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An Investigation of the Application of Machine Learning as a Tool and a Method for Mathematics and Statistics Instruction Within the Context of ODeL

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Abstract
The application of machine learning (ML) in mathematics education has increased in recent years, but not without its own challenges. This study investigates how ML can be used as a tool and method in Mathematics and Statistics instruction within the context of Open and Distance e-Learning (ODeL) and unravels the perceived challenges and prospects. Data was collected through email questionnaires with closed and open-ended statements. These questionnaires were delivered to 50 participants selected through random and purpose sampling to include those with experiences of both conventional and ODeL setups. The participants were qualified mathematics teachers and lecturers from secondary schools, teachers' colleges and universities in Gweru, Zimbabwe. They rated given statements on a Likert scale and stated their own perceived and observed challenges and prospects of applying ML in instruction. Data were analysed using descriptive and inferential statistics and qualitatively through content analysis and by categorizing and interpreting emerging themes. Thus, a mixed method design - using multiple sources, instruments and analysis methods - was used. Results indicated that most respondents were concordant on the Likert statements and that ML technologies have advantages such as personalised instruction, interactive assessments, and on time feedback, among others. Challenges included lack of creativity by students, lack of the human, moral and sympathetic aspect, data collection and algorithmic biases, among others. It was recommended that ML for mathematical sciences instruction could not be wholly done away with. This study could help in the evaluation and implementation of ML policies in ODeL institutions.

Introduction

Machine learning, which is an aspect of artificial intelligence (AI) allows a machine such as a computer to 'learn' from given data without depending on explicit programming. ML uses algorithms that use big amounts of data to produce formulas, text, graphs, and patterns that solve problems such as prediction of students' performance, setting examinations and marking guides, tutoring students, etc. (Dhilipan, 2021; Miao, Holmes, Huang, & Zhang, 2021; Van Vaerenbergh & Pérez-Suay, 2022**).** The ODeL context is defined by physical separation, asynchronous communication, scalability, and a diverse, often independent, learner population. The use of ML in the teaching and learning of mathematics and statistics, and also, in the context

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of ODeL is widely believed to be beneficial. For instance, the benefits of using ML have been articulated (Opesemowo, 2025; Yu, 2025; Hossein-Mohand, Albanese, & Olmos Gómez, 2024; Gautam & Dua, 2021).

Since it is believed that AI in ODeL can bridge the gap between student and teacher, it would appear that most teachers as well as their learners are not very conversant with the use of AI technologies such as ML. But education can be 'transformed' by these technologies leading to sustainable human socio-economic development. However, this is not without challenges. Hence, this study which investigates how ML can be applied to teach mathematics and statistics within the context of ODeL was embarked upon.

Statement of the problem

Nowadays the teaching and learning of mathematics and statistics have been made easy by the use of ML software, tools and educational applications. However, it would appear that many teachers and institutions in Zimbabwe are still ill-equipped in terms of resources, connectivity, and most importantly, know-how regarding the use of these gadgets. In the ODeL scenario where the learner may be far away from the institution and the library and may lack regular face-to-face interaction with the teacher and peers, the burden of learning mathematics and statistics like other conventional students may be worsened. Can ML systems be a panacea to these and other predicaments?

Purpose of study

This study investigates how machine learning, which is an aspect of AI, can be applied to teach mathematics and statistics within the context of ODeL. It investigates this by analysing teachers' and lecturers' concordance of their ratings of items on the 5-point Likert scale and by analysing (from the open-ended questions) their own perceived and observed challenges and prospects of ML for teaching and learning of Mathematics and Statistics.

Research questions

The following research questions guided this study.

1. How do the teachers rate their own understanding of using ML to teach Mathematics and Statistics through ODeL?
2. What are the artefacts, algorithms, products, services, and software that may be produced through ML?
3. How do mathematics and statistics teachers rate their own awareness of artefacts, algorithms, products, services, and software that may be produced through ML?
4. Are the teachers concordant on their ratings of the 5-point Likert items?
5. (a) What challenges do teachers face when teaching mathematics and statistics using machine learning and within the ODeL context and how can they be resolved?
   (b) How do mathematics and statistics teachers rate the items concerning challenges faced when teaching mathematics and statistics using machine learning and within the ODeL context?
6. (a) What are the benefits of using ML to teach mathematics and statistics in the ODeL context?
   (b) How do mathematics and statistics teachers rate the items concerning benefits of using ML to teach mathematics and statistics in the ODeL context?
7. What suggestions are offered by the participants with regards to using ML to teach mathematics and statistics in the ODeL context?

Hypotheses

These general hypotheses refer to Tables 2 to 7. The specific hypotheses are inserted and tested below each table.

Ho: There is no statistically significant concordance between the respondents' ratings of the Items on B to G.

H_1: There is statistically significant concordance between the respondents' ratings of the Items on B to G.

Friedman's chi square test was used to test the hypotheses at alpha = 0.05.

Review of related literature

This review is divided into these sections: Theoretical framework, Challenges of using ML for teaching and learning mathematics, Benefits and opportunities of using ML in mathematics education, Ratings scales for assessing understanding and awareness of ML.

Theoretical framework

This study is hinged on the AI-TPACK (Artificial Intelligence - Technological Pedagogical Content Knowledge) framework (Runge, Hebibi, & Lazarides, 2025; Mishra, & Koehler, 2006) and the TAM (Technology Acceptance Model) as propounded by Davis (1989). The AI-TPACK framework addresses how ML systems (and other tools) can be integrated with pedagogical and content knowledge in teaching contexts (Celik, Yildiz Durak & Aydin, 2022). The TAM model shows that teachers' and learners' acceptance of AI tools is mediated by perceived usefulness and ease of use (Yim, Park, & Cho, 2024). With this paired framework, one can design interventions (via ML) to boost teachers' awareness and instructive pedagogies and learners' uptake and use, the alignment with mathematics and statistics and the success of those interventions in ODeL settings. For instance, Al-Abdullatif (2024) found that "intelligent TPACK" and AI literacy could be used to study the relationship between ease of use and teachers' intention to use generative AI (ML) in higher education. Also, training courses can boost the intention to use and the actual usage of ML tools in the teaching and learning of mathematics and statistics, especially within the ODeL scenario. So, combining these frameworks can help this study to examine how technologically knowledgeable and prepared the teachers and lecturers are (AI-TPACK) and why they may or may not use ML tools (TAM), including barriers involving perceived usefulness, ease of use, trust, and resource constraints.

Challenges of using ML for teaching and learning mathematics

Deep learning (DL) is a subset of ML whereas ML is a subset of AI. So, some challenges of using ML, like those of using AI, have been documented. According to Opesemowo (2025), some of these are:

1. Lack of human creativity and problem - solving skills: Mathematics education is more than just answering routine problems. Some AI models overemphasize computational skills more than conceptual understanding, mathematical reasoning, critical thinking, metacognition, and mathematical applications in real world contexts.
2. Inability to explain reasoning: Some AI models, particularly complicated ones like deep neural networks (DL), provide solutions but not reasons.
3. Bias in data and algorithms: Some AI models are trained on historical data, which may contain accidental biases and deliberate prejudices against minority and vulnerable groups, etc.

In corroboration, ChatGPT has been termed as a 'disruptive technology' (Frith, 2023).

4. Lack of emotional intelligence: There is need for a welcoming learning atmosphere. AI cannot provide the same level of empathy, encouragement, and emotional support that human teachers can.
5. Data privacy and security concerns: AI and ML may infringe on the privacy and security of some people or organisations thus violating ethical and legal privileges.
6. Lack of real-time interaction: Some ML tools lack real time interactions with students.
7. Inequitable Access: AI implementation may lead to disparities in access to technology and resources. This may create a digital divide between students with access to AI-powered tools and those without.

Some similar challenges were also echoed by Yu (2025), that some students are lazy and rely heavily on AI tools, some cheat in assignments while some AI tools send fake information and impersonate people's identities. Other AI tools need large amounts of training data and computational resources which some teachers cannot access for their students (Estrada-Molina, Mena, & López-Padrón, 2024).

Benefits and opportunities of using ML in mathematics education

Opesemowo (2025) also contends that through the use of AI powered technologies (like ML), there have been some improvements in mathematics education such as:

- Personalized and interactive learning: Students can learn alone and/or with others according to their needs, learning styles, and at their own pace. They can chat and share information whenever necessary. This promotes active participation, problem- solving, and critical thinking skills, making mathematics more accessible and exciting for students. Hossein-Mohand, Albanese, and Olmos Gómez (2024) hold similar views.
- Adaptive Assessment: With use of ML, educators can identify students' weaknesses, easily assess and grade their work and offer real time feedback, using mathematics applications (such as Photomath, Socratic, Mahtway, Maple Calculator, and Microsoft Math Solver, etc.). Assessing and grading students' work saves teachers time and allows them to focus on other areas of their teaching.
- Teacher Professional Development: ML can help mathematics teachers with professional development. ML systems can offer teacher-centred training modules, workshops, and resources to improve their instructional skills and pedagogical approaches.
- Online Math Competitions: ML can power online math competitions and challenges, providing participants with adaptable and demanding problem sets. These tournaments establish a competitive yet enjoyable environment, motivating children to thrive in mathematics and demonstrate problem- solving abilities (p.8). This would, according to the researcher, replace or enhance the face-to-face Mathematics Olympiads that many teachers and students are familiar with.
- ChatGPT: ie., Chat Generative Pretrained Transformer which uses ML tools, can replace the writing process. It is also a search engine tool, editing software, a statistical software, and reference management system (Firth, 2023). It is a chatbot that responds to questions using AI and natural language processing. Hence, its many benefits include saving time, creating quality content, virtual assistance, learning exploration, and generation of mathematics assessment questions. This boost users' satisfaction as well.

There is a strong link between AI and mathematics. Richard et al. (2022) cited in Opesemowo (2025) says that AI depends heavily on mathematics (such as logic and set theory, calculus, probability and statistics, linear algebra, and optimization, etc.) since it provides the formal

language and tools for expressing and understanding the concepts and algorithms that drive the AI technology (p. 5).

In the context of ODeL, Gautam and Dua (2021) opine that the application of AI (inclusive of ML) in open and distance learning (ODL) has led to bridge the gap between student and teacher. In corroboration with Opesemowo (2025), Gautam and Dua (2021) say AI tools in ODL mode (such as ezTalks Cloud Meeting, WeVideo, scrible and Dropbox) provide learning opportunities to students, helps the teacher in effective teaching, improves pedagogical methods and enhances learning experiences of students (p. 59). ML also handles the design of intelligent tutoring systems and performance prediction as well as unstructured data such as images, text, and voice (Estrada-Molina, Mena, & López-Padrón, 2024, p. 372). ML can also be integrated with traditional analysis of academic performance in resource-constrained settings (Abdulkadir Ali, Hassan Muse, Khadar Abdi, Abdi Ali, Hassan Muse, & Axmed Cumar, 2025) such as those in Zimbabwe. In tandem is the work of Adewale, Azeta, Abayomi-Alli, and Sambo-Magaji (2024, p.1) who used a systematic literature review to investigate the 'impact of artificial intelligence adoption on students' academic performance in open and distance learning.' Findings pointed to the need for a "… framework designed to forecast AI's educational impacts with greater precision, especially across gender and regional lines." This benefits students especially those learning through ODeL where they are far from their institution, far from the teacher and often disadavnatged in terms of resources and sometimes internet connectivity. Yu (2025) says the 'good' of AI and Machine Learning can be observed in their application in teaching and research. They help as teaching assistants, and in research they show and solve the limitations of some statistical analyses.

Some scholars such as Nauryzbayev, Baygamitova, Akhmetova, Pak, Karipzhanova and Urazbaeva, (2022) have also developed intelligent analytical diagnostic systems for teaching elementary mathematics problem-solving; a system which has been implemented under the Windows Operating System. Guided by the above literature review, this study hopes to also unravel the Zimbabwean related challenges and opportunities of using ML for teaching mathematics and statistics through ODeL.

Ratings scales

Many variables studied in social sciences like education (eg., teachers' understanding of the way ML can be used to teach mathematics and statistics and teachers' awareness of algorithms, products and services that can be produced using ML) cannot be directly observed (Tanujaya, Prahmana1, & Mumu 2022). Hence rating scales such as the 5-point Likert scale have been used to solve such problems. However, it is essential for researchers to examine the quality of the items and whether the respondents are likely to understand those items so as to ensure the validity and reliability issues (Tanujaya, Prahmana1, & Mumu 2022). Since Likert type scales can be treated as ordinal or as interval data, both parametric and non-parametric tests can be conducted. Likert scales can be used for assessing understanding and awareness of ML.

Methodology

This study investigates how ML can be used as a tool and a method for mathematics and statistics instruction within the context of ODeL. Data were collected through an email questionnaire with closed (Likert-type) and open-ended statements. These questionnaires were delivered to 50 mathematics teachers and lecturers selected through a mixture of random and purpose sampling so as to include participants with experiences of both conventional and ODeL setups. The participants were qualified teachers and lectures from secondary schools, teachers' colleges and universities in Gweru, Zimbabwe. The participants voluntarily agreed to take part

in the study, and they were assured that research ethics of confidentiality and anonymity would be adhered to. To ensure validity and reliability of the items, the researcher asked some mathematics education experts at a local university to check them. After some discussion, the instruments were passed for distribution to the participants. The participants were asked to rate given statements on a Likert scale and state their own perceived and observed challenges and prospects of ML for teaching and learning of Mathematics and Statistics. Thus, a mixed method design - using multiple sources, instruments and analysis methods - was used. Data from the Likert scale ratings were analysed quantitatively using descriptive and inferential statistics (means, standard deviations, Friedman's Chi square test statistics). Hypotheses pertaining data for each table (Tables 2 to 7) were statistically tested at 5% significance level. Data from the open-ended sections were analysed qualitatively through content analysis and by categorizing and interpreting emerging themes (Table 7).

Results and findings

The results and findings are divided into 7 parts A to G. Part A shows demographic data for teachers and lecturers who responded to the questionnaire instrument as is shown in Table 1 below.

Table1:
Demographic data for teachers and lecturers (n=50)

Number of participants	Age range	Gender	Qualification	Experience (years)
19	33-40	8F 11M	Diploma in Education (Sec)	5-10
20	36-44	10F 10M	BSc Math & Statistics	9-18
2	38-42	2M	MSc in Applied Mathematics 2	3-5
6	45-60	2F, 4M	MSc Statistics and Operations Research 6	3-6
3	58-62	1F 2M	DPhil Math Educ	18-20

Table 1 shows the age ranges and experiences of the respondents. They are not in ascending order nor disjoint because they were specifically grouped according to the number of participants for the given genders and qualifications in each row. Most of the respondents (78%) were relatively young, trained teachers (33-44 years) holding the Diploma in Education (Secondary) qualification or the BSC Mathematics and Statistics degree. There were some few (11) holders of Masters' and PhD degrees. The participants were somewhat balanced in terms of gender (29M and 21F). The diploma and bachelor's degree holders were secondary school teachers while the Masters' and PhD holders were college and university lecturers. Participants' experiences of teaching mathematics and statistics varied as follows: teachers (5-18 years), college lecturers (3-6 years), university lecturers (18-20 years). With this somewhat 'balanced' sample in mind, the researcher wished to investigate their ratings, views and suggestions on the use of ML to teach mathematics and statistics in general and also within the ODeL context.

For parts B to F the researcher used ChatGPT (a machine learning software) to do the computations (mean and standard deviation and hypotheses tests on 'Friedman's chi square test

for concordance). This was also in adherence to the research title of using ML to teach mathematics and statistics.

A 13 item 5-point Likert scale on Part B: Teacher's/Lecturer's understanding of Using Machine Learning (ML) to teach Mathematics and Statistics through ODeL was created. Respondents were requested to tick (✓) where applicable from SA= Strongly Agree, A= Agree, U = Undecided or Neutral, D=Disagree, to SD = Strongly Disagree. The results are given in Table 2 below which addressed Research Question (RQ) 1.

Table 2:
For B: Teacher's/Lecturer's Understanding of Using Machine Learning to teach Mathematics and Statistics through ODeL

Statement	Mean	Std Dev	Overall Mean
1. I know what ODeL is all about	4.6	0.78	= 4.59
2. Mathematics and Statistics can be taught in the ODeL scenario	4.8	0.4	
3. ML can be used to teach mathematics and Statistics through ODeL	4.56	0.58	**Overall Std Dev** = 0.63
4. ODeL coupled with ML enhances more understanding of mathematics and Statistics	4.6	0.49	
5. Machine learning enhances student engagement in mathematics and statistics when used in ODeL.	4.24	0.72	
6. Machine learning supports individualized learning in ODeL platforms.	4.6	0.49	
7. The use of AI-based learning systems improves performance in mathematics and statistics, especially in ODeL	4.72	0.54	
8. ODeL platforms equipped with machine learning foster interactive learning experiences.	4.2	0.76	
9. I feel confident using machine learning tools for teaching or learning mathematics and statistics online.	4.8	0.4	
10. Integration of machine learning and ODeL in mathematics and statistics classrooms promotes timely feedback and adaptive learning.	5	0.0	
11. Mathematics and statistics students benefit more from personalized learning paths generated by ML and in the ODeL scenario	4.14	0.9	
12. ODeL platforms equipped with machine learning foster interactive mathematics learning experiences.	4.6	0.49	
13. Machine learning has great potential for solving the teaching challenges in online mathematics education	4.76	0.43	

Table 2 above shows that the respondents, on average, leaned very positively (close to "Agree/Strongly Agree"), with relatively low spread. However, variation existed. For instance, item 10 'Integration of machine learning and ODeL in mathematics and statistics classrooms promotes timely feedback and adaptive learning' shows perfect agreement (everyone chose 5), while item 11 'Mathematics and Statistics students benefit more from personalized learning paths generated by ML and in the ODeL scenario' had the widest spread.

The hypotheses were Ho: There is no statistically significant concordance between the respondents' ratings of the Items on B, and H1: There is statistically significant concordance between the respondents' ratings of the Items on B (alpha = 0.05)

Friedman's Chi-Square Test statistics was (χ^2F) = 232.37 with p-value ≈ $6.42 \times 10^{-43} < 0.0001$. Since $p < 0.001$, the test strongly rejects the null hypothesis of *no concordance* among the items. This means there is high agreement in the ranking of responses across the 13 items (RQ4).

Sixteen items in part C asked about challenges of using machine learning to teach mathematics and statistics through ODeL. Results are shown in Table 3 addressing RQ5b.

Table 3:
For C: Challenges of Using Machine Learning to teach Mathematics and Statistics through ODeL

Statement	Mean	Std Dev	Overall Mean = 3.3
1. Mathematics and Statistics cannot be taught in the ODeL scenario	1.6	1.21	**Overall Std Dev** = 1.34
2. ML cannot be used to teach mathematics and Statistics through ODeL	1.46	0.81	
3. There are no challenges encountered in the teaching of mathematics and Statistics using ML and in the ODeL scenario	1.8	1.17	
4. ML is very difficult to understand	1.4	0.49	
5. ML technologies are not easy to find and install	2.4	1.03	
6. Effective use of ML in mathematics and statistics classrooms is hindered by limited internet connectivity	4.32	0.58	
7. There is non availability of ML experts or resource persons in mathematics and statistics learning areas	3.8	1.17	
8. I find machine learning tools too complex for teaching or learning mathematics and statistics online.	3.6	1.03	
9. The lack of technical support hinders effective use of ML tools in ODeL	4.2	0.75	
10. Machine learning applications are often unreliable in accurately assessing student performance in mathematics and statistics	3.6	1.03	
11. Machine learning creates more challenges than solutions when teaching mathematics and statistics remotely	2.84	1.2	
12. The cost of integrating machine learning tools in ODeL is too high for most institutions.	4.3	0.83	
13. Ethical concerns about data privacy hinder the adoption of machine learning in online Mathematics education.	4.6	0.49	
14. Many students lack the digital literacy required to benefit from machine learning tools in Statistics and Mathematics	4.36	0.82	
15. Mathematics and statistics teachers lack extensive training to effectively use ML tools in ODeL contexts.	4	1.2	
16. Lack of digital infrastructure limits the effective deployment of machine learning in ODeL environments.	4.5	0.5	

Table 3 shows that statements 1–5 and 11 have low means (≈1.4–2.8), suggesting predominantly negative/disagree responses. Statements 6, 9, 12–16 have high means (≈4.2–4.6), indicating predominantly positive/agree responses, while the overall mean (≈3.3) is slightly above the neutral midpoint (3), but with a high overall SD (≈1.49)**,** showing substantial variation across items and respondents.

The hypotheses were Ho: There is no statistically significant concordance between the respondents' ratings of the Items on C, and H1: There is statistically significant concordance between the respondents' ratings of the Items on C.

Friedman's Chi-Square Test statistics was $\chi^2F = 180.24$, df=15, with p-value < 0.0001. The test strongly rejects the null hypothesis of *no concordance* among the items (RQ4). This means that the respondents showed consistent preferences across the statements indicating that indeed there are challenges of using ML to teach Mathematics and Statistics through ODeL.

Part D asked about the benefits or opportunities of using ML to teach mathematics and statistics through ODeL. Results are shown in Table 4 below which addresses RQ6b.

Table 4:
For D: Benefits or opportunities of Using Machine Learning to teach Mathematics and Statistics through ODeL

Statement	Mean	Std Dev	Overall
1. Students understand Mathematics and Statistics better if they are taught in the ODeL scenario	4.50	0.573	**mean** = 4.08
2. It is more beneficial to teach mathematics and statistics using ML and in the ODeL scenario	4.36	0.647	**Overall Std Dev** = 0.76
3. Continuous assessment of Math and Statistics in ODeL is effectively done using ML	4.00	0.000	
4. Use of ODeL saves time and money by reducing travelling to and from school	4.60	0.495	
5. ML caters for students' varying goals, interests and learning styles in mathematics and statistics	3.84	0.796	
6. ML promotes self-control, self-pacing, self-management and improved sense of responsibility in ODeL classes	3.92	0.853	
7. Use of ML promotes creativity and innovation in Mathematics and Statistics learning	4.00	1.095	
8. Assessment of practical work, logs, diaries and portfolios for mathematics and statistics is effectively done using ML	4.00	1.095	
9. Machine learning has great potential for solving the teaching challenges in online mathematics education.	3.80	0.407	
10. AI-generated content (e.g., quizzes, visualizations) enhances the quality of online mathematics and statistics instruction.	4.16	0.795	
11. Machine learning facilitates data-driven decision-making in online mathematics education.	4.12	0.881	

Table 4 suggests that, by observing the means across all questions, respondents leaned strongly towards agreement that there are benefits of sing ML for teaching and learning of mathematics and statistics, even in the non-traditional ODeL context.

The hypotheses were Ho: There is no statistically significant concordance between the respondents' ratings of the Items on D, and H1: There is statistically significant concordance between the respondents' ratings of the Items on D. Friedman's Chi-square Test statistic was $\chi^2F = 310$, p-value: $< 1 \times 10^{-50} < 0.0001$. Hence the null hypothesis that respondents' ratings are not uniform across the 11 items was rejected. Thus, there is strong concordance (RQ4); also meaning that there are benefits or opportunities of using ML to teach Mathematics and Statistics through ODeL.

Part E asked about Teacher's/Lecturer's awareness of artefacts, algorithms, products and services that may be produced through ML of which results are shown in Table 5 below, addressing RQ3.

Table 5:
For E: Teacher's/Lecturer's awareness of artefacts, algorithms, products and services that may be produced through ML.

Statement	**Mean**	**Std Dev**	**Overall Mean** = 4.2
1. Machine learning can generate intelligent tutoring systems tailored for mathematics and statistics.	4.20	0.83	**Overall Std Dev** = 0.76
2. ML algorithms can be developed to recommend appropriate learning resources based on student performance.	4.18	0.85	
3. Adaptive testing engines powered by machine learning can improve the accuracy of student assessments	4.00	1.00	
4. ML-based virtual assistants can offer real-time problem-solving support to ODeL learners	4.24	0.89	
5. Predictive analytics services can help forecast student dropout risks in online mathematics and statistics courses.	4.20	0.86	
6. Educational dashboards using ML in mathematics and statistics classes help instructors monitor learning trends and performance in real time.	4.24	1.09	
7. Customized learning paths created by ML algorithms increase student motivation and retention in mathematics and statistics classes.	4.20	0.83	
8. ML-driven plagiarism detection tools are essential for maintaining academic integrity in ODeL	4.16	1.01	
9. The development of intelligent feedback systems using machine learning improves learning outcomes in mathematics and statistics subjects.	4.20	0.83	

Table 5 shows that all questions have high average scores (4.0–4.24), with low to moderate variation (SD 0.83–1.09) meaning respondents generally leaned toward *Agree/Strongly Agree*.

Friedman's Test statistic was Friedman $\chi^2(F) = 53.33$, df =8, p=0.0001. The hypotheses were: Ho: There is no statistically significant concordance between the respondents' ratings of the Items on E, and H1: There is statistically significant concordance between the respondents' ratings of the Items on E. Since the p value is significantly less than 0.05, the null hypothesis is rejected. The conclusion is that there is strong statistical evidence of concordance in how respondents rated the items (RQ4). Overall, the respondents were aware of artefacts, algorithms, goods and services that could be produced through ML. Some of these are mentioned in Section L below.

Part F asked respondents to rate their agreement/disagreement of teacher's or lecturer's awareness of Assessment and Feedback Tools using ML. Results are shown in Table 6 which addresses RQ3.

Table 6:
For F: Teacher's/Lecturer's awareness of Assessment and Feedback Tools Using ML

Tool	Description	Use in ODeL	Mean	Std Dev	Overall Mean = 2.53
1.Gradescope (AI-assisted grading)	Auto-grades math/statistics handwritten work	Saves time, provides faster feedback	2.80	1.60	**Overall Std Dev** = 1.7
2.Edmodo with AI Add-ons	LMS with AI integrations	Adaptive tests, ML-based feedback in math	2.40	1.74	
3.Otter.ai (for transcription and summarization)	AI tool for transcription	Summarizes math/statistics lectures from recorded content	2.40	1.74	

In Table 6 respondents rated Disagree to Undecided (average mean 2.53) indicating lack of awareness of assessment and feedback tools using ML.

Friedman's $\chi^2 = 75$, df = 2, $p < 0.001$. Ho: There is no statistically significant concordance between the respondents' ratings of the Items on F, and H1: There is statistically significant concordance between the respondents' ratings of the Items on F. The p value < 0.05 implying the rejection of Ho. Hence, significant concordance exists (RQ4).

Part G had open-ended questions. Table 7 addresses RQ's 2,5a, 6a and 7, and shows the questions, teachers' and lecturers' responses and emerging themes.

Table 7:
For Part G: Using Machine Learning to Teach Mathematics and Statistics through ODeL: Suggestions, Challenges and Prospects

Question	Teachers' responses	Emerging theme(s)
1. Outline some of the artefacts,	**Artefacts**: Trained ML Models: e.g., image classifiers, speech recognizers, Data Pipelines: systems that collect, clean, and	-Challenges of differentiating between services, products,

algorithms, products and services that may be produced through ML (RQ2).	prepare data for ML use. Feature Extraction Tools: tools or scripts that extract meaningful input variables, Model Evaluation Reports: documents showing performance metrics (accuracy, precision, etc.). Receipts, bills, bank statements **Algorithms**: Supervised Learning Algorithms- Linear Regression, Decision Trees, Support Vector Machines (SVM), Neural Networks, Deep Learning Algorithms, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Transformers (used in NLP tasks), Phet, Interactive simulation, Kahoot, Use of models Products: receipts, bills, bank statements, Phet, Interactive simulation, Kahoot, Use of models, Software to detect water leakages, Autonomous Vehicles: Use ML for vision, planning, and control, Recommendation Systems: e.g., Netflix, Amazon, YouTube, Language Translators: e.g., Google Translate using neural machine translation. **Services**: Predictive Analytics Services: in healthcare (disease risk), finance (credit scoring), Fraud Detection Services: in banking and e-commerce, Personalized Marketing Services: ML-driven targeting and content customization, Automated Diagnosis Systems: ML used to interpret medical scans (e.g., cancer detection), Interactive simulation, Software to detect water leakages	algorithms, and artefacts - Use of ML and ChatGPT to answer questions - Agreement that ML can be used for teaching math and statistics

2. Outline the challenges that you have faced in Using Machine Learning to teach Mathematics and Statistics through ODeL (RQ5a)	1. Data and resource-related challenges: Data Availability and Quality: High-quality, labelled datasets are essential for training ML models. However, in ODeL contexts - especially in under-resourced regions - data on learner behavior, performance, and interaction may be incomplete, inconsistent, or unavailable. Privacy and Ethics: Collecting and using student data raises ethical concerns around consent, data protection, and responsible AI use. Network challenges, disconnections of electricity, Shortage of electricity in some areas and poor WiFi connectivity, No compatible and user-friendly laptops, no supporting resources 2. Pedagogical Challenges: Complexity of Mathematical Concepts: ML systems may struggle to handle the layered reasoning required in Mathematics and Statistics (e.g., solving multistep problems or explaining abstract theories, AI does not absolutely create individual thinking, no training of staff members	-Categorization of challenges into data & resources- related and pedagogy- related -AI cannot operate as 'full' human being- (does not create individual thinking, AI does not have human feelings) -Infringement on personal privacy - Lack of training on AI and ML use
3. How can the challenges you have listed above be resolved? (RQ5a)	-Establish robust data collection systems (e.g., tracking learner interactions through LMS). - Encourage partnerships among ODeL institutions to build shared datasets. - Implement strict data governance policies aligned with GDPR or local privacy laws. - Combine ML with expert systems and rule-based logic - Government interventions(?) - Staff development on the use of e-gadgets/ Need for training of staff members - Clubs so that people work in groups - Need for government and institutional funding and resource-support	- Building shared data sets -Need for AI policies -Need for staff development/training on AI and ML use -Need for resources and funding support

4. What benefits and opportunities of Using Machine Learning to teach Mathematics and Statistics through ODeL have you experienced? (RQ6a)	-Personalized Learning Experiences**:** Adaptive content delivery: ML algorithms analyze student performance and adjust the pace, difficulty, and content to match individual learning needs. -Improved Assessment and Evaluation**:** Automated grading: ML tools can grade multiple-choice, numerical, and even short-answer math/stat questions quickly and consistently. - Fast and easy to get what you want, - One gets diverse information on solving different equations - Less expensive in terms of travelling expenses - One can operate two or more items at the same time - Have used AI on few occasions, befits include feeling of motivation, happy to experiment, my working time being shortened	-Personalized learning -Quick and improved learner assessment - Solving diverse math and statistics problems with ML - Feelings of motivation, happiness - ML allows creativity and experimentation - Operation of two or more items simultaneously - Saving time and money
5. Write any other comments or suggestions related to the topic under study (RQ7).	- Complement ML with human tutor interventions for deeper guidance. - Prioritize interpretable ML models (e.g., decision trees, linear regression) for educational use. - Integrate explainable AI (XAI) frameworks to show how the model arrived at answers. - Staff development for teachers in order to use e-gadgets, - Workshops and upgrading of teachers is necessary - Need for more resource support, monetary funding and training of personnel but being wary that work of human beings is not wholly taken up by computers. - Leaners need not depend wholly on AI, they need to be creative, innovative and cherish hard work- stop plagiarizing. - AI and ML need not encroach on privacy of human beings	- Avoidance of 100% dependance on AI -Need for step-by-step solutions and explanations -Workshops, staff development and upgrading of teachers -Availability of AI and ML resources and monetary support - Avoidance of plagiarism and encroachment on people's privacy

Table 7 shows various responses from the teachers and lecturers. Several mathematically related artefacts, algorithms and products that could be made using machine learning were suggested, although with anticipated challenges such as ML and AI not able to act like a full human being, lack of training on how to use such 'new software, the need to use AI and ML

with caution. The table also shows a variety of machine learning benefits and suggestions for ways forward such as resourcing learning institutions and staff development of teachers.

Discussion

Research questions 1, 3, 4, 5b and 6b addressed the quantitative aspect while RQ's 2, 5a, 6a and 7 addressed the qualitative aspect of the study. Hypotheses tests results indicated that most respondents were concordant on the Likert statements. This meant that the ratings were meaningful and valid, allowing use of the data in further analysis. Also, findings indicated that ML technologies have advantages such as personalised instruction, interactive assessments, and on time feedback, as also mentioned by Opesemowo (2025), Yu (2025), Abdulkadir Ali, Hassan Muse, Khadar Abdi, Abdi Ali, Hassan Muse, and Axmed Cumar, (2025), Gautam and Dua (2021). Most respondents agreed that ML could be used to make mathematics and statistics related artefacts, algorithms, goods and services that could be sold to raise money to benefit schools and surrounding communities. However, it could not be established whether the teachers/lecturers and their students could actually produce such items using ML. This could be a subject for another research. Challenges mentioned included lack of creativity by students, lack of the human, moral and sympathetic aspect, data security and privacy concerns, inability to thoroughly explain the reasoning behind the answers, data collection and algorithmic biases, among others. Estrada-Molina, Mena, and López-Padrón, (2024) and Yu (2025) have also alluded to these points. The views and suggestions given by the participants were categorised into emerging themes which were tabulated in Table 7. For instance, the themes emerging from 'comments and suggestions related to this study' were categorised and summarised. In particular, is the need for students and their teachers to be creative, innovative and cherish hard work- stop plagiarizing and produce their own work. A notable example is the work of Nauryzbayev, Baygamitova, Akhmetova, Pak, Karipzhanova and Urazbaeva, (2022).) who developed intelligent analytical diagnostic system for teaching elementary mathematics, and whose works were implemented under the Windows operating system. Can our teachers (and students) not do similar work?

Conclusion

The AI-TPACK and TAM models guided this study. The study asked participants to rate on the Likert scale their agreement with the statements relating to their understanding of using ML for teaching and learning of mathematics and statistics in the ODeL context. They also rated their awareness of ML tools, software, goods and algorithms for teaching and learning and items on related challenges and benefits. The challenges and benefits of ML for mathematics and statistics teaching were opined, and some agreed with those cited in the literature review. Despite the challenges, it was recommended that ML for teaching and learning mathematical sciences could not be wholly done away with in this technological age. This study could help in the evaluation and implementation of ML policies in ODeL institutions. In general, research questions for this study have been answered.

Recommendations

1. There is need to equip teachers of mathematics and institutions of learning (and their students) with ML gadgets, software, monetary support and tools for teaching and learning of mathematics and statistics.

2. Workshops, staff development and upgrading of teachers and lecturers should be done to enable them to appreciate the use of ML, to raise awareness of AI platforms for educational applications and be able to incorporate them in their lessons.
3. There is need to raise awareness on plagiarism, encroachment on people's privacy and violation of other ethical standards when using ML.
4. The use of ML for mathematics and statistics teaching and learning in the ODeL scenario should be encouraged.
5. There is need for evaluation and implementation of ML (and AI) policies in ODeL institutions.
6. Further research can and should be carried out on the use of ML for other subjects and in other educational contexts.

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Conflict of Interest
None.

Authors' contributions
The author confirms sole responsibility for the study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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