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Improving students' Python coding skills using automated tools in a learning management system

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Abstract

This study examined the effect of integrating automated assessment tools within a Learning Management System on Grade 10 students' Python coding skills at Jakar Higher Secondary School, Bhutan. Although Python has been prioritised in the national Information and Communication Technology curriculum, students demonstrated limited proficiency in Python functions and debugging, partly due to delayed feedback from manual assessment and limited access to guided practice. A one-group pre-test–post-test quasi-experimental design within a mixed-methods framework was employed over four weeks with 31 students. The intervention incorporated automated quizzes, coding activities, real-time feedback, and progress-tracking features embedded in the LMS developed by the Ministry of Education and Skills Development. Quantitative data from achievement tests and survey questionnaires were analysed using descriptive statistics and a paired-samples t-test, while qualitative data from semi-structured interviews and a research diary were analysed thematically. The results showed a statistically significant improvement in students' post-test scores, with a large effect size, indicating substantial improvement in Python functions and debugging performance. Survey findings also revealed high levels of student engagement, motivation, self-regulated learning, foundational knowledge acquisition, and perceived academic improvement. The qualitative findings supported these results by highlighting the value of instant feedback, self-paced learning, repeated practice, and access to Learning Management System-based learning resources. The study concludes that Learning Management System-based automated assessment may support the development of Python coding skills and promote learner-centred practices in resource-constrained Bhutanese classrooms.

Keywords: Academic performance; Automated assessment; Learning management system; Python

1. Introduction

Python has been prioritized in Bhutan's Information and Communication Technology [ICT] curriculum due to its beginner-friendly syntax and relevance to computational problem-solving, making it essential for students to develop proficiency in this language (Ministry of Education [MoE], 2019). However, in Jakar HSS, several barriers hinder effective Python instruction, including limited access to coding mentors, inconsistent internet connectivity, and reliance on rote-learning methods. As a result, students exhibit limited practical coding competence, with gaps in foundational concepts like function implementation and debugging. This has led to low acquisition of Python coding skills and poor academic performance in both the home examination and the BCSEA examination.

To address these challenges, this study used the Learning Management System [LMS] developed by the Ministry of Education and Skill Development [MoESD], which incorporates automated assessment tools like code auto graders and instant feedback modules. This approach aims to enhance student engagement and improve Python coding test scores, particularly for Grade 10E students, who have consistently underperformed in preliminary coding tasks. By leveraging these digital tools, the study seeks to promote active learning and problem-solving skills, ultimately enhancing students' proficiency in Python coding.

1.1. Identification of the Research Problem

Preliminary classroom observations, student feedback, and baseline assessment results indicated that Grade 10 students at Jakar Higher Secondary School experienced considerable difficulties in Python coding, particularly in using functions and debugging errors. Students often struggled to apply theoretical concepts in practical coding tasks, and feedback from manual assessment was frequently delayed, limiting opportunities for timely correction and improvement. These initial findings suggested a need for an instructional approach that could provide immediate feedback, support repeated practice, and help students monitor their progress.

The Learning Management System developed by the Ministry of Education and Skill Development includes automated assessment features such as coding quizzes, auto-graded tasks, and instant feedback. These features were considered relevant to the identified problem because they could help students recognize coding errors more quickly and engage in more independent practice.

1.2. Contextual Analysis of Python Learning Challenges

Grade 10 at Jakar Higher Secondary School consists of 160 students across five sections, with approximately 32 to 34 students in each section. The students are between 14 and 16 years old. For this study, Section 10E was purposively selected because the class demonstrated diverse learning needs and persistent difficulties in Python coding. Students in this section had varying levels of prior exposure to programming, ranging from basic ICT knowledge to limited experience with introductory coding activities from Grade 9.

A key challenge observed in the class was the gap between theoretical understanding and practical coding application. Many students found it difficult to translate programming concepts into working Python code, especially when writing functions, identifying errors, and organizing code logically. Although collaborative coding activities and peer support were used, these strategies were not sufficient for all learners, particularly those who needed more individualized and immediate feedback.

Access to learning resources also varied among students. Some students had access to computers and internet resources at home, while others relied mainly on the school's ICT laboratory. This difference limited opportunities for some students to practise coding outside school hours. In addition, the ICT timetable consisted of two 45-minute periods per week, which provided limited time for extended coding practice, individualized support, and feedback.

Baseline evidence suggested that a substantial proportion of students had not yet reached the expected proficiency level in Python coding, particularly in functions and debugging. These challenges highlighted the need for a structured intervention that could provide immediate feedback, promote repeated practice, and support students with different levels of prior knowledge. Therefore, LMS-based automated assessment was selected as a possible approach to support students' learning of Python coding in this classroom context.

1.3. Objective

The main objective of this study was to examine how LMS-based automated assessment tools support the development of Grade 10E students' Python coding skills, particularly in learning Python functions and debugging, at Jakar Higher Secondary School. The intervention aimed to provide students with immediate feedback, opportunities for repeated practice, and progress-tracking support to enhance their learning.

Based on this aim, the study addressed the following research questions:

RQ 1) To what extent do Grade 10E students' Python coding achievement scores differ before and after the LMS-based automated assessment intervention?

RQ 2) How do students perceive the role of LMS-based automated assessment in enhancing their engagement and interest in learning Python coding?

RQ 3) How do students perceive the role of LMS-based learning resources in supporting pre-class preparation and foundational knowledge acquisition?

RQ 4) How do students perceive the role of LMS in promoting self-regulated and autonomous learning behaviours?

RQ 5) How do students perceive the influence of LMS-based learning on their motivation and perceived academic achievement?

RQ 6) How do students perceive the role of LMS in supporting collaboration, interaction, and higher-order cognitive engagement?

2. Literature Review

Technology has the potential to transform education, and classrooms in Bhutan are progressively adopting it to promote deeper learning and innovation. This aligns with the global recognition of the role of technology in enhancing teaching and learning processes (Maddux & Johnson, 2006). In Bhutan, educators acknowledge its transformative potential in improving instructional practices and learning outcomes (Gyeltshen & Zangmo, 2021). However, existing research indicates that many teachers primarily engage with technology at the Substitution and Augmentation levels of the SAMR model, rather than employing more transformative practices at the Modification and Redefinition stages (Boonmoh & Kulavichian, 2023). Consequently, while technological adoption in education is increasing, efforts to integrate technology in ways that redefine learning experiences remain limited. Therefore, there is a pressing need to encourage pedagogical practices that utilize technology for higher-order transformation rather than mere enhancement.

In this context, LMS equipped with automated assessment capabilities have emerged as a transformative innovation, particularly in Python programming education, offering a scalable solution to enhance student performance. Specifically, automated assessment systems [AAS] leverage artificial intelligence [AI] and machine learning to evaluate student work, provide feedback, and track progress autonomously (Luckin et al., 2022). Furthermore, when integrated into LMS-based programming instruction, automated assessment tools can support scalable evaluation of coding tasks by providing timely feedback, opportunities for repeated practice, and structured learning support (Combéfis & de Moffarts, 2019; Messer et al., 2024). Additionally, advanced error detection algorithms enhance feedback quality and consistency while significantly reducing instructor workloads. As a result, automated assessment systems can support programming education by evaluating code correctness, detecting selected syntax or logic-related errors, and providing timely feedback or hints that help learners revise their solutions (Marwan et al., 2022; McBroom et al., 2021; Messer et al., 2024).

The implementation of automated assessment in programming education, particularly Python instruction, has demonstrated substantial benefits. As Ihantola et al. (2010) assert, automated tools ensure consistent and impartial grading while significantly reducing the administrative burden on educators. Moreover, the immediate feedback mechanisms inherent in these systems promote iterative learning, thereby improving students' understanding and retention. Similarly, Prather et al. (2017) note that large-enrollment institutions benefit considerably from automated grading, as it maintains grading accuracy while minimizing human effort.

Nevertheless, automated assessment is not without its challenges. Critics argue that such systems may inadequately assess creative problem-solving and unconventional coding approaches, which are essential components of programming expertise (Keuning et al., 2018). Furthermore, Denny et al. (2008) highlights that while AAS effectively identify syntax and logic errors, they often overlook important elements such as code readability, structure, and efficiency. Consequently, this limitation underscores the need for a hybrid assessment approach that combines both automated and manual evaluations for a more comprehensive understanding of student work.

In terms of engagement and motivation, automated tools have proven to enhance student interest due to their interactive and responsive features. Ala-Mutka (2005) found that these tools support differentiated learning by adapting to students' skill levels. However, despite these benefits, access remains a critical issue. According to Ahuja et al. (2025) and Dorji, Lhamo, et al (2025), students in remote or underprivileged areas often face challenges, such as inadequate internet connectivity and limited access to computing devices, which hinders the effective use of AAS.

3. Method

3.1. Research Design

This study adopted a one-group pre-test–post-test quasi-experimental design within a mixed-methods framework. The quasi-experimental component was used to examine the effect of LMS-based automated assessment on students' Python coding achievement, while the qualitative component was used to explore students' experiences and perceptions of learning Python functions through the LMS. The integration of quantitative and qualitative data enabled a more comprehensive understanding of the intervention outcomes.

3.2. Researcher Competence and Positionality

The teacher-researcher had prior academic and professional experience in educational research, particularly in technology-supported instruction and biology education. The researcher completed a Master of Education in Biology at Samtse College of Education, where the dissertation focused on the flipped classroom approach in biology teaching. This work resulted in two manuscripts, one of which was published in the *International Journal of Applied Chemical and Biological Sciences*, while the other was under review. The researcher also co-authored a study on challenges in conducting biology laboratory work and presented action research on animation-based instruction at the 3rd National Education Seminar, which was later published in the seminar proceedings.

The co-researcher, Tenzin Namgyal, Technology Domain Head, held a master's degree in educational technology and communications from Naresuan University, Thailand. He had also published internationally, including in the *International Journal of Engineering and Technology*. His expertise in digital tools, educational technology, and instructional design contributed to the design and implementation of the LMS-based intervention.

3.3. Participants

The participants were 31 Class 10E students enrolled at Jakar Higher Secondary School. Baseline observations and preliminary assessment indicated that students had varying levels of competence in Python coding. While some students demonstrated relatively strong coding skills, others experienced difficulty with basic concepts and applications. The intervention was therefore designed to provide targeted, interactive, and feedback-oriented support through an LMS-based automated assessment system.

3.4. Instruments

Four instruments were used to collect data: an achievement test, a closed-ended survey questionnaire, semi-structured interviews, and a research diary.

The achievement test was administered as both a pre-test and a post-test. The pre-test measured students' baseline knowledge and skills in Python functions, whereas the post-test assessed changes in achievement after the LMS-based automated assessment intervention. The test consisted of 25 multiple-choice questions adapted from BCSEA materials and aligned with national curriculum objectives.

A closed-ended survey questionnaire was adapted from Dorji and Dorji (2022) to examine students' perceptions of using the LMS to learn Python functions. The questionnaire used a five-point Likert scale and was administered after the intervention.

Semi-structured interviews were conducted with five students selected through convenience sampling. The interviews aimed to gain deeper insight into students' conceptual understanding of Python functions and their perceptions of LMS-based automated assessment in the Python classroom. The interview data also supported triangulation with the achievement test and survey findings.

In addition, the researchers maintained a research diary throughout the intervention process. The diary was used to document implementation challenges, classroom observations, students' engagement, and positive outcomes observed during the intervention.

3.5. Validity and Reliability

To ensure the validity of the achievement test, five senior ICT teachers and the co-researcher reviewed the test items for face and content validity. Their feedback was used to revise and refine the items before administration. The survey questionnaire was pilot-tested, and its internal consistency was examined using Cronbach's alpha in Jamovi. The semi-structured interview questions were also reviewed and pilot-tested to ensure clarity, relevance, and effectiveness in eliciting meaningful responses.

3.5. Baseline Data Collection and Analysis

Baseline data were collected through a pre-test and semi-structured interviews before the intervention. The pre-test provided information about students' existing knowledge and skills related to Python functions, while the interviews offered initial insights into students' learning difficulties and perceptions. These baseline findings confirmed the existence of the instructional problem and informed the planning of the LMS-based intervention.

3.6. Intervention Plan

The intervention was implemented over four weeks, from the first week to the fourth week of August. Students received two instructional periods per week, with each period lasting 45 minutes. The intervention focused on teaching Python coding, specifically the topic of functions, through LMS-based automated assessment.

The intervention incorporated two key features of automated assessment: real-time feedback and progress tracking. The teacher-researcher created and administered automated quizzes and coding challenges through the virtual learning platform. These activities provided immediate feedback, enabling students to identify their strengths and weaknesses in Python coding. The progress-tracking feature was also used to monitor students' development and encourage continuous improvement.

Students accessed the LMS using school-provided desktop computers in the ICT laboratory. Smartphones were also used where permitted. Since smartphone use during school hours was generally restricted, permission was obtained from the school administration to allow students to use mobile devices for the purposes of this study. Device use was monitored by the teacher-researcher to maintain a focused learning environment.

3.7. Data Analysis

Both quantitative and qualitative data analysis procedures were used. Quantitative data obtained from the pre-test, post-test, and survey questionnaire were analyzed using Jamovi. Descriptive statistics were used to summarize students' achievement scores and survey responses. A paired-samples *t*-test was conducted to determine whether there was a statistically significant difference between students' pre-test and post-test scores.

The mean scores obtained from the closed-ended survey questionnaire were interpreted using the mean score interpretation guideline adapted from Brown (2010). Accordingly, mean values between 4.51 and 5.00 were interpreted as the highest level of perception, 3.51 to 4.50 as high, 2.51 to 3.50 as moderate, 1.51 to 2.50 as low, and 1.00 to 1.50 as the lowest level of perception.

Before conducting the paired-samples *t*-test, the normality assumption was examined using the Shapiro–Wilk test. The results indicated that both pre-test scores, $W = 0.97$, $p = .50$, and post-test scores, $W = 0.97$, $p = .42$, did not significantly deviate from normality. Since both *p*-values were greater than .05, the data were considered appropriate for parametric analysis.

Qualitative data from the semi-structured interviews and research diary were analyzed thematically, following Braun and Clarke's (2006) thematic analysis approach. The qualitative findings were used to explain and enrich the quantitative results. Triangulation of achievement test scores, survey responses, interviews, and research diary entries enhanced the credibility and trustworthiness of the findings.

4. Findings

4.1. Analysis of Pre-test and Posttest Data after Intervention

Table 1 illustrates the paired sample *t*-test of pre-test and post-test after the intervention.

Table 1
Paired-Samples t-Test Results for Pre-test and Post-test Scores

	N	*Mean*	*SD*	*Mean difference*	*p*	*Cohen's d*
Pretest	31	10.70	2.26	5.06	.001	0.94
Posttest	31	15.70	2.13			

Note. The mean difference was calculated by subtracting the pre-test mean from the post-test mean. Cohen's *d* = 0.94 indicates a large effect size.

Statistical results of a paired sample t-test comparing pretest and posttest scores indicated there a statistically significant difference (p=.001). The mean difference of 5.06 indicates that students performed substantially better in the posttest compared to the pretest, demonstrating the effectiveness of the LMS in teaching Python Functions I and II. The significant improvement in posttest scores suggests that students benefited from the instructional intervention. The higher mean score reflects improved academic achievement and indicates that the LMS contributed positively to students' learning outcomes. Furthermore, the effect size (Cohen's d =0.94) represents a large effect, providing strong evidence that the LMS had a substantial impact on students' performance. Similarly, semi-structured interviews also confirmed that student's academic performance has been enhanced by learning Python coding using the LMS digital platform.

4.2. Students' Engagement

Table 2 presents students' perception regarding enhanced learner engagement and subject interest using the LMS. The table includes five indicators with corresponding mean scores, standard deviation, and levels of perception.

Table 2
Enhanced Learner Engagement and Subject Interest through LMS

Item	*Indicator*	*Mean*	*SD*	*Level of perception*
1	I liked the learning Management System (LMS).	4.06	0.73	High
2	LMS attracts my attention to the learning and teaching process.	3.97	0.61	High
3	LMS is more engaging than the traditional classroom.	4.03	0.75	High
4	LMS can improve interest in exploring topics.	4.10	0.65	High
5	LMS can improve interest in learning coding.	3.97	0.66	High
	Overall	4.02	0.68	High

The findings indicate overall mean score for this theme (M = 4.02, SD = 0.68), which falls under the high level of perception. This indicates that students generally hold positive view regarding the role of LMS in enhancing engagement and subject interest. The highest mean score was recorded for "LMS can improve interest in exploring topics" (M = 4.10, SD = 0.65). This suggests that students strongly perceive LMS as a tool that stimulates curiosity and encourages deeper exploration of learning content. The lowest mean score was observed for "LMS attracts my attention to the learning teaching process" and "LMS can improve interest in learning coding," both with a 3.97 (SD = 0.61 and 0.66 respectively). Although these are the lowest within the table, they still fall within the high perception level, indicating consistent positive responses across all indicators. The narrow range between the highest (4.10) and lowest (3.97), mean scores demonstrate consistency in students' positive perceptions. The strongest perception relates to exploratory learning, while attention attraction and coding interest, although slightly lower, remain highly rated. This suggests that LMS is particularly effective in fostering curiosity-driven learning while also maintaining strong engagement in subject-specific areas such as coding.

Semi-structured interview data further supported the quantitative findings, as participants described LMS as engaging and learner centered. Student 01 recalled his/her experiences:

> I find LMS easier to learn and understand when I actively participate in the learning process. Being involved in activities helps me engage more deeply with the lesson. It also allows me to explore ideas independently and construct my own understanding. As a result, I am able to grasp concepts better and retain the knowledge I gain through my own efforts.

These qualitative insights align with the high quantitative mean scores for engagement and interest, particularly the strong agreement that LMS improves interest in exploring topics. Additionally, students 02, student 03 and student 04 also reported increased interest in coding due to LMS's "interesting and highly curious methods," reinforcing the quantitative finding of high interest in subject exploration. However, the qualitative data suggests that engagement is closely tied to active participation rather than the LMS platform alone. While the survey results indicate consistently high engagement, the interview implies that engagement depends on how LMS activities are designed and implemented. Thus, engagement may not be inherent to LMS itself but to pedagogical strategies embedded within it.

4.3. Foundational Knowledge Acquisition

Table 3 illustrates students' perceptions regarding the role of the LMS in improving pre-class preparation and foundational knowledge acquisition. The table includes five indicators with corresponding mean scores, standard deviations, and level of perception.

Table 3
Improved Pre-Class Preparation and Foundational Knowledge Acquisition

Item	*Indicator*	*Mean*	*SD*	*Level of perception*
1	I learn more if I have the pre-concept before the class begins.	4.16	0.78	High
2	Learning foundational content before class greatly enhances my understanding of the material.	3.90	0.70	High
3	With LMS, I feel more prepared for my exam.	3.90	0.75	High
4	I feel that watching videos, reading PowerPoint presentations and taking notes contribute efficiently to my learning.	4.19	0.83	High
5	LMS reduces the effort to understand the basic knowledge of the subject matter.	3.68	0.75	High
	Overall	3.97	0.76	High

The overall mean score for this theme is (M = 3.97, SD = 0.76), which falls under the high level of perception. This indicates that students generally perceive LMS as effective in supporting pre-class preparation and strengthening foundational understanding. The highest mean score was recorded for "I feel that watching videos, reading PowerPoint presentations and taking notes contribute efficiently to my learning" with a mean of (M = 4.19, SD = 0.83). This suggests that multimedia resources and active note taking strategies significantly enhance students' learning experiences. The lowest mean score was observed for "LMS reduces the effort to understand the basic knowledge of the subject matter" with a mean of (M = 3.68, SD = 0.75). Although this is the lowest within the table, it still reflects a high level of perception, indicating that students generally agree that LMS reduces learning difficulty, though to a slightly lesser extent compared to other indicators. The differences between the highest mean (M = 4.19) and lowest (M = 3.68) mean scores suggest that students strongly value structured multimedia learning materials for preparation, while the perceived reduction of effort in understanding basic knowledge is comparatively moderate. This implies that LMS is highly effective in delivering instructional content but may still require active leaner engagement to fully reduce cognitive effort. Overall, the consistently high means across all indicators confirm that LMS plays a significant role in enhancing pre-class readiness and foundational knowledge acquisition.

Qualitative data from the semi-structured interviews indicate that prior knowledge plays an important role in enhancing students' understanding of the lesson. For instance, student 05 expressed:

> Yes, it definitely helps students learn better because prior knowledge makes it easier to understand new concepts, connect ideas, and improve memory and reasoning skills. Students are able to grasp the concept by referring to their prior knowledge and understand the lesson more effectively.

These findings align with the high quantitative mean, indicating that pre-concept learning enhances students' comprehension. Participants (student 01, student 03, student 04 and student 05) also praised multimedia resources for making lessons "easier to understand," suggesting that such materials support comprehension. Nonetheless, the comments indicate that independent exposure alone may not fully replace guided instruction, which is consistent with the slightly lower mean scores in Table 3 regarding students' preparedness to complete tasks after watching instructional videos.

4.4. Students' Self-Regulated Learning

Table 4 presents students' perception regarding the development of self-regulated and autonomous learning behaviours using LMS. The table includes five indicators measuring students' independent learning practices, along with their corresponding mean, scores, standard deviation, and levels of perception.

Table 4
Development of Self-Regulated and Autonomous Learning Behaviours

Item	*Indicator*	*Mean*	*SD*	*Level of perception*
1	I try to learn as much as possible while watching the videos.	3.87	0.62	High
2	I frequently pause or repeat parts of the videos to increase my understanding of the material.	4.16	0.59	High
3	I got the ability to self-pace my learning with LMS.	3.81	0.54	High
4	With LMS, I have to do more work outside the classroom.	3.71	0.64	High
5	LMS matches my learning style.	3.61	0.80	High
	Overall	3.83	0.64	High

The overall mean score for this theme (M = 3.83, SD = 0.64), which falls under the high level of perception. This indicates that students generally perceive LMS as supportive in promoting self-regulated and autonomous learning behaviours. The highest mean score was recorded for "I frequently pause or repeat parts of the videos to increase my understanding of the materials" with a mean (M = 4.16, SD = 0.59). This finding suggests that students actively engage in metacognitive strategies, such as monitoring and regulating their comprehension while using LMS resources. The lowest mean score was observed for "LMS matches my learning style" with a mean of (M = 3.61, SD = 0.80). Although this is the lowest level within the table, it still reflects a high level of perception, indicating that most students feel LMS aligns with their learning preferences, though not as other self-regulated learning behaviours. The differences between the highest (M = 4.16) and lowest (M = 3.61) mean scores indicates that students strongly practice strategic learning behaviours, particularly through video control functions such as pausing and repeating content. However, the comparatively lower mean regarding learning style alignment suggests that while LMS supports autonomy, it may not equally cater to all individual learning preferences. Overall, the consistency high means demonstrates that LMS significantly contributes to the development of self-regulated and independent learning skills.

The interview participants highlighted the benefits of self-paced learning, noting that students often pause or replay videos to grasp challenging concepts. Student 03 shared his/her experience:

> Yes, I often pause or reply to the videos in order to understand certain points better and take notes.

> This helps me understand the lesson better because you can work at your own pace due to the availability of the lessons.

Similarly, student 05 also shared:

> Yes, pausing allows me to write down key concepts. It gives my brain time to process new or challenging information. I pause the video to work through problems or coding examples alongside the instructor, I grasp each step of the process before proceeding.

This observation aligns with the highest quantitative mean reported in Table 4 regarding pausing and repeating video content. The qualitative findings provide clear evidence of metacognitive regulation, including monitoring understanding, controlling learning pace, and revisiting content, confirming that the LMS supports elements of self-regulated learning.

4.5. Students' Motivation

Table 5 presents students' perceptions regarding increased motivation and perceived academic achievement with the LMS. The table outlines five indicators measuring motivational orientation and academic improvement, along with their corresponding mean scores, standard deviation, and levels of perception.

Table 5

Increased Learning Motivation and Perceived Academic Achievement

Item	*Indicator*	*Mean*	*SD*	*Level of perception*
1	I am more motivated to learn the concepts of the course via the LMS.	3.87	0.62	High
2	Mastering learning through LMS improved my academic achievement.	3.81	0.60	High
3	Mastering learning through LMS improved my course understanding.	3.87	0.72	High
4	I believe that I can learn material with LMS instruction better than with traditional lecture-based instruction.	3.71	0.72	High
5	I would like to participate in similar classes in the future.	4.03	0.71	High
	Overall	3.86	0.67	High

The overall mean score for this theme is (M=3.86, SD=0.67), which falls under the high level of perception. This indicates that students generally perceive LMS as positively influencing their motivation and academic performance. The highest mean score was recorded for "I would like to participate in similar classes in the future" with mean of (M=4.03, SD=0.71). This suggests a strong positive motivational response towards LMS-based instruction and a willingness to continue engaging in similar learning environments. The lowest mean score was observed for "I believe that I can learn material with LMS instruction better than with traditional lecture-based instruction" with a mean of (M=3.71, SD=0.72). Although this is the lowest level within the table, it still reflects a high level of perception, indicating moderate agreement when directly comparing LMS with traditional lecture methods. The differences between the highest (M=4.03) and lowest (M=3.71) mean scores that while students are highly motivated to continue learning through LMS, their preference over traditional instruction is comparatively moderate. This implies that students value LMS as an effective teaching approach. Overall, the consistently high mean scores confirm that LMS contribute positively to both motivation and perceived academic achievement.

Findings based on the semi-structured interview, participants (student 01, student, 02, student, 03, student 04 and student 05) reported that their "grades and performance have drastically increased," strongly reinforcing the high quantitative means for motivation and perceived academic achievement. For instance, student 03 elaborated:

> Having 24/7 access to all course materials accommodates diverse schedules and learning environments, allowing us to integrate studying more easily into our daily routines. By removing logistical barriers, this accessibility can promote more consistent engagement and improve

knowledge retention. Therefore, this has resulted in improvement in our academic performance.

Participants also expressed willingness to participate in similar LMS-based classes in the future, aligning with the highest mean in Table 5 regarding future participation.

4.6. Collaboration and Interaction among Students

Table 6 presents students' perceptions regarding strengthened collaborative interaction and higher-order cognitive engagement using the LMS. The table includes five indicators assessing communication, interaction, critical thinking, and task preparedness, along with their corresponding mean scores, standard deviations, and levels of perception.

Table 6
Strengthened Collaboration Interaction and Higher-Order Cognitive Engagement

Item	*Indicator*	*Mean*	*SD*	*Level of perception*
1	I wish more teachers use the LMS.	3.61	0.76	High
2	LMS encourages me to practice critical thinking.	3.81	0.70	High
3	LMS allows me to ask more questions in the discussion forum.	3.71	0.69	High
4	I felt prepared to complete the course tasks in class after listening to the video content.	3.65	0.71	High
5	LMS gives me greater opportunities to communicate with other students.	3.77	0.76	High
	Overall	3.71	0.72	High

The overall mean score for this theme is (M=3.71, SD=0.72), which falls under the high level of perception. This indicates that students generally perceive LMS as supportive in promoting collaboration and cognitive development. The highest mean score was recorded for "LMS encourages me to practice critical thinking" with a mean of (M=3.81, SD=0.70). This suggests that students perceive LMS as effective in fostering high-order thinking skills. The lowest mean score was observed for "I wish more teachers use the LMS" with a mean of (M=3.61, SD=0.76). Although this is the lowest within the table, it still reflects a high level of perception, indicating that students moderately agree with expanding LMS use among teachers. The difference between the highest (3.81) and lowest (3.61) mean scores suggest that LMS is particularly valued for promoting critical thinking, while the desire for broader teacher adoption is comparatively moderate. Additionally, communication-related indicators such as asking questions in discussion forums (M=3.71, SD=0.69) and opportunities to communicate with peers (M=3.77, SD=0.76) show consistent positive perceptions, though slightly lower than cognitive engagement indicators. Overall, the findings indicate that LMS support collaborative learning and higher-order cognitive development, while institutional adoption and structured interaction may require further strengthening.

Additionally, student 01 and student 04 in their semi-structured interview described the discussion forum as a space to "connect with other people who are able to give us knowledge and information that we ourselves don't possess," supporting the quantitative findings that LMS promotes communication and collaboration. Student 02 also noted that LMS encourages leaners to "try to find your own knowledge and visit various sources," demonstrating higher-order thinking and independent inquiry. For instance, student 03 shared:

> As a self-paced learner, the LMS suits me perfectly because I can spend extra time on challenging topics by replaying videos or reviewing documents, while quickly moving through concepts I already understand.

This strongly aligns with the highest mean in Table 6 related to critical thinking. However, the participant's explanation suggests that meaningful interaction depends on active participation from peers. While quantitative data shows high perceptions of collaborative opportunities, the qualitative account implies that actual engagement may vary depending on peer involvement and task structure. Therefore, while LMS provides opportunities for collaboration and cognitive engagement, the depth of interaction may depend on facilitation and learner participation.

4.7. Research Diary

The research diary shows strong alignment between quantitative data and qualitative findings. Initial observations and the pretest revealed weak understanding of Python functions and low confidence due to delayed feedback. After the four-week LMS intervention with automated tools, students demonstrated greater engagement, self-regulated learning, and improved debugging skills. This qualitative improvement was supported by a significant increase in posttest scores, Cohen's d, indicating a larger effect. Overall, both statistical and students' reflections confirm that the automated LMS intervention enhanced academic performance and motivation.

5. Discussion

The findings of this study demonstrate that integrating automated assessment tools within the LMS significantly improved Grade 10E students' Python coding skills. The paired sample t-test revealed a statistically significant improvement between pretest and posttest scores, with a large effect size (Cohen's d). This substantial gain confirms that the intervention had a meaningful impact on students' understanding of Python functions. The result aligns with Ihantola et al (2010), who argue that automated assessment system enhances programming performance through consistent grading and immediate feedback. Similarly, Luckin et al. (2022) emphasise that AI-supported tools empower learning by providing personalized feedback that strengthens conceptual understanding. In the context of Jakar Higher Secondary School, where delayed manual feedback previously hindered progress, the real-time feedback feature of the LMS appears to have directly addressed this gap.

The quantitative findings on student engagement indicate that learners perceived the LMS as highly engaging and interest-enhancing. Students particularly valued their ability to stimulate exploration. This supports Ala-Mutka's (2005) assertion that automated tools foster differentiated and interactive learning environments. Qualitative responses further revealed that engagement was driven by active participation and curiosity. However, interviews suggested that engagement was dependent on how activities were designed rather than the platform alone. This reflects the argument by Keuning et al. (2018) that technology effectiveness depends on pedagogical integration, reinforcing that LMS tools must be purposely structured to achieve transformative learning, rather than remaining at substitution levels of integration.

Regarding foundational knowledge acquisition, students reported that pre-class exposure through videos and materials enhanced understanding. This supports the idea that such tools also support iterative and self-directed learning by allowing students to revisit tasks, respond to feedback, and monitor their own learning progress through structured digital activities (Messer et al., 2024). Students' acknowledgement that prior knowledge improved comprehension aligns with Dorji, Zangmo, et al. (2025), Dorji and Dorji (2022), and Ptather et al. (2017), who highlight the importance of knowledge scaffolding and metacognitive support in education. However, qualitative findings revealed leaner variability; some students required additional teacher guidance despite LMS support. This suggests that while automated tools reduce cognitive load, they cannot entirely replace instructional scaffolding.

The development of self-regulated learning behaviours further strengthens the argument for LMS integration. Students frequently paused and replayed videos, demonstrating metacognitive regulation. Such findings are consistent with Marwan et al. (2022), who show that adaptive immediate feedback can provide learners with continuous, task-specific support during programming activities. This type of feedback may help students monitor their progress, identify errors, and revise their work more independently. The qualitative data confirmed that students controlled their learning pace, reflecting greater autonomy. Nonetheless, the slightly lower rating for learning style alignment indicates that LMS flexibility does not equally suit all learners, echoing concerns raised by Tang et al. (2017) regarding accessibility and contextual limitations.

Students' motivation and perceived academic achievement were also positively influenced. Many reported improved grades and expressed willingness to participate in similar LMS-based classes in the future. This finding aligns with Wang et al. (2022), who found that automated programming assessment enhances performance and learner confidence. However, when comparing LMS with traditional lecture-based instruction, students showed moderate preference rather than outright replacement. This supports Denny et al. (2008), who argue that automated systems should complement, rather than replace, human instruction, especially for evaluating higher-order thinking and code quality.

Finally, collaboration and higher-order cognitive engagement were positively perceived. Students valued discussion forums and critical thinking opportunities, supporting Leinonen et al. (2020), who emphasize the importance of feedback-driven reflection in programming education. However, qualitative insights indicated that meaningful collaboration depends on active peer participation. Thus, while LMS provides opportunities for inetract5ion, effective facilitation remains crucial.

Overall, the triangulated findings confirm that automated LMS tools significantly improved Python coding skills, engagement, motivation, and self-regulated learning among Grade 10E students. However, the study also underscores the importance of blended pedagogical approaches, structured facilitation, and contextual adaptation to maximize the transformative potential of technology in Bhutanese classrooms.

6. Conclusion and Recommendation

The study aimed to enhance Grade 10E students' Python coding skills, particularly in functions and debugging, through the integration of automated assessment tools within LMS developed by the MoESD. Using a quasi-experimental design with mixed methods, the findings revealed a statistically significant improvement in students' academic performance, supported by a lager effect size. Students also reported high levels of engagement, motivation, foundational knowledge acquisition and self-regulated learning. Qualitative findings further confirmed that real-time feedback, progress tracking, and multimedia resources strengthen conceptual understanding and confidence in coding. Overall, the intervention demonstrated that automated LMS tools can effectively address delayed feedback and promote active-centered learning in resource-constrained contexts.

Despite these positive outcomes, the study has limitations. First, it involved only one section (10E) with a relatively small sample size, limiting generalizability. Second, the absence of a control group restricts causal comparisons. Third, the intervention duration of four weeks may not fully capture long-term retention of coding skills. Additionally, inconsistent internet connectivity and unequal access to digital devices may have influenced student experiences.

Based on these findings, it is recommended that schools adopt a blended instructional approach combining automated assessment with teacher scaffolding. Future researchers should consider larger samples across multiple schools, including control groups, and extend the intervention period to examine long-term effects. Future studies may also explore the impact of LMS tools on other programming topics and investigate strategies to address the digital divide in Bhutanese classrooms.

7. Reflections

The study conducted at Jakar Higher Secondary School demonstrated several positive outcomes in improving students' Python coding skills through the LMS-based intervention. The positive outcome of this research is the establishment of significant improvement in academic performance, as reflected in the paired sample t-test results, which showed a statistically significant increase in posttest scores with a large effect size (Cohen's d=0.94). This confirms that the four-week intervention using automated tools, including real-time feedback and code auto graders, effectively strengthened students' understanding of Python functions and debugging skills.

The research diary further documented noticeable changes in classroom dynamics. It recorded increased engagement, improved confidence, and stronger self-regulated learning behaviours among students. Learners actively paused and replayed videos practiced coding tasks repeatedly and used instant feedback to correct errors independently. Qualitative interviews supported these observations, indicating that students felt more motivated and better prepared for assessments. The intervention also reduced delayed feedback, which had previously hindered learning progress.

What next involves refining the intervention by adopting a blended approach that combines automated assessment with structured teacher scaffolding. Future research cycles should expand the study to other sections, enhance collaborative coding tasks, and incorporate hybrid assessment methods to evaluate creativity and code quality. Continuous reflection through the research diary and guided iterative improvements can be used to ensure sustainable impact.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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