

## LEARNING ANALYTICS IN ONLINE EDUCATION: INVESTIGATING STUDENT ENGAGEMENT AND INTERACTION PATTERNS IN DIGITAL LEARNING ENVIRONMENTS

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### **Abstract**

*The student interaction and engagement patterns in the digital learning settings through learning analytics framework. Due to the rapid increase in online education, the way the student engages with digital learning platforms has become a critical issue of enhancing teaching strategies and learning outcomes. The research examines a dataset of educational technology comprising demographic data of students and the interaction records in detail obtained using an online learning platform. The data cover the activities of watching the videos, submitting assignments, quizzes, participating in discussions, downloading resources, and notes taking. Patterns of engagement, duration of interaction, frequency of activity and the correlation between behavioral engagement and learning performance were analyzed quantitatively. The results indicate that students engage in various types of interaction, note-taking and attempts at quizzes being the most common. Video-based learning and assessment-related activities had longer interaction times, which demonstrated more profound learning. The findings also indicate that mobile gadgets are the most utilized technology in accessing online learning platforms which makes mobile friendly learning settings paramount. Moreover, the analysis reveals that sustained engagement has a positive correlation with the better academic performance. In general, the research highlights the value of learning analytics in explaining the behavior of students in digital education systems and offers insights to be utilized in the development of more efficient and engaging online learning settings.*

**Keywords:** Learning Analytics, Online Learning, Student Engagement, Digital Learning Environments, Educational Technology

## 1. Introduction

The innovativeness of the digital world has had a great impact on the educational systems of the world. Learning management systems and online learning platforms have assumed central roles in the education sector to the extent that learners can now access learning material outside the classroom setting. These online platforms offer flexibility in learning, individualized learning, and mass access. Nonetheless, the research of student-digital interactions is a pressing issue among teachers and scholars. The interaction in online learning platforms can be regarded as a major indicator of successful digital learning and the overall learning process. Recent research has demonstrated that behavioral patterns of web-based learning systems can be analyzed to better understand how students devote effort and time during online learning tasks. (Martin and Bolliger, 2018)

With the development of learning analytics, new opportunities to study engagement patterns in digital learning systems have appeared. Learning analytics is measurement, gathering and processing of educational data produced by interacting with digital resources by students. These data-based methods enable scholars to analyze the manner in which students interact with learning data and to establish trends along with learning outcomes. Dashboards and analytics platforms are among the learning analytics tools developed to assist instructors and learners in tracking progress and the nature of learning strategies. According to research assessing the efficacy of learning analytics dashboards, these tools have the potential to impact student engagement, motivation, and achievement provided they are created with the right design. Recent research has highlighted the role of learning analytics in comprehending student engagement in a higher education setting. (Matcha et al., 2019) Through the behavioral data (frequency of activities, length of interaction and patterns of participation), researchers can determine how learners are engaging with digital learning environment. A systematic review of learning analytics studies in higher education indicates that the engagement measures based on data on interaction with a platform can be used as crucial insights into student learning processes (Bergdahl et al., 2024).

Different pedagogical approaches have been proposed to enhance student interest in learner-oriented technologies. An example of this is gamification, which has been extensively discussed in terms of motivation and engagement by game features in the learning process. Studies that have investigated the effects of gamification in schools show that school gamification may increase student engagement and participation in learning activities (Ruiz et al., 2024). Presence of instructors and quality of instructional interaction also determine the effectiveness of digital learning environments. Presence, or design of courses, facilitation of discussions, and guidance by instructors are critical factors in the design of student engagement. The research on blended learning and emergency remote teaching space has shown that teaching presence is a strong contributor to better participation and learning experience in online education (Su et al., 2024). The results indicate a need to develop digital learning systems that facilitate interaction with students and efficient instructional support.

Besides assisting instructors, learning analytics technologies have also been applied progressively to assist students in self-regulated learning. An example of learning analytics dashboards enables students to keep track of their learning behaviors, progress along with studying strategies. Studies of the design and assessment of such dashboards suggest that the availability of behavioral learning data can boost student control over the study process and their engagement in digital learning contexts (De Vreugd et al., 2024). The interaction between technology based learning and student involvement has been well covered in recent research on education. Digital learning technologies offer a variety of ways in which learners can engage with the learning materials in the form of multimedia input, online discussions and interactive tests. Nonetheless, the level of engagement may differ greatly when these technologies are applied to learning settings. A systematic review of the research on technology-based education outlines that a digital learning environment design is a decisive factor in the way learners be engaged and participate (Balalle, 2024).

Although there are benefits of digital learning platforms, issues of engagement and learning outcomes still persist. Research into the effects of online learning on student achievement shows that engagement is a major predictor of academic success in online learning. There is a tendency of better learning outcomes and academic success that is linked to higher levels of engagement and interaction with course materials (Akpen et al., 2024). Nevertheless, a lack of engagement may have adverse consequences like the decrease of the learning effectiveness and the rise of the dropout rates. The problem of student dropout is quite common in online education, and it is commonly associated with the lack of engagement and interaction in the learning space. Studies on online distance learning have demonstrated that a lack of engagement in learning processes may lead to student dropout, thus the necessity to develop measures that encourage continuous engagement in online courses (Elibol and Bozkurt, 2023).

Online learning has also spread globally, and this has intensified the need to study student engagement in the digital education systems. Engagement patterns used to be a critical measure of the continuity and effectiveness of learning during periods of emergency remote teaching and mass adoption of online education. Studies examining the engagement of students in the periods of remote teaching have proven that the contact with digital learning resources is the key to the engagement in learning (Yang et al., 2023). Moreover, other learner factors like self-efficacy and social presence have been found to impact engagement behaviors in the online learning setting. The analyses of these connections show that students who feel better about their social interaction and confidence in their learning skills are more likely to exhibit higher scores of engagement in online education (Wu, 2023).

The proposed study focuses on exploring the patterns of student engagement and interaction in online learning settings through learning analytics methods. Through a data analysis of behavioral interaction and student demographic features,

the study identify patterns of participation, observe the level of engagement between various learning activities, and also determine the correlation between interaction behaviors and learning outcomes in online education systems.

## **2. Methodology**

### **2.1 Research Design**

In this research, the research design used was a quantitative study that took a learning analytics approach to study the engagement and interaction patterns of students in online learning environments. Learning analytics allows the analysis of high quantities of educational data produced by online learning systems and determine the patterns of participation, engagement, and learning outcomes. The research aimed at the analysis of data on behavioral interactions and student demographic and learning features to investigate the impact of various parameters on the engagement in online learning. A cross-sectional analytical framework was adopted to examine the relationship between characteristics of the learners, interaction behavior and engagement indicators within the digital learning environment.

### **2.2 Dataset Description**

The data set of educational technologies analyzed was based on two combined data sets: student profile dataset and interaction dataset (Singh, 2024). The student data set comprises both demographic and learning related characteristics such as student identifier, age, education level, academic field of study, his or her learning style preference, device preference, time zone, number of online courses that he or she has completed before, learning disability, and level of motivation. The interaction data is a record of the activity logs that the students are generating while utilizing the online learning platform. Every interaction record contains an interaction ID, student ID, course ID, time of interaction, type of interaction, time of activity in seconds, completion rate, assessment mark where relevant, attempt ID and device that was used in the interaction. Some of the interaction types, which are captured in the dataset, are video watching, submission of assignments, trying quizzes, posting discussion messages, downloading resources, and taking notes. These are the records that indicate measurable signs of the engagement of the learner in the digital learning environment.

### **2.3 Data Preparation**

The datasets were cleaned and processed before the analysis to be accurate and consistent. Logs that did not have the full identifiers, inconsistent time stamps or records that were duplicated were deleted. Student dataset and interaction dataset were then joined with the help of student identifier as the linking variable and this created a comprehensive dataset which would integrate learner attributes with the behavioral interaction data. Values of time stamps were converted into uniform sets and durations of interaction analyzed in a way that could identify possible outliers. Interaction activities were also divided based on instructional engagement forms such as content consumption, assessment engagement, collaborative engagement and access to learning resources.

### **2.4 Variables and Measures**

The interaction data were used to obtain several behavioral indicators that measure student engagement. The level of engagement was measured based on the number of interactions recorded in various forms of activities. The interaction duration was the amount of time that was spent working on learning materials, and the completion rates were a measure of the level of tasks that were done successfully. Learning performance was measured by the assessment score of quizzes and assignments. The profile dataset was used as explanatory variables of student characteristics in the analysis. These are age, the level of education, learning methods, preference to devices, online learning experience in the past, and motivation degree. A combination of these variables enabled the study to explore the effects of the attributes of the learners on the engagement behaviors in the digital learning environment.

### **2.5 Data Analysis**

The analysis has been carried out in several steps. The characteristics of the students and their interaction behaviour in the data were initially summarized using descriptive statistical analysis. This entailed the analysis of the frequencies of the various types of activities, time of interaction as well as the frequency of the interaction between students. After that the correlation between student traits and the measures of engagement was tested to find out the patterns in the participation of various learner groups. It was conducted through correlation analysis in which interaction behaviors were associated with learning performance indicators, including the completion rate and the assessment score. Lastly, the regression analysis was conducted to identify the main factors that affect the engagement levels and to determine how the demographic traits and behavioral patterns in the process of interaction relate to the outcome of learning in the online learning setting.

## **3. Results**

### **3.1 Student Demographic Characteristics**

Students with different educational backgrounds were represented in the dataset. Most of the respondents were undergraduate level and then high school students and graduate students and professional learners. This distribution demonstrates that the digital learning platform was applied at various educational levels, which contributes to the fact that

the dataset can be analyzed at a broader level to determine how students are represented at different educational levels. To implement the analysis of the composition of the learner population covered by the dataset better, the distribution of students at different levels of education was considered. This background gives a significant background understanding of how the further analysis of interaction patterns and engagement behaviors can be understood within the context of online learning platform.

**Table 1. Distribution of Students by Education Level**

Education Level	Number of Students
Undergraduate	3166
High School	2408
Graduate	1630
Professional	796

The findings in Table 1 suggested that the greatest number of users in the platform consisted of undergraduate students. This distribution implies that the main population, which is utilizing the digital learning system, is made up of higher education learners, although the involvement of secondary education learners and professional learners also adds to the active use of the platforms.

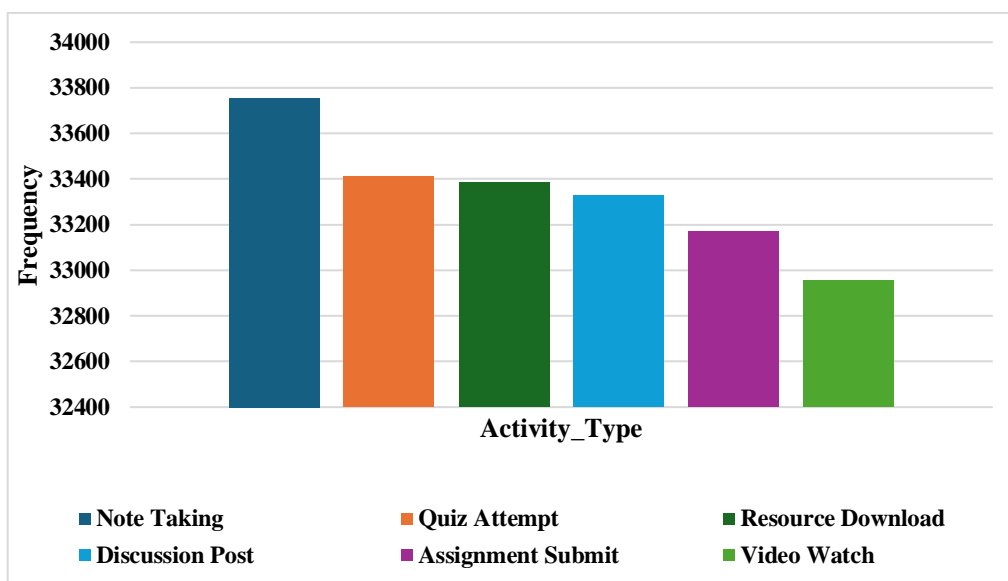
### 3.2 Patterns of Learning Activities

The interaction dataset was used to analyze the level of student engagement in the platform by the frequency of various learning activities in the dataset. The data set was rich in different kinds of activities that represented instructional engagement, collaborative interaction, and learning resource access. To determine the most frequent types of student engagement, the frequency of every type of activity was computed. This discussion gives an insight on the ways learners engage the digital learning space and some of the activities that prevail in the overall learning experience Table 2.

**Table 2. Frequency of Learning Activities**

Activity Type	Frequency
Note Taking	33,754
Quiz Attempt	33,411
Resource Download	33,383
Discussion Post	33,328
Assignment Submit	33,170
Video Watch	32,954

The most common activity of the learner was taking notes, which means that they were actively reading course materials. Quiz attempts and downloading of resources also followed the same pattern and it is possible that students actively visited learning materials and engaged in activities related to assessment. Watching videos was a smaller percentage of associated activities than other learning behaviors but still a large percentage of learning interactions. To show the proportional distribution of the type of activities, the frequency of each type of interaction is presented in Figure 1.



**Figure 1. Distribution of Learning Activities in the Online Learning Platform**

Figure 1 shows the distribution of the interaction activities with respect to the dataset. The participation was relatively equal in the types of activities, indicating that students applied several characteristics of the digital learning platform, and did not depend on one of the interaction modes. These results underscore the fact that students engage in a variety of activities, which involve content consumption, collaborative learning, and assessment activities in the learning setting.

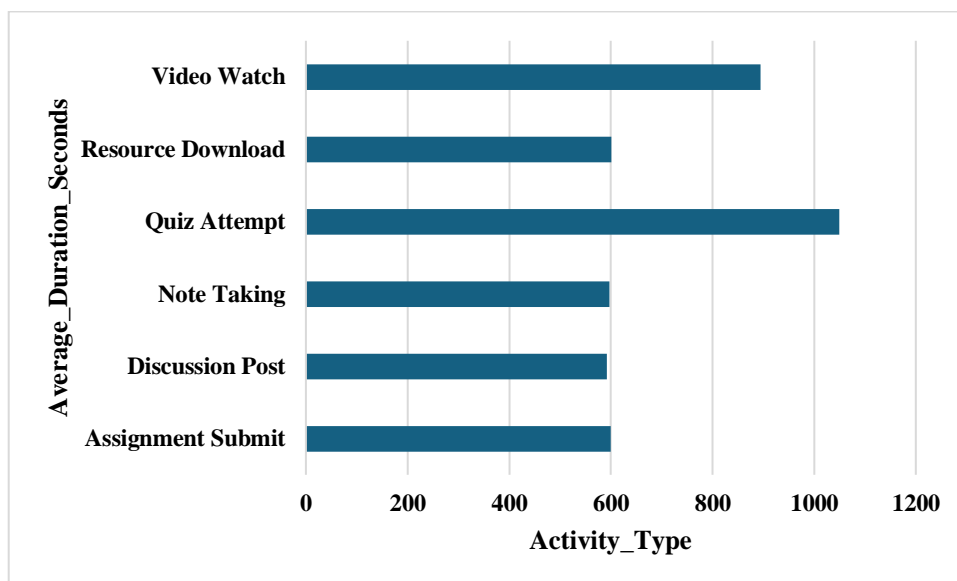
**3.3 Interaction Duration Across Learning Activities**

The duration of interaction was examined to know how much time the students were taking on various learning activities. The average duration of interactions also differed with the type of activity, as they were based on the complexity and the instructions needed by each activity. To take a closer look at the intensity of engagement, mean durability on each type of activity and completion rates were calculated. These metrics can be used to demonstrate the way learners spend their time on various learning activities in the system Table 3.

**Table 3. Average Duration and Completion Rate by Activity Type**

Activity Type	Mean Duration (seconds)	Mean Completion Rate
Assignment Submit	599.40	0.80
Discussion Post	592.61	0.79
Note Taking	596.94	0.80
Quiz Attempt	1048.93	1.00
Resource Download	600.94	0.80
Video Watch	894.67	0.67

Attempts of quiz took the longest average time of interaction, which suggests that the assessment activities were more involved than any other learning activity. There was also a big interaction duration in video watching, which indicated the duration of time needed to eat instructional information. The average time that was spent on the activities included in the study, like taking notes, downloading resources, and submitting assignments, was similar, which indicates that there were regular patterns of engagement during these learning activities. Figure 2 represents the comparative time of each type of activity to allow students to have a more straightforward idea of the engagement time difference among the learning interactions.



**Figure 2. Average Interaction Duration by Activity Type**

The figure exposes the variations in time spent on activities type as the activities that yield the most time spent in terms of duration are associated with assessment. Such a trend suggests that activities that involve mental effort and appraisal are likely to attract higher attention to learners and more time compared to more passive learning tasks.

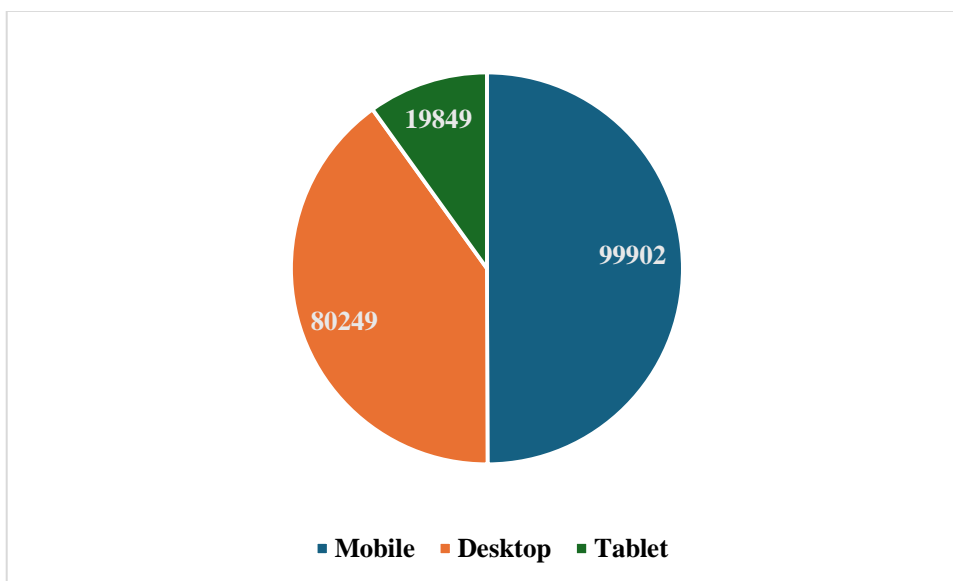
**3.4 Device Usage in Online Learning**

The use of the device was studied to know how students used the learning platform. The record of interaction indicates that the learners used various devices to interact with course activities. The examination of the patterns of using devices contributes to the understanding of the way the learners engage with the digital systems of learning and the types of technologies that are most utilized to gain access to learning content Table 4.

**Table 4. Device Usage for Learning Activities**

Device	Frequency
Mobile	99,902
Desktop	80,249
Tablet	19,849

The most common means of accessing the online learning platform was through mobile devices with most interactions being made through them. A high number of desktop computers were used as well whereas tablets had a lower percentage of activity. These findings suggest that mobile accessibility is a significant attribute of enabling student interactions in online learning communities. To elaborate on these patterns of access, Figure 3 shows how the devices are distributed in different learning activities.



**Figure 3. Device Usage Distribution in the Learning Platform**

The figure indicates that the use of mobile devices is dominant in the learning interactions between students, making the significance of mobile-friendly educational technologies. These findings indicate that learning websites ought to consider the use of mobile compatibility and responsiveness in promoting efficient learning activities.

**3.5 Relationship Between Interaction Duration and Learning Performance**

The interaction period with assessment scores was investigated to identify the association between engagement level and learning outcome among the activities that reported the scores of the performance. The result showed that there is moderate positive relationship between the length of interaction and the assessment scores. These results pose active and extended engagement with learning material as relevant to the success of learning. The findings show that there are some significant trends of interaction in the virtual learning context. To begin with, students were active in different types of activities, and the most common interactions were note-taking and attempts at quizzes. Second, the activities that involved assessment like quizzes took the longest time and thus showed their cognitive requirements. Third, mobile devices became the major method of accessing the learning processes, which further emphasizes the growing significance of mobile learning technologies.

**4. Discussion**

The results of the research present significant information on the way students interact with online learning platforms in various ways. The findings indicated that students were active in various types of activities such as note-taking, attempts at quizzes, discussion, and downloading of resources. These patterns of interaction have indicated that learners interact with online platforms by way of mixes of both instructive, collaborative and assessments activities. This type of behavior interaction is regarded as one of the primary signs of involvement in the digital learning setting. The studies that investigate the perception of students toward online engagement also suggest that active engagement of course materials and learning activities are factors that increase a sense of engagement and participation of students in online courses (Redmond et al., 2023).

The current research also illustrates the importance of learning analytics in the determination of engagement pattern in online learning systems. Students create interaction logs, the analysis of which allows studying the way learners spend time and effort on various learning activities. Analytics dashboards and monitoring systems have been created extensively to facilitate this kind of analysis. Research comparing the use of learning analytics dashboards with the effectiveness of

other tools reveals that the tools can raise student engagement considerably through feedback on learning behaviors and progress (Ramaswami et al., 2023). Moreover, learning analytics technologies could provide actionable information which can enable students and instructors to learn more about engagement behaviors. These systems ensure that the learners can monitor their activities, the level of participation, and manipulate their learning strategies. Studies have demonstrated that learners are more prone to learning behavior regulation and to engage more in online learning activities if they have access to analytics-based feedback (Susnjak et al., 2022).

Among the major results of this work, there was the positive correlation existing between the duration of interaction and learning performance. Quizzes and video viewing involved more time of engagement which showed that they involved deeper engagements. The question of what ties time investment to learning outcomes has been much debated in the research on online education. The engagement intensity via interaction period and count of participation is usually associated with better school performance. The systematic review of the involvement in large-scale online courses emphasizes that long-term interaction in learning activities is a major factor in enhancing learning in the digital education setup (Wang et al., 2022). Also, according to the findings, students who spend more time engaging with course content have better-assessment scores. This observation favors the fact that active learning in learning materials helps to gain knowledge and develop skills. Keeping track of the length of engagement can thus be a significant way of determining who the student might need more academic support or intervention.

Another finding is the significance of team-based and social interaction in online learning. Such activities as discussion posts are the opportunities of the learners to interact with peers and share knowledge. The social interaction is a key element of activity of online learning since it assists in building a community and common experience of learning. The studies investigating the connection between social presence and engagement show that communication with peers and instructors promotes motivation and engagement in online courses (Miao and Ma, 2022). It is thus possible to enhance engagement and facilitate more meaningful learning processes through integration of collaborative activities on online platforms. Learning environments based on discussions require critical thinking, sharing of knowledge, and an active participation that are all effective in enhancing learning outcomes.

The other significant study finding is associated with the use of the device among the students. The most common technology that was used to access the online learning platform was mobile devices, then desktop computers, and tablets. This tendency is indicative of the increased significance of the mobile learning technologies in modern education. The mobile accessibility enables the learners to access educational content at anytime and anywhere and this facilitates flexible learning practices. The growing use of mobile devices indicates the importance of learning platforms that would be compatible with mobile technology. Mobile-friendly learning conditions have the potential to make digital learning tools more accessible and prompter to keep using them on a regular basis. The results align with general studies on online learning, which highlight the need to have accessible and flexible technological platforms to facilitate learners' involvement.

To enhance participation in online learning, it is necessary to implement efficient training methods and interventions using technologies. One of the methods that can help to increase student motivation and engagement is gamification as it implies the use of games in the learning process. The studies that explored the effect of gamification in online learning settings demonstrate that point, rewards, and challenges are some of the features that can motivate learners to engage more in online courses (Saleem et al., 2022). Moreover, the interaction design strategies allowing interaction and feedback to be encouraged can greatly enhance the level of engagement. Learning environments involving interactive activities, collaborative discussions, and frequent tests can offer chances to the learners so that they can be actively engaged in the learning process. The strategies can assist in sustaining the motivation of learners and can assist in sustaining their engagement in digital systems of education.

Although online learning platforms have immense potential about access and flexibility, student persistence is also one of the problems. This is because low rates of engagement are largely linked to higher rates of dropout in online learning. Reports on the topic of persistence in online learning settings indicate that lack of engagement in learning activities may be among the major reasons that lead to student dropouts (Shaikh and Asif, 2022). The learning analytics can be used in understanding the patterns of engagement in students and can hence be critical in determining those students who are likely to drop out. Educators can use the observed interaction patterns and engagement rates to adopt early interventions to assist learners with interactions showing a waning engagement rate. Some of such interventions can be personalized feedback, providing more instructional support or modifying course design to promote more involvement.

## 5. Conclusion

The interaction and engagement behaviour of students in the digital learning platforms using the learning analytics techniques. The research has given information on the participation of learners in different activities in an online learning environment by examining the data of behavioral interaction and the demographic characteristics of students. The findings indicated that students utilize digital learning environments by undertaking various activities including taking of notes, attempting quizzes, submitting assignments, participating in discussions and downloading of resources. These activities had longer interaction times among which the assessment related activities and the video-based learning sessions that were observed to have the greater interaction with longer period of interaction. The results also showed that mobile gadgets are the most popular technology that is used to access online learning platforms and this demonstrates the increased significance of mobile accessibility in digital learning. Also, the analysis implied that there was a positive correlation

between the period of interaction and learning performance, which means that the prolonged use of learning material may lead to better academic performance. Generally, the research shows that learning analytics is useful in interpreting student engagement in online learning. With the help of interaction patterns and behavioral clues, educators and institutions can find information about the interaction of learners with digital platforms that be useful. Such insights may be used to create more efficient instructional approaches, better course designs, and specific interventions that may address the lack of student engagement and achievement in digital learning settings.

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