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# Relationship Between On-site Learning and Students' Mindfulness, Conceptual Understanding and Academic Performance in Chemistry: A Focus on the Mole-Concept

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This study examines the relationship between On-site Learning and Students' Mindfulness, Conceptual Understanding and Academic Performance in Chemistry amidst Nigerians Insecurity while focusing on the Mole-Concept in Gwale secondary schools, Kano-Nigeria. The correlational research design was engaged in the study. A sample of 181-respondents consisting 91-male and 90-female students, from eight secondary schools in Gwale Education Zone was drawn from the study area using Simple random sampling technique. The instruments of data collection include the Questionnaire on Classroom Attendance, Students' Mindfulness and Conceptual Understanding of Mole-Concept (QCASMCUMC) with a reliability index of 0.87 and Mole-Concept Achievement Test (MCAT) with a reliability index of 0.98. The statistics used for data analyses include; mean and Spearman's rank order Correlation. Results of the study reveal a significant influence of on-site learning on students' mindfulness as well as on-site learning on Academic performance. However, no significant influence of on-site learning was found on students' Conceptual understanding of Mole Concept. The study recommends among others that government should provide transportation allowance for students to cushion the impact of economic hardship on students' on-site learning in Gwale Zone of Kano State, Nigeria.

*Keywords:* on-site learning, Mole concept, students' mindfulness, conceptual understanding, academic performance

## Introduction

Chemistry teachers are expected to create inclusive learning opportunities for collaboration and development of metacognitive skills, where students feel comfortable to ask questions, express doubts, think reflectively and participate actively in the classroom (Mudau & Tawanda, 2024). The metacognitive skills such as self-awareness, self-regulation and critical thinking are expected to be fully developed in science learners and enable them solve personal and social problems. However, the menace of absenteeism or inadequate face-to-face classroom attendance in schools caused by bad economy, insecurity and emergence of alternative classroom opportunities presented by new technologies such as AI ChatGPT, teleconferencing and virtual laboratory has been hindering such development (Babalola, Ahmad, & Tafida, 2024). These two dichotomy problems of inadequate conventional classroom attendance and high rate of absenteeism in Nigerian schools need adequate exploration. This is because the question of significance or otherwise of conventional face-to-face classroom

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attendance for students has not been answered and a point of concern to chemistry teachers and policy makers (Adeleke & Temisanren, 2023).

In the modern-day school setting, a classroom may be virtual, physical or blended. Virtual classroom does not involve the teacher and students in face-to-face interaction while a physical classroom involve the physical face-to-face collaboration of both parties. On the other hand, a blended classroom is the combination of physical and virtual characteristics in a single setting. In a blended classroom situation, teachers and students are in the same classroom environment where a virtual teacher's lesson inform of video is used as a resource assisted teaching during classroom lessons. However, On-Site Learning (OSL) in this study implies physical in-person instruction synchronous in term of real-life attendance and face-to-face learning in a conventional classroom setting in the school environment and blended classrooms. It does not include virtual classroom.

OSL in this study is a crucial aspect of academic life, as it provides students with opportunities for social interaction, hand-on learning, and immediate feedback from instructors (Babalola, Umar, & Tafida, 2025). However, the relationship between OSL and students' academic outcomes, particularly in Chemistry, is not well understood. Even though; physical classroom attendance is a measure of the extent to which students are participating in the classroom activities and engage with teacher, learning content and context.

An act of regularly attending classes has been associated with students' opportunities to experience different patterns of interaction with teachers, engage in discussions with classmates and actively participate in the teaching and learning process (NFES, 2018; Babalola, Awaisu, & Tafida, 2025). Whereas, few scholars have argued that attendance is crucial for academic success, others have questioned its relevance and effectiveness in the digital age. As an example, a meta-analysis research conducted by Shah and Khan (2015) revealed that students who attend classrooms regularly tends to earn higher grades than those who often avoid classes. This suggests that being present in the classroom may provide students with opportunities for direct interaction with instructors, increase access to firsthand course materials, and enhance engagement in lesson discussions, all of which may contribute to a deeper understanding of the subject matter.

Owing to the unfavorable economic waves and insecurity bedeviling Nigeria presently, irregular attendance and high rate of absenteeism in school have become prevalent concerns for teachers and school administrators not only in Nigeria but globally (Bong & Lee, 2016). This issues in Kano State to be specific may be suggested to have emanated from a variety of factors, ranging from the economic constraints forcing students to engage in part-time work to cultural, religious and social dynamics that may prioritize other obligations over regular school attendance. The cultural aspect of the bargain include that a newly marrying female student may have to stay indoor for a number of days before coming out to attend classes in schools. The religious factor may include Muslim students' absenteeism from school for travelling to Mecca for religious obligation while the social dynamic may include the pandemic issues and security threats and fear among others.

Nevertheless, a research conducted by Chepkorir, Cheptonui, and Chemutai (2014) which investigated the effectiveness of online learning, discovered that a well-designed online courses can be as effective as physical classes in terms of learning outcomes. This challenges traditional notions of physical attendance and prompts educators to consider alternative ways of measuring student engagement and learners' participation. As a result, the impact of physical classroom attendance on students' academic variables including academic performance remains unclear and requires careful investigation which is one of the gaps this study filled in the literature.

However, academic performance otherwise learning outcome signifies the level of success or accomplishment attained by students in their academic pursuits. It is typically measure through various means, including grades, examination scores, and overall performance in educational assessments. Talton (1985) observed that academic performance is the hallmark of scholastic success, encapsulating the attainment of educational objectives and goals. This implies that Academic performance may plays a pivotal role in shaping future opportunities of students. This is because elevated academic performance can unlock access to scholarships, esteemed educational institutions, and potential career prospects (Awan, Sarwar, Naz, & Noreen, 2011). Academic performance is typically measure through diverse metrics such as grades, examination scores, and overall accomplishments in educational evaluations. In regards to this, Hoyle (2019) argued that schools are established with the aim of imparting knowledge and skills to those who go through them and behind all this is the idea of enhancing good academic performance. Academic performance determines the human capital development of an economy which enables students and parents to know the current academic state of their students. It governs the failure and success of an academic institution (Narad & Abdullah, 2019). Nevertheless, there is a tendency that Academic performance may be a reflection of other educational variables including students' mindfulness.

Mindfulness as a variable of investigation in chemistry education denotes a mental state, characterized by focus and non-judgmental awareness of the present moment by the students. Mindfulness has been referred to a psychological state of awareness and a practical mode for individuals to be able to process information (Andriessen, 2007). Mindfulness brings one's complete attention to the present experience or paying attention in a particular way, on purpose, in the present moment, and nonjudgmentally. Numerous studies, including a meta-analysis by Khoury and Ali (2019), show that mindfulness practices reduce stress, anxiety, and depression, making it a valuable tool for mental health. Mindfulness has also been linked to improvements in attention, working memory, and cognitive flexibility (Tang & Adesoji, 2020). In an educational context, it pertains to a student's ability to concentrate on classroom activities, engage in learning without distraction, and be fully present during lessons (Babalola, 2023a). Mindfulness constitutes a mental practice in an educational context which underscores students' capacity to sustain undivided attention during classroom activities, immersing themselves fully in the learning process (Sanger & Dorjee, 2019). This state of mindfulness, is pivotal in fostering deep engagement with educational material which may potentially influence academic performance, particularly in chemistry topics such as Mole-Concept. Thus, fostering mindfulness among secondary school students in the Nigerian educational system is challenging and may present a unique set of issues (Babalola & Umar, 2023). Ranging from distractions from digital devices, social media, and a fast-paced modern lifestyle, students often struggle to maintain focused attention during classroom activities. This lack of mindfulness can hinder their ability to engage with subject matter, potentially affecting their conceptual understanding in chemistry.

Conceptual understanding refers to a deep and thorough comprehension of fundamental concepts and principles within a particular subject or field of study. It implies the capacity to connect, apply, and manipulate these concepts to solve problems after thinking critically. A robust conceptual understanding empowers individual student to apply their knowledge flexibly, surmount complex challenges, and establish meaningful correlations with related ideas or disciplines (Mills, 2016). Conceptual understanding constitutes a cornerstone of critical thinking and higher-order cognitive capabilities, affording individuals the capacity to extrapolate their understanding to novel contexts and adapt to unfamiliar scenarios. Lack of conceptual understanding may hinder students' ability to engage smoothly with chemistry, potentially affecting a complex topic like Mole concept.

There are a number of studies showing different views of mole. For instance, Vikasana-Bridge (2012) describes a mole as an amount of substance having as equal mass as its gram atomic mass. One mole of oxygen atom is equivalent to 16 g and two moles of oxygen atom is equivalent to 32 g. Mole has also been viewed as an amount of substance of a system containing as many elementary entities (atoms, molecules, and ions) as are there in 0.012 kg of carbon 12 (Oberholtzer, 1972). Petrucci, Herring, Madura, and Bissonnette (2017) described a mole as the amount of compound containing Avogadro's number ($6.02214 \times 10^{23}$) of formula units or molecules. This is an indication that, mole is a substance containing one Avogadro's number ($6.02 \times 10^{23}$). Mole is a substance that occupies the volume of 22.4 $dm^3$ at STP or 0.0224 $cm^3$.

Mole concept is under submicroscopic level of chemical representation, which provides basic knowledge for solving quantitative problems in chemistry such as mass-mole calculations of chemical reactions. Mole concentrates on the number of particles and uses quantity that connects the mass unit of matter, number of particles, and the volume of gases involved in chemical reactions (Petrucci et al., 2017). Mastery of mole concept is crucial to equip students to learn the solution concentration concept with ease. The knowledge of mole concept is crucial in the study of stoichiometry and the experience gained can be applied in solving problems of chemistry concepts such as: chemical kinetics, chemical equilibrium, and concentration (McLeod, 2017). Without a good mastery of mole concept, students would find it troublesome in understanding stoichiometry and other subsequent concepts (Musa, 2009).

Mole concept has been generally acknowledged by scholars to be one of the most difficult concepts in chemistry. For instance, Moss and Pabari (2010) reported that mole concept is a chemistry topic that is difficult to understand because it is unfamiliar to most students leading to rote learning of equations and difficulty solving application questions related to mole-concept. Nelson (2013) has also reported that most students lack accurate understanding of mole-concept causing misconception. Shehu (2015) added that difficulty in identifying mole concept often leads to errors and wastage of resources during scientific experiments. Experiments such as biochemical assays, animal cell culture, polymerase chain reactions, spectrometry, and routine buffer preparation require a very accurate understanding of mole concept (Arya & Kumar, 2018).

As observed by Malcolm, Rollnick, and Mavhunga (2014), students' inability to understand mole concept could be due to poor conceptualization of the concept by the majority of teachers. The teachers themselves are unsure about their knowledge in mole-concept, therefore transmitting it wrongly to students (Moss & Pabari, 2010). Bond-Robinson (2005) revealed that mole concept is a concept at sub-microscopic level, but chemistry students' reasoning is at a macroscopic level, based on personal interactions with objects associated with chemical processes. Hence, teachers and students need to shun semantic mistakes in mole concept due to what Pekdağ and Azizoğlu (2013) referred to as a "missing concept, which cannot be located at either the macroscopic, microscopic or symbolic level of representation. For example, asking 'how many moles are in 20 g of sulphur (IV) oxide?" is missing the macroscopic level of representation and should rather be expressed as: what is the amount of substance in 20g of the sulphur (IV) oxide? This would also ensure that the expressions are in consonance with the SI unit definition. In Nigeria, one of the aims of teaching chemistry is to help the Nigerian student "demonstrates an understanding of the mole concept and its significance to the quantitative analysis of chemical reaction" (Ministry of Education, 2010, p. 11). The mole concept covers areas such as: Carbon-12 scale, Solutions, Stoichiometry and Chemical Equations, Acids and Bases, Chemical Equilibrium and Power of Hydrogen ion (pH), and Power of Hydroxide ion (pOH).

However, the West African Examinations Council (WAEC) Chief Examiners' Reports (WAEC, 2015; 2016; 2017) on chemistry revealed that students had difficulties in answering examination questions on mole concept, which is an important fundamental concept in studying other chemistry concepts noted earlier. Mole concept seemed a great challenge to students and unfortunately, not much had been done to look into the teaching mole concept in Ghana (Ministry of Education, 2010, p. 11; WAEC, 2015; 2016; 2017). Hanson (2016) indicated that there are challenges in learning mole concept and that teachers and students encounter those challenges being the basis for correct comprehending of other concepts in chemistry and the sciences in general (Taber, 2001).

Teachers like their students perceived chemical concepts in different ways relating to terminologies, structures, and calculations of these chemical concepts (Mahdi, 2014). As cited in Vorsah and Adu-Gyamfi (2021), the mole has been perceived as a certain mass, a certain number of gas particles, and a property of molecules. Strömdahl, Tullberg, and Lybeck (1994) reported that only 11% of teachers perceived the mole as the unit of amount of substance, 61% as Avogadro's number, and 25% as mass. Students' conceptions of the mole are as a result of teachers' accumulated knowledge and views expressed by teachers. Teachers have difficult perceptions about chemical concepts and these difficult perceptions are transferred to students in lessons which go a long way to affect the students' learning outcomes (Boz & Uzuntiryaki, 2006). Therefore, pre-service teachers need to learn and master the mole concept so as to transfer the appropriate conceptual understanding to students.

Nevertheless, the influence of physical classroom attendance, academic performance, students' mindfulness, and conceptual understanding is intricate and multifaceted. While face-to-face classroom attendance is often considered a precursor to academic success, its role in students' mindfulness as a gap remains underexplored. Similarly, the extent to which this face-to-face and mental classroom attendance mediates students' academic performance in the context of Mole concept is a crucial but uncharted territory. These are the knowledge gaps the present study examined among students within the unique educational setting of secondary schools in Gwale education zone of Kano State, Nigeria.

Specifically, three research questions formulated to guide the study are:

(1) To what extent does on-site learning influence students' mindfulness towards mole-concept in chemistry?

(2) How does on-site learning relate to students' conceptual understanding of the mole-concept in chemistry?

(3) To what extent does on-site learning influence students' academic performance in mole-concept in chemistry?

However, these three research questions were answered and their three corresponding null hypotheses were tested at 0.05 level of significance by following the methodology bellow.

## Methodology

This study examined the relationship between face-to-face classroom attendance and participation (on-site learning) and students' mindfulness, conceptual understanding, and academic performance in chemistry focusing on the Mole-concept in Gwale secondary schools of Kano, Nigeria. The study followed the correlational research design methodology, where simple random sampling technique was used to sample 181 students from eight senior secondary schools within the Gwale education zone of Kano State of Nigeria. The instruments of data collection are: Questionnaire on Classroom Attendance, Students' Mindfulness and Conceptual Understanding of Mole-Concept (QCASMCUMC) with a reliability index of 0.87 obtained through split-half method and Spearman's correlation statistics. The second instrument used is the Mole-Concept Achievement Test (MCAT)

with a reliability index of 0.98 obtained using test-re-test method and PPMC statistics. However, validity is the extent to which a data collection instrument accurately measures the variable for which it was designed while the reliability refers to the degree of consistency of an instrument in measuring similar value upon repeated testing (Babalola, 2023b).

In order to ascertain the face, content and construct validity of the instruments, three experts in Measurement and Evaluation, Science Education, and Educational Psychology at Yusuf Maitama Sule University, Kano and Bayero University Kano were engaged. After thorough scrutiny of the experts to ensure the validity of the instruments, their suggestions were fully effected on the final copy of the instruments. The statistics used for data analysis include: mean, standard deviation, and Spearman's correlation statistics.

## Results

Research Question One: To what extent does on-site learning influence students' mindfulness towards mole-concept in chemistry?

Table 1

*On-Site Learning and Students' Mindfulness Towards Mole-Concept*

| S/N | Items | Mean | S.D. | Decision |
|---|---|---|---|---|
| 1 | Practicing physical classroom attendance has improved my overall mindfulness towards Mole concepts. | 2.74 | 1.073 | Accept |
| 2 | I apply my knowledge mindfully in solving mole-concept problems when mentally attending my classrooms regularly. | 2.81 | 1.089 | Accept |
| 3 | Face-to-face classroom attendance contributes to my mindfulness towards Mole concept. | 2.94 | 1.036 | Accept |
| 4 | Combining face-to-face classroom attendance with e-learning strategies like blended learning enhances my mindfulness towards Mole Concept. | 2.70 | 1.103 | Accept |
| | Average mean score | 2.80 | | |

Table 1 revealed that the mean influence of physical classroom attendance on students' mindfulness is 2.80 which is greater than the cut-off mean of 2.50. This is an indication that there is an influence of physical classroom attendance on students' mindfulness towards Mole Concept in Gwale secondary schools. However, to test the significance of this influence, the corresponding null hypothesis is tested as follow.

$H0_1$: There is no significance influence of on-site learning on students' mindfulness towards Mole concept of chemistry among students of Gwale secondary schools.

Table 2

*Spearman's Test of Physical Classroom Attendance and Students' Mindfulness*

| Variables | *N* | Mean | S.D. | Rho | Df | *p*-value |
|---|---|---|---|---|---|---|
| Students' mindfulness | 35 | 56.11 | 15.15 | 0.805 | 58 | 0.04 |
| Conceptual understanding | 25 | 49.48 | 12.28 | | | |

Sig. at 0.04 < 0.05.

Table 2 shows the Rho-value of 0.805 and *p*-value 0.036 tested at 0.05 level of significance with degree of freedom 58. Since the *p*-value 0.04 is less than 0.05 and Rho of 0.805 is greater than 0.50, the null hypothesis is rejected. Hence, there is a significance of classroom attendance on students' mindfulness towards Mole concept in Gwale secondary schools.

Research Question Two: How does on-site learning relate to students' conceptual understanding of the mole-concept in chemistry?

Table 3

*Students' On-Site Learning and Conceptual Understanding of Mole-Concept*

| S/N | Items | Mean | S.D. | Decision |
|---|---|---|---|---|
| 1 | Students that physically attend classrooms regularly understand the Mole concept better. | 2.53 | 1.093 | Accept |
| 2 | Students that physically and mentally attend classroom regularly grasp Mole-Concept more clearly. | 2.74 | 1.093 | Accept |
| 3 | Face-to-face classroom attendance helps students to identify and clarify doubts about Mole Concept during class discussions. | 3.03 | .989 | Accept |
| 4 | Students' overall understanding of mole-Concept is deeper when physically attending classrooms more often. | 2.88 | 1.055 | Accept |
| | Average mean score | 2.79 | | |

In Table 3, the mean of 2.79 obtained from the influence of classroom attendance on conceptual understanding of Mole Concept is greater than the cut-off point mean of 2.50. This is an indication that there is influence of classroom attendance on students' conceptual understanding of Mole Concept in Gwale secondary schools. However, to test the significance of the influence the corresponding null hypothesis is tested as follow.

$H0_2$: There is no significant influence of students' on-site learning on students' conceptual understanding of Mole Concept in Gwale secondary schools.

Table 4

*Spearman's Correlation of On-Site Learning and Conceptual Understanding*

| Variables | *N* | Mean | S.D. | Rho | Df | *p*-value |
|---|---|---|---|---|---|---|
| Students' classroom attendance | 181 | 52.87 | 14.45 | 0.361 | 58 | 0.019 |
| Conceptual understanding of Mole-concept | 181 | 54.30 | 14.32 | | | |

Table 4 shows that Rho is 0.361 and *p*-value 0.019 tested at 0.05 level of significance with degree of freedom 58. Since the *p*-value 0.019 is less than 0.05 and the Rho of 0.361 is less than 0.50, the null hypothesis is accepted. Hence, there is no significance influence of classroom attendance on students' conceptual understanding of Mole concept in Gwale secondary schools.

Research Question Three: To what extent does on-site learning influence students' academic performance in mole-concept in chemistry?

Table 5

*On-Site Learning and Academic Performance in Mole-Concept*

| S/N | Items | Mean | S.D. | Decision |
|---|---|---|---|---|
| 1 | Face-to-face classroom attendance increases students' test and assignment scores in Mole Concept. | 2.73 | 1.080 | Accept |
| 2 | Physical absenteeism and absent mindedness make students fall behind in Mole concept's academic performance. | 2.62 | 1.092 | Accept |
| 3 | Physical classroom attendance develops in students more confidence to discuss and answer questions on Mole-concept. | 2.61 | 1.124 | Accept |
| 4 | Blended physical classroom attendance improves students' critical thinking and academic performance in Mole Concept. | 2.78 | 1.092 | Accept |
| | Average mean score | 2.68 | | |

Table 5 shows that the average mean influence of classroom attendance on academic performance of 2.68 is greater than the cut-off point mean of 2.50 obtained from the four point scale. This implies that there is influence of classroom attendance on students' academic performance in Mole concept in Gwale secondary schools. However, to examine the significance of the influence, the corresponding hypothesis is tested as follow.

$H0_3$: There is no significance influence of on-site learning on students' academic performance in Mole concept of chemistry in Gwale secondary schools.

Table 6

*Spearman's Correlation of On-Site Learning and Academic Performance in Mole Concept in Gwale Secondary Schools, Kano*

| Variables | *N* | Mean | S.D. | Rho | Df | *p*-value |
|---|---|---|---|---|---|---|
| Student's classroom attendance | 181 | 68.30 | 12.07 | 0.722 | 59 | 0.000 |
| Students' academic performance in Mole-concept | 181 | 53.35 | 14.30 | | | |

Table 6 shows the Rho value of 0.722 with *p*-value 0.001, tested at 0.05 level of significance and degree of freedom is 59. Since the *p*-value of 0.001 is less than 0.05 and Rho 0.722 > 0.500, the null hypothesis is rejected. That is, there is a positive influence of classroom attendance on students' academic performance in Mole concept in Gwale Secondary schools, Kano.

## Summary of Major Findings

Based on the result presented above, the following are summary of major findings:

(1) The study revealed that on-site learning has positive influence on students' mindfulness towards chemistry with focus on Mole-concept in Gwale secondary schools.

(2) The results further showed that on-site learning positively influences students' conceptual understanding of Mole concept of chemistry in Gwale secondary schools. But, the corresponding hypothesis tested shows that the influence is not significant.

(3) The study also found that on-site learning significantly influences students' academic performance in Mole concept in Gwale secondary schools.

## Discussion of the Major Findings

It has been suggested by Frances (2020) that school administrators should identify other factors that are likely to influence students' academic performance and strengthening community school interaction to help improve attendance in schools. Several researches have also shown that mindfulness is one of such factors that contributes to academic success in chemistry (Babalola, 2023a). Therefore, the question one of this study was fine-tuned to elucidate the influence of physical classroom attendance on students' mindfulness towards Mole concept. The findings obtained from this question reveal that there is a significant positive influence of physical classroom attendance on students' mindfulness needed to identify and clarify doubts about mole-Concept concepts during classroom discussions. This finding agrees with that of Burzler (2022), which revealed that mindfulness cultivation is a process induced by mindfulness practice and the dispositional mindfulness functions as a baseline for this process. This finding may be because physical and mental presence of students in the classroom increases their access to firsthand information, course materials, and clarification of ambiguities. Unlike absentee students who often rely on lesson notes taken by other students which may lack facts given by

the teachers in classroom, such notes may also be characterized by wrong spellings of important concepts due to bad handwritings of the actual note taker.

However, the findings obtained from the question two, show that there is influence of physical classroom attendance on students' conceptual understanding of Mole-Concept concepts of chemistry among the students of Gwale secondary schools. But, the hypothesis tested showed that the influence is not significant. This finding may be because being mentally, emotionally, and face-to-face present in the classroom provides students with opportunities for direct interaction with instructors and classmates which often contributes to deeper conceptual understanding of the subject.

Moreover, the finding obtained from the research question three and its corresponding hypothesis revealed that there is a significant influence of physical classroom attendance on students' academic performance in Mole Concept of chemistry among the students of Gwale secondary schools. This finding agrees with that of Pain, Whitman, and Milledge (2019), whose results revealed a significant effect of classroom attendance marks on academic performance and showed a positive relationship between school attendance and academic performance, although school attendance explains only 11.8% variations in academic performance while 88.2% is explained by other factors affecting academic performance. This finding may be because attendance enhances students' engagement in lesson discussions, which may increase students' academic performance.

## Recommendations of the Study

(1) Parents should improve their children mindfulness by enrolling them in neighborhood schools where they can easily reduce transportation cost to school and checkmate absenteeism.

(2) Principals should promote conceptual understanding of Mole concept in students by reinforcing physical classroom attendance such as giving prizes to punctual students.

(3) As face-to-face classroom attendance increases students' academic performance, Government should provide school bus or transportation allowance for students to cushion the impact of economic hardship on student's mental and face-to-face classroom attendance.

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