Strengthening Statistics Education for Bachelor-Level Nursing Students in Open and Distance Learning: Insights from an Applied Healthcare Curriculum

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ABSTRACT

Statistics plays an important role in nursing education as it supports clinical judgement, patient assessment, and the interpretation of healthcare findings. Many nursing undergraduates find this subject difficult, especially in Open and Distance Learning (ODL), where academic commitments must be managed together with shift duties and personal responsibilities. This study explores learning behaviour, performance patterns, and topic-level mastery among more than 300 nursing students enrolled in an online statistics course built around healthcare examples. The course uses e-lessons, a digital flipbook, guided discussions, online quizzes, and a final examination. Results show that learners perform well in descriptive topics that use common patient data but face difficulty with inferential topics such as sampling, probability, confidence intervals, and hypothesis testing. Engagement peaks were recorded before assessments, showing that many students study close to deadlines. The study outlines suggestions for improving support, such as structured scaffolding, healthcare-based examples, and early alerts for students who require additional help.

Keywords: Statistics, nursing students, open and distance learning, healthcare data, engagement, assessment performance, student behaviour, digital learning, inferential skills, clinical examples

INTRODUCTION

Statistics forms a central foundation in undergraduate nursing education, supporting informed judgement, clinical monitoring, and the use of evidence in healthcare settings. Nurses routinely interpret numerical information such as patient vital signs, laboratory values, risk estimates, and outcomes from screening tools. These activities require the ability to summarise data, interpret variation, and draw basic conclusions to guide safe practice. As healthcare becomes increasingly data-intensive with digital charting, clinical dashboards, and performance indicators which requires nursing students to develop competency in interpreting both descriptive and inferential statistical information (Chiesi & Primi, 2020). A strong grounding in statistics is therefore essential for ensuring that future nurses can make sound decisions informed by reliable data.

For students enrolled in Open and Distance Learning (ODL) programmes, learning statistics takes place within a unique set of constraints. Many nursing undergraduates are working adults who balance coursework with demanding shift duties, clinical responsibilities, and family commitments. Their study routines are shaped by unpredictable work schedules, affecting the amount of time available for continuous learning. While ODL platforms offer flexibility through asynchronous lessons, videos, digital modules, and mobile access, these tools alone may not be sufficient to support deeper understanding of key concepts. Research shows that nursing learners often rely on surface approaches when time is constrained, leading to gaps when transitioning from basic summaries to more abstract topics such as probability, sampling, distributions, and hypothesis testing (Kozlovski et al., 2023). These gaps are especially notable when topics have limited direct visibility in routine clinical practice.

To understand these learning challenges, theoretical lenses such as Adult Learning Theory and the Cognitive Load Framework offer useful explanations. Knowles' principles of adult learning suggest that mature learners engage better when content is practical, self-directed, and clearly relevant to their professional roles. Statistics content that uses clinical examples, patient datasets, or real scenarios tends to resonate more strongly with nursing students, increasing both motivation and comprehension. At the same time, Cognitive Load Theory explains why topics such as sampling distributions or hypothesis testing remain difficult: these areas impose a high level of intrinsic load that may overwhelm learners without structured guidance. When working nurses attempt these tasks after long shifts or limited study windows, mental overload can impede the development of deeper statistical reasoning.

The shift towards digital and data-informed teaching further highlights the role of learning analytics in understanding how ODL nursing students engage with statistics content. Learning analytics can reveal patterns such as the time spent on key topics, the frequency of revisiting complex materials, and the tendency for activity to cluster near assessment deadlines. Evidence shows that such analytics can identify early signs of disengagement and help institutions provide targeted support (Johar et al., 2023). For statistics courses, analytics often show that learners return repeatedly to descriptive topics while avoiding inferential content, signalling areas where additional scaffolding is needed. By integrating analytics with instructional design, educators can develop timely interventions for students who struggle before performance declines become more severe.

Given these considerations, there is a need to examine how nursing undergraduates in ODL settings respond to the design and delivery of statistics courses. Understanding their engagement behaviour, areas of mastery, and points of difficulty can help refine teaching approaches that improve learning outcomes. The present study contributes to this need by analysing assessment patterns and topic-level access among a large cohort of Bachelor-level nursing students enrolled in an applied, healthcare-based statistics course. Through a review of their interaction with course tools including a digital flipbook, e-lessons, quizzes, and guided clinical discussions. This study offers insights into how ODL nursing students learn statistics and how teaching practices can be improved to support deeper understanding across both descriptive and inferential domains.

Conceptual Framework

The conceptual framework explains how nursing students in an Open and Distance Learning (ODL) environment develop statistical competence through the interaction of learner factors, instructional design, cognitive processing, engagement behaviour, and performance outcomes.

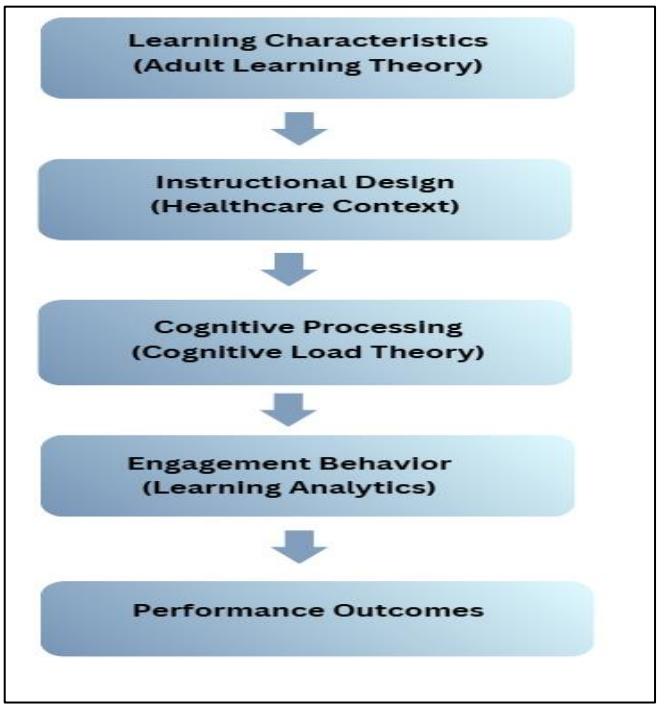

Figure 1. Conceptual Framework for Statistics Learning among Nursing Students in an ODL Environment

Learner characteristics form the starting point of the framework, guided by principles from Adult Learning Theory. Most students in Bachelor-level nursing programmes are working nurses who manage demanding clinical duties alongside academic responsibilities. Their readiness to learn statistics varies, as they bring different levels of prior knowledge, mathematical confidence, and workplace exposure. In addition, work–study balance plays a large role in shaping motivation, as shift schedules and fatigue influence how consistently learners engage with statistical content.

The second component, instructional design, reflects how course materials support clarity and relevance. Statistics tends to be more meaningful for nursing students when taught using healthcare-based examples, patient scenarios, and clinical datasets. Digital tools such as the interactive flipbook, structured e-lessons, and guided discussions are intended to scaffold learning by presenting concepts step-by-step. When these materials align with nursing tasks, they improve perceived relevance, which encourages students to persist with more challenging topics.

The third component focuses on cognitive processing, drawing on Cognitive Load Theory. Descriptive topics such as averages, variation, and graphical displays involve lower cognitive load and are generally easier for learners to grasp. However, inferential topics such as probability distributions, sampling proportions and hypothesis testing impose a higher level of mental demand. Working adult learners, who often study at irregular hours, may struggle to manage this increased load, which affects their learning pace and depth of understanding. Effective instructional design can reduce unnecessary cognitive load and help learners' transition across these levels of difficulty.

The fourth component, engagement behaviour, is informed by learning analytics principles. Engagement is reflected in patterns such as how frequently students access specific topics, when they interact with digital materials, and how strongly their activity increases near assessment deadlines. These behavioural indicators provide insight into whether learners revisit difficult topics, engage consistently, or rely heavily on last-minute study. Such patterns have direct implications for the depth of learning achieved.

The final component is performance outcomes, which represent the observable results of the interactions among the earlier elements. Coursework marks, and final examination results serve as indicators of statistical mastery. They also reveal which areas require improvement, especially when linked back to engagement patterns and cognitive difficulty. High performance typically corresponds with consistent engagement and effective navigation of both descriptive and inferential content.

Overall, the framework illustrates a structured flow in which learner characteristics shape how students interact with the instructional design, which then influences cognitive processing. This processing affects engagement behaviour, which ultimately determines performance outcomes. Understanding these relationships helps educators refine teaching strategies and develop targeted interventions to support statistics learning among ODL nursing students.

LITERATURE REVIEW

Statistics plays an important role in undergraduate nursing programmes, as it supports clinical work such as interpreting patient readings, identifying risk patterns, understanding treatment outcomes, and evaluating research evidence. Despite this importance, statistics remains a demanding subject for many nursing students, particularly those enrolled in Open and Distance Learning (ODL) environments. Prior studies report that learners frequently struggle when moving beyond descriptive summaries to more abstract areas such as probability, sampling logic, and hypothesis testing (Chiesi & Primi, 2020). These challenges are intensified among working adult learners who balance academic requirements with irregular clinical schedules, leading to uneven study habits and varying levels of preparation. As healthcare becomes increasingly data-dependent, strengthening statistical competence among nursing undergraduates is essential to support safe clinical decisions and evidence-based practice.

Learner readiness and perceived relevance strongly influence how well adult nursing students engage with statistical content. Adult Learning Theory posits that mature learners participate more actively when learning

materials are practical, meaningful, and connected to their prior experience (Knowles et al., 2015; Merriam & Bierema, 2014). In statistics education, healthcare-based examples such as ward infection trends, fluid balance charts, or diagnostic accuracy indicators can improve motivation and comprehension. Research shows that contextualised tasks enhance the perceived usefulness of statistics in clinical decision-making, thereby increasing engagement and persistence (Kozlovski et al., 2023). When learners view statistical reasoning as directly relevant to patient care, they are more inclined to invest effort in mastering foundational and advanced topics, an important consideration for ODL students who rely heavily on self-directed learning.

Instructional design plays a central role in supporting students as they navigate complex statistical concepts. Digital modules, interactive flipbooks, e-lessons, and multimedia explanations align closely with Cognitive Load Theory, which examines how learners process information of varying complexity (Sweller et al., 2011; Paas et al., 2003). Descriptive topics such as central tendency and data displays generate lower cognitive demand and are generally easier to manage. In contrast, inferential topics including confidence intervals, distributions, and hypothesis testing carry higher intrinsic cognitive load, particularly for students studying independently after long shifts. Multimedia learning principles further highlight that well-structured visual and verbal explanations reduce extraneous processing and improve concept acquisition in online environments (Mayer, 2021; Clark & Mayer, 2016). Breaking content into smaller steps, embedding healthcare scenarios, and providing guided examples can help nursing students manage cognitive demands more effectively.

Learner engagement patterns also shape how well nursing students understand statistics. Constructivist perspectives emphasise that learners build knowledge through active participation, discussion, and the application of ideas to meaningful situations (Vygotsky, 1978; Biggs, 1996; Jonassen, 1999). In ODL settings, guided forums, applied tasks, and short practice activities allow students to clarify misconceptions and deepen their understanding. Yet evidence suggests that nursing students often display assessment-driven behaviour, increasing activity shortly before deadlines and reducing engagement at other times (Soffer & Cohen, 2019). Such patterns can limit the depth of understanding required for more challenging inferential content, which typically benefits from spaced practice and repeated exposure. Sustained engagement is therefore essential for supporting conceptual development and improving overall performance in statistical subjects.

To better understand these learning processes, ODL institutions increasingly use Learning Analytics to track behavioural indicators such as topic access, navigation patterns, and timing of interactions. Analytics help identify strategic behaviour, avoidance of difficult content, and early signs of disengagement (Siemens & Long, 2011; Ifenthaler & Yau, 2020). Recent work shows that students often access descriptive topics more frequently than inferential ones, reinforcing known patterns of difficulty (Johar et al., 2023). For large nursing cohorts, analytics offer educators a systematic way to detect learners who require additional support and to refine digital materials based on real-time usage patterns. This analytical insight is particularly useful in ODL environments where lecturers have limited direct contact with students.

Taken together, the literature indicates that statistics learning among ODL nursing students is shaped by multiple interacting factors, including learner readiness, relevance of instructional design, cognitive demands, engagement behaviour, and guidance supported by analytics. While descriptive content is generally manageable, inferential topics require clearer clinical applications and stronger scaffolding. Evidence suggests that integrating contextualised healthcare examples, multimedia design principles, and analytics-informed monitoring can significantly improve outcomes. However, research focusing specifically on statistics education for nursing students within fully online or distance-based formats remains limited. This study addresses this gap by examining how assignment results, final examination performance, engagement patterns, and flipbook usage influence learning among Bachelor-level nursing students enrolled in an ODL statistics course.

METHODOLOGY

This study adopted a quantitative and analytics-driven design to examine the relationship between assessment performance and engagement behaviour among Bachelor-level nursing students enrolled in a statistics course delivered through an Open and Distance Learning (ODL) environment. The course involved more than 300 learners, most of whom were practising nurses balancing clinical duties with academic commitments. By integrating assessment records with digital traces from the university's learning management system (MyInspire)

and access logs from the course flipbook, the study aimed to capture natural variations in readiness, participation, and learning consistency typical of adult learners in ODL.

Data were gathered from four primary sources: assignment performance, final examination scores, LMS engagement analytics, and flipbook access logs. Assignment marks, which constituted 40 percent of the overall grade, were extracted from the institutional assessment system and reflected learners' ability to apply descriptive statistics to structured healthcare scenarios. Final examination results, also weighted at 40 percent, were obtained from the examination database and captured independent mastery of both descriptive and inferential topics such as probability, distributions, sampling, and hypothesis testing. LMS analytics provided detailed information on engagement patterns, including the number of forum posts, frequency of views, topic-specific access, and the timing of interactions across the semester. Flipbook usage data were collected from the digital e-module platform to determine how often learners accessed the content, which sections they revisited, and how usage patterns shifted as assessments approached.

All data were anonymised prior to analysis, following institutional requirements for confidentiality and ethical handling. The datasets were cleaned to remove system-generated test accounts, duplicate entries, and incomplete records. Missing values due to non-submission were coded to reflect actual performance rather than omitted from analysis. The cleaned datasets were merged using anonymous identifiers to allow cross-comparison of engagement and performance without compromising student privacy.

Data analysis involved descriptive statistical techniques using SPSS Version 29. Measures such as mean, median, standard deviation, and frequency distributions were used to summarise assignment scores, final exam results, and engagement levels. Learning analytics outputs were used to plot temporal trends, identify peak activity periods, and observe differences in access patterns between descriptive and inferential topics. While the study did not employ inferential tests, correlational observations were made to compare high- and low-engagement groups, allowing insight into behavioural tendencies that shape academic outcomes.

Reliability was supported through the use of system-captured LMS logs, which minimise manual entry errors, and through internal moderation of assignments and examination papers to preserve consistency. Validity was reinforced by the course's structured design, which ensures alignment between learning outcomes, content delivery, and assessment tasks. However, the study acknowledges that engagement data cannot fully capture the depth of learners' cognitive processing, and external factors such as shift work or fatigue may influence results in ways not reflected in digital traces.

RESULTS AND DISCUSSION

The descriptive statistics for NBHS3112 provide a clear overview of learners' performance across the overall course grade, coursework component, and final examination. The overall mean score of 76.00, coupled with a median of 89.25, indicates a positively skewed distribution in which a substantial proportion of students achieved marks in the upper range. This pattern is consistent with the grade distribution where nearly half the cohort obtained Grade A. The relatively high overall mean suggests that learners were generally able to demonstrate mastery across both descriptive and inferential topics.

Coursework performance shows even greater consistency. The coursework mean of 30.39 out of the allocated marks, alongside a median and mode of 31.13, highlights a strong cluster of scores within a narrow range. This is supported by the low standard deviation of 5.23, indicating minimal variability between learners. The tight distribution suggests that most students were able to handle descriptive tasks effectively, likely due to clear instructional scaffolding and the use of healthcare-based examples provided through the digital flipbook. This component focused on lower cognitive load concepts such as measures of central tendency, dispersion, and graphical summaries, which adult learners typically manage with greater confidence.

Final examination performance demonstrates a slightly wider distribution, with a mean of 47.95 and a median of 48.75. The standard deviation of 7.82, higher than that of coursework but still relatively moderate, reflects increased variability as students engaged with more conceptually demanding inferential topics. The higher cognitive load associated with probability distributions, confidence intervals, and regression analysis likely

contributed to this spread. Despite this, the median remained high, suggesting that a majority of learners were able to manage the analytical demands of the examination, supported by the applied multiple-choice format and structured revision resources.

The number of incomplete scores was notable for the overall and final examination categories (151 and 159 respectively), reflecting students who did not complete all assessed components. This may relate to factors commonly observed in ODL nursing cohorts, such as shift work, competing responsibilities, and withdrawal patterns. However, among students who completed the assessment tasks, the performance indicators demonstrate strong engagement and competence across the statistical content.

Table 1: Descriptive Statistics for NBHS3112 Statistics Course

Measure	**Overall**	**Coursework**	**Final Examination**
Mean	76.00	30.39	47.95
Median	89.25	31.13	48.75
Mode	31.13	31.13	32.00
Standard deviation	15.91	5.23	7.82
Incomplete (n)	151	1	159

Overall, the descriptive statistics confirm that the instructional design, digital learning resources, and assessment structure effectively supported student learning. Consistent coursework performance and high final examination medians indicate that learners were able to progress from foundational descriptive concepts to more advanced inferential reasoning, aligning with the theoretical expectations of adult learning and cognitive scaffolding.

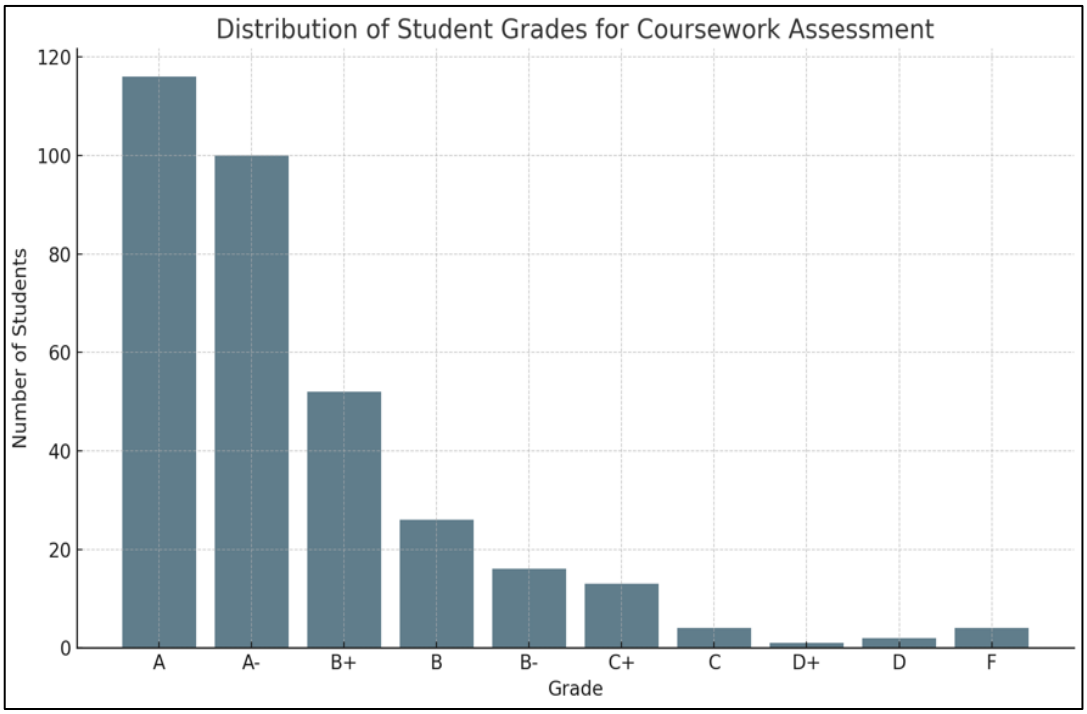

Figure 1: Grade Distribution Bar Chart for Coursework Assessment

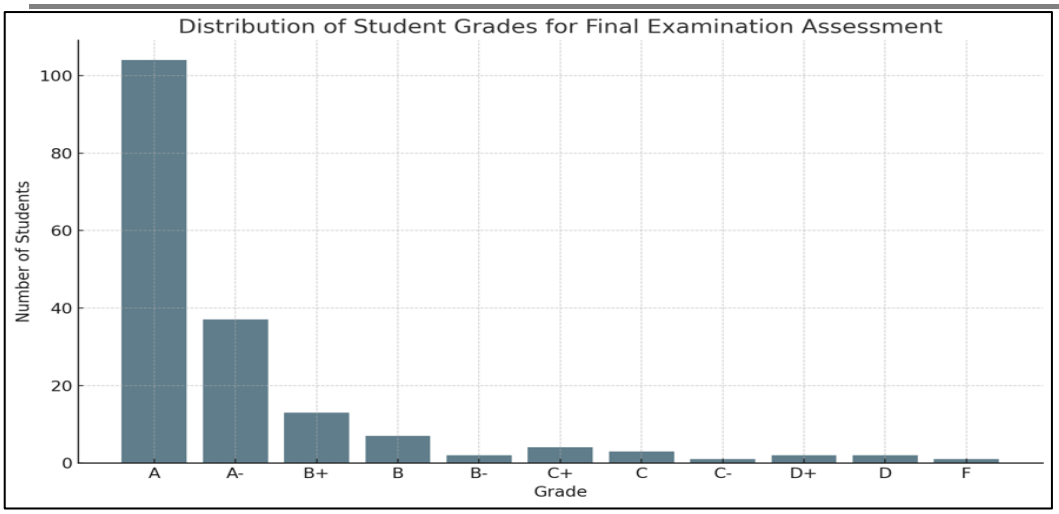

Figure 2: Grade Distribution Bar Chart for Final Assessment

Based on the Figure 1, the coursework assessment results echo this pattern. A large percentage of students achieved distinctions, with 34.73 percent scoring A and 29.94 percent scoring A−. The structured design of the flipbook, which presented step-by-step examples using healthcare situations, appears to have helped students grasp descriptive concepts with ease. These healthcare-linked demonstrations made statistical ideas more concrete and familiar, supporting consistent performance with low variability across the cohort. The strong coursework achievement suggests that most learners were able to apply descriptive methods accurately when provided with clear, guided instruction.

The final examination results shown in Figure 2 demonstrate similar success, despite covering a broader range of statistical content including inferential procedures and simple linear regression. The multiple-choice format, with three options per item, assessed applied and analytical reasoning. Here, 59.09 percent of students secured Grade A, and 21.02 percent earned A−. These outcomes indicate that learners were able to extend their understanding beyond descriptive tasks and apply statistical reasoning more independently. Although inferential topics carry greater conceptual demand, students showed the capacity to manage these challenges when supported by the structured e-lessons and digital materials provided throughout the course.

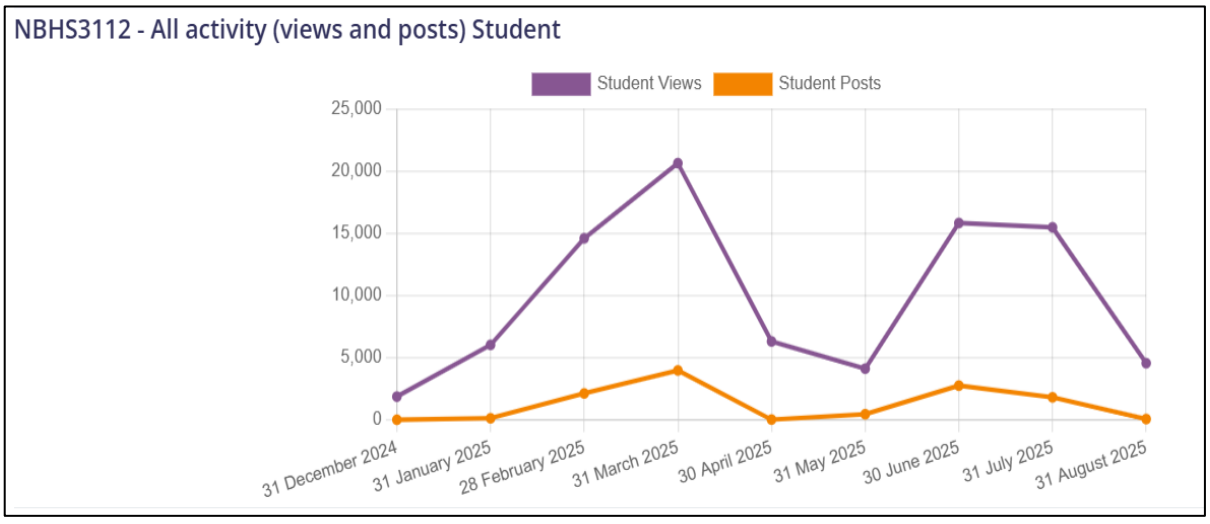

Figure 3: Temporal Patterns of Student Views and Forum Contributions in the NBHS3112 Statistics Course

Figure 3 depicts the learning analytics pattern for NBHS3112 which illustrates clear fluctuations in student engagement across the semester, with a consistent distinction between viewing behaviour and forum posting. Overall, the number of content views substantially exceeded the number of forum posts, reflecting a predominantly passive engagement style among nursing students—an established pattern in ODL environments where adult learners often prefer content consumption over active participation.

The data reveal two major peaks in engagement. The first occurred between late February and the end of April 2025, where student views rose sharply from approximately 6,000 to over 20,000. This period coincides with the middle of the semester, which typically aligns with the release of coursework tasks and the introduction of more cognitively demanding topics such as probability and inferential reasoning. The gradual rise suggests that students increased access to learning materials as assessment deadlines approached, reflecting a strategic, assessment-driven engagement pattern commonly reported among working adult learners.

Forum posting followed a similar but more muted trajectory. Posting activity remained relatively low throughout the semester, with small increases in February and March months that correspond to the release of guided discussion prompts and preparation phases for both coursework and exams. The limited posting suggests that while students accessed materials frequently, they engaged less actively in peer-to-peer discussions. This behaviour is typical among nursing students juggling shift work and study, where time constraints reduce participation in optional interactive activities. The disparity between viewing and posting also reflects tendencies highlighted in Constructivist and Adult Learning frameworks, where learners prioritise efficiency and relevance, engaging deeply only when tasks directly support assessment performance.

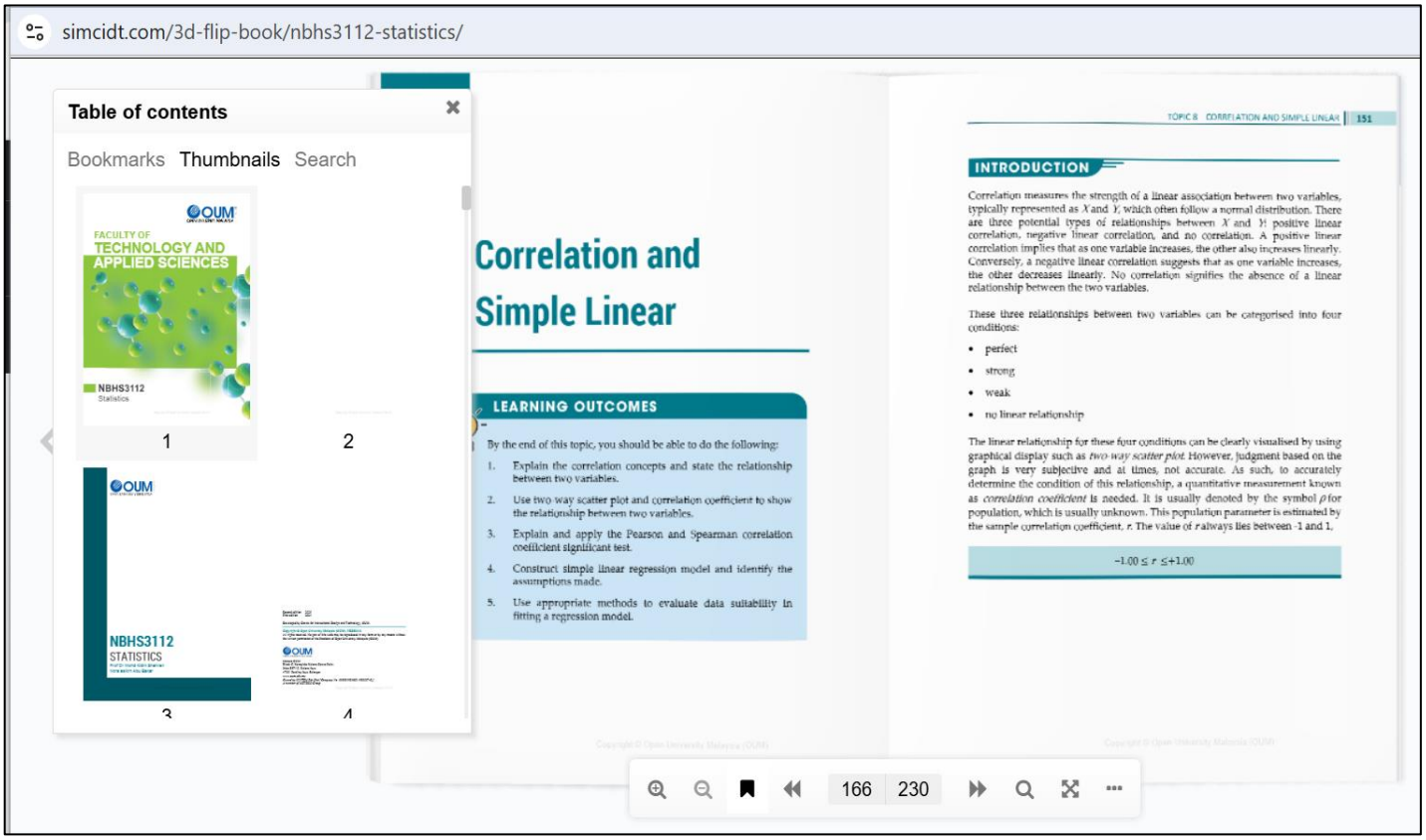

Figure 4: Digital Flipbook Interface for the NBHS3112 Statistics Course

Collectively, these engagement patterns indicate that students utilised the digital materials in a strategic, assessment-oriented manner, with content views spiking before major assessments and dipping during non-assessment periods. The high volume of views during peak intervals suggests strong reliance on the digital flipbook (shown in Figure 4), e-lessons, and multimedia explanations. This aligns with the strong assessment performance reported earlier, supporting the interpretation that consistent access to structured digital resources played a central role in helping ODL nursing students navigate both descriptive and inferential statistics.

The findings indicate that the instructional structure of the ODL statistics course supported nursing students effectively across descriptive and inferential content. The strong distinction rates in coursework reflect a close fit between adult learners' needs and the focus of the continuous assessment. As the coursework emphasised descriptive statistics, learners engaged with content that was clear, familiar, and supported through worked examples. This aligns with Adult Learning Theory, which explains that mature learners respond well to material that is relevant and connected to their experience in clinical settings. The use of healthcare examples in the

flipbook provided immediate relevance, helping students link new concepts to their daily work and improving confidence in handling descriptive tasks.

The strong final examination results reveal the value of structured scaffolding throughout the course. Although the exam required independent analysis across a range of statistical methods, students continued to perform well. Inferential topics generally impose higher mental demand, yet the combination of e-lessons, stepwise demonstrations, and clinical examples appears to have supported learners in managing this complexity. This reflects ideas from Cognitive Load Theory, which suggests that instructional design can ease mental effort by reducing unnecessary distractions and presenting abstract ideas in smaller, clearer components. The prepared presentation of the flipbook likely helped minimise overload and allowed students to progress through more demanding topics.

The results also demonstrate features of Constructivist learning. Continuous assessment tasks and forum activities provided opportunities for students to work through examples, apply techniques to healthcare scenarios, and refine their understanding over time. This iterative learning process encourages the gradual construction of conceptual knowledge, which is especially important in statistics where understanding develops through repeated practice. The strong performance across both assessments suggests that students internalised core ideas through active engagement and applied problem-solving.

Finally, the results correspond with patterns reported in Learning Analytics research. Although analytics data were not presented in the tables, the high scores across both assessments suggest consistent use of digital resources such as the flipbook, e-lessons, and LMS materials. Studies show that learners who access content frequently, revisit challenging topics, and space their study sessions tend to perform better in online and distance courses. The strong distinction rates imply that learners were engaging with the materials at regular intervals and using the resources as intended.

Taken together, the findings highlight that the combination of contextualised clinical examples, scaffolded instruction, applied assessment design, and analytics-supported engagement produced a supportive learning environment. This synergy enabled nursing students in the ODL course to demonstrate high levels of statistical understanding across descriptive and inferential content.

CONCLUSION

The findings of this study demonstrate that Bachelor-level nursing students in an ODL statistics course can achieve high levels of mastery when instructional design, assessment structure, and digital learning resources are aligned with the needs of adult learners. The strong performance across both coursework and final examination indicates that students were able to progress from foundational descriptive statistics to more complex inferential reasoning when supported through structured examples, healthcare-based scenarios, and scaffolded digital materials. The coursework component, which emphasised descriptive concepts, provided a stable platform for learners to build confidence, while the applied and analytical nature of the final examination demonstrated their readiness to engage with higher-order statistical thinking independently.

Several theoretical perspectives help explain these outcomes. Adult Learning Theory clarifies why contextualised healthcare examples were effective in enhancing learners' motivation and comprehension. Cognitive Load Theory explains how structured e-lessons, the digital flipbook, and stepwise demonstrations helped students transition across varying levels of cognitive demand. Constructivist principles were reflected in learners' ability to internalise statistical concepts through repeated applied practice, while insights from learning analytics point to the role of consistent engagement with digital materials in supporting overall performance. Together, these theories illuminate how carefully designed ODL environments can compensate for the lack of face-to-face interaction and provide the cognitive, motivational, and contextual support required for statistical learning in nursing programmes.

Overall, the results underscore the value of integrating applied healthcare examples, scaffolded instruction, and analytics-supported learning pathways into the teaching of statistics for nursing students in ODL settings. Given the increasing data-intensity of modern healthcare, strengthening statistical competence is essential for preparing

nurses to make informed clinical judgments and participate effectively in evidence-based practice. This study contributes to the growing understanding of how ODL learners navigate statistical content and highlights key areas where instructional design can be further refined to enhance learning outcomes.

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