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Effect of formative assessment on academic achievement of postgraduate students in advanced educational statistics in public universities in southeast, Nigeria

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Abstract
Advanced Educational Statistics is one of the important courses taught in higher institutions in Nigeria, which has witnessed poor academic achievements by students. Educators are faced with the need to look out for innovative assessment techniques that will enhance learning and bring about improved academic achievement. This study investigated the effect of formative assessment on the academic achievement of postgraduate students in Advanced Educational Statistics, as well as how its effect varies across gender. Two research questions guided the study and two hypotheses were tested. A quasi-experimental, non-equivalent control group design was utilized in the investigation. The population consist of 1,367 postgraduate students of all government owned universities in South East offering Advanced Educational Statistics at the postgraduate levels for the 2018/2019 academic session. A sample of 122 postgraduate students from Nnamdi Azikiwe University, Awka, Anambra State and 112 postgraduate students from University of Nigeria Nsukka, Enugu State were purposively selected. Advanced Educational Statistics Achievement Test (AESAT) was the instrument used for data collection. This instrument was validated by three experts and tested for reliability. A reliability coefficient of 0.82 was obtained using test re-test. Mean was used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings of the study showed a significant effect of formative assessment on students' academic achievement in Advanced Educational Statistics. The findings also indicated that both male and female students' academic achievement was enhanced equally. With the use of formative assessment a there was no significant difference the mean performance of male and female students. This study has revealed that formative assessment method of teaching and learning had a lot of significant effect on the students' achievement in postgraduate students' subjects such as Advanced Educational Statistics. In fact, formative assessment has demonstrated its effectiveness in increasing meaningful learning in Advanced Educational Statistics because it is an activity-oriented method which involved assimilation of previous knowledge by learners, checking and assessing individual academic confidence level at every new stage or units in knowledge never leaving a stone unturned.

Keywords: formative assessment, academic achievement, educational statistics, evaluation and assessment technique

Introduction

Assessment covers the ways teachers support, track children's learning, monitor progress and identify next steps in learning process. It is described as a process by which feedback gotten is used by teachers to adjust their teaching strategies, and by students to adjust their plan of action for learning. Assessment is a systematic determination of a subject's merit, worth and significance using criterion governed by a set of standards (Loyce, 2012). Johnson (2009) [12] defined assessment as the use of a variety of procedures to collect information about learning and instruction. Assessment could be summative and formative. Formative assessment is commonly referred to as assessment for learning, in which the focus is on monitoring student response to, and progress in instruction, while summative assessment is carried out at the end of lesson or programme for grading and certification. Assessments are said to be formative when the information is utilized in adapting teaching and learning to meet the needs of students, individually or collectively. Popham (2008) [20] defined formative assessment as a process by which assessment-elicited evidences of students' learning are gathered and instruction modified in response to the feedback obtained through the process. The feedback given as part of formative assessment helps learners become aware of any gap that exist between their desired goals and their current knowledge, understanding or skills and guide them through actions necessary to obtain the goal (Sadler, 2006) [21].

Formative assessment is defined by Olagunju (2015) [18] as a strategy designed to identify learners' learning difficulties with a view to providing remediation measures to enhance the performance of majority of students. Nnaji (2018) [15] also defined formative assessment as a diagnostic use of assessment to provide feedback to teachers and students over the course of instruction. Nnaji further opined that formative assessment can take the form of daily work (e.g. essays, quizzes, presentation and participation in class), projects/term papers and practical work (e.g. laboratory work, fieldwork, clinical procedures, drawing practice). Gronlund and Lin in Ajogbeje (2013) [2] stated that formative assessment serves three specific uses namely: (i) to plan corrective actions to overcome learning deficiencies; (ii) to aid in motivating learners and (iii) to increase retention and transfer of learning. According to the author, the sequence for formative assessment is that students are taught with well-defined objectives, assessed during the course of the programme with quiz, tests, and assignment

after the lesson, given corrective instruction to those who require additional clarification. These provide feedback to both the students and the teacher about what material was learned well and what was not. Ibrahim (2017) was of the opinion that the key requirements for successful formative assessment include the use of quality assessment tools and the subsequent use of the information derived from these assessments to improve teaching and learning.

Ajogbeje (2013) [2] opined that the utilization of formative testing in the teaching-learning process involves breaking up the subject matter content or course into smaller hierarchical units for instruction; specifying objectives for each formative test; offering a group-based remediation in areas where students are deficient before moving to another unit and then administration of summative test on completion of all units. Ojugo, (2013) [17] stated that the breaking up of subject or course into small units makes for adequate preparation for the test by the students. Moreover, such frequent testing enables the student to get more involved and committed to the teaching-learning process thereby enhancing their performance. Bloom and Hastings in Philias (2012) [19] were of the opinion that formative assessment is useful to both the students (as a way of diagnosing students' learning difficulties and the prescription of alternative remedial measures) and to the teacher (as means of locating the specific difficulties that the students are experiencing within subject matter content) and forecast summative assessment result.

Formative assessment is designed to be an integral part of the teaching-learning process that is why it is administered at the close of a unit; thereby, providing an in-depth picture of what skills each student has or has not learned. Consequently, it would suggest ways in which his original instruction must be supplemented if he is to complete his learning before moving to a new instructional unit (Piere, Marion, Gong and Wurzeh, 2007). Formative assessment, as Scriven modeled it, is not graded for judgment; rather it strives to identify un-mastered learning areas early enough to permit the corrections before the final grading or evaluation (Clark, 2011) [7]. However, it has been found useful to mark each student‘s unit test with non- grade designations such as "mastery" or 'more work needed'. The "mastery" marking gives those who receive it positive evidence of the academic achievement while the "more work needed" encourages students to complete their unit Learning (Clark, 2011) [7].

In addition, formative assessment practices involve the use of corrective procedures. They are used to meet specific learning goals, identify strengths and weaknesses and also support students' learning. They include the use of tests, re-teaching, and peer and individualized tutoring (Guskey, 2005) [11]. Formative assessment is also systematic evaluation procedure done at the end of each unit of instruction to determine the students who have mastered the unit and those yet to master it for remediation. This implies that the normal assessment during and at the end of each classroom lesson can be done by a teacher but at the end of each unit, the teacher formally assesses the students on that unit. The class does not progress to the next unit until about 85% of the class has mastered the unit (depending on the teacher's criterion of class mastery level). This does not negate the practice of a teacher continuously asking students questions in the class during a classroom lesson.

For students who have thoroughly mastered the unit, the formative tests should reinforce their learning and assure them that their learning and study habits are adequate. Formative assessment tests also help to reduce anxiety about end-of- course achievement for students who consistently demonstrate unit mastery. For students who fail to master a given unit, formative assessment tests should pinpoint their particular learning difficulties. Before assessing students, it is essential to communicate the purpose of assessment to everyone involved. Both formative and summative assessments have impact on the learning process. Ajogbeje (2012) [1] observed that formative assessment serves the educational process better, and as such, helps in improving the student's achievement in school subjects.

In the school setting, part of the reason for which students perform poorly in some subjects is because of the uncertainties surrounding these subjects like a haze. Students want to be rest assured of their competencies in subjects, even before summative assessments and evaluations are made; hence, if they do not think they can succeed at a subject, it is usual for them to be anxious about their performance in the subject out of learned helplessness (attrition due to the inability to cope in a learning activity). It now behooves the teacher to deploy strategies to build students' confidence about their abilities and potentials in a taught subject. This is why formative assessment is crucial to every sound educational system.

In order to achieve the aims of formative assessment, feedback information provided by formative assessment must be translated into specific supplementary instructional procedures which will help each student to pinpoint and correct his particular unit learning difficult. These corrective procedures include the use of follow up tests, workbooks, re-teaching, programmed instruction, audio-visual methods, small group study session and individual tutoring (Guskey, 2005) [11]. Formative assessment and its learning correctives are applicable in all school subjects/courses, including Statistics.

Statistics is the science of collection, presentation, analysis and interpretation/conclusion of numerical data under study. It enables us to draw general conclusions and to make prediction about what will happen under certain conditions. Statistics is studied at various fields of endeavour such as education at the postgraduate level and it is called Advanced Educational Statistics. Advanced educational statistics is the method for collecting, analyzing numerical data, interpreting, drawing conclusions and presenting the educationally related information. There are two major types of statistics namely descriptive and inferential statistics.

Descriptive statistics is devoted to the collection, organisation, summarization, and presentation of data. It also entails the construction of graphs, charts, and tables, and the calculation of measures of central tendencies, measures of dispersion and standard scores (Esomonu, Okoi and Eleje, 2018) [9, 10]. Inferential statistics on the other hand is used for generalizing information from samples to population, performing estimations, hypothesis testing, determining relationship among variables and predictions. They are based on probability theory used for drawing and measuring the reliability of conclusions about population based on information obtained from the sample of the population (Esomonu, Okoi and Eleje, 2018) [9, 10].

In higher education in Nigeria, students are required to complete successfully a statistics course to enable them learn how to use statistics as a tool to improve their educational research, interpret research results or statistical data in their field of study as well as to obtain a certificate. An additional goal of teaching statistics is to prepare students to deal effectively with statistical aspects of the world outside the classroom (Nasser, 2004). According to Nworgu (2012) [16], statistics serves a useful purpose in modern life. It helps us to make tentative statements (hypotheses), analyze the problem relating to the stated hypotheses and make conclusions/interpretations of the analyzed problem. It charges its recipients to make wise decisions that will satisfy their quest for answers. Advanced educational statistics is also very useful in analysis and interpretation of result in project, thesis and dissertation of students' work. Advanced educational statistics is a general course taught at both the undergraduate and postgraduate levels of education at the faculty of education in many Nigerian universities. It is one of the compulsory courses all master's degree students in the faculty of education must pass upon graduation. However, it is the culture of some faculties of education that students pursuing their doctorate degree with a masters' degree from another institution must enroll for the course and have a minimum grade of C.

Despite the importance and usefulness of advanced educational statistics in the field of education and in the society at large, and the efforts instructors of advanced educational statistics make in simplifying the subject, many postgraduate students' performances in the course have been poor over the years (Esomonu, 2018) [9, 10]. According to her, most college students view statistics courses as obstacles standing on the way of attaining their desired degree. Advanced educational statistics is viewed as a 'dry' course at the PG level and therefore students' achievement in the course has always been a topic for discussion among lecturers, evaluators, counsellors and researchers. From available statistics from Imo State University Owerri, the credit grade hovers around 32 percent for educational statistics. Uwazie (2018) in support of the above assertion noted that it was only 48.8% of the postgraduate students who sat for the examination in Michael Okpara University of Agriculture, Umuahia in 2016 that had credit grade and above in the course.

The results of advanced educational statistics examination at Nnamdi Azikiwe University, Awka also recorded poor performance by students in faculty of education of the institution. For instance, in the 2014/2015, 2015/2016, 2016/2017 and 2017/2018 postgraduate students' results in Advanced educational statistics published in faculty of education, Nnamdi Azikiwe university, Awka, only 42.21%, 46.11%, 32.09% and 49.17% respectively of students were able to make C grade and above. Similar data was obtained from Imo State University for 2014/2015 (38.3%), 2015/2016 (42.8), 2016/2017 (48.6) and 2017/2018 (41.0%). This consistent poor performance by PG students in advanced educational statistics has negatively affected their academic achievement and calls for serious action to remedy the situation. This is because it has been barely unable to maintain a satisfactory level.

Extensive research has been carried out in respect to academic achievement and its accruing expectations with a view to improving the status of achievement in the school setting and, ultimately, ensuring that learning outcomes are positive and steady (Akinsanya and Ajayi [3], 2011; Atovigba, Vershima, Okwu and Ijenkili, 2012) [6]. Achievement as defined by the Oxford Advanced Learners Dictionary (2020) refers to a person's strong performance in a given area. In the school context, it is the extent to which a student, teacher or institution has attained their educational goals. Ensuring that academic achievement is positive in terms of outcomes is a herculean task for schools, as they have to please stakeholders and attract the input of resources for their sustenance. Other variables that can cause students' poor academic achievement and poor performance are teacher characteristics, teaching method, students' attitude etc.

Academic achievement is associated to a series of variables like gender, and school location. A study by Efanga (2014) [8] revealed that there is no significant difference in academic achievement between male and female students taught certain concepts in technology package using formative assessment. The influence of gender on achievement and attitude is therefore still a controversial issue among researchers. These contradictive evidences in academic achievement and lack of clear trend on gender influence in the study of statistics has resulted in the need to carry out this study. Several empirical studies have demonstrated the effectiveness of formative assessment technique in many subjects when compared to the teacher-centered method. The works of Awotua-Efebo and Uchenna (2017) and Ajogbeje (2012) [1] are examples of such studies. Ajogbeje (2012) [1] did a study on the effect of formative testing on student's achievement in junior secondary school mathematics in Akure South local Government of Nigeria. The study was guided by three hypotheses. The Sample consisted of 312 JSS11 students assigned to three experimental groups and one control group through purposive sampling technique. It was discovered in the study that, there was a significant difference in the level of achievement of members of the four treatment group in the post test scores after correcting for initial group differences.

The formative test with feedback and remediation grouped performed better than the other three groups. The results of the study also revealed that males' students did not perform better than female students in the posttest score. Formative assessment if well managed enables learners accomplish a high level of understanding in a given area if they are given enough time. There is need for teachers and lecturers to exploit formative assessment technique in different subject areas and units. Upon this background, the study sought to investigate effect of formative assessment technique on academic achievement of postgraduate students in Advanced Educational Statistics in Public Universities in Southeast, Nigeria.

Purpose of the Study

The main purpose of the study was to determine the effect of formative assessment on the academic achievement of postgraduate students in advanced educational statistics. Specifically, the study determined:

1. The pretest and posttest mean achievement scores in Advanced Educational Statistics of postgraduate students taught using formative assessment (experimental group) and those taught without formative assessment (control group).

2. The mean achievement scores in Advanced Educational Statistics of male and female postgraduate students taught with formative assessment (experimental group) and those taught without formative assessment (control group).

Research Questions

The following research questions guided the study:

1. What are the pretest and posttest mean achievement scores of postgraduate students taught Advanced Educational Statistics using formative assessment (experimental group) and those taught without formative assessment (control group)?
2. What are the pretest and posttest mean achievement scores of male and female postgraduate students taught Advanced Educational Statistics with formative assessment (experimental group)?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

1. There is no significant difference in the mean achievement scores of postgraduate students taught advanced educational statistics using formative assessment (experimental group) and those taught without formative assessment (control group).
2. There is no significant difference in the mean achievement scores of male and female postgraduate students taught Advanced Educational Statistics using formative assessment (experimental group).

Materials and Methods

The design of the study was quasi-experimental design. Specifically, it used pre-test and post-test non-randomized control group design. Non-equivalent control group design was used because the students were not randomly sampled. Rather, intact or pre-existing classes were used which were randomly assigned to experimental and control groups (Nworgu, 2015) [16]. The study was carried out in South East, Nigeria. South East of Nigeria is one of the six geopolitical zones in the country. The South East States of Nigeria comprises Anambra, Abia, Ebonyi, Enugu and Imo States. The population of the study consisted of 1,367 postgraduate students of all government owned universities in South East offering Advanced Educational Statistics at the postgraduate levels for the 2018/2019 academic session. The sample size of the study was 122 postgraduate students from Nnamdi Azikiwe University, Awka, Anambra State and 112 postgraduate students from University of Nigeria Nsukka, Enugu State. The researcher used purposive sampling to select two federal government owned universities out of the ten (5) federal government owned universities in the five states in the South East, Nigeria. Nnamdi Azikwe University, Awka was the experimental group (122 postgraduate students) while University of Nigeria Nsukka was the control group (112 postgraduate students). Advanced Educational Statistics Achievement Test (AESAT) with 50 multiple-choice items was used for data collection. The Advanced Educational Statistics Achievement Test (AESAT) with 50 items was validated by two experts. The scores for AESAT obtained from the 40 students were used to estimate the reliability coefficient of the instrument using test re-test which yielded a reliability of 0.82. Before the treatment which involves teaching the experimental group using formative assessment and the control group with the conventional lecture method, pretest was administered to the two groups. After the treatment, posttest was administered to the two groups to measure their academic achievement in advanced educational statistics. Mean scores and standard deviations were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 alpha level.

Result

Research Question 1: What are the pre-test and post-test mean achievement scores of postgraduate students taught Advanced Educational Statistics using formative assessment technique (experimental group) and those taught without formative assessment (control group)?

Table 1: Pre-test and Post-test Mean Achievement Scores of Postgraduate Students Taught Advanced Educational Statistics using Formative Assessment and Without Formative Assessment (N=234)

Groups	N	Pretest Mean	Posttest Mean	Gained Mean	Pretest SD	Posttest SD
Experimental Group	122	31.64	82.49	50.85	10.78	11.91
Control Group	112	27.81	51.34	23.53	10.59	12.82

The analysis in Table 1 shows that the student of Advanced Educational Statistics taught with formative assessment had a gain in mean of 50.85, while those taught without formative assessment had a gain in mean of 23.53. The mean gain scores of students taught with formative assessment technique is higher than those taught without Formative assessment technique. This means that those taught with formative assessment performed higher than those taught without formative assessment

Research Question 2: What are the pre-test and post-test mean achievement scores of male and female students taught Advanced Educational Statistics using formative assessment (experimental group)?

Table 2: Pre-test and Post-test Mean Achievement Scores of Male and Female Students Taught Advanced Educational Statistics using Formative Assessment (N=122)

Gender	N	Pretest Mean	Posttest Mean	Gained Mean	Pretest SD	Posttest SD
Male	55	28.77	70.38	41.61	10.42	16.23
Female	67	28.13	72.16	44.03	10.97	15.79

Data analyses in Table 2 reveals that the male students taught Advanced Educational Statistics with formative assessment had a gain in mean of 44.03 for female students is higher than the gain in mean of 41.61 for male students taught Advanced Educational Statistics using formative assessment. This means that the mean achievement scores of female students taught with formative assessment technique is higher than their male counterparts taught with formative assessment.

Hypotheses

Hypothesis 1: There is no significant difference in the mean achievement test scores of students taught Advanced Educational Statistics using formative assessment (experimental group) and those taught without formative assessment (control group).

Table 3: ANCOVA Test on Significance of Difference between Mean Achievement Test Scores of Students Taught Advanced Educational Statistics with Formative Assessment and those Taught Without Formative Assessment

Source of Variation	SS	DF	Mean Square	F	P value	Decision
Corrected Model	12373.874[a]	4	3093.469	19.903	.000	
Intercept	81060.507	1	81060.507	521.530	.000	
Pretest	168.097	1	168.097	1.082	.301	
Method	11998.303	1	11998.303	77.195	.000	S
Error	17874.251	115	155.428			
Total	641575.000	120				
Corrected Total	30248.125	119				

*p < 0.05

The analyses in Table 3 reveal that formative assessment effect on achievement is significant given that $F_{(1,234)} = 77.195$ and $p < 0.05$ (.000 < 0.05). Therefore, the null hypothesis is rejected, thus, the difference in the mean achievement scores of students taught Advanced Educational Statistics using formative assessment and those taught without formative assessment is significant. The mean achievement score of students taught Advanced Educational Statistics with formative assessment is higher than those taught without formative assessment.

Hypothesis 2: There is no significant difference in the mean achievement test scores of male and female student taught Advanced Educational Statistics using formative assessment technique (experimental group).

Table 4: ANCOVA Test on Significance of Difference between Mean Achievement Test Scores of Male and Female Students Taught Advanced Educational Statistics using Formative Assessment

Source of Variation	SS	DF	Mean Square	F	P value	Decision
Corrected Model	12373.874[a]	4	3093.469	19.903	.000	
Intercept	81060.507	1	81060.507	521.530	.000	
Pretest	168.097	1	168.097	1.082	.301	
Method	11998.303	1	11998.303	77.195	.000	S
Gender	29.871	1	29.871	.192	.662	NS
Error	17874.251	115	155.428			
Total	641575.000	120				
Corrected Total	30248.125	119				

*p > 0.05

Table 4 reveals that $F_{(1,119)} = .192$, and $p > 0.05$ (.662 > 0.05). This implies that gender effect on achievement is not significant. Therefore, the null hypothesis is not rejected, thus, the difference in the mean achievement scores of male and female students taught Advanced Educational Statistics using formative assessment is not significant.

Summary of the Major Findings

Based on the analyses presented in this chapter, the following major findings emerged:

1. The mean achievement score of students taught Advanced Educational Statistics with formative assessment technique is higher than that of students taught Advanced Educational Statistics without formative assessment.
2. The mean achievement score of male students taught Advanced Educational Statistics with formative assessment is higher than that of their female counterparts taught Advanced Educational Statistics with formative assessment.
3. The difference in the mean achievement scores of students taught Advanced Educational Statistics with formative assessment and those taught Advanced Educational Statistics without formative assessment is significant.
4. The difference in the mean achievement test scores of male and female students taught Advanced Educational Statistics with formative assessment is not significant.

Discussion of Findings

The results from this study has revealed that students taught Advanced Educational Statistics with formative assessment method performed significantly better than students taught Advanced Educational Statistics without formative assessment. The trend of higher performance by the treatment group could be as a result of self- evaluation and remedial activities provided by the stages and protocols in formative assessment technique which helped the students to master the Advanced Educational Statistics concepts better than the control group who were not exposed to formative assessment. It could also be as a result of the excitement over the new approach of assessing them continuously knowing their weakness and strength up to the level of their confidence in the subject before the final grading assessment. The formative assessment method which entails breaking the subject to be learned into smaller units such as a chapter in a book, a well-defined segment of content or a particular unit of time during the duration of the instruction process is a unique technique which made for a better performance of the experimental group over the control group. This finding is in consonance with the opinion of Ajogbeje (2012) [1] who discovered in his study that, there was a significant difference in the level of achievement of members of the four treatment groups in the post test scores after correcting for initial group differences. The formative test with feedback and remediation group performed better than the other three control groups which were not formatively assessed.

The gender issue in science has been very controversial; the ANCOVA analysis revealed that gender effect on achievement is not significant. Therefore, the null

hypothesis was not rejected, thus, the difference in the mean achievement test scores of male and female students taught Advanced Educational Statistics with formative assessment was not significant.

This study has revealed a non-significant gender related differences in students' achievement in Advanced Educational Statistics. Extensive researchers has revealed significant gender difference in science achievement across many educational systems and still there are some conflicting evidence on gender difference in science achievement, but this study findings is once more supported by the findings of Ajogbeje (2012) [1] in the results of the study which revealed that male students did not perform better than their female counterpart in the posttest score. So therefore, the Advanced Educational Statistics achievement scores of students in relation to their gender in formative assessment are not significantly different.

Conclusion

This study has revealed that formative assessment method of teaching and learning had a lot of significant effect on the students' achievement in postgraduate students' subjects such as Advanced Educational Statistics. In fact, formative assessment has demonstrated its effectiveness in increasing meaningful learning in Advanced Educational Statistics because it is an activity-oriented method which involved assimilation of previous knowledge by learners, checking and assessing individual academic confidence level at every new stage or units in knowledge never leaving a stone unturned.

Recommendations

The following recommendations were made in view of the efficacy of the formative assessment approach.

1. Teachers as agents of educational reforms should be encouraged to make use of formative assessment more to improved academic performance in Advanced Educational Statistics course content
2. Formative assessment technique should be suggested to the Ministry of Education and School of Postgraduate studies of high institutions, so that longitudinal researches be organized and commissioned by the government and their agencies informing all categories of Advanced Educational Statistics lecturers and tutors to further confirm the efficacy of this approach in all areas of Advanced Educational Statistics, this could be done through seminars, conferences and workshops organized by government and professional bodies like the Association of Educational Researchers and Evaluators of Nigeria (ASSEREN) Science Teachers of Association of Nigeria (STAN) and Curriculum Organization of Nigeria (CON).
3. Advanced Educational Statistics lecturers should be encouraged to include formative assessment process in their instructional approach to check, motivate, stimulate and sustain critical thinking and proper evaluation of self-knowledge level in the students which would help to enhance achievement in Advanced Educational Statistics concepts.
4. Curriculum Planners and developers of Advanced Educational Statistics should adopt formative assessment method perspective in restructuring Advanced Educational Statistics curriculum in our institutions in other to help the students to see meaning in what they learn and be carried along in the subject as they are being taught.
5. The Ministry of Education should start now to think of a way of adopting formative assessment for the purpose of promoting gender equality in the Advanced Educational Statistics classroom.

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