UJME 13 (3) 2024: 241-253
UNNES JOURNAL OF MATHEMATICS EDUCATION
https://journal.unnes.ac.id/journals/ujme
ISSN: 2252-6927 (print); 2460-5840 (online)

Digital Didactics Embedded in Ethnomathematics Assessment of Online Mathematics Instruction

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ARTICLE INFO

Article history:
Received 3 September 2024
Received in revised form 18 November 2024
Accepted 23 November 2024

Keywords:
Digital didactics; ethnomathematics; online assessment.

Abstract

Online and e-learning programmes have shifted the power bloc to the learner within their cultural settings. In a case study-based qualitative design, the researchers sampled 40 student-teachers to produce and laminate works of prominent women scientists' contributions. The data was collected through observations and unstructured interviews. The items were coded on four 7-point Likert scales to represent the planning and design (satisfaction), teaching and learning (reflection), as and through learning (priority), formative assessment (quality), and assessment of virtual class (satisfaction). In qualitative content analysis, the medians predominantly pooled 6 while the modes pooled between 5 and 8 (multimodal). In cases where the median was greater than the mode, we had positive skewness and the reverse was negative skewness. The Spearman's correlation coefficients showed that only one pair recorded strong positive correlation and two to three pairs recorded strong negative correlations. The chi-square tests for independence showed the null hypothesis was rejected to mean that there were associations among the variables. It was concluded that digital didactics was the central point for the design and use of teaching and learning. It was therefore concluded that digital didactics innovated mathematics instruction and learning.

1. Introduction

Ethnomathematics can be described as the mathematical practices of identifiable cultural groups and/or the study of mathematical ideas found in any culture (Amit, 2023). Abah et al. (2021), Chahine (2020), Fouze & Amit (2023), and Vitoria, et al. (2021) has assessed the effect of ethnomathematics teaching on students' understanding of mathematics. The findings revealed links between mathematics and the culture of the people. In particular, Abah et al. (2021) have researched an assessment of a web-based ethnomathematics instruction, and Prahmana and D'Ambrosio (2020) on the assessment of geometry. This study extends the discussion to online assessment.

1.1 The focus of the Study

Broadly speaking, the main stages of the evolution of didactics are pre-didactics, didactics-dialectics, classical didactics, and digital didactics. The pre-didactics stage began with Socratic dialogues and later transformed into the Socratic method of teaching classical fine arts curricula. So, the two major blocs of trivium and quadrivium emerged. The didactics-dialectics stage began with the study of reading and further continued with dialectics (Ali & Akayuure, 2021). Joshi et al. (2023) contend that classrooms are perceived as the art of teaching.

Classical or traditional didactics began with the transition from the art to the science of teaching and learning (Kjellsdotter, 2020). However, the involvement of digital didactics in this study focuses on using assessment for, about, and through teaching and learning on the online portals. Therefore, at each stage of

To cite this article:
Ali, C. A. (2024). Digital Didactics Embedded in Ethnomathematics Assessment of Online Mathematics Instruction. *Unnes Journal of Mathematics Education*, *13*(3), 241-253. https://doi.org/10.15294/ujme.v13i3.13292

the digital didactics, student-teachers are expected to exhibit the basic tenets of the assessment for, about, and through digital didactics. This helps them apply face-to-face classroom mathematics instruction to solve problems using the various online portals.

1.2 Intersubjective theoretical framework

Ginting and Hasibuan (2024, p.2) agree that ethnomathematics is considered a successful method in transforming the learning environment into a more enjoyable one. Ali and Akayuure (2021) traced the genesis of digital didactics from the reconceptualization and reconstruction of classical didactics in the era of Information and Communication Technologies (ICT). The stages of pre-didactics and didactics-dialectics see the emergence of the first teaching method (e.g., Socratic dialogue), curriculum (e.g., Classical Fine Arts), and dialectics (e.g. digital Technology innovations in mathematics instruction). The stages of didactics-dialectics and classical didactics witnessed the emergence of didactics fields, theories, frameworks, and models for teaching and learning. However, the current emergence of digital didactics ensures quality innovations in the assessment of mathematics instruction through ICT-based online artifacts (Ali & Akayuure, 2021).

Drijvers (2019) comments on the validity of the theoretical framework in digital assessment. This study is significant and contributes immensely to the intersubjectivity of theoretical, methodological, and practical knowledge of didactics of mathematics in the Sociocultural Framework for Understanding Technology Integration (Jackson, 2017). This framework views assessment as an interaction between societal and environmental factors within and outside of the classroom. This interaction promotes an understanding of the factors affecting the integration of technology into mathematics classrooms, and the extension of Valsiner's (1997) theories of Vygotsky's theory of Zone Proximal Distance (ZPD), Zone of Free Movement and Zone of Promoted Action (Kjellsdotter, 2020).

The Zone of Proximal Development (ZPD) describes the gap between the current and potential capabilities of learners that can be traversed with appropriate support. The Zone of Free Movement (ZFM) refers to constraints that affect the ways an individual can interact with their environment, and the Zone of Promoted Action (ZPA) describes the efforts of an experienced learner, who is developing new skills. While ZPD refers to mathematics pedagogy, pedagogical beliefs concerning technology, and experiences in working with technology, ZFM describes ICT access, attitudes, and ability in teaching, learning, and assessment requirements (Jackson, 2017). It is expected that using assessment for, about, and through teaching and learning on the online portals may consolidate and equip student-teachers with the requisite knowledge, skills, and competencies in mathematics instruction.

1.3 Teaching and learning in digital didactics

Generally, digital education is the innovative use of digital tools and technologies during teaching and learning and is often referred to as technology-enhanced learning (TEL) or e-learning. Exploring the use of digital technologies allows educators to design engaging learning opportunities in the courses they teach, and these can take the form of blended or fully online courses and programs (McLaughlin, 2018).

In furtherance to this, the researchers used the blended model to offer the student-teachers the opportunity to delve into deeper the assessment of mathematics concepts and collected data based on how they employed them to teach. This helped the researchers to properly situate the findings about the intersection of research, theory, and practice (Lütge & Merse, 2020).

1.4 Online assessment--formative and summative

In the sessions, student-teachers were tasked to self-evaluate the discourse through formative assessment (assessment about and through). Their comments and criticism were crucial to define the further sessions' management. Then they defined the general features of the digital didactics environment they would like to meet and solve the problems (Perri, 2018).

In summative (assessment for), student-teachers were required to co-create and compile final albums containing ten female scientists. At this point, all the digital didactics works had been shared on the class platform. The student-teachers were required to comment on their favourite female scientists (Perri, 2018).

Therefore, the following researcher questions were answered:

1. How does the middle score differ from the most occurrence score in student-teacher *satisfaction*), *reflection*, *priority*), and *quality* of digital didactics?

2. What is the extent of the interrelationships in *satisfaction*, *reflection*, *priority*, and *quality* of digital didactics?

Consequently, from the Research question 2, the following hypothesis was tested:

Null hypothesis (H_0): There are no associations among the variables.

2. Methods

2.1 The Design

The case study-based qualitative methodology with an ethnographic approach was adopted from Ginting and Hasibuan (2024), Hernández-Carranza et al. (2015) and Kjellsdotter (2020). The case study methodology focused on people's actions on a small scale and in an everyday school context, which is suited to qualitative ethnographic work (Kjellsdotter, 2020). The study was purely based on analysis of observations rather than experiments, in words and images rather than numbers, and in inductive, hypothesis-generating research rather than hypothesis testing (Kjellsdotter, 2020). This led to an interpretation of student-teachers actions and their school practice, as well as implications for a wider context (Kjellsdotter, 2020).

Ethnography was a particularly appropriate method for the assessment strategies because there are strong similarities between the way people teach, learn, and assess instruction via the Internet. Because ethnography usually involves the researchers participating over an extended period, watching, listening, asking questions, and collecting documents (Kjellsdotter, 2020), which also means that the researchers must be prepared to consider many different types of data and that the researchers have to be engaged in the material, to invest time and to have a mutually trustful human connection with the participants (Kjellsdotter, 2020), the research methods used in the study ensured long-term observation of classroom practice, formal and informal assessment of the student-teachers.

2.2 The study setting

The studied class consisted of 40 participants. The overall study focused on the work of using the internet to generate important women scientists. Over three weeks of interactions, there were different classroom assignments involving individual, group, and whole-class work, which was the basis for the empirical data, on the student-teacher preparations and demonstrations in whole-class activities and individual work. The tasks they carried out sought to use the internet for collecting artifacts in groups of five, and in individual work about women scientists, some of whom must be Africans.

Each participant was required to create and laminate ten important women scientists out of five in a group. The main aim of the exercise was not only to create albums containing personalities but also to offer the participants an opportunity to use the Internet to perform various assessments.

2.3 Data collection procedures

The data was collected through classroom observations, formal and informal interviews, presentations of work, field notes, and descriptive documents. These different data collections of data were later processed and analyzed to interpret student-teacher interaction with online portals about digital didactics research. The data collection began with observations of many different features, observing the kinds, models, and types of digital tools available to the student-teachers. These tools were smartphones, laptops, desktop computers, and smart calculators. This resulted in rich empirical data that gradually became even more detailed and comprehensive (Perri, 2018).

The assessment analysis, for, and of learning in digital didactics mainly occurred in four areas: dissemination, discussion, discovery, and demonstration. During the demonstrative phase, the researchers created a digital assessment frame, organized into three stages: an initial diagnosis, a formative intermediate analysis, and a final test. The other three stages (discussion, discovery, and demonstration) were performed with the use of the university learning management system (LMS) software (Perri, 2018).

Finally, the assessment questions were shared on the LMS class platform so that student-teachers gradually monitor and observe the co-building of their knowledge. The general evaluation frame was designed as an assessment system for learning, of learning, and as learning as adopted from the Ministry of Education of Ghana's (2020) new education reforms. In this way, participants did not only directly engage in the assessment process, but through their metacognition, critical thinking, and collaboration, they also

experienced the art and science of creating their own sets of artifacts to support their future digital didactics (Perri, 2018).

2.4 Data analysis

The data analysis adopted the 7-pointed Likert scale from Bhandari and Nikolopoulou (2023). Likert scales are most useful when you are measuring unobservable individual characteristics like attitudes, feelings, or opinions that cause variations in behaviours on either ordinal-level or interval-level data even though most Likert-derived data is treated as ordinal: with the assumption that there is not an equal distance between responses (Bhandari & Nikolopoulou, 2023). The four scales were satisfaction, reflection, priority, and quality as seen in Table 1.

Table 1. Seven-Point Likert scale

Satisfaction	**Reflection of me**
Very dissatisfied (VD)	Very untrue of me (VU)
Dissatisfied (D)	Untrue of me (U)
Slightly dissatisfied (SD)	Somehow untrue of me (SU)
Neutral (N)	Neutral (N)
Slightly satisfied (SS)	Somehow true of me (ST)
Satisfied (S)	True of me (T)
Very satisfied (VS)	Very true of me (VT)
Priority	**Quality**
Not a priority (NP)	Very poor (VP)
Low priority (LP)	Poor (P)
Somehow a priority (SP)	Below average (BA)
Neutral (N)	Average (A)
Moderate priority (MP)	Above average (AA)
High priority (HP)	Good (G)
Essential priority (EP)	Excellent (E)

In Table 1, four different 7-point Likert scales commonly comprise seven options, called response anchors. The midpoint is the neutral item, with positive options on the right side, and negative options on the left. Each item is scored 1 to 7 to correspond with the assessment scores of 'D', 'D+', 'C', 'C+', 'B', 'B+', and 'A'. The four scales also represent the planning and design for assessment (*satisfaction*), teaching and learning of assessment (*reflection of me*), diagnostic assessment as and through learning (*priority*), formative assessment of learning (*quality*), and assessment of the virtual class (*satisfaction*) (Bhandari & Nikolopoulou, 2023).

The Likert-derived data as ordinal had categories that were presented in a ranking order such as 1 for 'very satisfied', 2 for 'dissatisfied', 3 for ''slightly dissatisfied', 4 for 'neutral', 5 for 'slightly satisfied', 6 for 'satisfied', and 7 for 'very satisfied'. However, the distances between the categories cannot be presumed to be equal. Treating Likert-derived data helps one to use descriptive statistics to summarize the data collected in simple numerical or visual form (Bhandari & Nikolopoulou, 2023).

In qualitative data, content analysis is best suited to analyze large volumes of textual or visual data collected from surveys, literature reviews, or other sources. The most appropriate descriptive statistics are medians (ordinal), modes (nominal), Spearman's correlations, and chi-square tests. The medians and modes generally were used as the measure of central tendency and Spearman's correlations and chi-square tests for independence (Bhandari & Nikolopoulou, 2023). The median is greater than the mode in the positively skewed dataset and less than the mode in the negatively skewed dataset.

Correlation coefficients measure the degree to which two variables are interdependent or linearly related. Thus, correlation coefficients of 1.0-0.8 mean very strong positive, 0.8-0.6 is strongly positive, 0.6-0.4 is moderately positive, 0.4-0.2 is weak correlation, 0.2-0.0 is very weak, and 0.0 is no correlation. On the left-hand side, correlation coefficients of 0.0 to -0.2 mean very weak negative, -0.2 to -0.4 is weakly negative, -0.4 to -0.6 is moderately negative, -0.6 to -0.8 is negative strong, and -0.8 to -1.0 is very strong negative correlations (Bhandari & Nikolopoulou, 2023; Hegedus et al., 2016).

In the Chi-square test, if the X^2 value is greater than the critical value, then the difference between the observed and expected distributions is statistically significant ($p < \alpha$). Then we reject the null hypothesis

that the variables are unrelated and provide support for the alternative hypothesis that the variables are related. But if the X^2 value is less than the critical value, then the difference between the observed and expected distributions is not statistically significant ($p > \alpha$). Then we do not reject the null hypothesis that the variables are unrelated and do not provide support for the alternative hypothesis that the variables are related (Turney, 2023).

2.5 Ethical considerations

This study followed the basic ethical principles (honesty; openness; orderliness; consideration; impartiality). To conduct the study, permission from the participants was necessary. The participants were informed orally about the content of the study, in class before the data collection. In all cases, the researchers were not only dependent on permission from the student-teachers but also followed the UN Convention on the Rights of the Child. So, it was necessary to explain the purpose of our presence and to obtain approval from the student-teachers. All student-teachers approved the study except those who were absent from class.

Our role as participatory observers could be described as adults in the classroom without responsibilities. The study was overt and the student-teachers were informed of the intentions of the study and our role as researchers in the room. However, as responsible adults, there could have been situations in which we had to consider how to act in overhearing that student-teachers downloaded obscene, pornographic, or other unacceptable materials from the internet. In such cases, we helped to avert the ethical principles of harm to participants.

During the participatory observations, we had always availed ourselves of the class and face-to-face sessions and no situations occurred in which we had to abstain from classes. However, there were situations where we undertook video recordings in many circumstances unproblematic. In these cases, the researchers were not only dependent on permission from the student-teachers but must also follow the UN Convention on the Rights of the Child. So, it was necessary to explain the purpose of our presence and to obtain approval from them. All of them were approved except truant and absentee ones.

Another aspect is whether there was an invasion of privacy linked to informed consent, in that the student-teachers must have a detailed understanding of what participation in the research was likely to entail. The ethics of confidentiality state that the identities and records of individuals should be maintained as confidential (Kjellsdotter, 2020). During our presence, we obtained information concerning student-teachers that were not of interest to the research study.

3. Results & Discussions

In section, the researcher has analysed the research questions with the types of 7-point Likert Scale. Each table contains 10 items. The four scales also represent the planning and design for assessment (*satisfaction*), teaching and learning of assessment (*reflection of me*), diagnostic assessment as and through learning (*priority*), formative assessment of learning (*quality*), and assessment of the virtual class (*satisfaction*)

Table 2. Satisfaction with planning and design for assessment

Statement	VD	D	SD	N	SS	S	VS	N	Median	Mode
1. How satisfied are you with the new lesson plan format?	8	7	7	6	5	4	3	40	6	7
2. How satisfied are you with all the tools in the plan?	6	7	8	6	6	4	3	40	6	6
3. How satisfied are you with all the instruments in the plan?	7	6	7	6	7	4	3	40	6	7
4. How satisfied are you with the laboratory for assessments?	7	8	9	6	5	3	2	40	6	--
5. How satisfied are you with all the computers in the lab?	6	8	7	6	6	4	3	40	6	6
6. How satisfied are you with all the software in the lab?	8	7	6	6	6	4	3	40	6	6
7. How satisfied are you with all Indigenous artifacts in the lab?	7	8	8	6	5	3	3	40	6	8
8. How satisfied are you with all the arrangements in the lab?	7	7	7	6	6	4	3	40	6	7
9. I am willing to set up my virtual laboratory	9	6	7	6	6	3	3	40	6	6
10. I will continue to use the laboratory	9	8	8	6	5	2	2	40	6	8

The results in Table 2 were observed and recorded through the activities analyzed and tested during the class sessions that the use of digital didactics improves curricular planning and design of the assessment process. A noteworthy fact is that the participants had the same level of slight satisfaction (Median = 5.7) in knowledge, skills, and competencies to set up and develop the assessment activities.

This shows that planning and designing pictures from search engines, identifying class features, and drawing up a teaching strategy for incorporating class, printing, dissemination, and implementation were not of much a challenge. However, the seemingly mild differences of the mode in new lesson plans/instruments/arrangements (Mode = 7), laboratory assessments (no mode), and Indigenous artifacts/use of laboratory (Mode = 8) mean the data was negatively skewed and required further investigations to determine their relationships.

Table 3. Correlation of satisfaction with planning and design

	VD	*D*	*SD*	*N*	*SS*	*S*	*VS*
VD	1						
D	0.75	1					
SD	-0.06	0.13	1				
N	0	-0.08	-0.29	1			
SS	-0.65	-0.78	0.22	0.29	1		
S	-0.48	-0.21	-0.46	-0.40	-0.20	1	
VS	-0.77	-0.88	-0.35	0	0.49	0.45	1

In Table 3, each cell in the table shows the correlation between two specific variables. The highlighted cells show a correlation between “D and VD is 0.75, indicating that they are strongly positively correlated. So ‘dissatisfaction’ in online planning and design of assessments is strongly related to ‘VD’. On the other hand, SS and VD, SD and VD, SS and D, and SD and D show strongly negative correlations.

This indicates that the more student-teachers are strongly satisfied, the less they are ‘very dissatisfied’ or ‘dissatisfied’. The more they are ‘very satisfied’, the less they are either strongly ‘dissatisfied’ or ‘slightly satisfied’. All other correlations show either positive or negative ‘weak’ and ‘very weak’ relationships.

Table 4. Chi-square coefficients of satisfaction with planning and design

Item	**VD**	**D**	**SD**	**N**	**SS**	**S**	**VS**
1	0.004678	0.008151	0.008151	0.014306	0.025347	0.0455	0.083265
2	0.014306	0.008151	0.004678	0.014306	0.014306	0.0455	0.083265
3	0.008151	0.014306	0.008151	0.014306	0.008151	0.0455	0.083265
4	0.008151	0.004678	0.0027	0.014306	0.025347	0.083265	0.157299
5	0.014306	0.004678	0.008151	0.014306	0.014306	0.0455	0.083265
6	0.004678	0.008151	0.014306	0.014306	0.014306	0.0455	0.083265
7	0.008151	0.004678	0.004678	0.014306	0.025347	0.083265	0.083265
8	0.008151	0.008151	0.008151	0.014306	0.014306	0.0455	0.083265
9	0.0027	0.014306	0.008151	0.014306	0.014306	0.083265	0.083265
10	0.0027	0.004678	0.004678	0.014306	0.025347	0.157299	0.157299

In Table 4, the expected counts show similarities in levels of satisfaction. We discover that in the expected table each level proportion of 0.008151 of items 3, 4, 7, and 8 favour VD. No item was indifferent. Therefore, the null hypothesis was rejected, and we concluded that there are associations among the variables.

In Table 5, the results show how the participants produced didactic resources using digital didactics technology. It was revealed that participants had the same reflections of ‘somehow true’ (Median = 6) and mode = 6) on the Likert scale. The varied items were recorded in 11 (I know all three forms of assessment in the virtual class), 14 (All the forms of assessment yield different outcomes), 15 (Formative assessment is the best form), 16 (Summative assessment is the best form), 18 (Assessment as learning is the best) and 19 (Assessment for learning is the best).

Table 5. Reflection on Teaching and Learning of Assessment

Statement	VU	U	SU	N	ST	T	VT	N	Median	Mode
11. I know all three forms of assessment in the virtual class	8	7	7	6	6	4	2	40	6	7
12. I use all the three forms of assessment in the virtual class	6	6	7	6	7	4	4	40	6	6
13. All the forms of assessment yield the same outcomes	5	6	8	6	7	4	4	40	6	6
14. All the forms of assessment yield different outcomes	8	7	6	7	6	3	3	40	6	7
15. Formative assessment is the best form	7	7	8	6	6	3	3	40	6	7
16. Summative assessment is the best form	5	6	7	7	7	4	4	40	6	7
17. Diagnostics assessment is the best form	5	6	6	6	6	6	5	40	6	6
18. Assessment as learning is the best	8	7	7	6	5	4	3	40	6	7
19. Assessment for learning is the best	7	8	7	6	5	5	2	40	6	7
20. Assessment of learning is the best	6	6	6	6	6	5	5	40	6	6

The results showed that as many as seven items had different modes. These differences demand further analysis to determine the true relationships among the items.

Table 6. Correlation of the reflections in teaching and learning

	VU	*U*	*SU*	*N*	*ST*	*T*	*VT*
VU	1						
U	0.76	1					
SU	-0.08	0.14	1				
N	0.06	-0.10	-0.28	1			
ST	-0.73	-0.76	0.23	0.41	1		
T	-0.50	-0.23	-0.45	-0.45	-0.18	1	
VT	-0.71	-0.93	-0.38	-0.07	0.53	0.49	1

In Table 6, the highlighted cells show a correlation between “U and VU is 0.76, indicating that they are strongly positively correlated. So ‘untrue’ is strongly related to ‘very untrue’. On the other hand, ST and VU, ST and U, VT, and VU, and VT and U show strongly negative correlations, indicating that the more student-teachers strongly ‘reflected’, the less they are ‘very untrue’ or ‘untrue’.

The results show that the more they are ‘very true’, the less they are either strongly ‘untrue’ or ‘very untrue’. All other correlations show moderate to mild positive or negative ‘weak’ and ‘very weak’ relationships.

Table 7. Chi-square coefficients of the reflections in teaching and learning

item	*VU*	*U*	*SU*	*N*	*ST*	*T*	*VT*
11	3.53183E-14	1.55E-15	1.55E-15	3.9E-17	3.9E-17	1.8E-21	3.5E-29
12	3.90314E-17	3.9E-17	1.55E-15	3.9E-17	1.55E-15	1.8E-21	1.8E-21
13	4.59343E-19	3.9E-17	3.53E-14	3.9E-17	1.55E-15	1.8E-21	1.8E-21
14	3.53183E-14	1.55E-15	3.9E-17	1.55E-15	3.9E-17	1.23E-24	1.23E-24
15	1.55066E-15	1.55E-15	3.53E-14	3.9E-17	3.9E-17	1.23E-24	1.23E-24
16	4.59343E-19	3.9E-17	1.55E-15	1.55E-15	1.55E-15	1.8E-21	1.8E-21
17	4.59343E-19	3.9E-17	3.9E-17	3.9E-17	3.9E-17	3.9E-17	4.59E-19
18	3.53183E-14	1.55E-15	1.55E-15	3.9E-17	4.59E-19	1.8E-21	1.23E-24
19	1.55066E-15	3.53E-14	1.55E-15	3.9E-17	4.59E-19	4.59E-19	3.5E-29
20	3.90314E-17	3.9E-17	3.9E-17	3.9E-17	3.9E-17	4.59E-19	4.59E-19

In Table 7, the sample counts show similarities in levels of reflection. We discovered that no item was indifferent. Every item has two or more similar counts of the levels of reflection. Therefore, the null hypothesis was rejected, and we concluded that there are associations among the variables.

Table 8. Priority on diagnostic assessment as and through learning

Statement	NP	LP	SP	N	MP	HP	EP	N	Median	Mode
21. Assessment as learning is summative	4	5	6	7	8	7	3	40	6	7
22. Assessment as learning is formative	3	5	6	7	8	7	4	40	6	7
23. Assessment as learning is diagnostic	4	6	5	7	8	7	3	40	6	7
24. Assessment for learning is summative	3	5	7	6	8	7	4	40	6	7
25. Assessment for learning is formative	6	5	5	6	8	7	3	40	6	6
26. Assessment for learning is diagnostic	7	5	6	6	7	6	3	40	6	6
27. Assessment as and for learning are summative	3	4	5	6	8	7	7	40	6	7
28. Assessment as and for learning is formative	6	7	6	7	5	5	4	40	6	6
29. Assessment as and for learning are learner-centred	5	5	6	7	7	7	3	40	6	7
30. Assessment as and for learning are teacher-centred	4	4	5	7	8	9	3	40	5	4

In Table 8, the participants had the same moderate priority (Median = 6) except item 30 (Median = 5). Only three items had the same mode (Mode = 6) as the median, as many as five items had a mode more than the median (Mode = 7) and only one item had a mode less than the median (Mode = 4). In these assessment sessions, student-teachers utilized many skills of digital didactics to discover, create, and innovate artifacts from the LMS class. This helped them not only learn to teach but also to assess themselves in the process of teaching, learning, and assessment.

The results show that over 70% differences between the median and the mode failed to confirm the statement that 'Assessment as and for learning is teacher-centred' but prioritized that 'Assessment as and for learning is learner-centred'. This is a positive priority for online assessment.

Table 9. Correlation of the priorities in and through learning

	NP	*LP*	*SP*	*N*	*MP*	*HP*	*EP*
NP	1						
LP	0.40	1					
SP	-0.06	0.24	1				
N	-0.15	0.34	-0.06	1			
MP	-0.60	-0.72	-0.25	-0.22	1		
HP	-0.51	-0.75	-0.38	0.13	0.75	1	
EP	-0.46	-0.27	-0.12	-0.38	0.05	-0.12	1

In Table 9, the highlighted cells show a correlation between "HP'' and 'MP' is 0.75, indicating that they are strongly positively correlated. So 'high priority' is strongly related to moderate priority'. On the other hand, 'MP' and NP', 'MP' and 'LP', and 'HP' and 'LP' show strongly negative correlations. All other correlations show moderate to mild positive or negative 'weak' and 'very weak' relationships.

Table 10. Chi-square coefficients of priorities in as and through learning

Item	*NP*	*LP*	*SP*	*N*	*MP*	*HP*	*EP*
21	1.79612E-21	4.59E-19	3.9E-17	1.55E-15	3.53E-14	1.55E-15	1.23E-24
22	1.23E-24	4.59E-19	3.9E-17	1.55E-15	3.53E-14	1.55E-15	1.8E-21
23	1.79612E-21	3.9E-17	4.59E-19	1.55E-15	3.53E-14	1.55E-15	1.23E-24
24	1.23E-24	4.59E-19	1.55E-15	3.9E-17	3.53E-14	1.55E-15	1.8E-21
35	3.90314E-17	4.59E-19	4.59E-19	3.9E-17	3.53E-14	1.55E-15	1.23E-24
26	1.55066E-15	4.59E-19	3.9E-17	3.9E-17	1.55E-15	3.9E-17	1.23E-24
27	1.23E-24	1.8E-21	4.59E-19	3.9E-17	3.53E-14	1.55E-15	1.55E-15
28	3.90314E-17	1.55E-15	3.9E-17	1.55E-15	4.59E-19	4.59E-19	1.8E-21
29	4.59343E-19	4.59E-19	3.9E-17	1.55E-15	1.55E-15	1.55E-15	1.23E-24
30	1.79612E-21	1.8E-21	4.59E-19	1.55E-15	3.53E-14	5.26E-13	1.23E-24

In Table 10, the sample counts show similarities in levels of reflection. We discovered that no item was indifferent. Every item has two or more similar counts of the levels of priority. Therefore, the null hypothesis was rejected and concluded that there are associations among the variables.

Table 11. Quality of formative assessment of learning

Statement	VP	P	BA	A	AA	G	E	N	Median	Mode
31. I provided all the responses to the mathematics tasks	9	8	7	5	5	4	2	40	5	5
32. I provided all the responses to the mathematics tools	8	8	8	5	5	4	2	40	5	8
33. I provided all responses to the mathematics instruments	8	8	7	6	5	4	2	40	6	8
34. I provided all responses to the mathematics artifacts	8	8	7	5	5	5	2	40	5	5
35. I provided all responses to the mathematics symbols	8	8	7	5	5	4	3	40	5	8
36. I created all the responses to the mathematics graphs	7	8	8	6	5	4	2	40	6	8
37. I created all the responses to the mathematics charts	7	8	7	6	6	4	2	40	6	7
38. I created all the responses to the mathematics formulas	8	8	7	5	6	4	2	40	6	8
39. I created all responses to the mathematics personalities	9	7	7	6	5	4	2	40	6	7
40. I created all responses to the mathematics organizations	9	7	7	5	5	4	3	40	5	7

In Table 11, 50% of the participants agreed that the quality of online formative assessment was above average and another 50% agreed that formative assessments were below average (Median = 5). However, only items 31 (I provided all the responses to the mathematics tasks) and 34 (I provided all responses to the mathematics artifacts) recorded the same mode as the median of the five items. The rest of the eight items either recorded modes of 7 or 8 and above their respective medians.

The results show that many more student-teachers developed their critical thinking as well as were greatly motivated after participating in using the mathematics symbols. Hence, they were prepared to imbibe digital didactics from their culture to enhance the teaching and learning of mathematics.

Table 12. Correlations between the qualities in formative assessment

	VP	P	BA	A	AA	G	E
VP	1						
P	-0.64	1					
BA	-0.43	0.25	1				
A	-0.41	-0.10	0.10	1			
AA	-0.43	0.25	-0.25	0.10	1		
G	-0.05	0.17	-0.17	-0.27	-0.17	1	
E	0.29	-0.38	-0.25	-0.41	-0.25	-0.17	1

In Table 12, the highlighted cells show a correlation between "P'' and 'VP' is -0.64, indicating that they are strongly negatively correlated. So 'poor quality' is NOT related to 'very poor quality'. All other correlations show 'moderate' to 'mild positive or negative 'weak' and 'very weak' relationships.

Table 13. Chi-square coefficients of the qualities in formative assessment

Item	*VP*	*P*	*BA*	*A*	*AA*	*G*	*E*
31	5.26E-13	3.53E-14	1.55E-15	4.59E-19	4.59E-19	1.8E-21	3.5E-29
32	3.53E-14	3.53E-14	3.53E-14	4.59E-19	4.59E-19	1.8E-21	3.5E-29
33	3.53E-14	3.53E-14	1.55E-15	3.9E-17	4.59E-19	1.8E-21	3.5E-29
34	3.53E-14	3.53E-14	1.55E-15	4.59E-19	4.59E-19	4.59E-19	3.5E-29
35	3.53E-14	3.53E-14	1.55E-15	4.59E-19	4.59E-19	1.8E-21	1.23E-24
36	1.55E-15	3.53E-14	3.53E-14	3.9E-17	4.59E-19	1.8E-21	3.5E-29
37	1.55E-15	3.53E-14	1.55E-15	3.9E-17	3.9E-17	1.8E-21	3.5E-29
38	3.53E-14	3.53E-14	1.55E-15	4.59E-19	3.9E-17	1.8E-21	3.5E-29
39	5.26E-13	1.55E-15	1.55E-15	3.9E-17	4.59E-19	1.8E-21	3.5E-29
40	5.26E-13	1.55E-15	1.55E-15	4.59E-19	4.59E-19	1.8E-21	1.23E-24

In Table 13, the sample counts show similarities in levels of quality. We discovered that no item was indifferent. Every item has two or more similar counts of the levels of reflection. Therefore, the null hypothesis was rejected, and we concluded that there are associations among the variables.

Table 14. Satisfaction with assessment of the virtual class

Statement	VD	D	SD	N	SS	S	VS	N	Median	Mode
41. I can now attend all lectures in virtual mathematics class	8	8	7	6	5	4	2	40	6	8
42. I can now access all lectures in the virtual mathematics class	8	8	7	6	5	3	3	40	6	8
43. I can now download all apps on virtual mathematics class	9	7	7	5	6	4	2	40	6	7
44. I can now transfer all apps to a virtual mathematics class	7	8	8	5	5	4	3	40	5	8
45. I can now subscribe to all the apps on virtual mathematics	7	9	7	5	5	4	3	40	5	7
46. I can now subscribe to all blogs on virtual mathematics	8	9	7	5	5	4	2	40	5	5
47. I can now work on all mathematics software applications	7	9	8	5	5	4	2	40	5	5
48. I can submit my work on mathematics software applications	7	8	9	5	5	4	2	40	5	5
49. I can now score task sheets of virtual users in mathematics	8	8	7	5	5	5	2	40	5	5
50. I can now rate the best online mathematics portals/blogs	8	8	7	5	5	5	2	40	5	5

In Table 14, seven of the items had the same level of satisfaction with online assessment with the virtual class (Median = 5), and only three with a median of 6. However, only five items recorded the same mode (Mode = 5) as their respective medians. The other five items recorded modes (Mode = 7 or 8) greater than their respective medians. This means the student-teachers stood in favour of the assessment of the online virtual class. The applications of mathematics software, apps, blogs, and portals were the brains behind their satisfaction.

Table 15. Correlations Between the satisfactions with an Assessment of Virtual Class

	VD	D	SD	N	SS	S	VS
VD	1						
D	-0.62	1					
SD	-0.66	0.05	1				
N	0.23	-0.17	-0.30	1			
SS	0.68	-0.67	-0.20	-0.17	1		
S	0.09	-0.06	-0.11	-0.56	-0.06	1	
VS	-0.37	0.15	-0.07	0.22	-0.22	-0.53	1

In Table 15, the correlation between “SS and VD’’ is 0.68, indicating that they are strongly positively correlated. So ‘slight satisfaction’ is strongly related to ‘Very Dissatisfied’. On the other hand, SS and VD, SD and VD, SS and D, and SD and D show strongly negative correlations to indicate that the more student-teachers are strongly satisfied, the less they are ‘very dissatisfied’ or dissatisfied. The more they are ‘very satisfied, the less they are either strongly ‘dissatisfied or ‘slightly satisfied. All other correlations show either positive or negative ‘weak’ and ‘very weak’ relationships.

Table 16. Chi-square coefficients of the satisfaction with assessment of virtual class

Item	VD	D	SD	N	SS	S	VS
41	5.26E-13	3.53E-14	1.55E-15	4.59E-19	4.59E-19	1.8E-21	3.5E-29
42	3.53E-14	3.53E-14	3.53E-14	4.59E-19	4.59E-19	1.8E-21	3.5E-29
43	3.53E-14	3.53E-14	1.55E-15	3.9E-17	4.59E-19	1.8E-21	3.5E-29
44	3.53E-14	3.53E-14	1.55E-15	4.59E-19	4.59E-19	4.59E-19	3.5E-29
45	3.53E-14	3.53E-14	1.55E-15	4.59E-19	4.59E-19	1.8E-21	1.23E-24
46	1.55E-15	3.53E-14	3.53E-14	3.9E-17	4.59E-19	1.8E-21	3.5E-29
47	1.55E-15	3.53E-14	1.55E-15	3.9E-17	3.9E-17	1.8E-21	3.5E-29
48	3.53E-14	3.53E-14	1.55E-15	4.59E-19	3.9E-17	1.8E-21	3.5E-29
49	5.26E-13	1.55E-15	1.55E-15	3.9E-17	4.59E-19	1.8E-21	3.5E-29
50	5.26E-13	1.55E-15	1.55E-15	4.59E-19	4.59E-19	1.8E-21	1.23E-24

In Table 15, the sample counts show similarities in levels of satisfaction. We discovered that no item was indifferent. Therefore, the null hypothesis was rejected, and we concluded that there are associations among the variables.

3.2 Discussions

Ethnomathematics assessment of the online digital didactics has enabled the participants to examine the role of local artifacts and systems in the mathematics assessment (Abah et al., 2021). Prahmana and D'Ambrosio (2020) found that the rich and diverse culture in Indonesia has improved the mathematics education system through students' reality and culture. This was evident right from the demonstrative phase, the participants used local knowledge on their initial diagnosis, formative intermediate analysis, and final test. This helped them to transition into the discussion, discovery, and demonstration of the university LMS software (Perri, 2018).

COVID-19 provided us the opportunity to explore more digital didactics lessons (Ali & Akayuure). The didactics-dialectics and classical didactics refocus on didactics fields, theories, frameworks, and models for teaching and learning (McLaughlin, 2018. These findings further epitomized quality innovations digital didactics add to the assessment of mathematics instruction. This contributes significantly and immensely to the theoretical, methodological, and practical knowledge of didactics of mathematics in the Sociocultural Framework for Understanding Technology Integration (Jackson, 2017).

The framework enabled student-teachers to interact between societal and environmental factors within and outside of the classroom (Lütge & Merse, 2020**)**. In particular, the Zone of Proximal Development efficiently bridged the gap between the current and potential capabilities that can be traversed with appropriate support (Kjellsdotter, 2020).

Four scales represented planning and design for assessment (*satisfaction*), teaching and learning of assessment (*reflection of me*), diagnostic assessment as and through learning (*priority*), formative assessment of learning (*quality*), and assessment of the virtual class (*satisfaction*) (Bhandari & Nikolopoulou, 2023). The medians (ordinal) predominantly pooled 6 while the modes (nominal) pooled 5,6,7, and 8 (multimodal). Half of the student-teachers marked below 6 and another half marked above 6 for satisfaction, reflection, priority, and quality of digital didactics. But the majority of them scored either 5, 6, 7, or 8 as their predominant determiner of digital didactics and this raised concerns. In cases where the median (6) is greater than the mode (5) then we have a positively skewed dataset and less than the mode (7 or 8), we have negative skewness (Bhandari & Nikolopoulou, 2023).

The Spearman's correlation coefficients efficiently and effectively measured the interdependences or linearly relationships in planning and design (*satisfaction*), teaching and learning (*reflection of me*), as and through learning (*priority*), formative assessment (*quality*), and assessment of the virtual class (*satisfaction*). The findings showed that only one positive strong correlation was recorded in these variables, and two to three strong negative correlations were recorded in the four variables except formative assessment of learning (*quality*). However, all other correlations showed weak relationships (Bhandari & Nikolopoulou, 2023). These were further subjected to Chi-square tests for independence.

The chi-square tests for independence showed the differences in the planning and design for assessment (*satisfaction*), teaching and learning of assessment (*reflection of me*), diagnostic assessment as and through learning (*priority*), formative assessment of learning (*quality*), and assessment of the virtual class (*satisfaction*), every item has two or more similar counts of the levels of reflection. So, many of the variables were interrelated. The null hypothesis was rejected, and we concluded that there were associations among the variables (Turney, 2023). Whether weak or strong, the fact remains that qualitative digital didactics positions mathematics teaching, learning, and assessment in modern theory, methodology, and applications to real life.

4. Conclusion

The results of the medians and modes show that digital didactics, as an innovation in the assessment of mathematics instruction, was the central point for the design and use of teaching and learning. Therefore, digital didactics should be used to innovate mathematics instruction and motivate learning. Particularly, student-teachers need the model to plan and produce their instructional designs for teaching and learning.

Secondly, the results of the correlations and chi-square show that digital didactics allowed for the development of knowledge, skills, and competencies in promoting collaborative learning, group discussion, independent innovation, and problem-solving. Student-teachers need involvement, collaboration, and synergy to extend their knowledge and skills in digital didactics.

Again, the results show that student-teachers performed their activities and generated innovative ideas and problem-solving skills. Therefore, they should be allowed to explore varied online resources necessary for propelling the principles of assessment, in both formative and summative forms and all facets of assessment criteria.

References

Abah, J. A., Iji, C. O., Abakpa, B. O., & Anyagh, P. I. (2021). Design, Implementation, and Assessment of a Web-Based Ethnomathematics Instructional Content Repository for Mathematics Teachers in Benue State, Nigeria. Journal of Mathematics and Science Teacher, 1(1), em002. https://doi.org/10.29333/mathsciteacher/11075

Ali, C. A., & Akayuure, P. (2021). Didactics has Evolved to Digital Age Didactics. *2nd edition of the International Conference on Teaching, Assessment, and Learning in the Digital Age*. Durban, South Africa, 2 – 3 December 2021.

Amit, M. (2023). The Importance of Ethnomathematics Education. *Creative Education, 14*, 729-740. https://doi.org/10.4236/ce.2023.144048

Bhandari, P. & Nikolopoulou, K. (2023). *What is a Likert Scale? Guide & Examples*. Scribbr. Retrieved May 20, 2024, from https://www.scribbr.com/methodology/likert-scale/

Chahine, I. C. (2020). Towards African humanicity: Re-mythologising ubuntu through reflections on the ethnomathematics of African cultures. *Critical Studies in Teaching and Learning, 8*(2), 95–111. https://doi.org/10.14426/cristal.v8i2.251

Drijvers, P. (2019). Digital assessment of mathematics: Opportunities, issues, and criteria. *Évaluation et didactique des mathématiques: vers de nouvelles questions, de nouveaux travaux*. https://doi.org/10.7202/1055896

Fouze, A. and Amit, M. (2023). The Importance of Ethnomathematics Education. *Creative Education*, *14*, 729-740. https://doi.org/10.4236/ce.2023.144048.

Ginting, S. S. B. & Hasibuan, A. R. (2024). Ethnomathematics in Serampang XII Dance by Deli Malay Ethnic Group: An Exploration. Unnes Journal of Mathematics Education, 13(2), 115-123. https://doi.org/10.15294/5bprs844

Hegedus, S. J., Tapper, J., & Dalton, S. (2016). Exploring how teacher-related factors relate to student achievement in learning advanced algebra in technology-enhanced classrooms. *Journal of Mathematics Teacher Education, 19*(1), 7–32. https://doi.org/10.1007/s10857-014-9292-5

Hernández-Carranza, E.-E., Romero-Corella, S.-E., & Ramírez-Montoya, M.-S. (2015). Evaluation of Digital Didactic Skills in Massive Open Online Courses: a Contribution to the Latin American Movement. *Media Education Research Journal, 44*(22), 81-89. https://doi.org/10.3916/C44-2015-09

Jackson, M. (2017). Integration of ICT in the Mathematics Classroom. *Journal of Initial Teacher Inquiry, 3*(1), 90-93. Available at Inquiry_2017_PUBLISHED-23.pdf.

Joshi, D. R., Adhikari, K. P., Khanal, J., Belbase, S., & Khanal, B. (2023). Developing and integrating digital resources in online mathematics instruction and assessment during COVID-19. *Cogent Education, 10*(2). https://doi.org/10.1080/2331186X.2023.2230394

Kjellsdotter, K. (2020). Didactical Considerations in the Digitalized Classroom. Gothenburg University: *Gothenburg Studies in Educational Sciences 448*. Retrieved from https://gupea.ub.gu.se/handle/2077/63174

Lütge, C., & Merse, T. (2020). *Digital Teaching and Learning: Perspectives for English Language Education*. Narr Franckie: Germany, available at https://www.narr.de/digital-teaching-and-learning-perspectives-for-english-language-educa-18244/.

McLaughlin, C. (2018). *What is digital education*? The University of Edinburg: Russell Group. Available at https://www.ed.ac.uk/.

Ministry of Education (2020). *Mathematics Common Core Programme Curriculum (Basic 7 - 10)*. Accra: National Council for Curriculum and Assessment (NaCCA). Retrieved from https://curriculum.nacca.gov.gh/wp-content/uploads/2020/02/MATHEMATICS-CCP-CURRICULUM-B7- B10-DRAFT-ZERO.pdf

Perri, F. (2018). *Digital Didactics*: *An Introductory Training Course for Teachers*. ResearchGate. Retrieved from https://www.researchgate.net/publication/323890180.

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning geometry and values from patterns: Ethnomathematics on the batik patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education, 11*(3), 439–456. https://doi.org/10.22342/jme.11.3.12949.439-456

Turney, S. (2023). *Chi-Square Test of Independence, Formula, Guide & Examples*. Scribbr. Retrieved from https://www.scribbr.com/statistics/chi-square-test-of-independence/

Valsiner, J. (1997). *Culture and the development of children's action: A theory of human development (2ed.)*. John Wiley & Sons Inc. Retrieved from https://psycnet.apa.org/record/1997-08922-000

Vitoria, L., Monawati, M., Fauzi, F., & Mislinawati, M. (2021). Assessing the Effect of an Ethnomathematics Teaching Material on Students' Understanding of Mathematics. *Jurnal Pendidkan dan Pembelajaran, 28*(1),10-16. https://doi.org/10.17977/um047v27i12021p010