Investigating the Attainment Gap in academic performance of Minoritised Ethnic groups for a STEM related subject.

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ABSTRACT

This paper addresses the attainment gap in academic performance for students of Minoritised and non-minoritised ethnicity, studying Discrete Mathematics, an undergraduate university level module, whereby an investigation of the effect of an intervention in one of the assessments is undertaken and statistically analysed. The attainment gap faced by the students of the UK higher education sector is concerning and between students of minoritised ethnic background and their counterparts, there is a sizeable achievement disparity in the education system. These groups' divergent academic performance is referred to as the attainment, and socioeconomic disadvantage, cultural hurdles, and institutional bias have all acted as a setback for the students from Black, Asian, and Minority Ethnic communities. However, there are obstacles to putting this strategy into practise, such as the need for suitable pedagogical techniques and assistance for students from different ethnic circumstances. Creating inclusive teaching methods in Science, Technology, Engineering and Mathematics (STEM) subjects that consider the linguistic and cultural diversity of the student is necessary to address these hindrances. Higher educational institutions can contribute to reducing the achievement gap for minoritised ethnic groups and fostering greater equity and social mobility by encouraging the teaching and study of modules in a responsive manner. Continuous analysis and study on the discrepancies faced by the students at their institutions should be performed to reduce this gap whilst promoting diversity. Moreover, a comparison over two academic years relative to the overall academic performance of students, considering the minoritised ethnic cohort, is accomplished so as to measure the approach's validity. The results from the performance ratio, t-test, hypothesis testing, effect size, chi-squared test, categorical variable analysis and the Cronbach alpha measure, all feed into and confirm the reliability of the study hence validating the positive impact of the intervention.

Keywords: Ethnicity; Higher Education; Attainment Gap; Statistics; STEM.

1. INTRODUCTION

The UK higher education institutions face issues with regarding to the attainment gap across their students and staff. Education that is inclusive is essential for the development of a more equitable society; a crucial component of education systems that seek to enhance educational quality and equity for all students. Tomlinson [1] notes that in an inclusive education and for the study of the attainment gap, mostly the concentration has been on learners with disabilities, whilst other groups of learners have received less consideration.

Consequently, it is necessary to comprehend the learning tendencies and circumstances of other underrepresented groups, such as minority students. The focus of this paper is on students of minoritised ethnic backgrounds (Black, Asian, and Minority Ethnic groups) studying the first-year undergraduate mathematics module called 'Discrete Mathematics'. This community in the UK encompasses a diverse range of cultures, languages, and backgrounds [2].

Although these students come from a variety of cultural backgrounds, they frequently face prejudice and institutionalised barriers in areas such as work, education, and healthcare [3]. These hurdles are made even more difficult by the many internal and external variables that have a disproportionately negative impact on the communities that are being considered in this paper. According to Ruvinga et al. [4], the attainment gap in STEM degrees is substantial compared to other subjects, therefore a mathematical topic that falls under the umbrella of STEM was the impelled incentive for this study.

The minoritised ethnic group of students in UK higher education, confront a variety of difficulties including underrepresentation in particular fields and industries, poorer rates of achievement, and a lack of diversity in faculty and curriculum [5]. Over one-third of the UK population is in fact underrepresented in higher education, and there is still a substantial achievement gap between students of minority ethnic groups and white students [6]. On campus, students may also encounter prejudice and minor acts of violence, which may affect their mental and intellectual health. However, to increase the representation and support of these students in higher education, there are efforts and programmes like staff diversity and inclusion training and the creation of inclusive curricula in place. [6].

This study consequently analyses the attainment gap within the different ethnic group of students with the aspiration to guide higher education institutions to invest more time to address the prevailing issues. A statistical analysis with qualitative and quantitative aspects of student response to an intervention that acts as a checklist before sub-mission of an assessment, comparable over two academic years, revealed the significance of the factor ethnicity in impacting the education of these students. The feedback from the questionnaire also acts as a students' voice which is important for the universities to act promptly to avoid drawbacks in the future. This research concentrates solely on students pursuing a STEM (Science, Technology, Engineering, and Mathematics) subject called 'Discrete Mathematics' for the Academic Year 2020/2021 and 2021/2022 respectively.

1.1 Literature Review

According to Crozier et al. [7], investigating the perceptions of a minority ethnic group of students regarding their identities in relation to the university and their peers, as well as whether these students feel compelled to change their classes or racialized identity in order to succeed, or if they resist such demands, all play a vital role in studying the attainment gap. Staff members in higher education also discuss instances of injustice, bullying, and prejudice. Problems caused by their simultaneous hypervisibility and invisibility, as well as constant questioning of their professional competence, was the most remarkable aspect [8]. This impacts the student's ability to acquire knowledge from higher education institutions. The achievement disparity between these minoritised ethnic students and White students persists even when factors such as entry qualifications and socioeconomic status are considered ([9], [10], [11], [12]).

Moreover, inequality when considering students for a specific programme and how race influences this decision is still prevalent in universities [13]. Therefore, reflective teaching in higher education employs strategies for mitigating negative effects on students [14]. The

presence of race during scholarship development is also evaluated in terms of its impact on the decolonization movement in UK higher education [15]. It is essential to recognise that gender and ethnicity have a strong correlation in higher education [16]. Despite their efforts, students frequently run into obstacles that prevent them from achieving their objectives [17,18]. During the worldwide Covid-19 pandemic, it is also vital to consider factors such as online learning versus traditional face-to-face learning for a mathematical subject [19], whereby these variations in teaching and learning methodologies may also have a negative impact on the attainment gap between racial and ethnic minorities in higher education.

In the context of STEM education, metacognitive thinking which entails under-standing and control of one's own cognitive processes, has attracted growing interest in recent years. Numerous researchers have investigated how metacognitive thinking might help students in STEM topics learn more effectively and solve problems. Specifically, Yeager et al. [20] discovered that the use of metacognitive methods, such as planning, monitoring, and evaluating, has a positive effect on students' mathematical performance. Similar findings have been made by other researchers who have discovered that metacognitive thinking fosters greater comprehension and conceptual growth in science [21,22]. The impact of meta-cognitive reflection on students' engagement and self-regulation in STEM learning contexts has also been examined in a number of studies [23,24]. Collectively, these results point to the critical role that metacognitive thinking plays in promoting successful learning experiences and supporting academic success in STEM education.

According to research, Minoritised ethnic populations in the USA continue to underachieve in STEM fields. The discrepancies between these students' academic performance and representation in STEM disciplines have been noted: For instance, according to a 2013 study by Wang [25], minoritised ethnic students especially those who are Black and Hispanic are severely underrepresented in STEM fields when compared to their White counterparts. Additionally, a National Science Foundation assessment [26] found that these minoritised ethnic students enrol in STEM programmes at lower rates of retention and completion, which results in a sizable difference in degree achievement. Additionally, Cheryan et al.'s [27] research showed the existence of implicit biases and stereotypes that contribute to these students' poor performance in STEM education.

Research also highlights that several Asian subgroups experience difficulties in educational attainment and representation in these disciplines, despite the perception that Asians excel in STEM. For example, Stevens [28] found significant differences in academic performance among Asian ethnic groups, with Southeast Asian and Pacific Islander children performing worse in STEM than their East Asian counterparts. A report by the Asian & Pacific Islander American Scholarship Fund [29] also emphasised differences in STEM degree completion rates among Asian American subgroups, revealing an accomplishment gap within the Asian community. Numerous factors, including socioeconomic differences, linguistic hurdles, and restricted access to STEM re-sources, might be blamed for this divide.

Although the use of technology in higher education are on the rise, there is still a need to incorporate a diversity and inclusive approach into staff training programs in order to better prepare teachers to integrate technology with students from underrepresented minority ethnic backgrounds [30,31,32]. Studies also show evidence of how the attainment gap can be reduced by grouping students according to their achievement levels and address the social justice and teaching issues [33].

To minimise the achievement gap and address the inequality, universities ought to take into consideration adopting a strategy on the level of the entire system [34]. This difference varies from university to university, and it even has an effect on the conditions that

prospective students must meet to enrol in an institution [35]. Although the performance of students from underrepresented groups has improved over the years, col-leges continue to fail to acknowledge the interrelationships that exist among the students who are experiencing an attainment gap [36].

2. MATERIAL AND METHODS

2.1 Research Approach

This paper begins with a literature review portraying the importance of student performance and the impact of the attainment gap prevailing in the higher education sector. For the qualitative analysis component of this study, data obtained from a questionnaire intervention are depicted using graphs for students undertaking 'Discrete Mathematics' for the Academic year 2021/2022. To supplement the data collection and analysis, tools such as box and whisker plots, pie charts which were designed to collect, interpret and present data and statistical analysis tests such as t-test, chi squared test were performed to produce p-values and categorical variable analysis in order to draw conclusions. For the quantitative analysis constituent of this research, the results of the assessments of the two Academic Years 2020/2021 and 2021/2022 were compared and the findings discussed.

The questionnaire may be considered valid as it was designed to explore the attainment gap relative to academic performance for all students in the Academic Year 2021/2022 studying 'Discrete Mathematics' focusing thereafter on the performance of the minoritised ethnic groups. As a part of this questionnaire, the overall performance and feedback of students was assessed by asking students different questions in order to address the attainment of learners. These questions are asked to analyse their learning and understanding; academic support, resources and opportunities available to them, organisation, management and their study experience. Students' responses for each question were then collated and presented graphically.

The implementation of an intervention via a questionnaire in fact, resulted in a favourable influence on the academic performance of the students in a STEM topic, as evidenced by a significant improvement in the students' overall results. Therefore, makes it feasible for conducting out the questionnaire intervention for this study, which gives a solid foundation of reliability [37,38]. The questionnaire acted as a recipe for students in this module, aiming to raise the attainment of learners [39]. By completing this questionnaire as a form of a checklist before submitting their assessment, it provides an opportunity for the students to reduce common errors. The questionnaire intervention addressed the attainment gap at module level between the Minoritised ethnic students and the non-minoritised ethnic students, anticipating an increase in student performance for all students, particularly minoritised ethnic students and a narrowing of the attainment gap between these two groups of students over the two consecutive academic years.

Over the two Academic Years 2020/2021 and 2021/2022, there were two written assessments (Assessment 1 and Assessment 2) for the module 'Discrete Mathematics'. In the Academic Year 2021/2022 the students had to complete the questionnaire intervention before the submission of their Assessment 2. With the aid of the outputs of the final assessments for both academic years, the academic performance of the students was measured by undertaking a comparison between Assessment 2 relative to the overall performance for the module. This difference in performance of the minoritised ethnic grouped students in the Academic Year 2021/2022, who experienced the questionnaire intervention, was additionally later then compared with the corresponding difference in

performance of the minoritised ethnic students of the previous year, Academic Year 2020/2021 who had no intervention in Assessment 2.

2.2 Statistical Analysis Models and Justification

A statistical evaluation of the assessments completed by the students of Academic Year 2020/2021 and Academic Year 2021/2022 of undertaking the module 'Discrete Mathematics' at undergraduate level was analysed. For the experimental year, Academic Year 2021/2022, the questionnaire was completed by the students before submitting their second assessment, underpinning the qualitative analysis and the assessment results of the two academic years are taken respectively into consideration for the quantitative analysis as shown below:

(1) Analysis of the Academic Year 2020/2021 and Academic Year 2021/2022.

The overall results from both the assessments of the module 'Discrete Mathematics' were compared using statistical tools. The Academic Year 2020/2021 had a sample size of 318 and Academic Year 2021/2022 had a sample size of 325 students. The students had similar educational background and the same educator for the module for the two consecutive Academic Years.

The hypothesis testing with the null and the alternative hypothesis were constructed on the results obtained from the two consecutive years, being:

H_0: There is no difference in the mean value of the overall assessment results of the two Academic Years 2020/2021 vs 2021/2022 for the Minoritised ethnic and non-minoritised ethnic groups.

H_1: There is a difference in the mean value of the overall assessment results of the two Academic Years 2020/2021 vs 2021/2022 for the Minoritised ethnic and non-minoritised ethnic groups.

(2) Analysis for the Academic Year 2021/2022.

An in-depth statistical analysis was performed on the outcomes of the two assessments incorporated in this module's descriptor for the same cohort of students. The first assessment was completed by the students before the intervention of the questionnaire and the second assessment was given after completing the questionnaire. The analysis is done to validate whether there was an impact of the intervention using the questionnaire on the students' results on the second assessment and their overall performance.

The following was presented to see whether there was an influence of the questionnaire on the assessment results for this particular year. The hypothesis testing was done with the following null and alternative hypothesis in mind:

H_0: There is no difference in the mean value of the two assessment results in the Academic Year 2021/2022.

H_1: There is a difference in the mean value of the two assessment results in the Academic Year 2021/2022.

Further to the above analysis, the following statistical calculations are considered to enhance the findings of this paper.

(a) Effect size

In order to strengthen and enhance further the findings of this study, the effect size is considered and calculated with the aid of the following equation ([40],[41]):

$$\text{effect size} = \frac{\text{The difference of means between the two groups}}{\text{Pooled standard deviation}}$$

The effect size plays a vital role when analysing data using statistics as it helps researchers to interpret the results significantly, validating the outcomes of their work [42]. The significance of effect size is also highlighted in this article. It is predominantly employed in statistical discussions. Additionally, the authors cited above argue that the effect size is independent of sample size, but the p value relies on it. Cohen's d effect size is given as below,

(i) When the value is 0.2 or less, it is a small effect size.

(ii) When the value is 0.5 or less, it is a medium effect size.

(iii) When the value is 0.5 or more, it is a large effect size.

(b) Performance Ratio

To add to the statistical analysis of this paper, a consideration of the performance ratio is chosen to exemplify the difference, if any, of the academic performance of students in the second assessment delivered after the intervention comparative to the overall marks the module for the Academic Year 2021/2022. The performance ratio was also evaluated using the following equation ([40],[43]):

$$\text{Performance Ratio} = \frac{\text{Total \% Marks for the second assessment}}{\text{Total \% Marks for the module}}$$

(c) Cronbach's Alpha coefficient

This is used to measure the consistency and provide more analysis on the reliability of the questionnaire used in this study for the Academic Year 2021/2022. The acceptable value of reliability lies between 0.7 to 0.9 [44]. The Cronbach's alpha is calculated as follows:

$$\alpha = \frac{N * c}{v + (N - 1) * c}$$

where N – the number of Students
c – Mean covariance between results of Assessment 1 and Assessment 2
v – Mean variance between results of Assessment 1 and Assessment 2

3. RESULTS

3.1 Demographic Characteristics of the students undertaking Discrete Mathematics in the Academic Year 2021/2022.

All students from the Academic Year 2021/2022, studying 'Discrete Mathematics' were eligible to be considered for the survey. Table 1 below depicts the demographic characteristics of the students who participated in the questionnaire intervention (See Appendix A).

Table 1. Demographic Characteristics of the students from the Academic Year 2021/2022.

Variable	Percentage
Age	
18-22 years	65.6%
23-27 years	20.3%
28-34 years	5.5%
35-39 years	5.9%
40-44 years	2.5%
> 45 years	0.2%
Gender	
Male	71.4%
Female	25.4%
Transgender	3%
Other	0.2%
Occupation	
Employed	25.8%
Self-employed	4%
Unemployed	0.8%
Student	69.4%
Marital Status	
Single	83.9%
Married	9.7%
Divorced	4%
Separated	2.4%
No. of children	
0	87.1%
1	3.3%
2	5.2%
3	3.2%
4 or more	1.2%

3.2 Graphical Representation

The questionnaire intervention (See Appendix B) was completed by the students of the Academic Year 2021/2022 before they undertook their second assessment. This questionnaire was constructed to address the attainment gap within the minoritised ethnic students studying the STEM related subject module 'Discrete Mathematics'. Students participated voluntarily in completing the questionnaire incorporating ethical considerations. Students' judgements were observed through the responses and some of the feedback from the students are shown below as Figure 1.

Fig. 1. Preferences from the students.

The results from the questionnaire were analysed and the following table, Table 2, shows a tabulation of correlation coefficients for each question relative to question 1 concerning ethnicity, Q1 *(What is your Ethnicity Background?)*. It can evidently be seen that Q2 *(Do you feel prepared and confident for the assessment?)*, Q3 *(Did you understand the marks allocation in the assessment criteria for each type of question?)*, Q5 (*Have you maintained an academic tone throughout your work and kept to the word count?),* Q8 *(Did you use the library resources when needed?)*, Q11 *(Do you participate in class activities and discussion?)* and Q12 *(Do you take enough time to organise and write the assessment in a critical manner?)* and Q15 *(Did you submit your own work?)* had a strong relationship with the Ethnicity backgrounds of the students' performance as their correlation coefficients are greater than 0.5.

Table 2. Correlation coefficient compared to the Ethnicity background of Question 1.

Questions	Ethnicity
Q2	0.681714
Q3	0.680962
Q4	0.128635
Q5	0.51032
Q6	0.386337
Q7	0.48475
Q8	0.55344
Q9	0.111943
Q10	0.394869
Q11	0.521753
Q12	0.656299
Q13	0.36065
Q14	0.145696
Q15	1.00000

The correlation coefficients relevant to the factors age, gender, occupation, marital status and no. of children are shown in Figure 2.

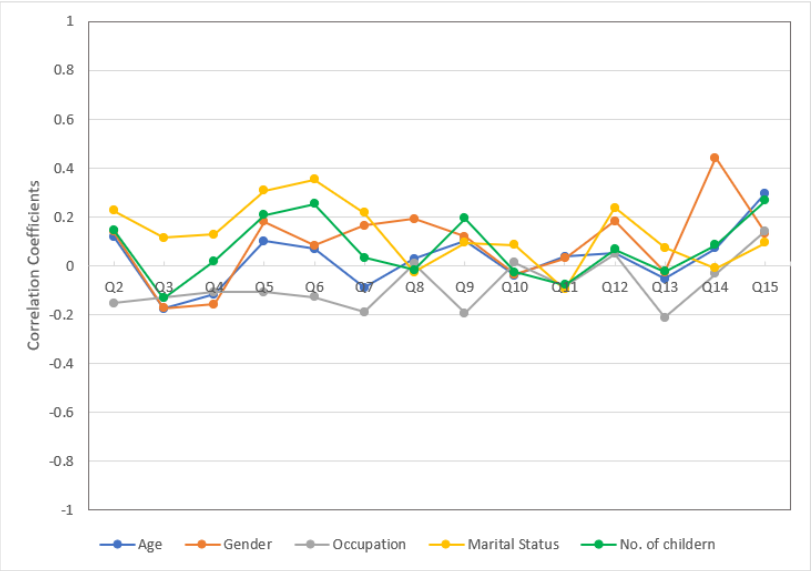

Fig. 2. Correlation Coefficients of demographic backgrounds.

It is established that the aforementioned demographic backgrounds of the surveyed participants are not strongly related to each other as none of the correlation coefficient values are close to 1. Hence these factors do not influence the attainment gap as per the feedback given by the students in their questionnaire responses. Consequently, based on the results of the survey, it is deduced that these factors do not have a major influence on the overall performance of students and increasing the attainment gap.

3.2.1 The Results of the Analysis of the Academic Year 2020/2021 and Academic Year 2021/2022

Initially a box plot is constructed for the results of the Minoritised ethnic students for both the Academic Years 2020/2021 and 2021/2022. The obtained results of the assessments were standardised for both years to have a uniform and consistent data set. Standardising the data is important when the results have irregular number of data sets [45], and when considering the proficiency level of each cohort.

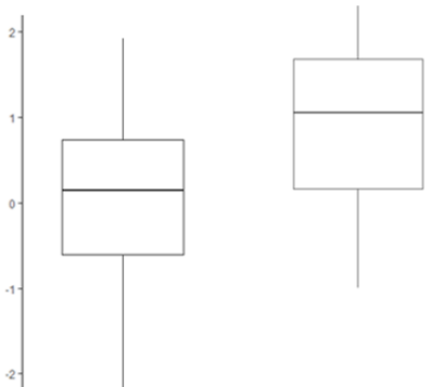

Fig. 3. Box Plots between the ethnic groups for the Academic Years 2020/2021 and 2021/2022.

The box plots above shown as Figure 3 portray that the students of Minoritised ethnic group from the Academic Year 2021/2022 performed better than the students of Minoritised ethnic background from the Academic Year 2020/2021. It must be noted that the Academic Year 2021/2022 was the year that the students experienced an intervention, that being the questionnaire and hence it can be determined that it had a positive impact on the students' performance.

(a) t-test

For the two academic years 2020/2021 and 2021/2022, a t-test was conducted between the results and the minority ethnicity categories. It focuses on whether there is a significant difference between the two groups' mean values, as shown in Table 3. The obtained p value was less than the significance value of 0.05. Therefore, the null hypothesis is rejected, and it is proved that there is a difference in the mean value of the overall assessment results for the Minoritised ethnic and non-minoritised ethnic groups between the two Academic Years 2020/2021 and 2021/2022.

Table 3. t- test results for the Academic Year 2020/2021 and Academic Year 2021/2022.

	Values
t	4.2115
Significant Value	0.05
Degrees of Freedom	641
p-value	3.23e-05

(b) Chi-squared test

The chi-squared test was also carried out and a very small p value was obtained as shown in Table 4. This value is less than the significant level of 0.05, hence validating the results from the t-test that there is a difference in the mean value of the overall assessment results of the two Academic Years 2020/2021 vs 2021/2022 for the Minoritised ethnic and non-minoritised ethnic groups.

Table 4. Chi-squared test results for the Academic Year 2020/2021 and Academic Year 2021/2022.

	Values
Chi-squared	4288.3
Significant Value	0.05
p-value	1.607e-10

(c) Categorical Variable Analysis

Additionally, a categorical analysis was done using binary values for this data in hand. The binary logistic model is fitted to the results of the two years' results. The model was studied to understand whether the intervention had an impact on the students' performance. If a student was from a 'Minoritised ethnic' group, a value of 1 was given and if a student was from the 'Non-minoritised ethnic' group, a value of 0 was given. The results in Table 4 show the values obtained for each variable.

Table 5. Categorical variable results for the Academic Year 2020/2021 and Academic Year 2021/2022.

	Dependent Variable (Ethnicity)
Academic Year 2020/2021	-0.0031
Academic Year 2021/2022	-0.0018

The coefficient of 'Academic Year 2020/2021' is -0.0031 ($e^{0.0031}$ =0.996), deducing that when the variable 'Academic Year 2020/2021' is increased by 1 unit while all other variables are held constant, the variable 'Ethnicity' has a negative effect on student performance and reduces it by 0.4%.

Similar to 'Academic Year 2021/2022', the coefficient of 'Academic Year 2021/2022' is -0.0018 ($e^{0.0018}$ =0.998), allowing us to conclude that when the 'variable Academic Year 2021/2022' is increased by 1 unit while all other variables are held constant, the student performance decreases by 0.2%. Recalling that this was the year in particular that students were given a questionnaire to narrow the attainment gap. It can be seen that the students performed better during the Academic Year 2021/2022, as their performance declined less comparatively to the previous year.

Taking into account the effect size, the calculated value was 0.52, indicating a medium effect size according to Cohen's effect size guidelines [46]. This value shows that the mean difference is approximately half the standard deviation ((51.69-48)/8.0064). Furthermore, this effect size value indicates that approximately 69% of the mean of all students' results for the Academic Year 2021/2022 fall above the mean of Academic Year 2020/2021 results.

(d) Performance Ratio

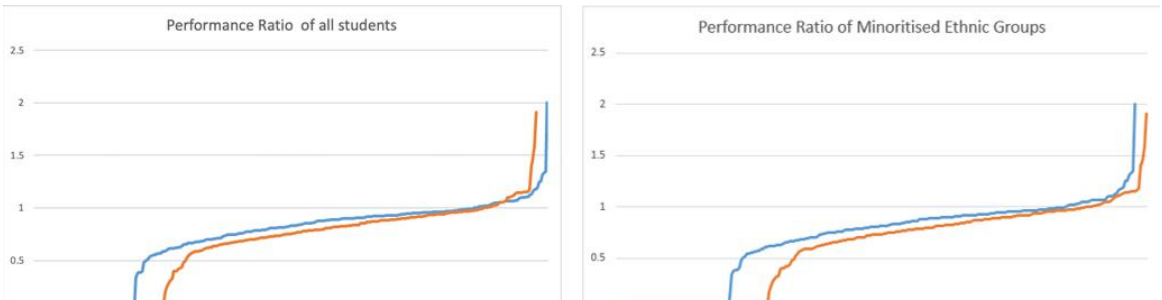

Fig. 4. Comparison of performance ratios between the Academic Years 2020/2021 and 2021/2022.

The performance ratios for the Academic Years 2020/2021 and 2021/2022 are displayed in the graphs presented as Figure 4. The first graph demonstrates the performance ratios of all students over the course of two years. After the questionnaire intervention, student performance improved, as seen by higher ratio values of the second assessment compared to the overall marks.

The performance ratio for exclusively Minoritised ethnic groups for both academic years is displayed in the second graph in the series of Figure 4. According to this, each student's performance ratio values are represented, for both academic years, whereby the year with the questionnaire being employed saw an improvement in students' learning performance.

An additional analytical measurement to investigate the presence of a narrowing of the attainment gap between Minoritised ethnic students and non-minoritised ethnic students was employed by considering the difference in the mean of the non-minoritised ethnic and the minoritised ethnic students analogously for the two academic years. A reduction of 19.6% in the mean overall results of the two groups over the two consecutive years was experienced, exemplifying that the impact of the intervention of the questionnaire was significant thus narrowing the attainment gap for this specific module.

3.2.2 The Results of the Analysis for the Academic Year 2021/2022

(a) t test

The obtained p value was less than the significance value of 0.05 as shown in Table 6. Therefore, the null hypothesis is rejected, and it is proved that there is a difference in the mean value of the two assessment results (Assessment 1 and Assessment 2) in the Academic Year 2021/2022.

Table 6. t- test results for the Assessment 1 and Assessment 2 (Academic Year 2021/2022).

	Values

t	5.5722
Significant Value	0.05
Degrees of Freedom	324
p-value	3.701e-08

(b) Chi-squared test

The chi-squared test shown in Table 7, was also carried out and a very small p value was obtained. This value is less than the significant level of 0.05, hence confirming the results from the t-test that there is a difference in the mean value of the two assessment results in the Academic Year 2021/2022.

Table 7. Chi-squared test results for the Assessment 1 and Assessment 2 (Academic Year 2021/2022).

	Values
Chi-squared	5565.5
Significant Value	0.05
p-value	2.2e-16

(c) Categorical Variable Analysis

Table 8. Categorical variable results for the Assessment 1 and Assessment 2 (Academic Year 2021/2022)

	Dependent Variable (Ethnicity)
Assessment 1	-0.0011632
Assessment 2	0.07553

The coefficient of the assessment 1 is -0.0011632 ($e^{0.0011632}$=0.998), inferring that when the 'variable Assessment 1' is increased by 1 unit, whilst others are fixed, student performance had an effect by the variable 'Ethnicity' and was reduced by 0.2%.

The coefficient of the assessment 2 is 0.07553 ($e^{0.07533}$ = 1.07820), allowing for the deduction that when the 'variable Assessment 2' is increased by 1 unit, whilst others are fixed, the student performance had an effect of the 'Ethnicity' variable and it increased by 7.8%. Therefore, the intervention of the questionnaire completed before the second assessment contributed to the better performance on students' learning in the Academic Year 2021/2022.

Examining in detail the effect size of the two assessments for the same cohort of students of the Academic Year 2021/2022, it was calculated to be the value of 0.789, indicating a rather large effect on the data. This shows that approximately 80% of the mean of the second assessments results (with the intervention) from the Academic Year 2021/2022 fall above the mean of the results of the first assessment.

The Cronbach's alpha value obtained for this data set of the Academic Year 2021/2022 was 0.899641. As this value is between the acceptable guideline range, it can be stated that

indeed there is a higher degree of internal consistency and reliability of the questionnaire intervention.

3.3 Discussion

In order to investigate the achievement disparity between students from Minoritised ethnic and non-minoritised ethnic groups taking the module "Discrete Mathematics," a statistical analysis was conducted. The findings in this paper demonstrate how a student's ethnicity had a significant impact on their learning performance and the factors that contribute to this for this specific STEM subject related module are observed.

Delving deeper, by examining the two Academic Years 2020/2021 and 2021/2022, as well as performing qualitative and quantitative analysis on the data collected, the attainment gap was also investigated. Both academic years had two assessments, and the Academic Year 2021/2022, in particular, featured a questionnaire intervention before the submission of the second assessment. The staff and students were able to use this questionnaire to better understand and address the attainment gap for this module. It was discovered that the variable "Ethnicity" lowered student performance of the Academic Year 2020/2021 by 0.4% when comparing the overall marks of the two assessments, but with the intervention of the questionnaire, the student performance of the Academic Year 2021/2022 decreased only by 0.2%. This demonstrates that the questionnaire had an advantageous effect on the students. Even more so, a narrowing of the attainment gap at module level between the Minoritised and non-minoritised ethnic students over the two consecutive years was found to be 19.6%. The benefits anticipated were firstly to see an increase in the overall result profile for all Minoritised ethnic students at this specific undergraduate module over the two consecutive years, a rise of 20.1%, and secondly to see a reduction of the attainment gap between the Minoritised and non-minoritised ethnic communities.

The variable "Ethnicity" decreased student performance for assessment 1 by 0.2% and raised student performance for assessment 2 by 7.8% during the Academic Year 2021/2022. This provides a compelling argument for the questionnaire's critical involvement in the attainment gap.

The attainment difference present in higher education is demonstrated statistically by the use of the t-test and the chi-squared test. All the students' performance improved as a result of the intervention of the questionnaire, that was given to them to complete before their second assessment for the Academic Year 2021/2022. This improvement in student performance following the intervention of the questionnaire is also portrayed by the performance ratio graphs. The results in this paper from the performance ratio, t-test, hypothesis testing, effect size, chi-squared test, categorical variable analysis and the Cronbach alpha measure, all feed into and confirm the reliability of the study since the results are consistent and the numerical accuracy of the test measures, show their significance and validity. Thus, the positive impact of the intervention holds strongly for the Minoritised ethnic group of students.

4. CONCLUSION

This paper acknowledged and highlighted a strategy that could address the attainment gap for Minoritised and non-minoritised ethnic group of students for a STEM related subject at undergraduate level. It aimed to investigate the effect of an intervention for this specific module in an experimental and controlled environment by comparing the results of students' performance over the two consecutive years.

As a result of the thorough investigation of the attainment gap, which included qualitative and quantitative evaluations, strong numerical insights have been obtained. The introduction of the questionnaire intervention demonstrated its effectiveness, especially during the academic year 2021/2022. It's interesting to note that the "Ethnicity" variable had a significant impact, with data showing a 0.4% reduction in student performance for the Academic Year 2020/2021, which was lessened to a 0.2% decline with the questionnaire's intervention in the following year. Particularly, over the course of two years, the achievement difference between minoritized and non-minoritized ethnic pupils decreased by a prominent 19.6%. The study's robustness was strengthened by statistical tests including t-tests and chi-squared tests, and the intervention's effectiveness was further highlighted by performance ratio graphs and effect size estimates. Together, these findings support the validity of the study and give concrete evidence of the intervention's beneficial effects, especially for students of minority ethnicities.

Efforts to close the STEM achievement gap in higher education have the potential to spark transformational change in a variety of fields. The quest of greater inclusivity and diversity within these crucial disciplines emphasises the significance of narrowing this gap, not just to ensure fair educational access but also to utilise a wider range of skills and perspectives. The reduction of the STEM attainment gap has the potential to foster a more skilled workforce, support economic growth, and improve the ability to address complex and urgent global issues as the global landscape depends more and more on technical and scientific innovation.

This study recognises that in order to pave the way forward and succeed in addressing fully the issue of the attainment gap, a post-racial approach must be taken, and a range of strategies must be considered at module, course and university level.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

All authors contributed to the development of this paper.

Conceptualisation, Anastasia Sofroniou; Methodology, Anastasia Sofroniou and Bhairavi Premnath; Analytical and Numerical Analysis Bhairavi Premnath; Validation, Anastasia Sofroniou and Bhairavi Premnath; Writing-original draft preparation, Bhairavi Premnath and Anastasia Sofroniou; Writing-review and editing, Anastasia Sofroniou and Bhairavi Premnath; Supervisor, Anastasia Sofroniou.

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APPENDIX A

Questionnaire

(a) What is your age group?

18-22 years
23-27 years
28-34 years
35-39 years
40-44 years
>45 years

(b) What gender do you identify as?

Male
Female
Transgender
Other

(c) What is your occupation?

Employed
Self-employed
Unemployed
Student

(d) What is your marital status?

Single
Married
Divorced
Separated

(e) How many children do you have?

0
1
2
3
4 or more

APPENDIX B

Questionnaire

1. **What is your Ethnicity background?**
   White
   Asian
   Black
   Mixed
   Other Ethnic Group
   Unknown

2. **Do you feel prepared and confident for the assessment?**
   Agree
   Disagree
   Not sure

3. **Did you understand the marks allocation in the assessment criteria for each type of question?**
   Agree
   Disagree
   Not sure

4. **Did you have the opportunity to work with other students in class?**
   Agree
   Disagree
   Not sure

5. **Have you maintained an academic tone throughout your work and kept to the word count?**
   Agree
   Disagree
   Not sure

6. **Did you receive enough guidance and support from the lectures?**
   Agree
   Disagree
   Not sure

7. **Did you receive enough guidance during the tutorial session?**
   Agree
   Disagree
   Not sure

8. **Did you use the library resources when needed?**
   Agree
   Disagree
   Not sure

9. **Have the facilities and resources given by the university helped you with your study?**
   Agree
   Disagree
   Not sure

10. **Did you refer and meet the learning outcomes of the module?**
    Agree
    Disagree
    Not sure

11. **Did you participate in class activities and discussions?**
    Agree
    Disagree
    Not sure

12. **Did you take enough time to organise and write your assessment in a critical manner?**
    Agree
    Disagree
    Not sure

13. **Have you checked that the referencing and bibliography is in line with the module descriptors?**
    Agree
    Disagree
    Not sure

14. **Did you proofread and check for any mistakes before submitting the assessment?**
    Agree
    Disagree
    Not sure

15. **Did you submit your own work?**
    Agree
    Disagree