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MOBILE-LEARNING INSTRUCTION: EFFECT ON TECHNOLOGICAL SKILL DEVELOPMENT AND CONCEPTUAL UNDERSTANDING OF PHYSICS AMONG UNDERGRADUATE STUDENTS

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ABSTRACT
*Mobile Learning (M-learning) is an emerging teaching-learning instructional tool that uses portable digital devices and has the potentials to strengthen both educational and technological capacity of students. This study examines the effect of M-learning on students' educational and technological skill development in undergraduate Physics. A quasi-experimental research design with a sample of 150 students was adopted. Data were collected using Technological Skill Development (TSD) Test and Conceptual Understanding of Physics (CUP) Test; and analyzed using descriptive and inferential statistics at 0.05 significance level. Findings showed that students taught using M-learning instruction recorded significantly higher post-test mean scores in both TSD (**$MS = 36.84$, $SD = 4.63$*) and CUP (*$MS = 35.98$, $SD = 5.07$*) compared to those taught using the traditional lecture method (TSD: *$MS = 31.26$, $SD = 5.12$*; CUP: *$MS = 31.22$, $SD = 5.56$*). ANCOVA analysis indicated that M-learning had a statistically significant effect on both students' TSD *[$F(1,146) = 33.45$, $p < 0.05$, partial $\eta^2 = 0.19$], and CUP [$F(1,146) = 18.57$, $p < 0.05$, partial $\eta^2 = 0.11$]* between experimental and control groups. Regression analysis further indicated that M-learning significantly predicts both students' TSD *[$F(1,148) = 40.33$, $p < 0.05$; $R^2 = 0.21$]* and CUP *[$F(1,148) = 22.21$, $p < 0.05$; $R^2 = 0.17$]*, with a moderate positive predictive relationship **(TSD: $\beta = 0.46$; CUP: $\beta = 0.41$, at $p < 0.05$).** It is recommended that school authorities should organize training workshops for science teachers on M-learning usage.*

KEYWORDS: *Mobile Learning, Physics, Technological Skill Development, Conceptual Understanding, Lecture Method.*

INTRODUCTION

Physics serves as the foundation for many scientific and technological fields such as engineering, materials science, and information technology; consequently playing a crucial role in scientific and technological development of any developing and developed society. However, despite its importance, Physics is frequently described by learners as one of the most challenging subjects in the science curriculum, due to the abstract nature of many of its concepts, such as electric fields, wave–particle interactions, and quantum phenomena, which cannot be directly observed in everyday experience. These challenges contribute not only to weak conceptual understanding but also to poor technological skill development.

Research indicates that traditional lecture-based approaches, which focus primarily on textbook and instructor explanations, may be insufficient for developing deep conceptual understanding in science subjects like physics leading to persistent misconceptions arising from transmission-reception teaching (Basantes-Andrade & Guevara-Betancourt, 2024). Conventional instruction often provides few opportunities for students to explore, experiment, and construct knowledge actively, which are essential processes for meaningful learning in science (Crompton & Burke, 2020). In response, Mobile learning (M-learning) has emerged as a promising alternative pedagogical approach to address these challenges that arises from the traditional instructional method.

Mobile-learning (M-learning) is an aspect of educational technology which provides learning via media technology in the form of portable mobile devices (such as smartphones, tablets, audio-visual players) that are capable of connecting to the internet, enabling communication, accessing learning information and materials at anytime and anywhere. Goksu (2021) defines M-learning as a form of learning that enables individuals to acquire experiences through individual or collaborative learning with the activities of accessing, producing and managing information through digital interaction using portable devices. M-learning also refers to a form of e-learning (Galimova et al., 2025) that uses portable devices such as smartphones, tablets, laptops, audio players, e-books and other portable devices to deliver educational content, facilitate learning and support interaction at anytime and anywhere, thus representing an informal and unstructured approach to education (Ashfaq, 2025; Goundar and Kumar, 2022; Hamidi and Chavoshi, 2018). Abduljawad & Ahmad (2023) describes M-learning as a modern approach to education that utilizes mobile networks and devices, broadens the digital learning avenue, and enables individuals to access educational resources, information, and services from any location at any moment.

Mobile learning has the ability to cover the mobility of learners, learning, educators and that of technological devices (Al-Emran

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et al., 2016). The ability of M-learning to provide access to learning materials and resources at anytime and anywhere enhances the flexibility of learning, and enables students to engage in learning activities at their convenience and pace both inside and outside the classroom, which is crucial in mastering the often-difficult concepts of physics as well as enhancing learning success and transfer of knowledge to others (Ashfaq, 2025; Bernacki et al., 2020; Naveed et al., 2023; Shuja et al., 2019). M-learning could assist in developing new educational approaches that allow students to engage in innovative and creative tasks throughout their learning (Subramani & Iyappan, 2018). The success of mobile learning is based on its unique characteristics of portability, connectivity, individuality, availability, and social interactivity (Abdullah et al., 2024). These unique features make mobile learning suitable for active learning in all situations, providing increased mobility and timely interactions that enhance learners' motivation to learn (Sung et al., 2019). In essence, m-learning has the potential to improve students' technological skill development as well as learning achievement if properly implement.

Research suggests that mobile learning supports active engagement, multimodal representations, and personalized interaction with content, which are particularly useful in complex domains like Physics (Crompton & Burke, 2020). Several meta-analysis studies have shown that mobile learning enhances learning achievement and significantly increase learner's motivation compared to learning methods without technology (Chauhan, 2017; Merchant et al., 2014; Sung et al., 2016). Research study indicated that using mobile technology has a significant effect on students' learning and academic performance in physics compared to without mobile learning (Abdullah et al., 2024; Ashfaq, 2025; Abdekhoda et al., 2023). Other research studies have also found M-Learning to encourage student collaboration (Amadu et al., 2018; Kuo & Kuo, 2020; Bhati & Song, 2019), facilitate skills development (Sulaiman & Dashti, 2018; Chavoshi & Hamidi, 2019; Alamer & Al Khateeb, 2021; Bere, 2018; Al-Emran et al., 2020; Iqbal & Bhatti, 2017), and enable self-assessment opportunities for students (Coskun-Setirek & Tanrikulu, 2021; Bhati & Song, 2019), act as a catalyst for enhanced student engagement and motivation (Alioon & glu, 2019; Chin et al., 2019a; Chin et al., 2019b; Hung et al., 2018; Jeno et al., 2017).

Recent research has shown that m-learning positively influences student learning across various disciplines. Yuan et al. (2025) in their studies reported substantial learning gains with M-learning, while Garzón et al. (2025) in their meta-analysis and research synthesis study results showed a large effect of mobile learning on student learning gains and indicated that mobile learning consistently benefits students across different educational settings. Pedraja-Rejas et al. (2024) in their systematic review results showed that integrating m-learning tools in teaching-learning can potentially to improve students' learning outcomes and critical thinking skills. Anselmo et al. (2024) in their study revealed that mobile learning tools are effective in enhancing conceptual understanding, increasing engagement and motivation, improving academic performance, development of higher-order thinking skills, hands-on learning and practical skills, and reduced cognitive load. A systematic review studies by Mercan et al., (2024) revealed that M-Learning positively impacts areas such as collaboration, skill development, and self-assessment among students. Galimova et al. (2025) in their study review concludes that mobile devices can catalyze sustained higher-order thinking skills.

However, some studies have indicated a negative impact of mobile learning on students' performance (Feng et al., 2018; Klimova, 2019; Abachi & Muhammad, 2014). Research by Stone and Logan (2018) found that through mobile learning, students use social media platforms like Facebook to share content and foster discussions. These activities have a significant impact on students' self assessments and academic performance.

STATEMENT OF THE PROBLEM

Persistent evidence had showed that many students demonstrate poor conceptual understanding and inadequate technological skills in physics largely due to the continued dominance of traditional, teacher-centered instructional approaches that emphasize memorization over meaningful engagement, inquiry, and practical application (Sung et al., 2016). As a result, students often struggle to understand abstract Physics concepts and to apply technological tools effectively in learning and problem-solving situations.

Despite the documented benefits of mobile-learning as discussed above, its integration in Physics classrooms remains limited, especially in developing educational system like Nigeria. Furthermore, relatively few to almost no empirical studies have examined the combined effect of M-learning on students' technological skill development and conceptual understanding of Physics. This consequently necessitates the need to empirically examine the effect of mobile-learning instruction on students' technological skill development and conceptual understanding of Physics, and provide educators and curriculum developers with empirical evidence-based insights which can inform instructional practice and educational policy.

PURPOSE OF THE STUDY

The main purpose of this study is to examine the impact of M-learning on students' educational and technological skill development in undergraduate Physics.

RESEARCH HYPOTHESES

1. There is no significant effect of mobile learning (M-learning) on students' Technological Skill Development (TSD).
2. Mobile learning does not significantly predict students' Technological Skill Development (TSD).
3. There is no significant effect of mobile learning (M-learning) on students' Conceptual Understanding of Physics (CUP).
4. Mobile learning does not significantly predict students' Conceptual Understanding of Physics (CUP).

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RESEARCH METHODOLOGY

This study employs a quasi-experimental-descriptive-inferential research method. The target population for the study includes all Physics (100L - 300L) students in the school of Secondary Education (Sciences), Federal College of Education, Abeokuta, Ogun state, Nigeria. Through random sampling technique, 200L class, consisting of 150 physics students were selected as the sample size. The sample students were divided equally into experimental and control groups.

Data were collected with the aid of Technological Skill Development Test (TSD-T), and Conceptual Understanding of Physics Test (CUP-T). The TSD-T and CUP-T are assessment tests developed by the researchers to measure the students' technological skill development and conceptual understanding of physics. The TSD-T and CUP-T were validated by expert colleagues in measurement and evaluation. The reliabilities of the instruments (TSD-T and CUP-T) were determined using Cronbach's Alpha statistic to yield reliability coefficient values, $\alpha = 0.78$ and 0.80, respectively. The teaching-learning activities covered four weeks with the experimental group taught using Mobile Learning Instruction (MLI), while the control group was taught using the Traditional Lecture Method (TLM). At the completion of the teaching-learning activities, the TSD-T and CUP-T were administered to all students (experimental and control groups) under strict examination conditions, marked and scored adequately. Collected data were analyzed using descriptive (mean, standard deviation) and inferential (ANCOVA) statistics at 0.05 significance level, with the aid of SPSS statistical software.

RESULT AND DISCUSSION

$H_0$1: There is no significant effect of mobile learning on students' technological skill development (TSD).

Table 1a: Pretest and posttest scores of students' TSD for students exposed to MLI and TLM.

Treatment		Students' technological skill development (TSD)					
		Pretest Score			Posttest Score		
Group	N	Mean	S.D	MSD	Mean	S.D	MSD
Experimental (MLI)	**75**	26.12	5.21	**0.25**	36.84	4.63	**5.58**
Control (TLM)	**75**	25.87	5.34		31.26	5.12	

SD = Standard Deviation; MSD = Mean Score Difference; Source: Fieldwork, 2025

Table 1a revealed the pretest and posttest scores of students' technological skill development (TSD) under MLI and TLM instructions. As revealed by the results, the pretest mean scores were similar across the groups (MLI = 26.12, *SD* = 5.21; TLM = 25.87, SD = 5.34, MSD = 0.25). So, the experimental and control groups do not significantly differ from each other.

Table 1a also revealed that students taught using the M-learning approach achieved significantly higher post-test mean scores in TSD (M = 36.84, SD = 4.63) than students taught using the traditional lecture method (M = 31.26, SD = 5.12) with a mean score difference (MSD) = 5.58, indicating large effect size due to MLI. Based on these results, the null hypothesis was rejected. This implies that M-learning has a significant effect on students' technological skill development.

Table 1b: Summary of One-way ANCOVA analysis for the effect of the instructional method on the students' technological skill development

Dependent Variable: Posttest Score (technological skill development, TSD)

Source	Type III Sum of Squares	df	Mean square	F	Sig	Partial Eta Squared
Corrected Model	877.07	2	438.535	17.65	0.000	0.194
Intercept	842.52	1	842.52	33.90	0.000	0.189
Pretest (Covariate)	184.62	1	184.62	8.91	0.003	0.057
Teaching Method (Independent Variable)	692.45	1	692.45	33.45	0.000	0.190
Error	3012.18	146	20.63			
Total	193845.00	150				
Corrected Total	3889.25	149				

Independent Variable: Teaching methods (MLI, TLM); **Covariate:** pretest technological skill development score; **Source:** Fieldwork, 2025.

Table 1b showed the ANCOVA results conducted to examine the effect of the teaching methods (MLI and TLM) on students' TSD. The ANCOVA results revealed that instructional method had a statistically significant effect on students' posttest TSD scores, $F(1,146) = 33.45$, $p < 0.05$, partial $\eta^2 = 0.19$, indicating a large effect size. This result further showed that about 19% of the variance in the posttest TSD scores was attributable to differences in teaching method, after controlling for pretest TSD. The pretest TSD was also statistically significant, $F(1, 146) = 8.91$, $p = 0.003$, $\eta^2 = 0.057$, suggesting that initial TSD levels had a little influence of about 5.7% on students' posttest TSD. Based on these results, the null hypothesis was rejected. This implies that M-learning has a significant effect on students' technological skill development.

H_02: Mobile learning does not significantly predict students' technological skill development (TSD).

Table 2a: **Model Summary of simple linear regression (SLR) analysis for students' technological skill development** (TSD) **prediction** from **M-learning**

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.46	0.21	0.20	4.46

Table 2a showed the model Summary of SLR analysis conducted to determine whether M-learning significantly predicts students' TSD in Physics or not. The summary result showed that M-learning has a positive relationship with the students' TSD (R = 0.46), influencing it to about 21% (R^2 = 0.21), while the remaining 79% may be due to other factors not included in this study.

Table 2b: ANOVA results of simple linear regression analysis for students' TSD prediction from **M-learning**

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	802.34	1	802.34	40.33	0.000
Residual	2941.91	148	19.88		
Total	3744.25	149			

Table 2b showed the ANOVA results of SLR analysis conducted for prediction of students' TSD from M-learning. The results showed, $F(1,148) = 40.33$, $p < 0.05$, indicating a statistically significant relationship between M-learning and TSD, thus M-learning significantly predicts students' TSD.

Table 2c: Coefficients of simple linear regression analysis for students' technological skill development prediction from M-learning

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant	19.42	1.86		10.44	0.000
Mobile Learning	0.46	0.07	0.46	6.35	0.000

Table 2c showed the coefficients of SLR students' carried out for prediction of students' TSD from M-learning. The standardized beta coefficient ($\beta = 0.46$, $t = 6.35$, $p < 0.05$) shows a moderate positive predictive relationship, indicating that M-learning contributed about 46% to students' TSD, and thus significantly predicts students' TSD. This implies that increased engagement with M-learning is associated with higher TSD. Consequently, the null hypothesis was rejected.

H_03: There is no significant effect of mobile learning on students' conceptual understanding of Physics (CUP).

Table 3a: **Pretest and posttest scores of students' CUP for students exposed to MLI and TLM**

		Students' conceptual understanding of Physics					
		Pretest Score			Posttest Score		
Group	N	Mean	S.D	MSD	Mean	S.D	MSD
Experimental (MLI)	**75**	25.94	5.62	**0.23**	35.98	5.07	**4.76**
Control (TLM)	**75**	25.71	5.48		31.22	5.56	

SD = Standard Deviation; MSD = Mean Score Difference; Source: Fieldwork, 2025

Table 3a showed the pretest and posttest scores of students' conceptual understanding of Physics (CUP) scores under MLI and TLM instructions. As indicated on the table, the pretest mean scores were similar across the groups (MLI = 25.94, SD = 5.62; TLM = 25.71, SD = 5.48, MSD = 0.23). So, the experimental and control groups do not significantly differ from each other.

Based on Table 3a result, students taught using the M-learning instruction performed significantly better with higher post-test mean scores in CUP (M = 35.98, SD = 5.07) than those taught using the TLM (M = 31.22, SD = 5.56) with a mean score difference (MSD) = 4.76. This indicates large effect size due to M-learning instruction, thus null hypothesis was rejected. This implies that M-learning has a significant effect on students' conceptual understanding of Physics.

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Table 3b: Summary of One-way ANCOVA analysis for the effect of the instructional method on the students' conceptual understanding of Physics

Dependent Variable: Posttest Score (conceptual understanding of Physics)

Source	Type III Sum of Squares	Df	Mean square	F	Sig	Partial Eta *Squared
Corrected Model	740.02	2	370.01	13.00	0.000	0.151
Intercept	885.27	1	885.27	31.10	0.000	0.176
Pretest (Covariate)	211.38	1	211.38	7.42	0.007	0.048
Instructional Method (Independent Variable)	528.64	1	528.64	18.57	0.000	0.110
Error	4154.29	146	28.46			
Total	194760.00	150				
Corrected Total	4894.31	149				

Independent variable: Teaching methods (MLI, TLM); **Covariate:** pretest conceptual understanding of Physics score; **Source:** Fieldwork, 2025.

Table 3b showed the ANCOVA results conducted to examine the effect of the teaching methods (MLI and TLM) on students' CUP. The results indicated that the instructional method had a statistically significant effect on students' posttest CUP scores, $F(1,146) = 18.57$, $p < 0.05$, partial $\eta^2 = 0.11$. This indicate a medium effect size, which further implies that about 11% of the variance in the posttest CUP scores was due to differences in teaching method, after controlling for pretest CUP. The pretest CUP was also statistically significant, $F(1, 146) = 7.42$, $p = 0.007$, $\eta^2 = 0.048$, suggesting that students' prior knowledge influenced post-test performance to about 4.8%. Based on these results, the null hypothesis was rejected. This implies that M-learning has a significant effect on students' conceptual understanding of Physics.

$H_0$4: Mobile learning does not significantly predict students' Conceptual Understanding of Physics (CUP).

Table 4a: Model Summary of simple linear regression analysis for prediction of students' CUP from **M-learning**

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.41	0.17	0.16	4.99

Table 4a showed the model summary of SLR analysis conducted to determine the predictive ability of M-learning on students' CUP. The summary result showed that M-learning has a moderate positive relationship with the students' CUP ($R = 0.41$), accounting for 17% of the variance in students' conceptual understanding ($R^2 = 0.17$), while the remaining 83% may be due to other factors not included in this study.

Table 4b: ANOVA results of simple linear regression analysis for prediction of students' CUP **from** M-learning

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	553.28	1	553.28	22.21	0.000
Residual	3686.71	148	24.91		
Total	4239.99	149			

Table 4b showed the ANOVA results of SLR analysis conducted for the prediction of students' CUP from M-learning. The results showed, $F(1,148) = 22.21$, $p < 0.05$, indicating a statistically significant relationship between M-learning and CUP, thus implying that M-learning significantly predicts students' CUP.

Table 4c: Coefficients of simple linear regression analysis for prediction of students' conceptual understanding of Physics from M-learning

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant	21.63	2.01		10.76	0.000
Mobile Learning	0.38	0.08	0.41	4.71	0.000

Table 4c showed the coefficients of SLR students' carried out for prediction of students' CUP from M-learning. The standardized beta coefficient ($\beta = 0.41$, $t = 4.71$, $p < 0.05$) shows a moderate positive predictive relationship, indicating that M-learning contributed about 41% to students' CUP, and thus significantly predicts students' CUP. Therefore, the null hypothesis was rejected.

DISCUSSION OF FINDINGS

Findings from this study revealed that M-learning significantly influence students' technological skill development (TSD) and exhibited a positive relationship with it, such that those taught via the M-learning approach achieving significantly higher post-test mean score in TSD than those taught using the traditional lecture method. Statistical analyses conducted also indicated a statistically significant effect of M-learning on the students' TSD (ANCOVA: $F(1,146) = 33.45$, $p < 0.05$, partial $\eta^2 = 0.19$; SLR analysis: $R = 0.46$, $R^2 = 0.21$; SLR-ANOVA results: $F(1,148) = 40.33$, $p < 0.05$; SLR coefficients: $\beta = 0.46$, $t = 6.35$, $p < 0.05$). The significant influence of M-learning on students' technological skill development might be due to the students' regular use of mobile devices and applications during exposure to M-learning activities. These findings supports previous research studies such as that of Abdullah et al. (2024), Ashfaq (2025), Garzón et al. (2025), Galimova et al. (2025), Mercan et al. (2024), Pedraja-Rejas et al. (2024), among others.

Abdullah et al. (2024) reported in a meta-analysis specific to physics education that mobile learning applications significantly improved students' intellectual skills and learning outcomes in physics, suggesting that mobile tools enhance both cognitive and practical competencies. Ashfaq (2025) found that the integration of mobile learning technologies positively impacted students' academic performance and cognitive development in higher education, with M-learning facilitating greater access to information and learning activities that contribute to improved performance and technological development. Garzón et al. (2025) conducted a large meta-analysis of 253 studies and found that mobile learning significantly enhances student learning gains across diverse contexts and disciplines, indicating strong overall effects of M-learning strategies on educational outcomes, including skill-related performance. Galimova et al. (2025) reviewed M-learning interventions in science education and reported that mobile devices support gains in higher-order thinking and communication skills — competencies that correlate with technological skill development when learners actively interact with science content through mobile platforms. Mercan et al. (2024) identified positive impacts of mobile learning on skill development in higher education, further substantiating the predictive relationship between mobile-learning scores and technological skill outcomes. Pedraja-Rejas et al. (2024) conducted a systematic review showing that M-learning can improve learning outcomes and critical thinking skills, a dimension closely tied to students' ability to engage with and develop technological competencies when using mobile tools.

In addition, this study also revealed that M-learning significantly influence students' conceptual understanding of Physics (CUP), exhibiting positive relationship together. Statistical analyses conducted further indicated a statistically significant effect of M-learning on the students' CUP (ANOVA: $F(1,146) = 18.57$, $p < 0.05$, partial $\eta^2 = 0.11$; SLR analysis: $R = 0.41$, $R^2 = 0.17$; SLR-ANOVA results: $F(1,148) = 22.21$, $p < 0.05$; SLR coefficients: $\beta = 0.41$, $t = 4.71$, $p < 0.05$). The significant influence of M-learning on students' conceptual understanding of Physics might be due to its special attributes of being able to support students' personalized learning, active engagement and somehow boost learning motivation. These findings are in line with previous research works of Anselmo et al. (2025), Fadillah et. al. (2025), Galimova et al. (2025), Magalong & Prudente (2020), among others.

Anselmo et al. (2025) found in a systematic review that mobile learning tools such as AR, VR, and interactive apps enhanced students' conceptual understanding in physics education by providing interactive, multimodal representations that make challenging concepts more accessible and reduce cognitive load. Fadillah, Hirahmah & Fitri (2025) found that students' preferences for mobile-based learning media (e.g., physics simulations, videos, mobile apps) were significantly positively related to their physics competence and understanding, suggesting mobile learning supports deeper conceptual grasp of abstract concepts. Galimova et al. (2025) highlighted that mobile technologies support communication and collaboration among learners - processes that are known to foster conceptual understanding by enabling access to content, peer interactions and teacher guidance anytime and anywhere. Magalong & Prudente (2020) showed that a next-generation blended learning approach, combining mobile devices and multimedia, improved students' conceptual understanding of physics topics like energy and momentum by empowering personalized and progressive learning processes.

CONCLUSION

The study concludes that M-learning instructional approach supports and promotes students' technological skill development and conceptual understanding of Physics compared to the traditional lecture method. The unique flexibility of M-learning to provide access to learning materials and resources at anytime and anywhere, coupled with its personalized learning opportunities, active engagement potentials and learning motivation boost, helps to create interactive and enjoyable learning environment that encouraged students to get more academically involved.

Recommendations

Based on the study findings, it is recommended that school authorities and other education stakeholders should (i) organize training workshops and seminars for science teachers on the use of M-learning in science teaching-learning systems, (ii) encourage and ensure science teachers integrate M-learning in their teaching-learning activities, (iii) support science teachers with all necessary learning materials needed for effective implementation of M-learning instructions.

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