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# Effect of Different Curricular Models on the Development of Clinical Reasoning Skills among Medical Students: A Quantitative Study

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## Abstract

**Background:** Current literature suggests that different curricular models have distinct impacts on the development of clinical reasoning (CR). However, there is a wide variety of evidence, which suggests superiority of one model over another. The University of Nottingham (UoN) has two different curriculums available to undergraduate medical studies: Problem-Based Learning (PBL) curriculum for Graduate Entry Medicine (GEM) and integrated curriculum for the Undergraduate Entry (UG). **Aims:** This quantitative study aimed to look at whether there are any significant differences in CR skills between the students undertaking PBL and integrated course, measured by the results of summative formative exams in Clinical Phase 1 (CP1) and Clinical Phase 3 (CP3) level. **Materials and Methods:** Data on how well the PBL and integrated students perform on CR questions were collected across three categories of school years (2012, 2013 and 2014) for CP1 and (2014, 2015, 2016) for CP3. Analysis using independent samples t-test was then performed to determine statistical significance. **Results:** In summary, it can be seen that the PBL students have achieved statistically significant better scores than integrated students in CP1 dataset across the three periods on the CR component of summative exam. However, there was not a significant difference in CR scores between these two groups in the CP3 dataset. **Conclusion:** Although there is a discrepancy of CR skills between UG and GEM students at the level of CP1, the gap gradually decreases as they progress through the later years of medical school. Comparatively long duration of UG can help the students develop necessary CR skills by the time they graduate.

## Abbreviations:

ACE: Advanced Clinical Experience; ANOVA: Analysis of Variance; CR: Clinical Reasoning; CP1 Clinical Phase 1: First clinical placement for medical students from University of Nottingham (taking place during the third year for Undergraduate course and second year for Graduate course); CP3Clinical Phase 3: Third and Final placement for medical students from University of Nottingham (taking place during fifth year for Undergraduate course and fourth year for Graduate course); CTT: Clinical Test Theory; GEM: Graduate Entry Medicine (graduate entry course for the medical students at the University of Nottingham); ID: Item Discrimination Index; IRT: Item Response Theory; NCR: Non-Clinical Reasoning; UoN: The University of Nottingham; UG: Undergraduate; PBL Problem-based Learning; SEM: Standard Error of Measurement

## Introduction

### Clinical Reasoning (CR) and Problem-based Learning (PBL)

Clinical Reasoning (CR) is defined as an interaction between the cognitive and non-cognitive processes of a healthcare profession and the patient, including the patient's environment to gather information about the patient and afterwards, weigh the risks and benefits of actions. Incorporation of patient's preference in addition to the aforementioned factors would then lead to determining a working diagnostic and therapeutic management plan to help improve a patient's well-being. [1]. Therefore, it is an essential skill which every healthcare professional should possess.

However, there has been various disputes and conflicting evidence on factors determining the development of CR skills in medical students. It has been proposed that the curriculum of medical school may affect the refining of one's cognitive processes and learning [2-6].

Nonetheless, there are a variety of factors, which can impact on the development of CR skills. Nafea [7] implied that the medical student's CR skills level can be affected by the stage of UG study [7]. However, Neufeld [8] implied that although the knowledge of medical students is developing, the development of CR skills remains comparatively unchanged during this period [8]. Nonetheless, there are other studies which suggest that as the students successfully progress through higher education, CR skills develop throughout [9,10]. Many studies reported that the curriculum during clinical phase of medical school has a strong influence on the development of CR skills within the students [11-13].

Problem-based learning (PBL) is thought to promote problem-solving and critical thinking in authentic learning situations and hence, it has been widely adapted to be used in diverse fields, such as, business studies, health sciences and engineering [14]. Studies have shown that PBL is a crucial factor in development of CR as it seems to encourage interest, motivation and self-directed learning [5,11,15-22]. However, various other studies have reported contrasting evidence on positive correlation between PBL and CR [7,9,13,23-28]. Some researchers have also reported weak association between PBL and problem-solving skills [12,29].

### Structure of the UoN Medical Curriculum

To get into the University of Nottingham (UoN) medical school, there are three different routes:

1. Five Year Undergraduate Course (A100)
2. Six Year Undergraduate Course (A108) which includes a foundation year beforehand
3. Four Year Graduate Entry Course (A101)

All three courses are designed for the students to acquire knowledge, skills and professional behaviour which will be crucial for a new graduate practicing in a healthcare environment. Despite having three different routes for entry, all cohorts congregate and converge at the start of clinical phase of the course (CP1). Afterwards, all the students are regarded as the same cohort (Figure 1).

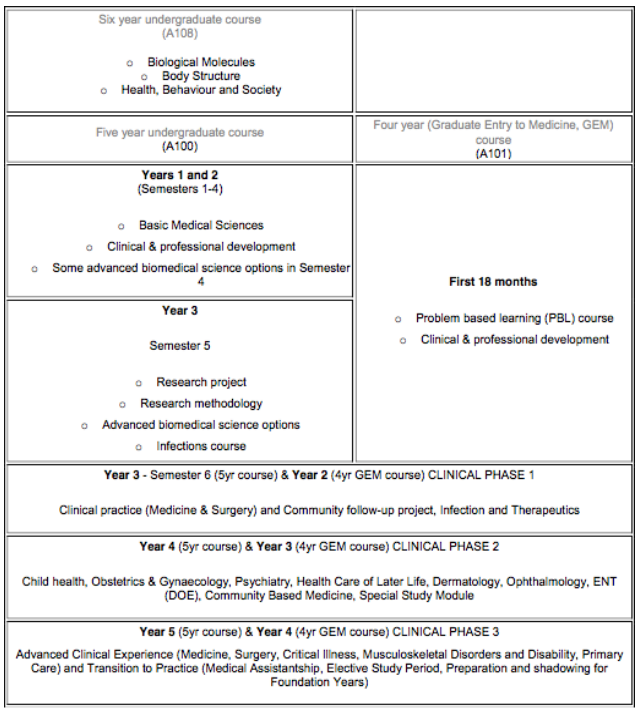


**Figure 1:** Diagram depicting different entry pathways to UoN Medical School and description of specific elements for each year.

### Aims and Objectives

In current literature, many studies focus on making a comparison between the PBL and the traditional curriculum [8,20,30- 32]. There are only a few papers which looked at the integrated model, which is another widely used style of curriculum. In a preceding qualitative study published, it has been concluded that medical students in the UoN perceived PBL students to have better CR skills than their peers in integrated course at the start of Clinical Phase 1 (CP1) [33]. However, interestingly, the self-perceived difference was very minimal to none at the end of clinical phase 3 (CP3) [33]. Therefore, this study aims to look at whether there are any significant differences in CR skills between the students undertaking PBL and integrated course, measured by the results of summative formative exams after CP1 and CP3 and it can be further divided into two null hypotheses.

**Null Hypothesis 1:** There is no statistical difference between the UG and GEM course with respect to CR skills at CP1 level.

**Null Hypothesis 2:** There is no statistical difference between the UG and GEM course with respect to CR skills at CP3 level.

## Materials and Methods

This research is classified as service evaluation. Ethics Committee stated that 'ethics approval is not required for processing data' when ethical approval is requested by the UoN to conduct this study (Appendix 1). Anonymity is kept when processing examination data and this research does not directly involve people.

### Research Design and Data Collection

Data is collected from clinically orientated summative assessment of CP1 and CP3 knowledge-based papers in different cohort years. Data is collected from six different cohorts; the CP1 (2012, 2013 and 2014) and CP3 (2014, 2015, 2016). Table 1 describes that there are approximately 318-351 students per cohort (Table 1). By comparing the results of those questions in the summative written exam that are considered to be predominantly CR questions, the outcomes of the course are measured to determine the impact of different curricular phases (PBL and integrated course) on CR.

| CP1 | Students in Cohort | CP3 | Students in Cohort |
|---|---|---|---|
| 2012 | 351 | 2014 | 335 |
| 2013 | 344 | 2015 | 350 |
| 2014 | 327 | 2016 | 318 |

**Table 1:** Represents number of participants in CP1 and CP3 by cohort.

### Classification of CR questions and non-CR questions before the exam

Review and categorisation of written papers into CR or non-CR questions takes place in standard setting meetings before the exams, which are attended by 15-25 experts for different cohort exams. These experts have a background of different specialities, namely, gastroenterology, respiratory medicine, general surgery, and etc. This expert team constitutes of consultants, GPs, Director of clinical skills, clinical teaching fellows, module leads, medical educators and some junior doctors.

When reviewing the questions to categorise them into CR or non-CR questions, if any discrepancies arises between the experts' opinions, they not only take Bloom's taxonomy of learning domains into account, but also map these questions against the three statements on 'Outcomes for Graduates from Tomorrow's Doctors' published by GMC (8c,

8g, 14f) [34]. Then, these questions are discussed further until they come to a mutually agreed conclusion.

### Psychometric evaluation after the exam

In order to provide an assessment tool with high quality, routine psychometric analysis of medical exam is carried out for each exam paper post-examination using Classical Test Theory (CTT) and Item Response Theory (IRT). Student-item maps allows for identification of problematic test items, for instance, the questions which are either too difficult or too easy. Analysis of knowledge papers are done using test-score reliability (Cronbach's alpha), item discrimination index (ID) and standard error of measurement (SEM).

In addition, each paper is also inspected using frequency and discrimination (U-L) analysis and learning objective analysis. For each item, discrimination value (d) is calculated using the following formula: total number of people with correct answers of the item/total number of people answering the item and item difficulty (p) is calculated. Afterwards, items with d<0.15 (low discrimination value) and p<0.2 (very difficult) are excluded. Reliability of the test is also measured.

Moreover, each test item is checked for descriptive statistics, which includes, sample characteristics according to gender/course (PBL or integrated) and item analysis, which consists of item discrimination, generalisability and decision studies. Correlation between cases and mean marks are also taken into account.

The papers are also internally and externally reviewed, which leads to the following overall results for the CP1 and CP3 (Table 2 and Table 3 respectively). CP3 has 2 summative papers.

| CP1 | Marks | | | |
|---|---|---|---|---|
| | CR | NCR | Total | CR % of Total |
| 2012 | 85 | 101 | 186 | 46 |
| 2013 | 73 | 112 | 185 | 39 |
| 2014 | 116 | 79 | 195 | 59 |

**Table 2:** Ranges of CP1 marks from 2012 to 2014.

| CP3 | Marks | | | | Mark | | | |
|---|---|---|---|---|---|---|---|---|
| | Paper 1 | | | | Paper 2 | | | |
| | CR | NCR | Total | CR % of Total | CR | NCR | Total | CR % of Total |
| 2014 | 151 | 41 | 192 | 79 | 87 | 83 | 170 | 51 |
| 2015 | 85 | 85 | 170 | 50 | 91 | 79 | 170 | 54 |
| 2016 | 113 | 57 | 170 | 66 | 98 | 77 | 175 | 56 |

**Table 3:** Ranges of paper 1 and paper 2 of CP3 marks from 2014 to 2016.

### Statistical Analysis

Data was analysed using an independent sample t-test and with IBM© SPSS® Statistics Version 22. As the parametric statistical tests of independent sample t-test requires the data of the data of the dependent study to be normally distributed, to ensure that the data meet normality, normality test of the data of different CR scores of the summative knowledge-based exam for each of the CP1 and CP3 datasets is performed. For each of the dependent variables, normality test was carried out by kurtosis statistics, investigation of skewness and histogram to check for the distribution of data. Skewness statistics <3 indicates strong normality and kurtosis between 10 and 20 indicates non-normality [35]. All datasets exhibit normality (Appendix 2).

Independent t-test was used to determine if there are any statistical differences between the continuous outcome measure course evaluation of CR scores of the summative written exam, using the three categories of school year (2011-2012, 2012-2013, 2013-2014 for CP1 and 2013-2014, 2014-2015, 2015-2016 for CP3) as the independent variables. If significant differences were observed, mean comparisons are conducted. P<0.05 was considered to be statistically significant.

## Results

To determine whether the CR scores were significantly different between each of the three periods between the CP1 and CP3 dataset, an independent sample t-test was used. For instance, CP1 students in the year 2013 are equivalent to CP3 students in the year 2015. This longitudinal analysis allows us to determine the development of CR when the students successfully progress from CP1 to CP3.

### Cohort 1

CR marks of integrated and PBL students in 2012 CP1 dataset is depicted in Figure 2. It shows that there is a significance difference between the two groups with respect to CR scores (t(190.30 = -2.45, p=0.01). When comparing the means of the two groups, CR scores of integrated students (M=57.03) is also significantly lower than the PBL students (M=59.98) with the mean difference of 2.95.

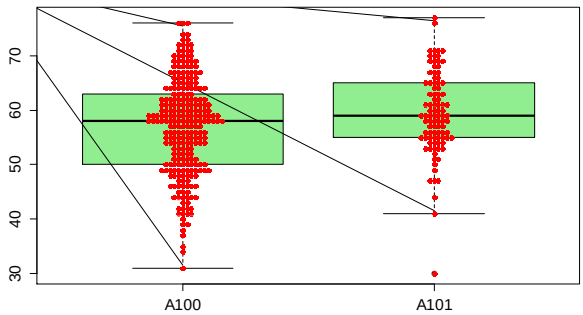


**Figure 2:** CR Scores of Integrated (A100) and PBL Students (A101) in Year 2012 CP1 Dataset.

In paper 1 of integrated and PBL students in 2014 CP3 dataset (Figure 3), it is shown that there are no significant differences between the two groups with respect to CR scores (p=0.72). The mean scores are also not significantly different between the groups: M=110.91 and M=108.06 for the integrated and PBL group respectively.

Similarly, in paper 2 of integrated and PBL students in 2014 CP3 dataset (Figure 4), it is shown that with regards to CR scores, there are no significant differences between the two groups (p=0.72). Moreover, the mean scores are also not significantly different for integrated (M=67.8) and PBL (M=64.19) students.

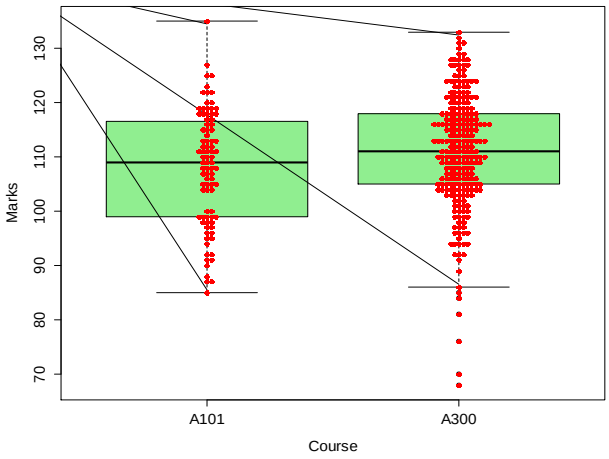


**Figure 3:** CR Scores in Paper 1 of Integrated (A300) and PBL Students (A101) in Year 2014 CP3 Dataset.

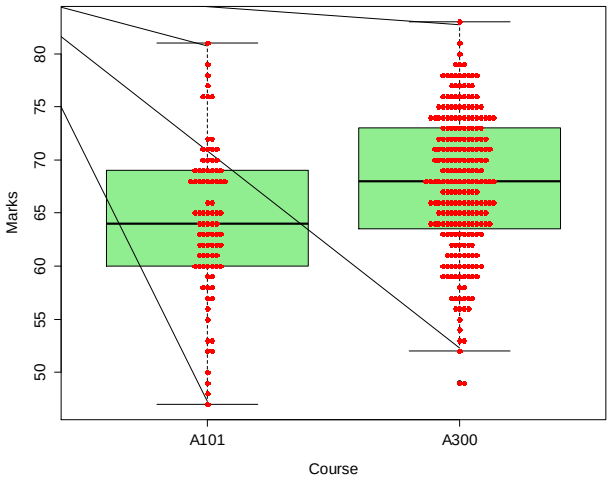


**Figure 4:** CR Scores in Paper 2 of integrated (A300) and PBL Students (A101) in Year 2014 CP3 Dataset.

## Cohort 2

When comparing the results of CR marks of integrated and PBL students in 2013 CP1 dataset (Figure 5), it is shown that there are statistically significant differences between the two groups (t(170.12)=2.97, p=0.003). In addition, the mean marks were the PBL group (M=58.06) having a higher average mean of 2.28 compared to the integrated group (M=55.77).

However, in paper 1 of 2015 CP3 dataset (Figure 6), there are no statistically significant differences between the two groups with respect to their exam scores (t(173.55)=-1.05, p=0.30). There is a mean difference of 0.90 between the two groups, with the mean score of integrated group being higher (M=64.50) but it is also not statistically significant.

In addition, paper 2 of 2015 CP3 dataset shows similar results to paper 1 (Figure 7). There are no significant differences between the integrated group and PBL group when the results are measured by independent sample t-test (t(160.81)=-1.80, p=0.07) and the mean scores are also not significantly different (M=62.08 for integrated students and M=60.37 for PBL students).

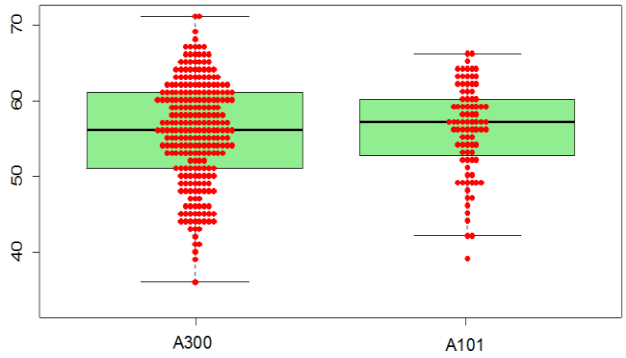


**Figure 5:** CR Scores of Integrated (A100) and PBL (A101) in Year 2013 CP1 Dataset.

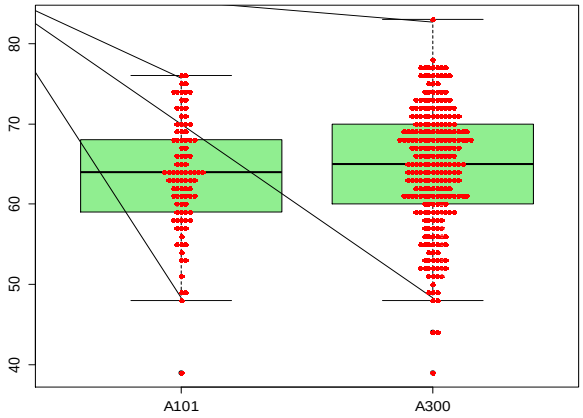


**Figure 6:** CR Scores in Paper 1 of Integrated (A300) and PBL (A101) in Year 2015 CP3 Dataset.

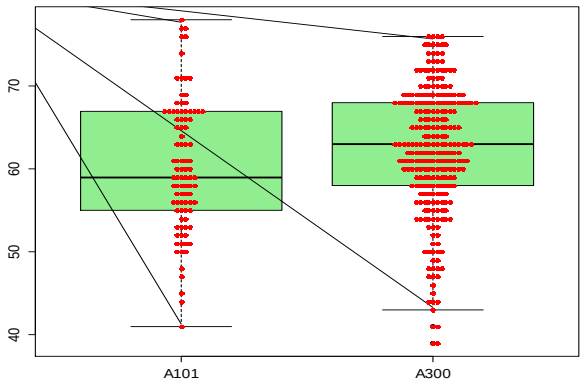


**Figure 7:** CR Scores in Paper 2 of Integrated (A300) and PBL Students (A101) in Year 2015 CP3 Dataset.

**Cohort 3**

Corresponding to the previous sections (Figure 8), the results of independent sample t-test shows that there are significant differences between the integrated and PBL students with regards to CR scores (t(164.45)=-2.48, p=0.01). In addition, the mean score of integrated group is (M=78.92) and the PBL group is (M=82.16) with the mean difference of 3.24.

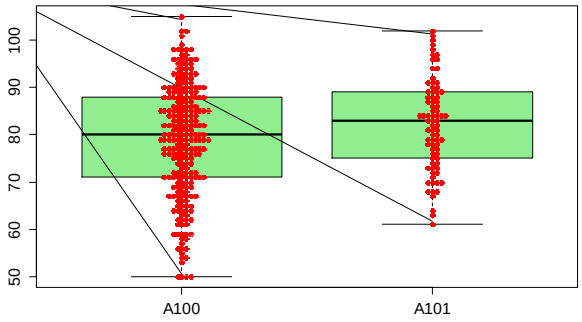


**Figure 8:** CR Scores of Integrated (A100) and PBL Students (A101) in Year 2014 CP1 Dataset.

In paper 1 of 2016 CP3 dataset (Figure 9), the CR scores are not significantly different between the integrated and PBL students (t(133.94=-1.48, p=0.14). Furthermore, the mean difference between the two groups is also not significant: M=83.66 for integrated students and M=81.83 for PBL students.

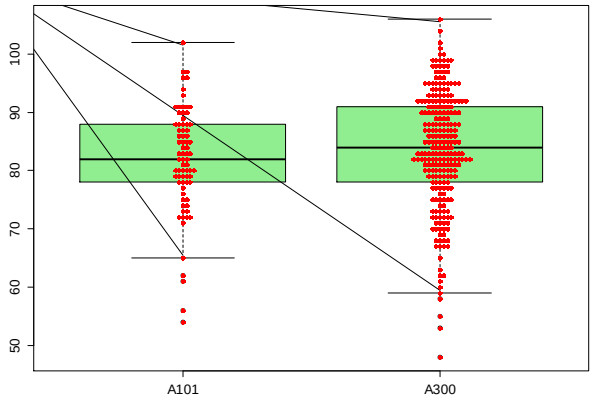


**Figure 9:** CR Scores in Paper 1 of Integrated (A300) and PBL Students (A101) in Year 2016 CP3 Dataset.

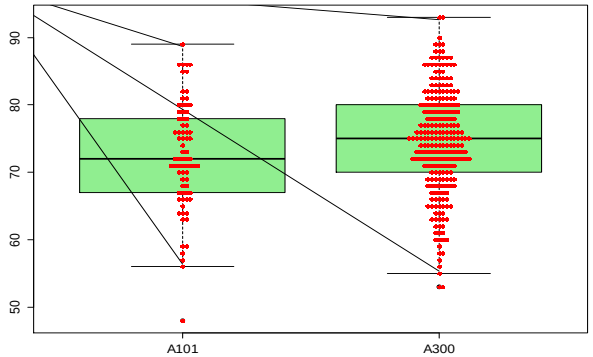


**Figure 10:** CR Scores in Paper 2 of Integrated (A300) and PBL Students (A101) in Year 2016 CP3 Dataset.

Likewise in paper 2 of 2016 CP3 dataset (Figure 10), it is noted that there is no significant difference between the two groups with respect to CR scores (t(121.36)=-2.01, p=0.05). Additionally, the mean score of integrated group (M=74.63) is higher compared to the PBL group (M=72.51).

## Discussion

### Key Findings

In CP1 datasets of all three periods, it can be remarked that all PBL students have achieved significantly better results than integrated students on the CR component of the summative exam. This could possibly be due to the difference in curriculum between the two groups at pre-clinical level. The various differences in mean of CR scores in each of the three periods can be explained by the difference in the number of CR questions. With these results, null hypothesis 1 which states that there is no statistical difference between the UG and GEM course with respect to CR skills at CP1 level is rejected.

In the CP3 dataset, it was shown that there were no significant differences between the PBL (A101) and integrated students (A300) with regards to CR scores. It can be seen that in all papers, integrated students scored higher than PBL students, but the results were not statistically significant except for CP3 paper 2 in 2016. This could suggest that integrated students in the CP3 dataset had caught up with the PBL group in terms of CR scores. Therefore, null hypothesis 2 which states that there is no statistical difference between the UG and GEM course with respect to CR skills at CP3 level is accepted.

These results echo the previous research which qualitatively measured the self-perceived CR skills of PBL and integrated medical students at CP1 and CP3 level [33]. The same paper also suggested that apart from the difference in curriculum, many other factors can influence the distinction between the two groups, namely, confidence, life experience, motivation and clinical background [33]. This is because all these factors are responsible for shaping and modifying one's way of conscious and unconscious thinking which leads to a variable clinical performance [33].

Across all time periods, CP3 students performed better than CP1 students in answering CR questions. In UoN, clinical placement takes place from third year onwards till a student graduates at the end of fifth year. This suggests that the comparatively long duration during the UG course can help the students to develop the CR skills. As another research have shown before, this study highlights the importance of clinical practice on the development of CR [28]. In addition, in the study of Da Silva [10], when comparing the three curricular types (traditional, integrated and PBL), she found that final year students performed slightly better than CP1 students for CR cases [10]. Previous researches and literature have illustrated that learning from practice is not a straightforward cause and effect phenomenon and therefore, careful planning is required by the educators to ensure creation of opportunities for students' experience in practice [36, 37].

There are many studies in the existing literature which states that the clinical phase of the curriculum has a strong impact on the CR of students which improves their ability to deal with different clinical scenarios [10-13]. One of those researches also stated that previous learning experience of the medical students could also have an effect on the clinical practice, which could potentially explain the difference between the performances in CR of GEM and UG medical students in CP1 [10].

There is a contradiction of this study's findings with Neufeld [8] which stated that there is no relative change in CR from the early years of medical to the entry of clinical practice [8]. The reason for this could be the difference in the curriculum of different medical schools which implies one medical school focusing more on allowing the students to have more clinical exposure leading to enhanced CR. Moreover, to further dispute those results, a longer longitudinal study with regular data collection intervals using more in-depth methodologies such as protocol analysis to access students' CR process would be required. Moreover, this research could be repeated in future cohorts of UoN medical school.

Despite different studies proving advantages of one curriculum over another on development of CR, it should be noted that there are many other factors which could influence CR [38]. There is a wide variety of styles within the PBL model itself, which might contribute to different results in proving superiority of PBL [39]. Therefore, modifying the research question to focus on the impact of specific aspects of PBL on defined variables instead of looking at the curriculum as a whole would be better suited to determine the quality of PBL. This would then lead to a more effective apprehension of the effects of PBL model on the CR skills of students.

## Limitations

In this study, there is a multitude of data sets with different number of students, summative knowledge exam papers and components of CR marks in each cohort. Therefore, according to the nature of data we have collected, instead of conducting a pairwise statistical analysis of the difference of scores, an independent sample t-test is carried out. The weight of correct answers is reflected by the total raw scores.

## Conclusion

In conclusion, it can be seen that the PBL students have achieved better scores than integrated students in CP1 dataset across the three periods in the CR component of summative exam. However, there was not a significant difference in CR scores between these two groups in the CP3 dataset, which implies that as the integrated students progress through the clinical years of medical school, they have caught up with the PBL group and improved their CR scores. However, this is still a monocentre measurement of the differences and therefore, further research looking at multiple teaching institutes are required.

## Conflict of Interest Statement

We have no conflict of interest to disclose.

## Funding Statement

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**Appendix 1:** Ethical approval.

The University of Nottingham

**Faculty of Medicine and Health Sciences**

Research Ethics Committee
School of Medicine Education Centre
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3rd May 2016

Professor Reg Dennick
Professor of Medical Education/Assistant Director
Medicine Education Centre, B Floor
School of Medicine
QMC Campus
Nottingham University Hospitals
NG7 2UH

Dear Professor Dennick

**Ethics Reference No:** MEU19012016 SoMEC **– please always quote**
**Study Title**: Developing and Implementing the incorporation of clinical reasoning elements into the undergraduate medical curriculum.
**Chief Investigator/Supervisor:** Professor Reg Dennick, Professor of Medical Education, School of Medicine Education Centre.
**Lead Investigators/student**: Dr Swe Khin-Htun, PhD Student, School of Medicine Education Centre.
**Type of Study:** Educational evaluation, secondary data analysis of anonymous datasets.
**Start Date:** 1/10/2011 **Proposed End Date:** 30/05/2017
**No of Subjects: n/a** anonymous datasets

Thank you for your letter dated 19th January 2016 requesting an opinion on whether the proposed analysis of anonymous exam data across the undergraduate curriculum for the presence of clinical reasoning questions requires full research ethics committee approval.

On review this is an educational/service evaluation/secondary data analysis of the assessments of the current undergraduate curriculum and does not require full research ethics review by this Committee. The data already exists, there will no direct contact with participants and the data will be anonymous.

If you wish to publish this you can indicate under "who gave ethical approval" that you have approached the Faculty of Medicine and Health Sciences Research Ethics Committee and they did not consider that this was necessary as it was considered to be an evaluation of pre-existing anonymous data of Medical Education course assessments and in our institution this does not require full research ethics review.

Yours sincerely

pp

**Professor Ravi Mahajan**
**Chair, Faculty of Medicine & Health Sciences Research Ethics Committee**

**Appendix 2:** Normality results.

## CP1 Dataset

As illustrated by Table 1, the value of skewness ranges from -0.35 to 0.63 and kurtosis ranges from -0.79 to -0.13 for CR scores, non-clinical reasoning (NCR) scores, and total scores of summative written exams which are dependent variables. Figure 1 also represents the normality of dependent variables when the values are plotted on the histogram.

| | N | Skewness | | Kurtosis | |
|---|---|---|---|---|---|
| | **Statistic** | **Statistic** | **Std. Error** | **Statistic** | **Std. Error** |
| CR | 1022 | 0.63 | 0.08 | -0.15 | 0.15 |
| NCR | 1020 | 0.04 | 0.08 | -0.79 | 0.15 |
| Summative written exams | 1021 | -0.35 | 0.08 | -0.13 | 0.15 |

**Table 1:** Skewness and Kurtosis Statistics of CR Scores, NCR scores and Total summative written paper for CP1 dataset.

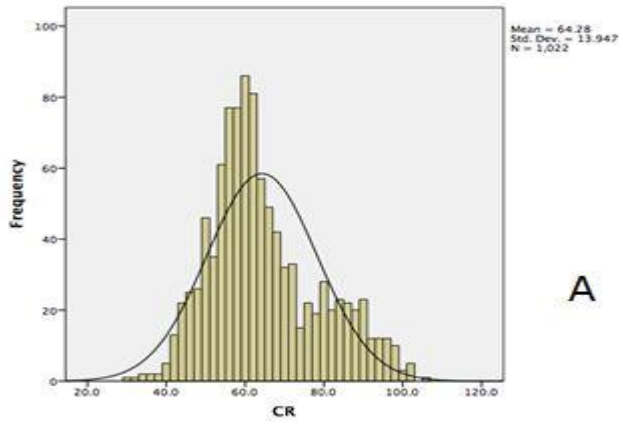
## CP3 Dataset

As represented by Table 2, the value of skewness ranges from -0.30 to 0.26 and kurtosis ranges from -1.02 to -0.49 for CR scores, non-clinical reasoning (NCR) scores, and total scores of summative written exams which are dependent variables. In addition, figure 2 illustrates the normality of the dependent variables data when plotted on a histogram.

| | N | Skewness | | Kurtosis | |
|---|---|---|---|---|---|
| | **Statistic** | **Statistic** | **Std. Error** | **Statistic** | **Std. Error** |
| CR Score (Paper 1) | 1003 | 0.26 | 0.08 | -1.02 | 0.15 |
| NCR Paper 1, 41/192 | 1003 | 0.10 | 0.08 | -1.02 | 0.15 |
| Summative written exams (Paper 1) | 1003 | -0.28 | 0.08 | 0.49 | 0.15 |
| CR (Paper 2) | 1003 | -0.11 | 0.08 | -0.01 | 0.15 |
| NCR paper 2, 98/185 | 1003 | 0.23 | 0.08 | -0.35 | 0.15 |
| Summative written exams (Paper 2) | 1003 | -0.30 | 0.08 | 0.01 | 0.15 |

**Table 2:** Skewness and Kurtosis Statistics of CR Scores, NCR scores and Total summative written.

Paper for CP1 dataset:




A

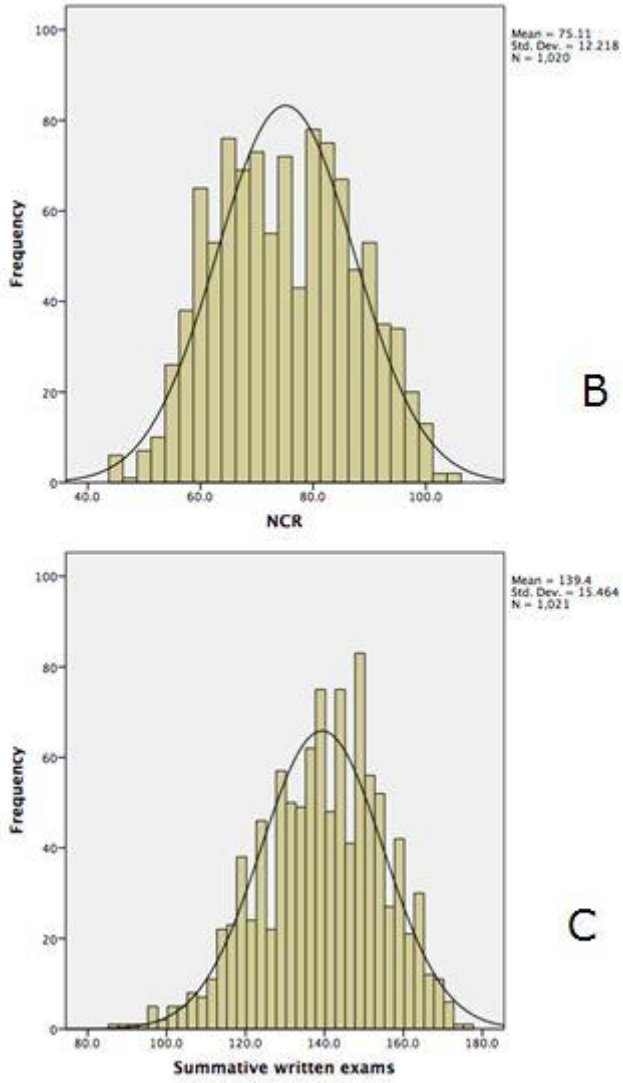
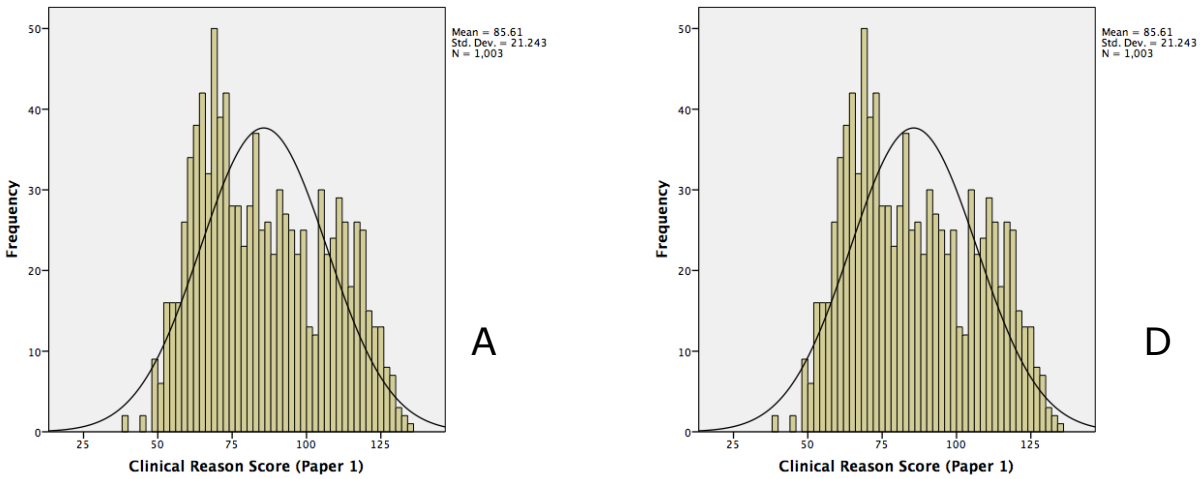



**Figure 1:** Histograms representing normality of dependent variables A. CR B. NCR C. Summative Written Exams.



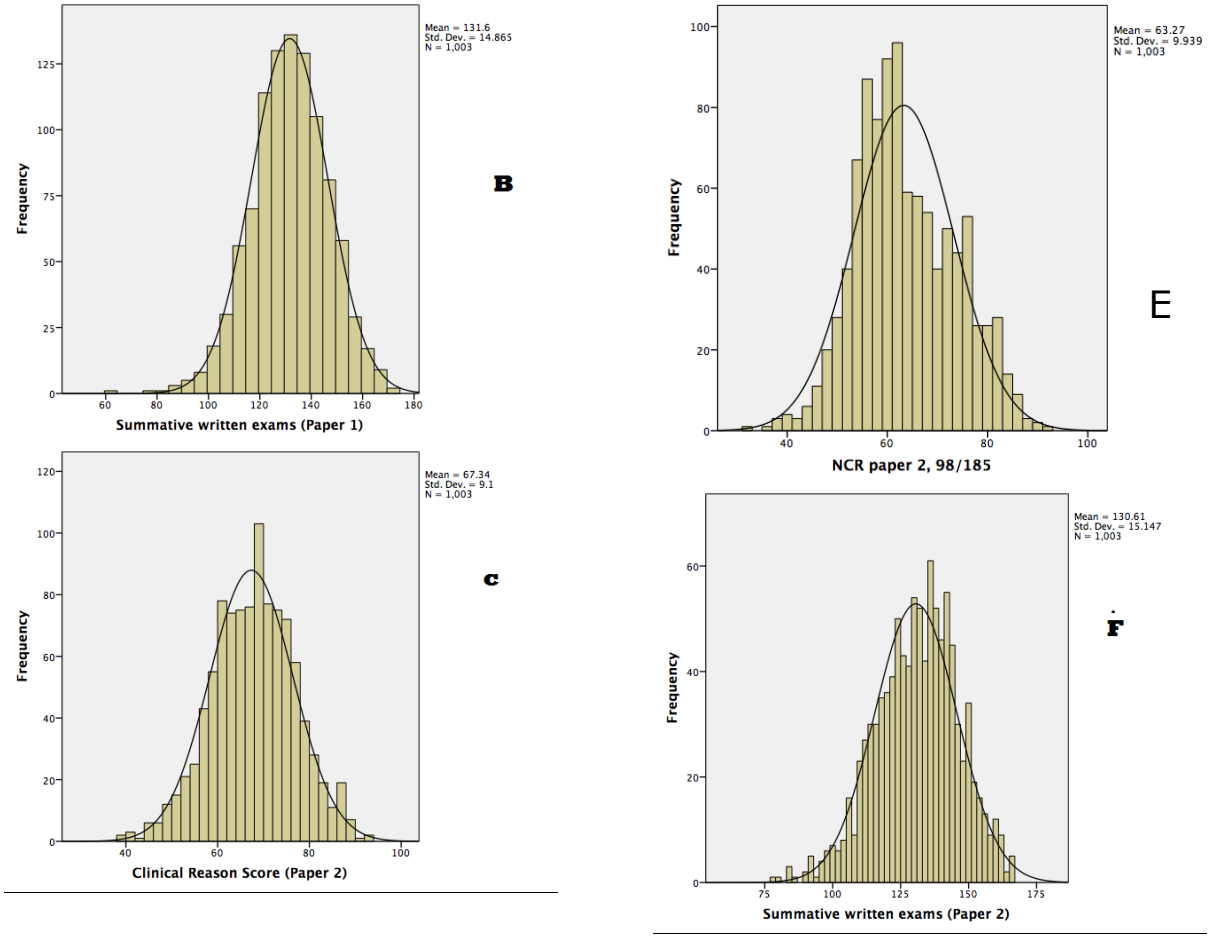



**Figure 2:** Histograms representing normality of dependent variables A. CR (Paper 1) B. NCR (Paper 1) C. Summative Written Exams (Paper 1) D. CR (Paper 2) E. NCR (Paper 2) F. Summative Written Exams (Paper 2).