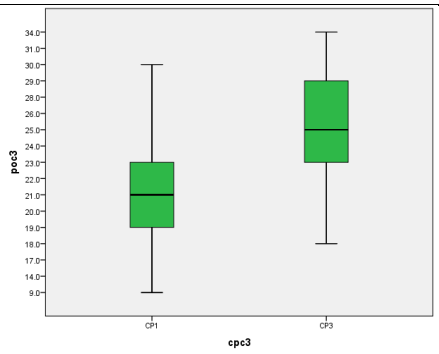


Table 60) Post-Test Case 4 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc4	n	Mean Rank	Sum of Ranks
poc4	CP1	15	14.30	214.50
	CP3	20	20.78	415.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 4 (poc4) for CP3 (Mdn = 23.0) vs CP1 (Mdn = 21.0) students. MW = 94.500, p = 0.063.

Boxplot

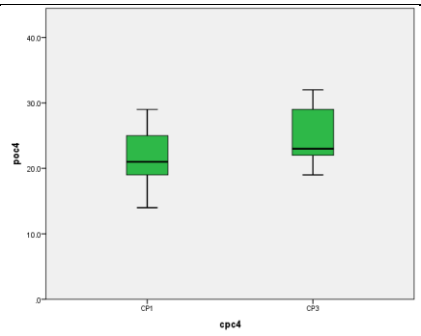


Table 61) Post-Test Case 5 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc5	n	Mean Rank	Sum of Ranks
poc5	CP1	15	12.40	186.00
	CP3	20	22.20	444.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 35.5) on 'Post-test' Case 5 (poc5) than CP1 students (Mdn = 27.0). MW = 66.000, p = 0.005.

Boxplot *

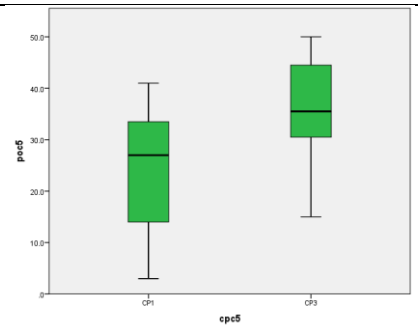


Table 62) Post-Test Case 6 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc6	n	Mean Rank	Sum of Ranks
poc6	CP1	15	13.30	199.50
	CP3	20	21.53	430.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 6 (poc6) for CP3 (Mdn = 11.5) vs CP1 (Mdn = 9.0) students. MW = 79.500, p = 0.018.

Boxplot

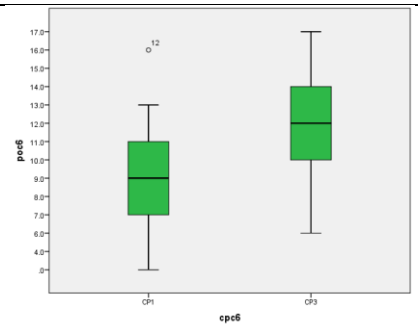


Table 63) Post-Test Case 7 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc7	n	Mean Rank	Sum of Ranks
poc7	CP1	15	10.20	153.00
	CP3	20	23.85	477.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 26.5) on 'Post-test' Case 7 (poc7) than CP1 students (Mdn = 13.0). MW = 33.000, p = 0.000.

Boxplot *

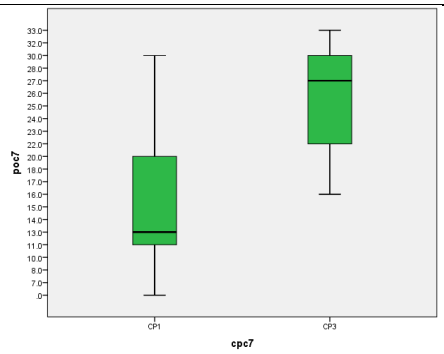


Table 64) Post-Test Case 8 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc8	n	Mean Rank	Sum of Ranks
poc8	CP1	15	12.80	192.00
	CP3	20	21.90	438.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 26.0) on 'Post-test' Case 8 (poc8) than CP1 students (Mdn = 20.0). MW = 72.000, p = 0.009.

Boxplot *

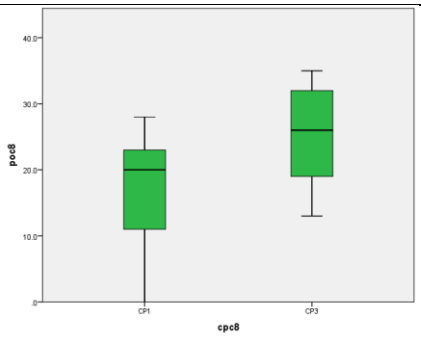


Table 65) Post-Test Case 9 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc9	n	Mean Rank	Sum of Ranks
poc9	CP1	15	13.10	196.50
	CP3	20	21.68	433.50
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 20.0) on 'Post-test' Case 9 (poc9) than CP1 students (Mdn = 14.0). MW = 76.500, p = 0.014.

Boxplot *

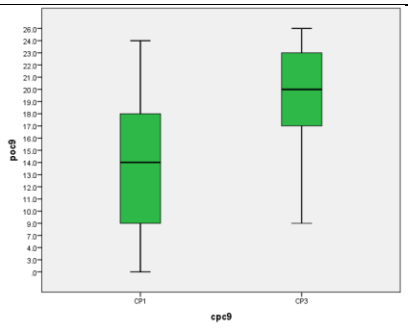


Table 66) Post-Test Case 10 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc10	n	Mean Rank	Sum of Ranks
poc10	CP1	15	9.60	144.00
	CP3	20	24.30	486.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 13.0) on 'Post-test' Case 10 (poc10) than CP1 students (Mdn = 5.0). MW = 24.000, p = 0.000.

Boxplot *

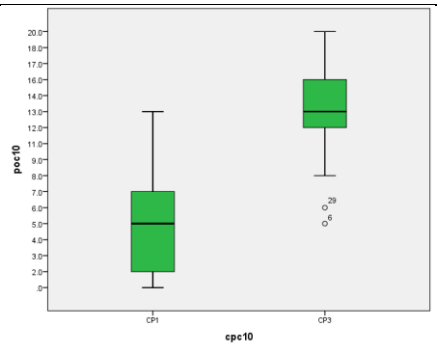


Table 67) Post-Test Case 11 – Student Mark vs. CP1 / CP3 (n=35)

Mann-Whitney

Ranks

	cpc11	n	Mean Rank	Sum of Ranks
poc11	CP1	15	12.87	193.00
	CP3	20	21.85	437.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 26.0) on 'Post-test' Case 11 (poc11) than CP1 students (Mdn = 19.0). MW = 73.000, p = 0.010.

Boxplot *

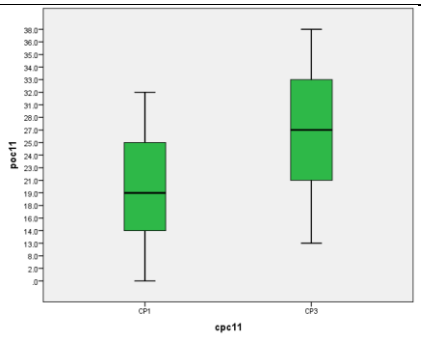


Table 68) Post-Test Total – Student Mark vs. CP1 / CP3 (n=35)

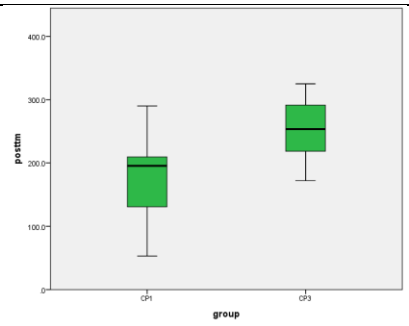
Mann Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
posttm	CP1	15	10.93	164.00
	CP3	20	23.30	466.00
	Total	35		

A Mann-Whitney test indicated CP3 students had a statistically significantly higher median (Mdn = 253.5) on the 'Post-test' paper (Cases 1-11) paper than CP1 students (Mdn = 195.5). MW = 44.000, p = 0.000.

Boxplot *



4.4.5) Pre-Test Cases – Mann-Whitney & Boxplot for Student Mark vs. Gender

Table 69) Pre-Test Case 1 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc1	n	Mean Rank	Sum of Ranks
prc1	FEMALE	23	16.54	380.50
	MALE	12	20.79	249.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 1 (prc1) for Male (Mdn = 15.5) vs Female (Mdn = 12.0) students. MW = 104.500, p =0.243.

Boxplot

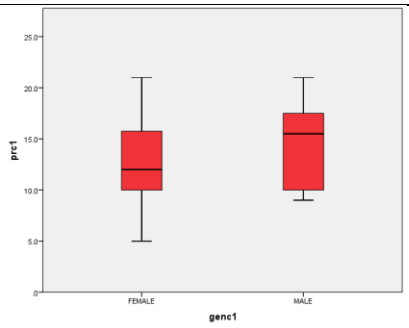


Table 70) Pre-Test Case 2 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc2	n	Mean Rank	Sum of Ranks
prc2	FEMALE	23	16.30	375.00
	MALE	12	21.25	255.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 2 (prc2) for Male (Mdn = 8.0) vs Female (Mdn = 6.0) students. MW = 99.000, p = 0.174.

Boxplot

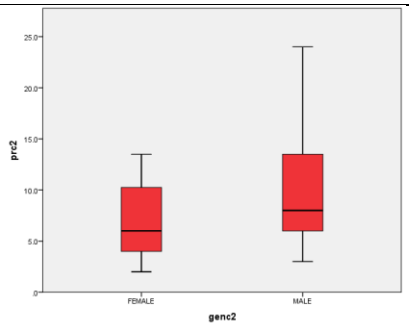


Table 71) Pre-Test Case 3 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc3	n	Mean Rank	Sum of Ranks
prc3	FEMALE	23	15.22	350.00
	MALE	12	23.33	280.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 21.5) on 'Pre-test' Case 3 (prc3) vs Female students (Mdn = 18.0). MW = 74.000, p = 0.025.

Boxplot *

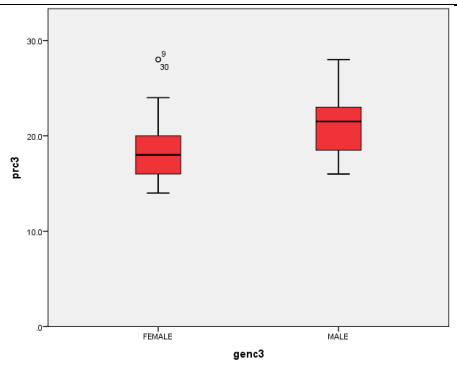


Table 72) Pre-Test Case 4 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc4	n	Mean Rank	Sum of Ranks
prc4	FEMALE	23	15.13	348.00
	MALE	12	23.50	282.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 22.5) on 'Pre-test' Case 4 (prc4) vs Female students (Mdn = 14.0). MW = 72.000, p = 0.021.

Boxplot *

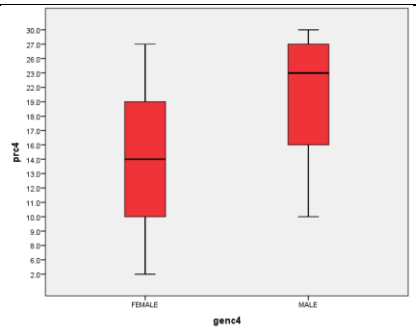


Table 73) Pre-Test Case 5 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc5	n	Mean Rank	Sum of Ranks
prc5	FEMALE	23	15.50	356.50
	MALE	12	22.79	273.50
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 24.0) on 'Pre-test' Case 5 (prc5) vs Female students (Mdn = 16.0). MW = 80.500, p = 0.045.

Boxplot *

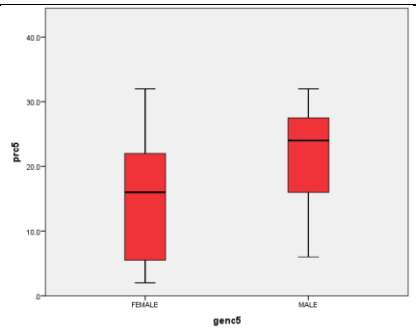


Table 74) Pre-Test Case 6 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc6	n	Mean Rank	Sum of Ranks
prc6	FEMALE	23	13.83	318.00
	MALE	12	26.00	312.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 9.0) on 'Pre-test' Case 6 (prc6) vs Female students (Mdn = 6.0). MW = 42.000, p = 0.001.

Boxplot *

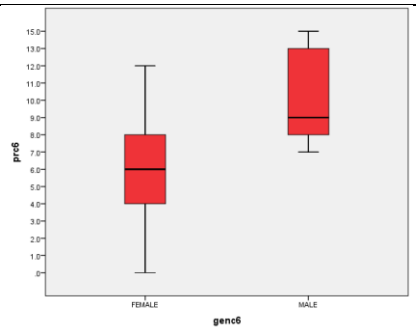


Table 75) Pre-Test Case 7 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc7	n	Mean Rank	Sum of Ranks
prc7	FEMALE	23	15.35	353.00
	MALE	12	23.08	277.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 15.5) on 'Pre-test' Case 7 (prc7) vs Female students (Mdn = 7.0). MW = 77.000, p = 0.033.

Boxplot *

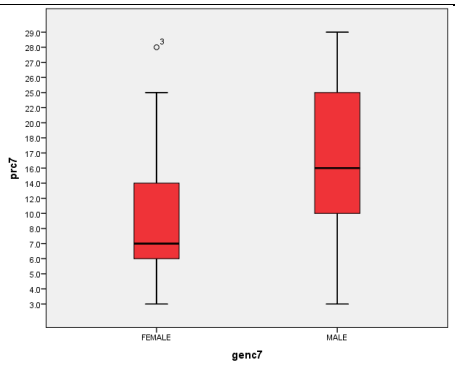


Table 76) Pre-Test Case 8 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc8	n	Mean Rank	Sum of Ranks
prc8	FEMALE	23	15.89	365.50
	MALE	12	22.04	264.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 8 (prc8) for Male (Mdn = 12.5) vs Female (Mdn = 11.0) students. MW = 89.500, p = 0.091.

Boxplot

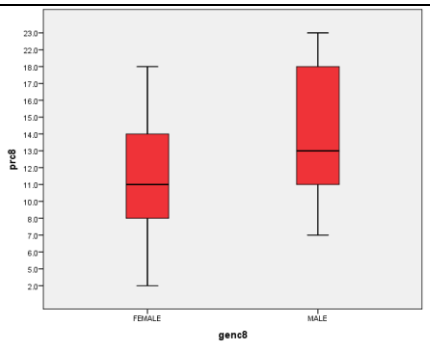


Table 77) Pre-Test Case 9 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc9	n	Mean Rank	Sum of Ranks
prc9	FEMALE	23	16.85	387.50
	MALE	12	20.21	242.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Pre-test' Case 9 (prc9) for Male (Mdn = 12.5) vs Female (Mdn = 10.0) students. MW = 111.500, p = 0.356.

Boxplot

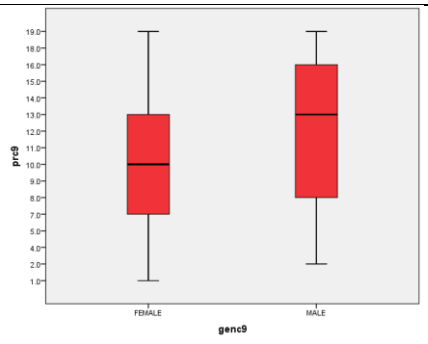


Table 78) Pre-Test Case 10 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc10	n	Mean Rank	Sum of Ranks
prc10	FEMALE	23	15.00	345.00
	MALE	12	23.75	285.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 6.0) on 'Pre-test' Case 10 (prc10) vs Female students (Mdn = 3.0). MW = 69.000, p = 0.016.

Boxplot *

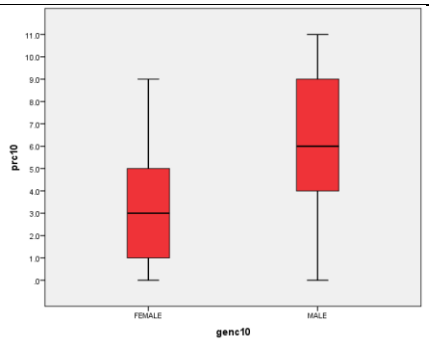


Table 79) Pre-Test Case 11 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc11	n	Mean Rank	Sum of Ranks
prc11	FEMALE	23	14.24	327.50
	MALE	12	25.21	302.50
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significant higher median mark (Mdn = 20.0) on 'Pre-test' Case 11 (prc11) vs Female students (Mdn = 12.0). MW = 51.500, p = 0.003.

Boxplot *

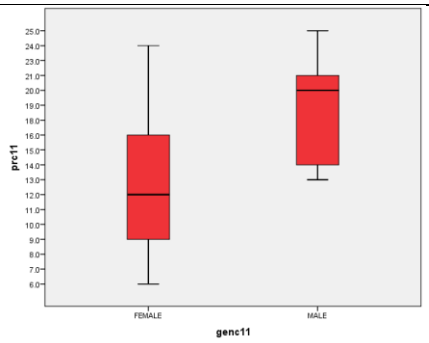


Table 80) Pre-Test Total – Student Mark vs. CP1 / CP3 (n=35)

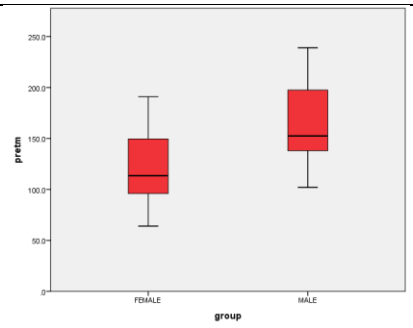
Mann Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
pretm	FEMALE	23	14.61	336.00
	MALE	12	24.50	294.00
	Total	35		

A Mann-Whitney test indicated Male students had a statistically significantly higher median (Mdn = 152.5) on the 'Pre-test' paper (Cases 1-11) than Female students (Mdn = 113.5). MW = 60.000, p = 0.007.

Boxplot *



4.4.6) Post-Test Cases 1-11 – Mann-Whitney & Boxplot for Student Mark vs. Gender

Table 81) Post-Test Case 1 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc1	n	Mean Rank	Sum of Ranks
poc1	FEMALE	23	17.67	406.50
	MALE	12	18.63	223.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 1 (poc1) for Male (Mdn = 20.0) vs Female (Mdn = 20.0) students. MW = 130.500, p = 0.764.

Boxplot

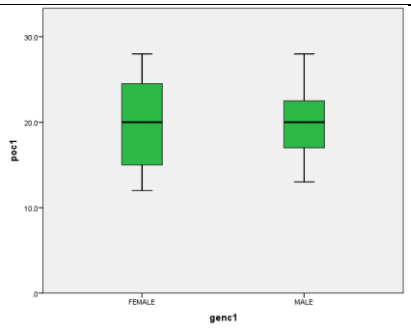


Table 82) Post-Test Case 2 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc2	n	Mean Rank	Sum of Ranks
poc2	FEMALE	23	17.09	393.00
	MALE	12	19.75	237.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 2 (poc2) for Male (Mdn = 23.5) vs Female (Mdn = 21.0) students. MW = 177.000, p = 0.465.

Boxplot

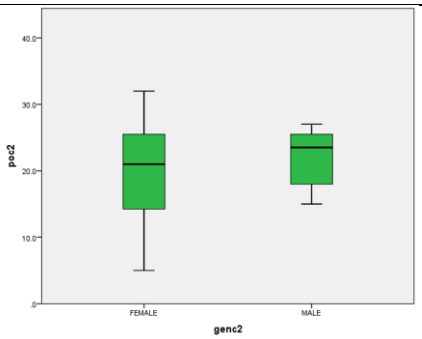


Table 83) Post-Test Case 3 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc3	n	Mean Rank	Sum of Ranks
poc3	FEMALE	23	16.89	388.50
	MALE	12	20.13	241.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 3 (poc3) for Male (Mdn = 23.5) vs Female (Mdn = 22.0) students. MW = 112.500, p = 0.374.

Boxplot

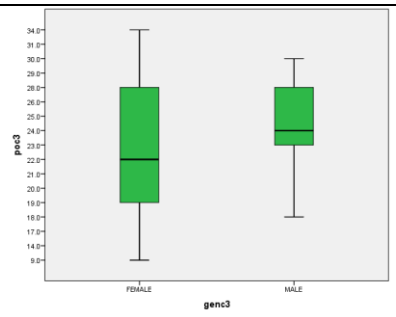


Table 84) Post-Test Case 4 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc4	n	Mean Rank	Sum of Ranks
poc4	FEMALE	23	18.43	424.00
	MALE	12	17.17	206.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 4 (poc4) for Male (Mdn = 23.0) vs Female (Mdn = 24.0) students. MW = 128.000, p = 0.727.

Boxplot

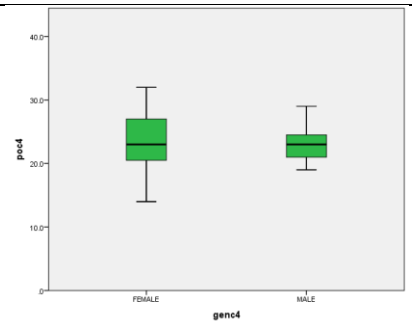


Table 85) Post-Test Case 5 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc5	n	Mean Rank	Sum of Ranks
poc5	FEMALE	23	17.54	403.50
	MALE	12	18.88	226.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 5 (poc5) for Male (Mdn = 33.5) vs Female (Mdn = 33.0) students. MW = 127.500, p = 0.715.

Boxplot

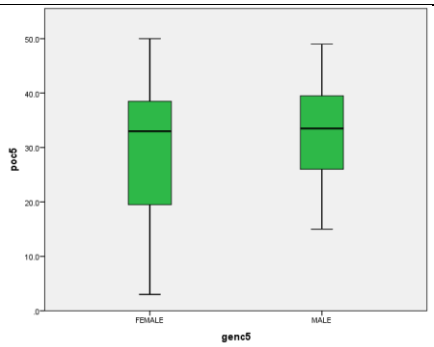


Table 86) Post-Test Case 6 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc6	n	Mean Rank	Sum of Ranks
poc6	FEMALE	23	15.91	366.00
	MALE	12	22.00	264.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 6 (poc6) for Male (Mdn = 12.0) vs Female (Mdn = 9.0) students. MW = 90.000, p = 0.093.

Boxplot

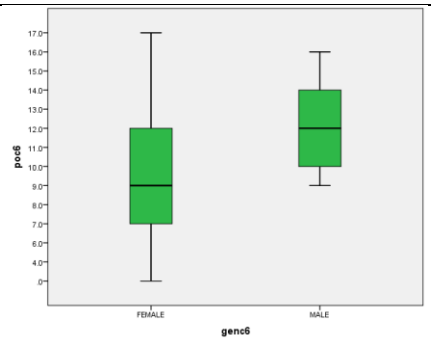


Table 87) Post-Test Case 7 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc7	n	Mean Rank	Sum of Ranks
poc7	FEMALE	23	17.67	406.50
	MALE	12	18.63	223.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 7 (poc7) for Male (Mdn = 22.0) vs Female (Mdn = 22.0) students. MW = 130.500, p = 0.794.

Boxplot

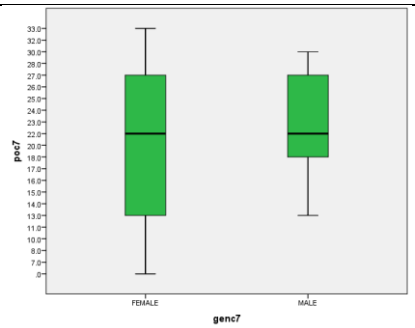


Table 88) Post-Test Case 8 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc8	n	Mean Rank	Sum of Ranks
poc8	FEMALE	23	17.59	404.50
	MALE	12	18.79	225.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 8 (poc8) for Male (Mdn = 25.0) vs Female (Mdn = 21.0) students. MW = 128.500, p = 0.741.

Boxplot

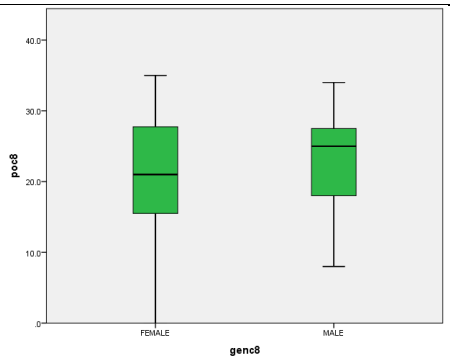


Table 89) Post-Test Case 9 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc9	n	Mean Rank	Sum of Ranks
poc9	FEMALE	23	17.35	399.00
	MALE	12	19.25	231.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 9 (poc9) for Male (Mdn = 18.5) vs Female (Mdn = 18.0) students. MW = 123.000, p = 0.601.

Boxplot

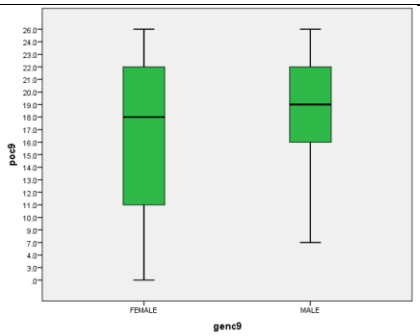


Table 90) Post-Test Case 10 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc10	n	Mean Rank	Sum of Ranks
poc10	FEMALE	23	16.72	384.50
	MALE	12	20.46	245.50
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 10 (poc10) for Male (Mdn = 13.0) vs Female (Mdn = 8.0) students. MW = 108.500, p = 0.303.

Boxplot

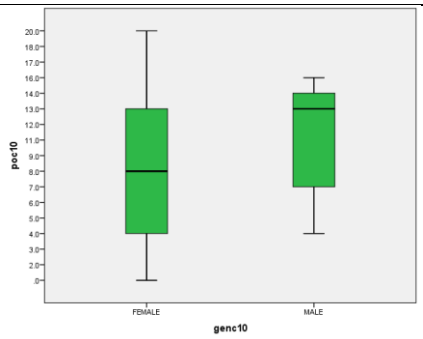


Table 91) Post-Test Case 11 – Student Mark vs. Gender (n=35)

Mann-Whitney

Ranks

	genc11	n	Mean Rank	Sum of Ranks
poc11	FEMALE	23	15.78	363.00
	MALE	12	22.25	267.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median mark on 'Post-test' Case 11 (poc11) for Male (Mdn = 27.5) vs Female (Mdn = 21.0) students. MW = 87.000, p = 0.076.

Boxplot

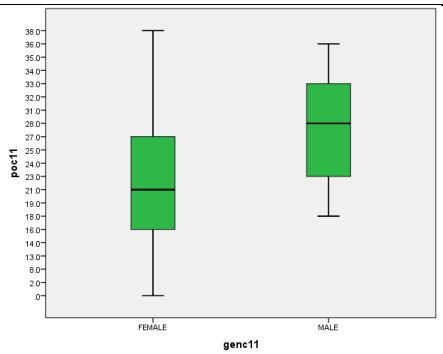


Table 92) Post-Test Total – Student Mark vs. Gender (n=35)

Mann-Whitney Test

Ranks

	group	n	Mean Rank	Sum of Ranks
posttm	FEMALE	23	17.04	392.00
	MALE	12	19.83	238.00
	Total	35		

A Mann-Whitney test indicated no significant difference between median total mark on the 'Post-test' paper (Cases 1-11) for Male (Mdn = 232.5) vs Female (Mdn = 212.0) students. MW = 116.000, p = 0.444.

Boxplot

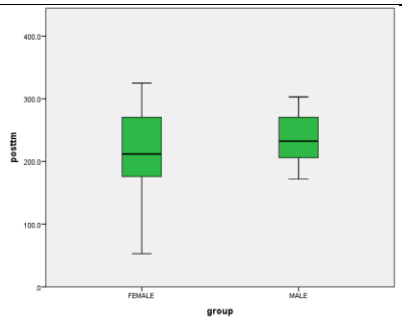


Table 93) Wilcoxon Rank Test Comparison of Pre & Post Test Cases 1-11 (n=35)

Case	Pre-Test Median (M) =	Post-Test Median (M) =	Z =	p =
1	13.3	20.0	-4.801	0.000*
2	8.0	20.6	-5.146	0.000*
3	19.5	23.2	-3.885	0.000*
4	16.9	23.5	-4.104	0.000*
5	17.1	31.0	-4.866	0.000*
6	7.4	10.4	-3.797	0.000*
7	12.2	20.9	-4.541	0.000*
8	12.1	21.8	-4.829	0.000*
9	10.3	16.7	-4.269	0.000*
10	4.1	9.7	-4.979	0.000*
11	15.0	23.2	-4.560	0.000*
Whole paper	135.8	220.9	-5.110	0.000*

This table illustrates there was a statistically significant increase in median mark between 'Pre-test' and 'Post-test' for all cases and for the paper over all, as demonstrated by a Wilcoxon Rank Test.

Chapter 5.0) Discussion

5.1) Introduction

In this chapter I will discuss a selection of results from this curriculum intervention. Teaching and training medical students is an inherently complicated process, especially given their future working environment. Kirkpatrick's four step curriculum evaluation method is particularly suited to medical education. Using a staged approach looking at evaluation of reaction, learning, behaviour and results allows an accurate assessment of the curriculum intervention and whether there is any translation into changes of behaviour and tangible results (88).

The (PBL-SGT)-Fusion process to date, forming the basis of this study, lends itself well to evaluation via steps 1 & 2 of Kirkpatrick's evaluation model (88). (PBL-SGT)-Fusion is particularly knowledge based with assessment via traditional written exams. Through analysing the results, it would appear certain topics are potentially less suited to this teaching and assessment methodology. One such example would be the application of technical and practical skills when dealing with medical emergencies such as tension pneumothorax. The way in which these elements could be taught is addressed in 'Chapter 7.0) Recommendations & Suggestions for Future Research'.

Kirkpatrick's 4 step evaluation process as a whole is summarized in Table 94). Steps 1 & 2 are looked at in detail and form the basis of discussion in this chapter.

Table 94) Kirkpatrick's 4 Step Curriculum Evaluation Model

Step	Process
1 – 'Reaction'	To what extent did the learners like the learning process?
2 – 'Learning'	How much did learners add to their skills and knowledge?
3 – 'Behaviour'	What changes in performance has resulted from the learning process?
4 – 'Results'	What are tangible results of the learning process? E.g. safer, more efficient doctors.

5.2) Kirkpatrick's Step 1

Step 1 'Reaction' was evaluated by collecting students' opinions. This was obtained via iscp.ac.uk, a website where 'Observation of Teaching' forms can be sent to students. All 35 students involved in this process were sent one of these online forms. The outcome of their feedback is provided in its entirety in the CD Appendix, where raw feedback for all students (1-35) involved in the process can be found. Quantitative feedback obtained is summarised in Appendix I. Also available on the CD appendix are tables with all positive and negative qualitative feedback, along with student identifier (1-35). This allows differentiation between CP1 or CP3 student comments. These comments have been grouped into themes and summarized in Tables 6 & 7). Step 2 'Learning' is evaluated through looking at differences in 'Pre- and Post-' test score and can be found in 5.3.0). Steps 3 & 4 would require further studies. Evaluation of Step 3 could partly be achieved via the TSP concept introduced in 'Chapter 7.0) Recommendations & Suggestions for Future Research', however much larger studies would be required to fully evaluate Step 4. Evaluation of steps 3 and 4 are beyond the scope of this study.

5.2.1) Discussion with Students

Throughout this process I have constantly been garnering student opinion and discussing aspects they like and where they would like changes. These conversations have continued beyond the student sample of 35 studied in this dissertation.

Student reaction has been overwhelmingly positive. I am aware it could be argued this is anecdotal. As the teacher of these students, I can also comment on observations I have made in class; students tended to be attentive and engage with discussions. I appreciate this may well be facilitator dependent.

One aspect students were particularly keen on was the short answer question element to (PBL-SGT)-Fusion. Many students have intimated these questions test deep understanding in a way multiple choice questions, which form the basis of their formal university assessments, do not. This is due to exam technique and question spotting methodologies, meaning students feel they can score well on questions without necessarily having a thorough understanding of the topic.

5.2.2) Quantitative Data

Students could rate 3 domains, 'Introduction', 'Presentation' & 'Conclusion' as one of 'Outstanding', 'Satisfactory' or 'Development required'.

Introduction to the process was generally favorably rated. 24/35 of students rated it as 'Outstanding', 9/35 rated it as 'Satisfactory' and 1/35 rated it as 'Development required'. There was 1/35 declining to answer.

Presentation of the sessions was very well received. The vast majority, 33/35, rated it 'Outstanding', 1/35 rated 'satisfactory' and 1/35 declined to answer.

Conclusion to the sessions was also rated positively. 27/35 rated it as 'Outstanding', 6/35 'Satisfactory' and 2/35 declined to answer.

When asked to rate the process overall. 30/35 felt it was 'Outstanding', 4/35 'Satisfactory' and 1/35 did not answer.

5.2.3) Qualitative Data

Positive and negative themes are summarised in Tables 6 & 7) which can be found in 'Chapter 4.0) Results'. From a positive point of view, the themes that were commented upon most favourably (n=17) were 'Good clear learning objectives, key points summarised and emphasised' and 'Group discussion useful, non-threatening, inclusive and relaxed environment.' It was particularly pleasing to see these aspects commented upon in a positive light. The (PBL-SGT)-Fusion process was designed to ensure these elements were included in sessions.

The next three themes had (n=14), (n=14), and (n=13) respondents respectively. 'Pre-test was an effective way to learn with good teaching to identify gaps in knowledge'. 'Good pacing / timing of sessions'. 'Knowledgeable / enthusiastic delivery, kept attention of group, approachable & non-judgmental (Questions welcomed)'.

In general, sessions were universally well received, with the process receiving far more positive qualitative feedback than negative. From a negative point of view, the most common theme (n=4) was students feeling sessions ran over time. A minority of students (n=3) felt questions were vague.

5.3.0) Kirkpatrick's Step 2

Graph 1) is a collection of histograms for student mark distribution on 'Pre-test' Cases 1-11. There is a general positive skewness, suggesting students found these cases challenging. This was particularly true for Case 2.

Graph 2) shows the collection of histograms for student mark distribution on 'Post-test' Cases 1-11. There is a general negative skewness, suggesting students found these cases easier. Mark distributions for each individual question have been plotted on histograms and are summarized in Graphs 3 & 4).

Interestingly on the 'Pre-test' paper there was no significant difference in median mark between undergraduate (UG) (112.25) and graduate entry (GEM) (145) students. Given GEM students prior exposure to PBL, one might expect them to perform better. With the 'Post-test' paper, again there was no statistically significant difference in median mark between UG (217.5) and GEM (230). This suggests both UG and GEM students are suited to this type of teaching, with UG median mark increasing the most dramatically.

When looking at cases on an individual basis, there was no significant difference between UG and GEM performance in any of the 11 cases. This was also true for 10 out of 11 'Post-test' cases. Case 11 on 'Soft tissue injuries and falls' was the only case where GEM students out-performed UG students (27 vs. 20), with a statistically significantly higher median mark.

Looking at the results from the CP1 students who took part in this study, there is nothing to suggest CP3 material is too complex for them to handle. These students successfully covered CP3 material in its entirely in terms of history, examination, investigation and management. The median mark of the CP1 cohort in their 'Post-test' paper (195.5) was higher than the CP3's 'Pre-test' paper

(155.0). This would confirm the suggestion this material is not covered in CP2. To efficiently learn about disease states, their effect on patients and appropriate treatments requires material to be covered in its entirety. Management of conditions is not traditionally covered in CP1. I have already commented teachers are surprised when students enter CP3 with minimal knowledge of disease management. These results would suggest there is an element of truth in this.

Finals are an incredibly stressful period and I firmly believe students should be made aware of what is ahead. As medical educators, we have a responsibility not only to our students, but to the patients our students will be caring for in the future (38). Evidence on a national scale, suggests students are not being adequately prepared for life as foundation doctors. This is highlighted by the increase in shadowing requirements. In addition to shadowing, a lot can be done from a medical education point of view - the results of this study have proved it is possible on a small scale. We must ensure time spent in classrooms optimizes and enhances time in clinical environments.

When looking at performance between CP3 and CP1 students it is perhaps unsurprising CP3 students out performed CP1 students in 8 of the 11 cases (1, 2, 4, 5, 7, 8, 9 & 10). In the remaining cases (3, 6 & 11) there was no significant difference between CP3 and CP1. These cases were covering 'Septic Arthritis', 'Tension Pneumothorax' and 'Soft tissue injuries and falls'. CP3 students out performed CP1 on the 'Pre-test' paper, with a higher median mark (155 vs. 101). In terms of performance on the 'Post-test' paper CP3 students again out performed CP1 students in 9 of the 11 questions. CP3 students also had a statistically significantly higher median vs. CP1 students on the 'Post-test' paper (253.5 vs. 195.5). It was interesting to note however that CP1 mark in the 'Post-test' paper was higher than that of CP3 on the 'Pre-test' paper. This suggests the CP1 students involved in the study were able to retain and comprehend CP3 level material. Whilst it is assumed the CP1

cohort was a representative sample, it would be interesting to see if this effect was replicated on a larger cohort.

Performance related to gender was interesting and differed between 'Pre-test' & 'Post-test'. Male students out performed female students on 7 out of 11 'Pre-test' cases (3, 4, 5, 6, 7, 10 & 11) and there was no statistical difference between males and females on the remaining 4 cases. Male and female median marks were 152.5 and 113.5, respectively. This trend was not repeated in performance on the 'Post-test' paper where there was no significant difference between scores of males and females on all 11 cases. The median marks for males and females on the 'Post-test' were 232.5 and 212.0, respectively. There was no statistically significant difference between these scores. Looking at these results, I feel there is fairly strong evidence to prove Steps 1 & 2 of Kirkpatrick's model have been fulfilled.

The item difficulty of each case and the component parts increased generally across the board, however, the rise was perhaps not as much as expected considering the same cases were used in both 'Pre-test' and 'Post-test' papers. This could be due to a combination of reasons; students were not expecting to sit the same paper in the 'Post-test' and they were not allowed to keep the question papers, it was never a case of rote learning the answers. Fatigue is also another critically important factor to consider. Just as for the 'Pre-test', students were not given a time limit to sit the 'Post-test' paper, which some students took almost 5 hours to complete.

In designing this teaching and delivering it to a number of students, I have come to appreciate the importance of ensuring teaching and learning map together forming part of a coherent educational strategy. This is of even more importance with high-stake exams, such as medical finals, where we are ensuring students have the appropriate knowledge, skills and attitudes for life as a foundation doctor. I feel the (PBL-SGT)-Fusion process goes someway to ensuring students have the appropriate knowledge, although there are improvements that can be made to the process as discussed in 'Chapter 6.0) Conclusions & Limitations'. An area for improvement for (PBL-SGT)-Fusion would be if the process could be extended to allow for simulation to be incorporated once core knowledge has been covered.

In the introduction to this dissertation I broached the issue of wanting to implement active learning techniques into the undergraduate medical curriculum. Having reviewed the implementation of (PBL-SGT)-Fusion with Kirkpatrick's model, I feel it has been a success in achieving the first two stages.

Further work needs to be done to modify this new style of teaching methodology in order for it to fulfil stages 3 and 4. Stage 3 will be achieved through the TSP approach introduced in 'Chapter 7.0) Recommendations & Suggestions for Future Research'. One element students have traditionally struggled with when answering questions in sessions was related to the management of various conditions. I have found tying in clinical reasoning (89) with the teaching of management, in the form of generic blocks that can be applied to various settings, has been successful. An example of this approach involves teaching guidelines for certain situations, regardless of causation, for example, the 'Bleeding patient', 'Dehydrated patient' or the 'Infected patient'. It would be interesting to see how easily students could apply these generic plans to patients in a simulation suite.

Although the CP3 curriculum is already established and set in terms of what must be taught to medical students, it is interesting to see what a positive impact a novel technique incorporating various constructivist educational theories has had on student engagement and attainment.

Having reviewed the literature this is a novel method that has not been implemented before. I am continuing collecting data in the hope to publish this work in the future and add to the literature.

Chapter 6.0) Conclusions & Limitations

6.1) Introduction

In this chapter I will discuss the overall conclusions from this study of an innovative teaching and curriculum intervention. These conclusions will be drawn from the results obtained on student performance, which are presented in 'Chapter 4.0) Results' and where appropriate will be compared and contrasted with pre-existing evidence from the literature.

In addition to considering what conclusions can be drawn, limitations of this study will also be discussed. Consideration of both conclusions and limitations lends itself well to thinking about how this project can be furthered. This is discussed in 'Chapter 7.0) Recommendations & Suggestions for Future Research'.

Albeit on a relatively small scale, this study has proved that a well-designed curriculum can have a positive impact on student attitude, engagement and attainment when delivered using active learning methodologies.

The challenge in making this teaching commonplace on a larger scale will depend on how successfully the limitations outlined in section 6.3) can be addressed.

6.2.0) Conclusions

When considering which conclusions can be drawn from this process I have looked at (PBL-SGT)-Fusion from both students' and teachers' perspectives. Combining both these views gives a powerful insight into medical education from a course administration point of view. This insight has been used to further develop (PBL-SGT)-Fusion as a teaching methodology.

6.2.1) Students' Perspective of (PBL-SGT)-Fusion

The active learning (45, 90) methodologies employed in (PBL-SGT)-Fusion where learning is centered on a 'Pre-test' followed by group discussion and mind mapping of the case has been universally well received. CP3 students have stated they wished they had access to this type of teaching earlier in their course, as this would have allowed them to make the most of many other learning opportunities. Taking this into account with the positive feedback from CP1 students, I consider exposing CP1 students to this process to be beneficial.

Of the 2014 CP1 cohort, one student declined to take part due to the social element of learning. This is certainly something to be mindful of. I believe a big factor in this student's decision to opt out was they did not want to be exposed to CP3 material in a group environment. On reflection, as a teacher, perhaps I should have done more to emphasise that learning by cases aimed to provide a construct around which to build knowledge, rather than a test. Had this proven to be a problem on a bigger scale, I would have considered changing the terminology of 'Pre-test'. I am pleased to say only one CP1 student has felt this way and dropped out. Given another 16 CP1 students from the class of 2015 actively engaged in the process, I do not feel this is a widely held concern among the student cohort.

I have continued delivering (PBL-SGT)-Fusion to CP1 & CP3 students. The process has been universally well received by all subsequent students CP3 (n=26) and CP1 (n=16). It is worth noting how students involved in the teaching after data collection for this dissertation ceased, have been equally positive in their praise for the process. This is encouraging as numerous studies (73, 77, 91) have acknowledged the link between student engagement and increased attainment.

The professionalisation process of qualifying as a doctor is physically (92), emotionally (61), and in the current climate, financially demanding (9). As a medical educator I feel a strong responsibility to adequately prepare the junior doctors of tomorrow and I see (PBL-SGT)-Fusion as the first part of that process. This will be built upon with the TSP approach, introduced in 'Chapter 7.0) Recommendations & Suggestions for Future Research'.

Several students, across both CP1 and CP3 cohorts, mentioned and reported in their feedback the way they approach learning has changed in a positive way. CP1 students have been particularly pleased with their ability to present patients in a polished way. This is something they have received positive feedback from their consultants on wards. Given the incredibly pressured clinical environment, if students are to get the most from their attachments, it is vitally important they make a positive first impression when meeting their clinical teams. If (PBL-SGT)-Fusion has contributed to helping students ingratiating themselves with their teams, it is an example of a positive effect of the 'hidden curriculum' (93, 94) surrounding this teaching.

It could be argued these students have personal characteristics which would increase the likelihood of successfully integrating within their teams. Regardless of this a primary objective of teaching students must be to encourage and facilitate their integration into clinical teams. I believe (PBL-SGT)-Fusion is useful in achieving this goal.

As Sir William Osler said:

'He who studies medicine without books sails an unchartered sea, but he who studies medicine without patients does not go to sea at all.'

I am mindful classroom teaching does not occur at times when students can be on the wards. There is a danger for medical education to become too classroom based, especially when compared with nursing training. There is a balance to be struck between classroom and ward teaching. (PBL-SGT)-Fusion aims to facilitate students in identifying learning opportunities on the wards once they are equipped with essential core knowledge.

6.2.2) Teachers' Perspective of (PBL-SGT)-Fusion

When considering (PBL-SGT)-Fusion from a teacher's point of view, this teaching methodology makes covering material with new groups incredibly easy. The 'Pre-test' not only activates prior knowledge for the students, but highlights gaps in their knowledge. Students are therefore receptive to having these deficiencies corrected, as they can immediately see the relevance to their future practice.

In addition to teaching an attentive audience I have found there is another major benefit to the (PBL-SGT)-Fusion methodology. If the teacher is familiar with their cases it does not take a long time to scan the responses of the students and make an assessment of the baseline ability of the group. This is vitally important as it allows the difficulty of the group CBD to be adjusted accordingly to match the ability level within the group. Time with students in class is invaluable; there are no other teaching methodologies that enable the groups' knowledge base to be assessed in such a short timeframe.

Teachers can also identify students who perform particularly strongly. This is beneficial in that such students can be given the opportunity to get involved in teaching other students in the group, under direct supervision. Not only does this maintain the concentration levels of all students in the group, but it allows top students to excel and develop whilst also motivating others to reach the required level of knowledge and achieve exam success.

Another technique (PBL-SGT)-Fusion permits is answers from all students to be read to the group. This is particularly beneficial for key topics where there is often misunderstanding. It allows students to get an unaltered view of what their peers thought. An example of a common question this is particularly useful for is "What is the empirical antibiotic for osteomyelitis?" This usually gives a range of answers, highlighting misunderstanding among the group, which provides rich topics for discussion.

6.3) Study Limitations

The major limitation concerns the small sample size, although more raw data is available for students who have participated in the process following the initial 35 analyzed in this study. Time constraints surrounding marking the short answer questions accounted for the number (n=35) included in this study. With data collection ongoing I hope to re-evaluate this process with a higher (n) in the future. Of the data analysed in this study only 11 cases are considered. There are 16 cases in total. This was due to the CP1 students only having time whilst on placement to complete cases 1-11. As further groups go through the process I will have more data on CP3 students who have completed all 16 cases.

Currently I am the only teacher delivering teaching using this methodology. In order to fully evaluate whether improvements in student knowledge are due to the effect of methodology further studies would be required with different facilitators. I have presented this work at two University of Nottingham internal conferences, The Faculty Education and Research Group (FERG 2014) and Delivering Effectively the CP3 Curriculum (DECC 2015). I hope with time CTFs at other sites will take up this methodology. This something I am more than happy to support them doing.

Another significant weakness of this study is the lack of a true control group. To achieve this would require delivering the CP3 curriculum to a cohort if students in a traditional lecture-based format rather than case studies, prior to sitting the 'Post-test' paper. Not only was this unfeasible, but it would be unethical to subject a group of MDD students to a form of teaching that is less well received. It would also have been problematic to justify such an approach when it was shown from an early stage this intervention was popular and effective. There is a wealth of literature on active learning (25, 26, 72) in other disciplines that would clarify and confirm the validity of the (PBL-SGT)-Fusion approach.

Chapter 7.0) Recommendations & Suggestions for Future Research

7.1) Introduction

In this chapter I will discuss my plans to continue this research. This involves short, medium and long-term goals. The success of the (PBL-SGT)-Fusion methodology to date has encouraged me to consider how best to further this work. Many students have said they would like more teaching like this throughout the medical course.

In the short-term I plan to continue delivering teaching to CP1 and CP3 students. For the CP1 students it provides a good introduction in to 'Case Based Learning' (95) and exposes them to active learning techniques (85, 96) that they can continue to use throughout medical school and their career. CP3 students with finals approaching can benefit from the synoptic holistic element to the cases. Data collection will be on going into the 2015/16 academic year and beyond.

My medium-term goals are to collect sufficient data to publish a paper about the (PBL-SGT)-Fusion method to spread the word. Longer term plans, which could happen concurrently with continuing data collection, involve developing the 'Theory, Simulation, Practise' (TSP) approach which represents the natural evolution of (PBL-SGT)-Fusion. TSP, with relevant educational theory, is introduced in section 7.4) of this chapter. The (PBL-SGT)-Fusion process, as it stands, satisfies the first two steps of Kirkpatrick's curriculum evaluation. However, to fulfill the third step, additional methodology would be required. I believe simulation is the best suited vehicle for achieving this goal. I also think an integrated approach to teaching will go a long way to increasing levels of student satisfaction among medical students.

7.2) What is The CP1-CP3 Disconnect?

When delivering (PBL-SGT)-Fusion, in addition to receiving praise and seeing CP1 students enthusiastically engage, I have also come to appreciate how CP3 students are frustrated with current teaching methodology. These discussions have arisen from feedback evaluating the (PBL-SGT)-Fusion process. It is inevitable students will draw comparisons between an innovative way of teaching and their current teaching methodology. I have termed this the 'CP1-CP3 disconnect'. Students report this annoyance, secondary to subject material being taught in a disjointed way. This is as a consequence of the modular nature of the course in the CP1, CP2 and CP3 years.

General medical and surgical topics are covered in CP1, although management is not explicitly covered. This comes as a shock to students in CP3. Having spent their CP2 year doing specialties such as Obstetrics & Gynaecology, then sitting summative examinations at the end of CP2, students work under the misconception specialty material cannot be re-examined in their final examinations. The inherent dangers of such an approach were highlighted in the final examinations of the 2013/14 academic year where their surgical station had a female patient of child bearing age with abdominal pain, yet very few students considered ectopic pregnancy. This creates the potential for students to adopt a short term and superficial approach to learning. With CP2 objectives already assessed there is no examination driven incentive for students to revisit material. A short term and superficial approach to learning is not conducive to producing good doctors and will not help them in practise. I firmly believe in the holistic approach to teaching and assessment mirroring the approach we would like our graduates to adopt as practicing doctors. The TSP approach could go a long way towards achieving this.

7.3) Further Developing (PBL-SGT)-Fusion (Short-Medium Term)

This dissertation has looked at the first 35 students (20 CP3 and 15 CP1) to complete the (PBL-SGT)-Fusion process. I appreciate these are small numbers from which to make far ranging conclusions. However the data collection process is ongoing. There are another 36 CP3 students from the 2014/15 academic year who have sat both the 'Pre-test' and 'Post-test' papers. This will give a total of 56 students who have completed the process at CP3 level. This summer these papers are going to be marked as part of an INSPIRE project in the hope we can create a sufficiently powered data set to stringently evaluate this teaching method. I would also like to compare all students, both CP1 and CP3, who have gone through this teaching with a random cohort of those who have not. The point of this comparison would be to determine whether this type of teaching has any impact on student attainment in university examinations. A request has been made for this dataset.

Anecdotally students who have gone through the (PBL-SGT)-Fusion process have done well in their finals examinations. In the 2013/14 academic year of the 29 students I taught none failed the musculoskeletal elements of their final examinations. This academic year (2014/15) of the 36 students that have completed the process only 2 failed their final examinations at the first sitting, this was not due to failing musculoskeletal stations however. I think this warrants further investigation and would require detailed statistical analysis to determine if there was any correlation.

7.4) Theory, Simulation, Practise (TSP) (Medium-Long term)

One of the major problems (97) medical students across the country face is getting up to speed with what is expected of them as an FY1 doctor. As students they spend a lot of time watching and not actually doing. This means the application of concepts taught at medical school to real life situations is not always an easy process. As educationalists we have a responsibility (98) to teach students in the most effective and engaging ways possible (38). It has always surprised, if not slightly concerned, me how little simulation based training medical students get. Considering the highly pressurised and risky environment in which they will work we owe it to future patients, that medical students are adequately skilled and prepared. Medicine as a discipline could learn a lot from the aviation industry when it comes to pilot training. This analogy is particularly apt given Sir Robert Francis's recent comments following the Mid Staffordshire enquiry, which I touched upon in 1.5.0).

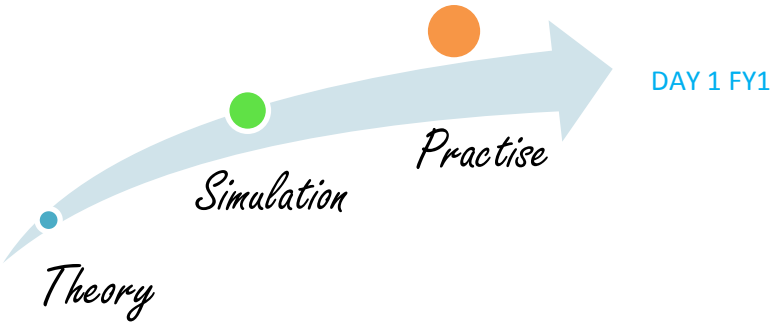
The current NHS climate is one where there is immense pressure to meet targets (99). When these targets are expected to be reached with limited resources, it can certainly make for a challenging educational environment. I would argue given the rise of CTFs, it is important to consider the quality of medical education delivered outside clinical environments. If a high quality educational solution can be delivered so we are putting capable students into clinical environments such that they are considered an asset to the team, their educational experience will increase as a result of being integrated within the team. Initial classroom teaching can be essential for aiding this process.

The (PBL-SGT)-Fusion methodology has been shown to be effective delivering material traditionally taught at CP3 stage to CP1 students. There is a lot to be gained for medical students if they are taught generic knowledge early therefore allowing application in clinical settings across various specialties in their CP2 and CP3 years. I have put together a proposal for how (PBL-SGT)-Fusion could be taught in the early years with knowledge being built upon and assessed in a simulation setting. The Theory & Simulation components of TSP will go a long way to providing students a steady foundation upon which they can build further knowledge.

7.5) The Value of Utilizing Simulation Appropriately

Simulation is a scarce resource but one which is extremely valuable when it comes to preparing students for life on the wards. It also permits the assessment of attitudes and behaviours in addition to knowledge. The TSP approach involves a sequential process where foundations of core knowledge are laid, in a classroom setting and then built upon in clinical environments. The process as a whole is illustrated in Figures 4 & 5.

Figure 4) Schematic for 'Teaching, Simulation, Practise' (TSP)

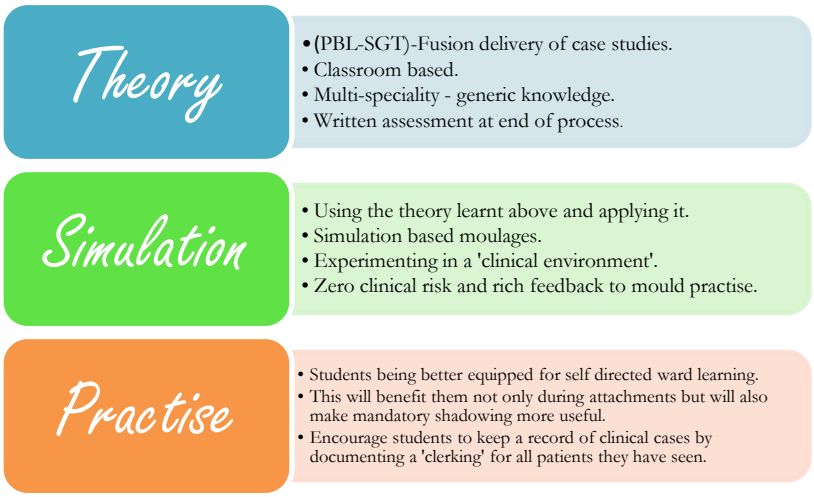


Within the arrow = classroom based activities.

As a student moves through 3rd, 4th & 5th years their clinical experience increases.

All teaching builds towards common end goal of becoming an FY1 doctor.

Figure 5) Components of TSP Process



As is stands University of Nottingham Medical Students experience simulation in isolation from the rest of their course and as a standalone event. There is no coordinated process to allow the use of the simulation suite to act as a bridge to practise in a clinical environment. I firmly believe through applying an educational structure such as TSP around simulation the potential of this limited resource could be maximised. This would however require an integrated approach to course design where themes run both horizontally and vertically through the curriculum (100).

(PBL-SGT)-Fusion as it stands is excellent for assessing knowledge however when looking at Miller's pyramid (101) for assessing clinical competence (102) it is very much within the domains at the base 'Knows' & 'Knows how'. Simulation would enhance this process immensely. It permits assessment of attitudes, behaviours and decision making via the 'Shows how' domain but also the opportunity to provide high quality individualized feedback to each student. Figure 6) illustrates the role of Miller's pyramid in TSP. The TSP approach would also go some way to achieving Step 3 of Kirkpatrick's curriculum evaluation model.

Figure 6) Miller's Pyramid & TSP Approach

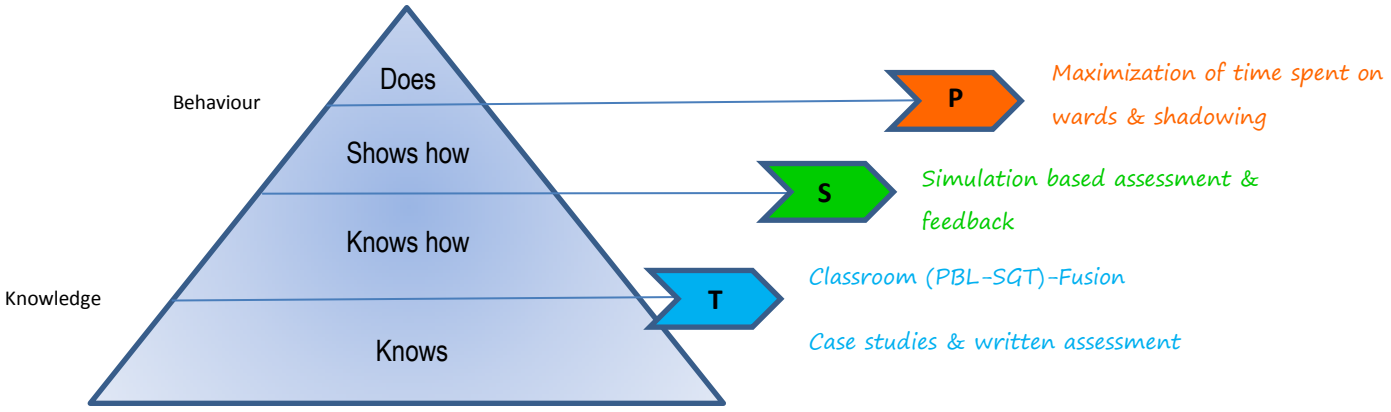


Table 95) How TSP Achieves FAIR Principles of Effective Learning

Principle	Example
Feedback	(PBL-SGT)-Fusion - Students get immediate feedback on written cases following the 'Pre-test paper. - They are also aware of their colleagues' answers in an anonymised manner, for key questions. With Simulation (TSP) - Students will get an immediate feeling as to how they performed. - Coupled with a formal debrief, this will create an emotionally powerful learning experience.
Activity	(PBL-SGT)-Fusion - Activities are paper based case studies. - Students can demonstrate they 'Know how' but the process does not currently provide the opportunity for students to 'Show how'. With Simulation (TSP) - The practical element will cater more for those who prefer an experiential style of learning. - Activities will be more lifelike. This will help prepare medical students for their time on the wards.
Individualisation	(PBL-SGT)-Fusion - Question difficulty is tailored to an individual level following the results of their 'Pre-test' paper. - This allows the teacher to identify struggling students and offer remedial sessions where necessary. With Simulation (TSP) - We will be able to assess students' performance in a stressful environment much more closely. - Specific scenarios could be tailored to students following analysis of their performance in the 'Post-test' paper.
Relevance	(PBL-SGT)-Fusion - All cases have a real life basis in practise. - They are all situations where medical students' theoretical knowledge can be assessed. With Simulation (TSP) - Through the addition of simulation based cases it opens up the possibility to test application of theoretical knowledge. - It will also better prepare students for time on wards so they can maximize that as a self-directed learning opportunity.

Table 96) An Example of TSP Applied to Teaching 'Hypovolaemic Shock'

PART OF TSP PROCESS	Example
THEORY	Pathophysiological concepts surrounding bleeding are taught via (PBL-SGT)-Fusion approach. Case studies are however written in conjunction with clinicians to ensure they are clinically relevant with scenarios students will recognize when they hit the wards. An example would be Poiseuille's Law, which states flow through a vessel is directly proportional to the 4^{th} power of the radius. Highlighting this in the context of cannula sizes available in a trauma setting makes this knowledge immediately relevant to the aspiring doctor. Another theory that would be useful to teach surrounding shock would be how it is classified according to a percentage of blood lost. Teaching the physiological parameters and how one would expect them to behave in a shocked patient. Also cover the variations in these parameters which would point in the direction of an alternative cause e.g. pyrexia and hypotension unresponsive to fluid challenge – would suggest septic shock.
SIMULATION	Place students in an assessed environment where they are required to assess and treat a patient who has shock. They are encouraged to give a fluid challenge and use how the patient responds to determine whether they are a 'transient responder' 'responder' or 'non responder'.
PRACTISE	By learning the core principles required through the theory and simulation phases students will be in a position where they have experienced common scenarios already in varying forms twice. By making mistakes in these safe, controlled environments it means students are more likely to engage with clinical teams this should bode well for shadowing and training in a challenging environment.

7.6) Moving Forward

(PBL-SGT)-Fusion has thus far, with limited numbers, been enjoyed by students and they have demonstrated retention of knowledge. Whether this translates into success when students are working post-graduation would require a much larger study to review Kirkpatrick's Step 4. In addition to collecting more data I would very much like to think about how this process could be furthered over the next three years. During this time I will continue as a Clinical Teaching Fellow and work towards building TSP into my teaching. This approach would allow the educational theory mentioned in the introduction to this dissertation, particularly scaffolding and experiential learning, to be applied in a simulation setting. I hope such an approach will be beneficial to todays' medical students as they begin their journey to become tomorrow's doctors.

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Abbreviations

CBD	Case Based Discussion
CP1	Clinical Phase 1
CP2	Clinical Phase 2
CP3	Clinical Phase 3
FY1	Foundation Year One (Doctor)
CTF	Clinical Teaching Fellow
GMC	General Medical Council
ISCP	Intercollegiate Surgical Curriculum Programme
MDD	Musculoskeletal Diseases & Disorders
MM	Mixed Methods
NHS	National Health Service
OOT	Observation Of Teaching
(PBL-SGT)-Fusion	This is the name of the new teaching style I have developed which involves incorporation of active learning techniques in to a small group setting. Clinical cases are used as the 'problem'.
SDL	Student Directed Learning
TSP	'Theory, Simulation, Practise' – An educational concept to build upon (PBL-SGT)-Fusion.

Appendix I
Quantitative Student Feedback

Summary of Student Rating 'Introduction, Presentation & Conclusion' (ISCP OOT Forms)

Student ID	Introduction			Presentation			Conclusion		
	DR	S	O	DR	S	O	DR	S	O
MDD 3 (n=10)									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
CP1 2014 COHORT (n=15)									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
MDD 4 (n=10)									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
TOTALS	1/35	9/35	24/35		1/35	33/35		6/35	27/35

Key

DR = Development required

S = Satisfactory

O = Outstanding

Summary of Global Student Rating for (PBL-SGT)-Fusion Process (ICSP OOT Forms)

Student ID	DR	S	O
MDD 3			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
CP1 2014 COHORT			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
MDD 4			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
TOTALS		1/35	30/35

CD Appendix Contains

- Cases 1-11
- ISCP 'Observation of Teaching' Feedback – Raw forms (Students 1-35)
- Free Text Comments Transcribed – Positive & Negative (Students 1-35)