Development and Validation of a Questionnaire for Microlearning Requirements in Micro-Credentials

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ABSTRACT

The study addresses the lack of a comprehensive questionnaire for designing effective micro-credential programs in Malaysian higher education. The study aimed to develop and validate a questionnaire to identify microlearning design requirements for micro-credentials. To achieve this, the questionnaire underwent validation through both exploratory factor analysis (EFA) and quantitative analysis. The study involved 48 participants who were micro-credential developers from a public higher education institution in Malaysia. These participants represented various designations and were affiliated with 16 different faculties. A 70-item questionnaire, initially developed based on a review of Khan's e-learning model was refined to 57 items by addressing overlaps and removing elements deemed inadequate. EFA identified 14 factors onto which 57 items exhibited high-loading, explaining 85.55% of the variance. The 57-item questionnaire demonstrated favourable multifaceted qualities. An expert panel confirmed the questionnaire's content validity, identifying six significant dimensions: pedagogical, technological, evaluation, management, resources support, and institutional. These six main constructs provided a framework for understanding microlearning design requirements essential for developing effective micro-credentials. By addressing the multifaceted requirements of microlearning design, this questionnaire has the potential to enhance the overall quality and effectiveness of micro-credential programs in the Malaysian higher education landscape and beyond.

Keywords: microlearning, micro-credential, higher education institution, exploratory factor analysis, questionnaire development

INTRODUCTION

Due to the increasing need to equip graduating students and employees with employable skills to adapt to rapid workplace changes, there has been a growing demand for systematic provision of such skills. Micro-credentials are compact digital credentials that recognise competencies and skills acquired through formal and informal learning, serving as a representation of learner achievements. They prepare learners for career pathways that align with employer demands [1]. These certifications access knowledge, skills and competencies in specific areas or fields, and they can also be a part of accredited programs or offered as stand-alone courses, supporting professional, technical, academic, and personal development [2]. In addition, micro-credentials offer learners the ability to earn certifications in shorter periods of time, while also allowing for greater customisation of educational experience, as exemplified by major MOOC platforms such as edX, Udacity, Coursera, FutureLearn. As a result, micro-credentialing has gained momentum due to its flexibility, affordability, marketability, and on-demand modules [3,4]. Micro-credentials enable businesses to fill specialised skill gaps that cannot be provided by traditional credentials, making it an ideal solution for working professionals to keep abreast with fast-paced changes in the workplace [4,5].

Moreover, the emergence of micro-credentials has facilitated microlearning, a stand-alone learning unit that delivers high-impact, complementary, engaging and interactive learning experiences through small digital

learning units or chunks [6,7]. These microlearning units can be delivered through various modalities which range from a few seconds up to 20 minutes or even an hour in some cases and can encompass different educational approaches [8]. As a result, microlearning has become an essential component of many online learning platforms, providing learners with a variety of learning materials in bite-sized pieces that can be easily consumed and integrated into their daily routine [6, 9].

Microlearning offers promising solutions to address the evolving needs of learners and employers, however there remains a pressing need to understand the specific requirements for designing effective microlearning experiences. With remote learning becoming the new norm or at least a significant feature for many educational institutions, it is becoming increasingly important to develop effective tools and strategies for designing and implementing programs which involve microlearning and micro-credentials. In Malaysia for instance, micro-credentials in higher education institutions (HEIs) have only recently emerged as the Malaysian Qualification Agency (MQA) only formally accredited micro-credentials in 2019. Consequently, there has been limited research conducted on its implementation [10, 11]. This early stage presents a unique opportunity to explore the integration of microlearning as a foundational element for developing robust micro-credential frameworks within the Malaysian context.

While a growing body of research utilises survey questionnaires to investigate microlearning in higher education [12, 13], these studies primarily focus on aspects like the effectiveness of microlearning content [14, 15], student learning strategies within microlearning environments [16], and user perception of microlearning benefits [17, 18]. Additionally, some studies explore design elements like optimal video length [18] and learner control over multimedia elements [19] to enhance engagement and effectiveness. However, there remains a significant gap concerning the comprehensive examination of design requirements and key features of microlearning tools used in content creation and delivery methods. Current literature lacks systematic evaluations of these tools, which limits our understanding of their strengths and limitations within increasingly digitised higher education environments. This gap highlights the need for research that explores the development and implementation of credentialing systems specifically designed for microlearning initiatives. This study addresses this critical gap by developing questionnaire items to comprehensively assess challenges and best practices in microlearning and micro-credential implementation, design, delivery and support specifically for higher education institutions (HEIs).

Research questions

This paper, part of a larger postgraduate design and development research (DDR) project, describes the development and validation of a questionnaire for microlearning design requirements in developing micro-credentials in Malaysian HEIs. These institutions play a significant role in enhancing employability and micro-credentials offer promising pathways for achieving this. The study address the following research questions:

1. What are the key dimensions of microlearning design requirements for the development of micro-credentials in Malaysian HEIs?

2. What are the main categories identified by developers as essential for effective micro-credentials?

3. How important do developers think different parts of teaching (pedagogical), technology, assessment (evaluation), organization (management), support materials (resource support), and the institution itself are when they are developing micro-credentials?

Significance

A validated questionnaire focused on microlearning design requirements is significant for several reasons. It provides a comprehensive and validated set of design requirements to guide the development of effective micro-learning content. This, in turn, supports the creation of micro-credentials that help learners acquire the specific competencies, skills and knowledge needed in the workforce. This pilot study is crucial as it provides preliminary validation of the questionnaire and generates specific insights into microlearning design for micro-credential; development, Contributing to more effective and targeted micro-credential programs.

LITERATURE REVIEW

The successful implementation of microlearning in micro-credentials requires addressing various challenges.

Challenges and Design Considerations in Microlearning for Credentialing

One notable challenge is microlearning for credentialing must cater to diverse and individual learner needs. Existing e-learning courses often fall short of meeting individual learner needs in terms of fragmented attention and information overload [20]. The digital generation, in particular, present new challenges in terms of attention spans [21]. To structure microlearning experiences across different learning stages, Baumgartner's Competence Spiral Model provides a framework for scaffolding learning through different stages, ranging from acquiring basic knowledge to applying knowledge to more complex scenarios [22]. In microlearning for credentialing, applying Cognitive Load Theory (CLT) principles can guide the design of micro-learning modules that minimise extraneous load (e.g., avoiding unnecessary information or complex interfaces) and optimising germane load by focusing on core concepts and encouraging problem-solving activities [23]. Designing microlearning effectively requires minimising extraneous cognitive load through efficient design, tailoring content to different learning stages and individual needs, catering to diverse learners and addressing the importance of progressive knowledge acquisition and application, and utilising diverse pedagogical approaches.

A critical challenge in implementing microlearning effectively is unequal access to technology. Students from under-resourced or remote areas may lack the necessary equipment or internet connectivity, creating unequal learning opportunities [24]. Bridging this digital divide is essential to ensure equitable access to microlearning, especially for credentialing programs. Fully utilising the functionalities of microlearning platforms, including online communication and assessment tools, becomes crucial to a more positive user experience (UX), which is essential for effective microlearning [25]. Effective microlearning experiences must prioritise UX, focusing on both accessibility and minimising friction caused by complex user interfaces in learning management systems (LMS) [25, 27]. Since poor UX can hinder the learning process, the Four Fundamental Pillars can provide essential support structures for student success in online learning environments [28].

Implementing microlearning in micro-credentials also necessitates a pivot towards competency-based approaches and the unbundling of curriculums, which prioritise the mastery of specific competencies tailored to individual learner needs over the traditional completion of courses [29]. Such a shift is particularly important in the context of microlearning, where bite-size content modules are carefully designed to fulfil specific learning objectives. These focused modules align well with competency-based learning, allowing learners to develop targeted skills and knowledge essential for credentialing purposes. Heutagogical practices represent a significant departure from traditional educational models, advocating learner-directed questions, flexible and negotiated assessment, and reflective practice [30]. The development of engaging and interactive assessment strategies that goes beyond conventional testing methods is critical for realising this goal [31]. However, to ensure the credibility and value of microlearning programs and the integrity of the learning process, the implementation of rigorous quality assurance principles throughout the micro-credential lifecycle (creation, validation, operation) is imperative [32]. This necessitates clear policies from governments regarding open, distance, and e-learning (ODDE) operations [33].

Another important consideration is the need for instructor training and support. The successful implementation of microlearning in credentialing programs relies heavily on addressing the training and support needs of instructors. The proficiency of e-content developers often varies, with many facing obstacles due to limited technical skills and resources, which can impede the development of high-quality micro-credential modules [11, 34]. Instructor training and support are paramount in addressing the time-intensive nature of content creation, the complexities surrounding digital content ownership, in addition to the discomfort experienced by traditional educators transitioning to microlearning [24]. [35] highlights how instructors' limited familiarity with microlearning tools may undermine learning effectiveness by noting the complex landscape of content development, collaboration strategies, technology access, and technical issues. For training purposes, The TPACK framework [36] can serve as a point of reference because it underscores the necessity of integrating technology, pedagogy, and content knowledge to craft effective and engaging learning experiences.

Gaining institutional recognition for microlearning initiatives remains a significant hurdle. Traditional policies in companies and educational institutions often fail to acknowledge the value of online learning for professional development [37]. Despite the benefits of microlearning in theory, the practical side presents additional challenges. For instance, integrating microlearning programs with existing human resources (HR) processes, such as performance evaluations and promotions, presents additional complexities. This stems from inconsistencies in credential recognition across various providers [38, 39].

To maximise the potential of microlearning, it's important to look beyond traditional delivery models and consider how it can be thoughtfully integrated into the workplace and beyond. Recent research highlights the potential of incorporating work-integrated learning (WIL) and mobile learning (ML) into microlearning designs [40, 41] to enhance practical application and accessibility. Integrating short, targeted activities into daily routines or workplace environments can significantly enhance self-directed learning, on-the-job support, and information retention. Furthermore, while the adoption of open educational resources (OERs) increases accessibility to microlearning, adopting them within institutions faces obstacles related to awareness, incentives, quality, licensing, and sustainability [42, 43].

Identified Gaps

Past studies investigating microlearning have frequently utilised questionnaires as key assessment tools. Researches employed surveys for diverse purposes, including evaluating student motivation and learner perceptions of microlearning's effectiveness, usability and impact [44, 45, 46], assessing content usefulness, applicability, and user experience [47] , gauging student attitudes towards microlearning [48], and exploring preferences for interaction with specific microlearning elements like video controls or assessment timing [49]. These questionnaire also served pragmatic functions, such as screening instruments to identify eligible participants based on criteria like experience or familiarity with microlearning strategies [50, 51, 52].

In contrast, the questionnaire this pilot study aims to develop goes beyond evaluation – it is a validated instrument designed to define the core design requirements for developing microlearning for credentialing programs in Malaysian HEIs. It involves a systematic development process, including a literature-informed review, expert validation and exploratory factor analysis (EFA) to uncover six significant design dimensions. Unlike prior studies, which focused on learner responses, this instrument aims to guide the development process itself, offering comprehensive framework for microlearning and micro-credential program design, delivery and support in HEIs. Thus, while previous studies assessed learner-focused outcomes, the developed questionnaire provides a developer-focused blueprint for designing microlearning systems.

Justification for the New Tool

The newly developed questionnaire is essential for Malaysian HEIs as it fills a critical gap in current assessment tools by specifically targeting the design requirements for microlearning within the context of micro-credentials. Its relevance is heightened by the recent formal recognition and accreditation of micro-credentials in Malaysia [2, 39], creating an urgent need for context-specific insights. This instrument enables a focused examination of implementation challenges and best practices unique to Malaysian HE, ultimately supporting efforts to improve the quality, relevance and impact of micro-credential programs.

METHODOLOGY

Participants

This paper reports on a pilot study which aimed at uncovering the factor structure to inform a postgraduate design and development research; thus, employing a smaller sample size is deemed appropriate. This approach allows for the identification of initial factors that affect microlearning in micro-credentials, with the intention of conducting more extensive validation studies across various HEIs in Malaysia in subsequent phases. Hence, a purposive sampling method was used to identify participants from a specific population of micro-credential developers in a public higher education institution in Shah Alam, Malaysia. The criteria for inclusion were:

- The participant was a micro-credential developer from a faculty within the institution
- The participant had to be either the leader or a member of a Micro-Credential (MC) module development team
- MC module which the participant was a member of must have been completed at the time of the survey

The list of eligible participants was ethically obtained from the Person-In-Charge (PIC) of the university's continuing education institution. The pilot study sample consisted of 48 micro-credential developers.

While Exploratory Factor Analysis (EFA) is typically associated with larger sample size [53, 54, 55, 56], studies suggest under specific conditions, reliable results can be obtained even with samples smaller than 50 [53, 55]. The study's use of EFA with a smaller sample (N=48) is justified by the researchers based on several key factors, for which support is found in previous studies [53, 55].

Firstly, it is noted that compensation for a smaller sample size can be achieved through high factor loadings (≥0.8) and high communalities; indeed, reliable factor recovery has been shown by some research. Even when samples as small as N=25 are used under these conditions [53, 54, 55, 57]. Secondly, smaller samples can be rendered adequate for EFA when a low number of factors is present alongside a high ratio variables to factors (overdetermination) [53, 54]. In this study, the sample size limitation was potentially mitigated by a higher item-to-factor ratio, which was contributed to by the initial questionnaire containing 70 items (refined to 57). Lastly, the likelihood of accurate results being obtained with smaller samples is increased by a well-defined factor structure that has minimal cross-loadings [54].

Table 1. Demographic Information of the Participants.

Variable	**Frequency**
Gender	
Male	8 (16.7%)
Female	40 (83.3%)
Designation	
Lecturers	21 (43.75%)
Senior Lecturers	24 (50.0%)
Professors	3 (6.25%)
Faculties	
Academy of Contemporary Islamic Studies	1 (2.1%)
Academy of Language Studies	2 (4.2%)
College of Computing, Informatics and Media	3 (6.25%)
College of Built Environment	1 (2.1%)
College of Creative Arts	1 (2.1%)
College of Engineering	2 (4.2%)

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Faculty of Education	1 (2.1%)
Faculty of Accountancy	9 (18.75%)
Faculty of Administrative Science and Policy Studies	1 (2.1%)
Faculty of Applied Sciences	3 (6.25%)
Faculty of Business & Management	16 (33.3%)
Faculty Of Computer And Mathematical Sciences	1 (2.1%)
Faculty of Health Sciences	1 (2.1%)
Faculty of Hotel & Tourism Management	3 (6.25%)
Faculty of Pharmacy	3 (6.25%)
Faculty of Sports Science and Recreation	1 (2.1%)

Furthermore, a clearer underlying factor structure was anticipated to be contributed by the expected homogeneity of the sample, given that the micro-credential developers were sourced from a single institution [53]. Therefore, while the general preference for larger samples is recognised, the decision was made to proceed with EFA because these anticipated data characteristics are suggested by the literature to potentially yield reliable results, even when a smaller sample size is utilised.

Research Design

This pilot study precedes a larger postgraduate design and development research which aims to explore microlearning practices in the development of micro-credential modules within HEIs across Malaysia. As part of the validation process of the larger study, this pilot study aims to develop and validate a questionnaire capable of identifying the design requirements for microlearning in the context of developing micro-credentials. The research process was structured into 4 distinct phases, each contributing to the development and validation of the questionnaire designed to collect data on microlearning practices in HEIs [58]. Phases 1 and 2 developed the questionnaire while Phases 3 and 4 validated the questionnaire.

1) Phase 1: Literature Review

The items developed for the questionnaire survey were based on various literature exploring both challenges and best practices in microlearning adoption. This knowledge base provided the foundation for an investigation into how microlearning approaches can be strategically applied to develop credentialing modules for Malaysian HEPs. The literature review indicated that six dimensions of Khan's e-learning model [8, 59] can be applied to several constructs of micro-credential adoption. The first dimension is the pedagogical dimension (PD) which emphasises the need to design effective microlearning experiences that align with the goals of the micro-credential. The items for PD intend to uncover a few challenges — specifically educators' hesitation to embrace new methods [24] and the necessity to cater to the varied learning needs of students [21] and possible solutions for incorporating microlearning into the credentialing programs of Malaysia's HEPs. The items in the questionnaire under PD are also designed to identify strategies that reduce unnecessary cognitive loads and improve learning efficiency according to CLT principles [23].

The second dimension is the technological dimension (TD). Items for TD address technological challenges and opportunities of microlearning. Items under TD include recognising unequal technology access [24], enhanced engagement and collaboration, investigating user experience (UX) aspects such as accessibility and the user-friendliness of learning management systems (LMS), as well as learning outcomes [25, 27]. The integration of UX considerations leads to the evaluation of how assessments are designed and implemented within

microlearning strategies.

The third dimension, the evaluation dimension (ED) of the questionnaire, aims to capture data on how assessment practices within microlearning programs contribute to achieving educational goals and fostering critical thinking skills in learners pursuing micro-credentials. Items under ED explore the limitations of traditional assessments [60], and the use of engaging and interactive assessment strategies [31], focusing on competency-based learning [29, 60] that align with heutagogical principles [30].

Fourthly, the management dimension (MD) addresses challenges in implementing microlearning for credentialing in Malaysian higher education. Items under MD consider the time-intensive nature of content creation and limitations in e-content developer skills or resources [11, 34]. MD further delves into addressing complexities like content development, collaboration, technology access, and technical issues [35]. Additionally, it assesses the availability and effectiveness of instructor training, support systems, and TPACK development [36] within institutions. Finally, it explores the use of user-friendly content creation tools to empower educators and alleviate management burdens.

Next, items for the resource support dimension (RSD) were derived from the challenges and solutions identified in addressing the creation and deployment of microlearning content. The questionnaire includes items aimed at evaluating strategies for creating distraction-free resources [61] and efficient content creation [62], and the utilisation of content partnerships with instructional designers and industry experts to facilitate the content development process [14, 63, 64].

The institutional dimension (ID) explores challenges and solutions on how institutions navigate microlearning implementation in Malaysia's HEPs for wider adoption. Limited recognition of online learning [37, 61] requires further investigation into strategies for communicating the value of microlearning and micro-credentials. Additionally, ID examines how institutions address integration with the current and existing HR processes and inconsistent credential recognition [38, 39]. Furthermore, items under ID explore institutional practices for integrating workplace microlearning [4] and mobile microlearning [40, 41] and analyse the adoption of open educational resources (OERs), considering challenges like awareness, incentives, and sustainability [42, 43].

In summary, a comprehensive literature review informed the development of a questionnaire to lay a strong theoretical foundation for a multifaceted adoption of microlearning approaches for credentialing modules in Malaysian HEPs.

2) Phase 2: Development of Questionnaire

The creation of questionnaire items using literature insights from Phase 1 was involved in this phase. To ensure translational validity, the questionnaire was developed both in English and in Bahasa Melayu. The 70-item questionnaire was grouped into six factors; Pedagogical Dimension (PD) with 16 items, Technological Dimension (TD) with 16 items, Evaluation (ED) with 17 items, Management (MD) with 8 items, Resources Support (RSD) with 4 items, and Institutional Dimension (ID) with 9 items. The items were evaluated using a Likert scale with a scoring range between 1 (Strongly Disagree) and 5 (Strongly Agree).

3) Phase 3: Data Collection

With the approval of the university's research ethics committee, the questionnaire was distributed to 50 micro-credential developers via email. The online survey platform was Google Forms, with data collection managed through Google Sheets. The distribution and completion of the questionnaires took three months, yielding 48 completed surveys from the participants who chose to participate voluntarily.

4) Phase 4: Validation Through Quantitative Analysis

The primary goal of this phase was to determine the strength of the questionnaire intended items and to reduce their quantity. The questionnaire's internal consistency was assessed using Cronbach's alpha coefficient using SPSS analysis, and its factor structure was evaluated using exploratory factor analysis (EFA). Several experts have verified EFA for scale development process and specification of construct dimensions [65], which aligns

with the aim of this pilot study. Without predetermined hypotheses, EFA also helps to explore the inherent groupings of responses (factors) without imposing rigid assumptions on the data. This initial exploration serves the crucial purpose of refining the questionnaire by identifying how items naturally cluster together. By understanding these groupings, hypo of interest [66]. Furthermore, the Kaiser-Meyer-Oikin (KMO) measure was used before EFA to ensure sample adequacy. The Oblique Rotation (Promax) technique was used as a rotation method to achieve the simplest structure for factor loading. This process of removing items that do not fit well into the factor structure is important to ensure the validity and reliability of the EFA results. Finally, this phase was assisted by two expert panels to confirm the questionnaire's content validity. Each expert held at least a doctorate's degree, and ten years of professional experience in adult education, instructional design and education and technology.

RESULTS

The analysis is divided into two parts. In the first part, the data was explored, and the reliability of the scale and item-wise reliability were determined. The results revealed that all 70 items related to the six constructs proposed by Khan were reliable with an alpha value of 0.962. All values for the item-wise reliability are indicated in Table 2.

Table 2. Items, Alpha, Mean and Standard Deviation for the Construct of Microlearning Requirements for Micro-credential Courses.

Items	Mean	SD	Alpha	Mean	SD
Pedagogical Dimension (PD)					
PD1	4.21	0.832	0.854	4.191	0.4935
PD2	4.3	0.689			
PD3	4.17	0.816			
PD4	4.06	0.942			
PD5	4.26	0.706			
PD6	4.47	0.687			
PD7	4.06	0.87			
PD8	4.6	0.742			
PD9	3.83	1.11			
PD10	4.15	0.722			
PD11	4.34	0.7			
PD12	4.11	0.866			
PD13	3.79	1.122			
PD14	4.6	0.577			
PD15	4.13	0.969			

PD16	4.09	0.974			
Technological Dimension (TD)					
TD1	3.96	0.779	0.846	4.086	0.5093
TD2	4.15	1			
TD3	4.43	0.617			
TD4	4.57	0.58			
TD5	4.36	0.673			
TD6	4.13	0.9			
TD7	4.26	0.706			
TD8	4.11	0.759			
TD9	4.09	0.905			
TD10	4.11	0.759			
TD11	3.72	0.949			
TD12	3.62	0.822			
TD13	3.94	0.763			
TD14	4.17	0.842			
TD15	4.15	0.691			
TD16	3.7	1.02			
Evaluation Dimension (ED)					
ED1	4.43	0.58	0.845	4.339	0.4845
ED2	4.45	0.544			
ED3	4.53	0.546			
ED4	4.47	0.584			
ED5	4.36	0.568			
ED6	4.4	0.577			
ED7	4.13	0.769			
ED8	4.26	0.765			
ED9	4.4	0.577			

ED10	4.36	0.529			
ED11	4.32	0.556			
ED12	4.28	0.615			
ED13	4.32	0.629			
ED14	4.28	0.682			
ED15	4.32	0.663			
ED16	4.32	0.695			
ED17	4.28	0.649			
Management Dimension (MD)					
MD1	2.26	1.259	0.853	3.789	0.6179
MD2	3.4	1.228			
MD3	4.17	0.842			
MD4	3.72	1.077			
MD5	3.98	0.989			
MD6	4.19	0.851			
MD7	4.26	0.846			
MD8	4.4	0.648			
Resource Support Dimension (RSD)					
RSD1	4.4	0.614	0.853	4.229	0.5716
RSD2	4.36	0.673			
RSD3	4.09	0.775			
RSD4	4.09	0.747			
Institutional Dimension (ID)					
ID1	3.09	1.457	0.871	3.824	0.6806
ID2	2.91	1.427			
ID3	4.17	0.94			
ID4	4.28	0.713			
ID5	4.17	0.789			

ID6	4.17	0.842			
ID7	3.85	1.042			
ID8	3.53	1.139			
ID9	4.26	0.736			

The results indicate that microlearning for micro-credentialing programs are important for enhancing the skills and competencies of learners. The PD showed a mean value of 4.191, with the item 'Micro-credentials are a good complement to a degree or diploma to indicate the specific skills a candidate possess' receiving a higher mean value of 4.47. Similarly, the TD has an average value of 4.086 and a standard deviation of 0.5093, with the item 'The microlearning units for micro-credentials offered from my institution are available anytime' receiving a higher mean value of 4.57 and a standard deviation of 0.58. Furthermore, analysis of the ED, with an alpha value of 0.845, emphasises the importance of micro-credentials based on both knowledge acquisition and demonstrating competence in a particular skill within a set of microlearning units (module), with a mean value of 4.53 and a standard deviation of 0.546. In addition, the MD, with an alpha value of 0.853, highlights the importance of having a dedicated micro-credential unit or department responsible for managing the quality control of the microlearning units for the micro-credential courses, with a mean value of 4.4 and a standard deviation of 0.648. Moreover, the RSD, with an alpha value of 0.853, underscores the importance of allowing learners to choose microlearning units that meet both their personal and professional needs. The mean value for 'The learners are allowed to choose a microlearning unit that meets their personal needs' is 4.4, with a standard deviation of 0.614. Similarly, the mean value for 'The learners are allowed to choose microlearning units that meet their professional needs' is 4.36, with a standard deviation of 0.673. Finally, the ID, with an alpha value of 0.871, highlights the value of micro-credentials issued by Malaysian public HEPs as a signal of skills, knowledge, and competencies to employers, with a mean value of 4.28 and a standard deviation of 0.713. The KMO value at 0.610 in the fourth iteration showed that there is a sufficient amount of variance in the data for factor analysis. Overall, the results emphasise the importance of microlearning for micro-credentialing programs for enhancing the skills and competencies of learners and provide suggestions as to how institutions can manage and implement these programs in a systematic and effective manner.

Table 3. Total Variance Explained.

Items	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**
1	21.967	36.012	36.012	21.967	36.012	36.012	13.467
2	5.325	8.729	44.741	5.325	8.729	44.741	10.712
3	4.303	7.055	51.795	4.303	7.055	51.795	10.629
4	3.714	6.089	57.884	3.714	6.089	57.884	12.858
5	2.741	4.493	62.377	2.741	4.493	62.377	7.530
6	2.485	4.073	66.450	2.485	4.073	66.450	9.543
7	2.136	3.501	69.952	2.136	3.501	69.952	8.039
8	1.900	3.115	73.067	1.900	3.115	73.067	3.776

9	1.600	2.623	75.690	1.600	2.623	75.690	5.534
10	1.427	2.339	78.029	1.427	2.339	78.029	3.199
11	1.374	2.252	80.282	1.374	2.252	80.282	4.872
12	1.162	1.904	82.186	1.162	1.904	82.186	2.042
13	1.045	1.713	83.900	1.045	1.713	83.900	3.604
14	1.006	1.650	85.549	1.006	1.650	85.549	2.362
15	.913	1.496	87.046				
16	.803	1.316	88.362				
17	.750	1.229	89.591				
18	.688	1.128	90.719				
19	.645	1.057	91.776				
20	.555	.909	92.686				
21	.508	.833	93.518				
22	.454	.744	94.262				
23	.420	.689	94.951				
24	.406	.666	95.617				
25	.347	.569	96.186				
26	.322	.528	96.714				
27	.268	.440	97.154				
28	.249	.408	97.562				
29	.232	.380	97.942				
30	.180	.295	98.237				
31	.159	.260	98.498				
32	.153	.251	98.748				
33	.127	.208	98.957				
34	.109	.178	99.135				
35	.101	.165	99.300				
36	.097	.159	99.459				

37	.074	.121	99.580				
38	.062	.101	99.681				
39	.054	.089	99.770				
40	.041	.067	99.837				
41	.036	.059	99.896				
42	.023	.038	99.934				
43	.017	.028	99.962				
44	.011	.018	99.980				
45	.009	.014	99.994				
46	.004	.006	100.000				
47	2.543E-15	4.168E-15	100.000				
48	1.380E-15	2.263E-15	100.000				
49	9.747E-16	1.598E-15	100.000				
50	5.287E-16	8.667E-16	100.000				
51	4.003E-16	6.562E-16	100.000				
52	2.768E-16	4.538E-16	100.000				
53	1.969E-16	3.228E-16	100.000				
54	6.223E-17	1.020E-16	100.000				
55	-2.201E-16	-3.609E-16	100.000				
56	-5.327E-16	-8.732E-16	100.000				
57	-6.175E-16	-1.012E-15	100.000				
58	-1.039E-15	-1.703E-15	100.000				
59	-1.108E-15	-1.816E-15	100.000				
60	-1.505E-15	-2.467E-15	100.000				
61	-2.310E-15	-3.786E-15	100.000				

Extraction Method: Principal Component Analysis. A. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

The initial EFA revealed that the construct measured responses against 16 factors (Table 3). The pattern matrix indicated cross loading of eight items (items no. 7, 9, 13, 20, 22, 35, 57 and 68), which were removed from the construct except for two items with a cross-loading difference of 0.2 (item no. 20 and item No 68). In the next

iteration, 14 factors were identified that could explain the variance of 84.949% in the construct (Table 4). All six items which showed cross-loading (items no. 4, 26, 41, 59, 64 and 68) were removed; however, item no. 26 and item no. 68 showed cross loading differed by 0.2 between primary and alternate factors were retained. In the third iteration, EFA suggested 14 factors but with a slightly higher total variance of 85.549% (Table 4). The pattern matrix indicated cross loading of five items at no. 15, 20, 26, 43 and 68 but only item no. 43 was removed from the construct while remaining items were moved to their higher loading factor due to cross loading difference of around 0.2 with alternate factors. In addition, items no. 12, 24 and 30 which did not indicate loading against any factor were also removed from the construct. Finally, the EFA produced a 57-item questionnaire which demonstrated reliable properties, and it was observed that 13 outlier items were removed from the analysis.

At 0.956, the overall Cronbach Alpha value indicates that the newly developed construct is still within an excellent range and can be effectively utilized for structured decision making. Table 5 shows how the constructs were consolidated into six distinct factors to streamline the process. These factors are Pedagogical Dimension (PD) with 13 items, Technological Dimension (TD) with 8 items, Evaluation Dimension (ED) with 5 items, Management (MD) with 7 items, Resources Support (RSD) with 4 items, and Institutional Dimension (ID) with 20 items.

The initial EFA revealed that the construct measured responses against 16 factors (Table 3). The pattern matrix indicated cross loading of eight items (items no. 7, 9, 13, 20, 22, 35, 57 and 68), which were removed from the construct except for two items with a cross-loading difference of 0.2 (item no. 20 and item No 68). In the next iteration, 14 factors were identified that could explain the variance of 84.949% in the construct (Table 4). All six items which showed cross-loading (items no. 4, 26, 41, 59, 64 and 68) were removed; however, item no. 26 and item no. 68 showed cross loading differed by 0.2 between primary and alternate factors were retained. In the third iteration, EFA suggested 14 factors but with a slightly higher total variance of 85.549% (Table 4). The pattern matrix indicated cross loading of five items at no. 15, 20, 26, 43 and 68 but only item no. 43 was removed from the construct while remaining items were moved to their higher loading factor due to cross loading difference of around 0.2 with alternate factors. In addition, items no. 12, 24 and 30 which did not indicate loading against any factor were also removed from the construct. Finally, the EFA produced a 57-item questionnaire which demonstrated reliable properties, and it was observed that 13 outlier items were removed from the analysis.

DISCUSSION

This study intended to develop a questionnaire to identify microlearning requirements for developing micro-credentials aimed at Malaysian HEIs. Two primary research questions guided the study. The first research question asked, "What are the key dimensions of microlearning design requirements for the development of micro-credentials in Malaysian higher education institutions (HEIs)?" To address this, the study utilized Khan's e-learning model [8], identifying six key dimensions relevant to microlearning within the specific context of Malaysian HEIs: Pedagogical Dimension (PD), Technological Dimension (TD), Evaluation Dimension (ED), Management Dimension (MD), Resource Support Dimension (RSD), and Institutional Dimension (ID). The selection of these dimensions was deliberate, omitting the ethical and interface design dimensions from Khan's original eight dimensions due to their limited direct applicability to the particular scope of microlearning for micro-credentials.

Table 5. Standardised Factor Loadings of EFA

Items	**Component**					
	PD	**TD**	**ED**	**MD**	**ID**	**RSD**
Micro-credentials hold significant value in showcasing competence in the essential skills required for upskilling and reskilling.	0.662					

Microlearning lessons used in micro-credential (courses) must be bite-size.	0.722					
Designing microlearning lessons with the industry in mind is key to successful micro-credentials.	0.505					
Microlearning is suitable for skill development.	0.802					
Microlearning lessons provide information that learners need to perform their day-to-day tasks.	0.671					
The microlearning lessons offered by my institution encompass a comprehensive range of skills, competencies, and knowledge relevant to specific fields.	0.805					
The microlearning lessons offered by my institution serve as tangible evidence specifically showcasing acquired skills.	0.51					
The microlearning lessons developed by my institution effectively emphasise the **acquisition and demonstration of theoretical knowledge** in specific subject areas.	0.434					
The microlearning lessons developed by my institution effectively focus on the **development and validation of practical skills** in specific domains.	0.737					
The microlearning lessons offered by my institution are tailored to meet the demands of the industry.	-0.449					
The microlearning lessons in my institution represent specific skills, competencies or knowledge relevant to **the current industry.**	0.821					
Microlearning is effective if it is based on **knowledge acquisition** in a particular skill within a **workplace setting.**	0.505					
Microlearning is effective if it is based on **demonstrating competence** in a particular skill within a **workplace setting.**	0.67					
The micro-credentials (certificates/ digital badges) issued by my institution are in an easy to read graphical format.		0.696				
The microlearning lessons for micro-credentials offered at my institution are available across multiple devices and operating systems.		0.658				
The microlearning lessons for micro-credentials are delivered in a media-rich format.		0.748				
The microlearning platform at my institution is designed to keep records of students' attainment of specific learning objectives.		0.768				
The microlearning platform at my institution is designed		0.468				

to support individualised instructional plans.						
The microlearning platform at my institution is designed to enhance learning opportunities.		0.65				
The microlearning lessons at my institution are exclusively delivered online.		0.789				
The microlearning platform at my institution is supported by an infrastructure that efficiently and effectively provides bandwidth, security, backups and other essential components.		0.675				
The assessment process for a micro-credential in my institution is transparent to the learners.			0.897			
Micro-credential effectiveness is derived from the **completion and focused knowledge acquisition** within a set of microlearning lessons.			0.628			
Micro-credential value is realised when it is built upon the **demonstration of competence in a specific skill.**			0.53			
Microlearning goals are more likely to be effectively achieved when specific performance problems are accurately addressed.			0.959			
Microlearning effectiveness is enhanced when learners can proactively identify their own knowledge gaps.			0.915			
Developing microlearning lessons requires a significant investment of time and effort.				0.753		
The **instructors** are responsible for updating and upkeep of the microlearning lessons used in the micro-credential courses.				0.626		
The faculty are responsible for overseeing security aspects (recognitions, achievement records, personal information management) in the microlearning lessons used in micro-credential courses.				0.787		
The faculty are responsible for overseeing quality control measures in the microlearning lessons used in the micro-credential courses.				0.897		
A micro-credential unit/ department at my institution is responsible for updating and upkeep of the microlearning lessons used in the micro-credential (courses).				0.955		
A micro-credential unit/ department at my institution oversees the security aspects (recognitions, achievement records, personal information) of the microlearning lessons used in the micro-credential (courses).				0.886		
A micro-credential unit/ department at my institution is responsible for managing the quality control of the microlearning lessons used in the micro-credential				0.611		

(courses).						
Micro-credentials (certificates/ digital badges) are a good signal to potential employers about the skills a candidate possesses.					0.762	
Micro-credentials (certificates/ digital badges) are a good way for employees to be recognised for skills they have developed.					0.909	
Micro-credentials (certificates/ digital badges) are a valuable addition to a degree or diploma, indicating the specific skills a candidate possesses.					0.573	
Microlearning lessons used in micro-credential courses must be aligned with the standards, instructions and assessment outlined by Malaysian Qualification Agency (MQA) for it to be formally issued.					0.648	
Micro-credentials offered at my institution can be stacked into macro credentials.					0.639	
Micro-credentials offered at my institution can be converted into other types of credentials, such as Professional Certification, Specialisations, Micro-Bachelors or Micro-Masters.					0.96	
The microlearning lessons in my institution are developed in partnership with employers, professionals, statutory or regulatory bodies, or other colleges and higher institutions.					.629	
Microlearning lessons provided by my institution are designed to be inclusive, ensuring accessibility for a diverse range of learners, including those who may be disadvantaged or vulnerable, to facilitate their learning and enable them to earn micro-credentials.					0.855	
The micro-credentials (certificates/ digital badges) from my institution are shareable on any platform.					0.592	
The micro-credentials (certificates/ digital badges) from my institution included details that could be used to confirm the date, location, and recipient of issuance.					0.64	
Micro-credential development and implementation in my institution are incentivised with monetary rewards for creating and delivering microlearning lessons used in micro-credential courses.					0.996	
Micro-credential development and implementation in my institution is accompanied by professional recognition for those who contribute to transforming microlearning lessons into micro-credentials courses.					0.471	
Micro-credential issued by the Malaysian public higher education providers (HEPs) hold significant value as indication of skills, knowledge and competencies to					0.711	

employers.						
Micro-credential issued by the Malaysian private higher education providers hold significant value as indication of skills, knowledge and competencies to employers.					0.831	
A micro-credential issued by an open online educational platform (LinkedIn Learning, MOOC, Udemy, Microsoft, etc) would be a valuable indication of skills, knowledge and competencies to employers.					0.865	
Micro-credential issuance quality is ensured by my institution.					0.717	
Micro-credentials issued by my institution demonstrate learners' job-ready skills and competencies.					0.983	
Micro-credentials issued by my institution exemplify industry-specific job-related skills and knowledge pertinent to a particular field or industry.					0.976	
The micro-credentials issued by my institution are recognized by other higher education providers.					0.614	
The micro-credentials issued by my institution are recognized by employers and industries.					0.874	
The microlearning lessons offered from my institution are available anytime.						0.756
The microlearning lessons offered from my institution are designed and delivered on-demand.						0.535
The microlearning lessons offered from my institution are just-in-time.						0.608
The microlearning lessons from my institution provide learners with the opportunity to select a unit that specifically caters to their individual and professional needs.						0.531

PD, pedagogical dimension; TD, technological dimension; ED, evaluation dimension; MD, management dimension; ID, institutional dimension and RSD, resource support dimension.

The second research question, "What are the main categories identified by developers as essential for effective micro-credentials?" was addressed through exploratory factor analysis (EFA). The analysis resulted in a refined factor structure with 57 items clearly organized into the six aforementioned dimensions. Initially, the questionnaire comprised 70 items, but through EFA, items with low loadings, redundancies, or cross-loadings were systematically eliminated, ensuring that each retained item uniquely and effectively represented a distinct aspect of microlearning design. Several contributed to the removal of items from the initially drafted construct. While all the deleted items (item 4, 7, 9, 12, 13, 22, 24, 30, 35, 41, 43, 57, 59, 64) offered valuable insights, they fell outside the scope of the overarching framework or overlapped with existing questions. Some deleted items were centred on the operational characteristics and accessibility of microlearning units. These items explored features like anytime/on-demand availability and user-friendliness. Another focused on the specific contexts in which microlearning is considered suitable. Items here addressed the value of micro-credentials as complements to degrees or replacements for workplace training. Additionally, another set of deleted items explored into the broader implications of micro-credentials, such as the value proposition based on institutional credibility and the

ability of learners to choose units based on their professional needs. While these aspects are all important considerations, they were deemed too specific for the overall goals of the framework. Furthermore, some items were redundant, providing information already captured by other questions, and thus offering no new contribution to the construct. For instance, both "item 7" on micro-credentials complementing degrees and a retained item (e.g., "item 6") explored this concept. Similarly, "item 22" on re possesses these characteristics – high factor loadings, conceptual alignment, and clarity – which demonstrate the questionnaire's reliability and validity and support consistent, accurate evaluations of its constructs.

The third research question, "What are the perceived levels of importance of different aspects of pedagogical, technological, evaluation, management, resource support, and institutional dimensions in the design of microlearning for micro-credentials in a Malaysian public HEI?" was answered by examining mean scores and standard deviations for each dimension derived from participants' responses. Results indicated varying levels of perceived importance across the dimensions, with Pedagogical and Technological dimensions generally perceived as highly critical, reflecting their direct influence on instructional effectiveness and learner engagement. The Evaluation and Management dimensions also demonstrated significant perceived importance, highlighting the need for robust assessment frameworks and efficient organizational structures. Meanwhile, Resource Support and Institutional dimensions, although perceived as essential, showed comparatively moderate mean scores, suggesting areas where enhancements and focused institutional efforts might be required.

The refined factor structure emphasizes critical aspects such as skill acquisition, credential recognition, institutional support, and operational characteristics necessary for implementing microlearning effectively. This systematic refinement process, complemented by expert validation, confirmed the questionnaire's construct validity and relevance to micro-credential development. Consequently, the final instrument offers a focused and practical approach to assessing microlearning design requirements, providing actionable insights for developers and educators engaged in micro-credential initiatives within the higher education landscape of Malaysia.

Potential Uses in Educational Settings

The validated 57-item questionnaire developed in this study, identified six key dimensions of microlearning design requirements, has significant practical applications in various educational setting:

Within Higher Education Institutions (HEIs):

Institutions can use this questionnaire as a structured guide when creating new micro-credential programs Addressing the items across the six dimensions helps ensure that critical design factors are considered from the outset, leading to more effective programs. For programs already in place, the questionnaire serves as an evaluation tool. Surveying developers of other stakeholders can pinpoint weakness in the current design, allowing institutions to make targeted improvements. Furthermore, the questionnaire reveals the diverse skills needed for effective microlearning design (e.g., teaching methods, technology use, assessment). Findings can shape traini8ng programs for educators and content developers,, helping them build necessary competencies. Moreover, different departments within an HEI developing micro-credentials can use the questionnaire to compare their design approaches. This facilitates sharing successful strategies and establishing best practices across the institutions.

Beyond Higher Education):

Then principles and structure of the questionnaire can be adapted for broader use. For instance, businesses can adapt the questionnaire to design microlearning for employee training, focusing on industry relevance and integration with HR process [37, 38, 39]. In addition, technical and vocational institutions can use a similar framework to ensure their micro-credentials effectively develop specific, job-related skills, aligning with the competency-based focus of this sector [1].

While versatile, applying this questionnaire outside its original context (Malaysian public HEIs) requires careful adaptation and validation. Factors like local culture, available technology, specific regulations, and different learning goals must be considered to ensure the questionnaire remains relevant and reliable in a new setting.

CONCLUSIONS

With Khan's e-learning model [8] as theoretical grounding, a questionnaire related to microlearning design requirements for developing micro-credentials aimed at Malaysian HEIs was constructed using a four-phase methodology [58] which included literature review, development of questionnaire, data collection and validation. The resulting instrument effectively categorised microlearning design needs into six factors: Pedagogical Dimension (PD), Technological Dimension (TD), Evaluation Dimension (ED), Management Dimension (MD), Resource Support Dimension (RSD), and Institutional Dimension (ID).

As part of a larger postgraduate design and development research (DDR), the next phase will be to implement the questionnaire as one of the data collection tools to identify the principal design elements for microlearning with reference to designing micro-credentials for Malaysian HEIs. While this pilot study involved 48 micro-credential developers, the next phase will include 100 micro-credential developers from multiple public HEIs in Malaysia to strengthen the questionnaire's robustness and applicability. This will be one out of three parts of the needs analysis phase of the complete study. Findings of the complete study can contribute to the advancement of effective and targeted approaches for the purposes of micro-credential program development, which in turn enhances employability by equipping learners with the specific skills needed to meet employers' demands, benefiting educators, learners and HEIs in Malaysia and beyond.

Admittedly, future studies could include larger and more diverse groups of participants from multiple institutions and countries. Implementing a longitudinal study could offer valuable insights into how design requirements evolve over time and influence the design and outcomes of micro-credential programs. Addressing these limitations in future research holds significant potential for the field of microlearning. By providing a more comprehensive understanding of design requirements for higher education microlearning, future research can contribute to the development of effective micro-credentialing programs that cater to the evolving needs of learners, educators and employers alike.

RECOMMENDATIONS

To foster the successful and effective implementation of microlearning and micro-credentials within Malaysian HE, the following recommendations are directed towards key stakeholders.

For policymakers, the focus should be on establishing clear national guidelines extending MQA standards to cover micro-credential quality assurance, portability, and articulation with traditional degrees. It is also vital to promote HEI-industry collaboration through targeted funding, actively address the digital divide to ensure equitable technology access, and support research for evidence-based practices. Building upon this policy foundation, educators within HEIs should utilise validated frameworks to inform program design. This involved focusing on sound pedagogy (applying CLT), investing in reliable and accessible technology infrastructure, and implementing meaningful competency-based assessments. Additionally, providing comprehensive support for faculty and learners, cultivating strong industry partnerships for workforce relevance and developing clear pathways for stacking credentials towards larger qualifications are crucial institutional actions. Complementing these institutional strategies, instructional designers must design engaging, focused, bite-sized microlearning content. Key actions include cognitive science principles, employing diverse multimedia, prioritising user experience and accessibility across devices, designing authentic assessments demonstrating skill mastery, ensuring content flexibility. And incorporating clear metadata for credential verifications. Effective implementation ultimately requires close collaboration among all these stakeholders to align effort and maximise impact.

LIMITATIONS AND FUTURE RESEARCH

Certain limitations associated with the pilot study are acknowledged, primarily concerning its sample size. Although justification was provided, for the use of EFA with a relatively small sample of 48 micro-credential developers, it is conceded that the questionnaire's comprehensiveness and generalisability could be strengthened. Therefore, for future studies, expanding the sample size to include larger and more diverse participants groups from multiple institutions is recommended. Furthermore, as the pilot study was focused on

a single public HEI in Malaysia, the findings cand the validated questionnaire may be limited in their transferability. Consequently, testing the questionnaire in different educational context, such as various Malaysian HEIs or institutions in other national settings, is suggested for future research to ensure wider applicability and address this limitation. It is also noted by the study that valuable insights into how design requirements evolve over time – a perspective not capture in this cross-sectional -pilot – could be offered if a longitudinal approach were adopted in future research.

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Table 4. Structure Matrix regarding Microlearning.

Items		Component													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Item 1	Micro-credentials (certificates/ digital badges) are a good signal to potential employers about the skills a candidate possesses.					.751									
Item 2	Microlearning is suitable for skill development.					.812									
Item 3	Micro-credentials hold significant value in showcasing competence in the essential skills required for upskilling and reskilling.		.571												
Item 4	Micro-credentials (certificates/ digital badges) are a good way for employees to be recognised for skills they have developed.						**.552**				**.464**				
Item 5	Micro-credentials (certificates/ digital badges) are a valuable addition to a degree or diploma, indicating the specific skills a candidate possesses.					.938									
Item 6	Microlearning lessons used in micro-credential courses must be aligned with the standards, instructions and assessment outlined by Malaysian Qualification Agency (MQA) for it to be formally issued.					.659									
Item 8	Microlearning lessons provide information that learners need to perform their day-to-day tasks.					.558									
Item 10	Microlearning lessons used in micro-credential (courses) must be bite-size.												.607		
Item 11	Micro-credentials (certificates/ digital badges) are a good way for employees to be recognised for skills they have developed.												.625		
Item 12	Microlearning helps reinforce deep learning.														.427
Item 14	Developing microlearning lessons requires a significant investment of time and effort.				.751										
Item 15	Micro-credentials offered at my institution can be stacked into macro credentials.										.661				
Item 16	Micro-credentials offered at my institution can be converted into other types of credentials, such as Professional Certification, Specialisations, Micro-Bachelors or Micro-Masters.										.958				
Item 17	The microlearning platform at my institution is designed to keep records of students' attainment of specific learning objectives.											.725			
Item 18	The microlearning platform at my institution is designed to support individualised instructional plans.			.442											

Item 19	The microlearning platform at my institution is designed to enhance learning opportunities.				.700										
Item 20	The microlearning lessons offered from my institution are available anytime.				.773										
Item 21	The microlearning lessons from my institution provide learners with the opportunity to select a unit that specifically caters to their individual and professional needs.				.646										
Item 23	The microlearning lessons for micro-credentials offered at my institution are available across multiple devices and operating systems.				.636										
Item 24	The microlearning units for micro-credentials offered by my institution are friendly and easy to navigate.						.434								
Item 25	The microlearning lessons for micro-credentials are delivered in a media-rich format.						.683								
Item 26	The microlearning lessons at my institution are exclusively delivered online.						**.709**					**-.455**			
Item 27	The microlearning platform at my institution is supported by an infrastructure that efficiently and effectively provides bandwidth, security, backups and other essential components.						.639								
Item 28	Microlearning lessons provided by my institution are designed to be inclusive, ensuring accessibility for a diverse range of learners, including those who may be disadvantaged or vulnerable, to facilitate their learning and enable them to earn micro-credentials.														.915
Item 29	The micro-credentials (certificates/ digital badges) from my institution included details that could be used to confirm the date, location, and recipient of issuance.	.641													
Item 30	The micro-credentials issued by my institution are displayed in a widely-spoken language														
Item 31	The micro-credentials (certificates/ digital badges) issued by my institution are in an easy to read graphical format.	.667													
Item 32	The micro-credentials (certificates/ digital badges) from my institution are shareable on any platform.			.592											
Item 33	Micro-credential effectiveness is derived from the completion and focused knowledge acquisition within a set of microlearning lessons.				.597										
Item 34	Micro-credential value is realised when it is built upon the demonstration of competence in a specific skill.				.521										

Item 36	The microlearning lessons offered by my institution serve as tangible evidence specifically showcasing acquired skills.			.489											
Item 37	Microlearning is effective if it is based on demonstrating competence in a particular skill within a workplace setting.			.652											
Item 38	Microlearning is effective if it is based on knowledge acquisition in a particular skill within a workplace setting.			.612											
Item 39	Microlearning goals are more likely to be effectively achieved when specific performance problems are accurately addressed.			1.005											
Item 40	Microlearning effectiveness is enhanced when learners can proactively identify their own knowledge gaps.			.935											
Item 41	Designing microlearning lessons with the industry in mind is key to successful micro-credentials.				**.538**								**.440**		
Item 42	Designing microlearning lessons with the industry in mind is key to successful micro-credentials.	.474													
Item 43	Designing microlearning units with the employers in mind is key to successful micro-credentials.	.405		.503											
Item 44	The assessment process for a micro-credential in my institution is transparent to the learners.	.896													
Item 45	The microlearning lessons offered by my institution encompass a comprehensive range of skills, competencies, and knowledge relevant to specific fields.	.802													
Item 46	The microlearning lessons in my institution represent specific skills, competencies or knowledge relevant to the current industry.	.819													
Item 47	Micro-credential issued by the Malaysian public higher education providers (HEPs) hold significant value as indication of skills, knowledge and competencies to employers.	.519													
Item 48	The microlearning lessons developed by my institution effectively emphasise the acquisition and demonstration of theoretical knowledge in specific subject areas.	.453													
Item 49	The microlearning lessons developed by my institution effectively focus on the development and validation of practical skills in specific domains.	.741													
Item 50	Micro-credential development and implementation in my institution are incentivised with monetary rewards for creating and delivering microlearning lessons used in micro-credential courses.													1.020	

Item 51	Micro-credential development and implementation in my institution is accompanied by professional recognition for those who contribute to transforming microlearning lessons into micro-credentials courses.						.415								
Item 52	The instructors are responsible for updating and upkeep of the microlearning lessons used in the micro-credential courses.									.677					
Item 53	The faculty are responsible for overseeing security aspects (recognitions, achievement records, personal information management) in the microlearning lessons used in micro-credential courses.									.767					
Item 54	The faculty are responsible for overseeing quality control measures in the microlearning lessons used in the micro-credential courses.									.885					
Item 55	A micro-credential unit/ department at my institution is responsible for updating and upkeep of the microlearning lessons used in the micro-credential (courses).							.977							
Item 56	A micro-credential unit/ department at my institution oversees the security aspects (recognitions, achievement records, personal information) of the microlearning lessons used in the micro-credential (courses).							.907							
Item 57	A micro-credential unit/ department at my institution is responsible for managing the quality control of the microlearning lessons used in the micro-credential (courses).							.602							
Item 58	The microlearning lessons offered from my institution are just-in-time.							.516							
Item 59	The learners are allowed to choose microlearning units that meet their professional needs.		**.434**					**.408**							
Item 60	The microlearning lessons offered from my institution are designed and delivered on-demand.			.524											
Item 61	The microlearning lessons offered by my institution are tailored to meet the demands of the industry.								-.415						
Item 62	Micro-credentials issued by my institution exemplify industry-specific job-related skills and knowledge pertinent to a particular field or industry.								.973						
Item 63	The micro-credentials issued by my institution are recognized by other higher education providers.								.966						
Item 64	The value of a micro-credential is dependent on the credibility of the institution provider that grants it.		**.481**									**.527**			
Item 65	Micro-credential issued by the Malaysian private higher education providers hold		.760												

	significant value as indication of skills, knowledge and competencies to employers.														
Item 66	A micro-credential issued by an open online educational platform (LinkedIn Learning, MOOC, Udemy, Microsoft, etc) would be a valuable indication of skills, knowledge and competencies to employers.		.860												
Item 67	Micro-credential issuance quality is ensured by my institution.		.892												
Item 68	The micro-credentials issued by my institution are recognized by employers and industries.		**.467**				**.616**								
Item 69	The microlearning lessons in my institution are developed in partnership with employers, professionals, statutory or regulatory bodies, or other colleges and higher institutions.						.858								
Item 70	Micro-credentials issued by my institution demonstrate learners' job-ready skills and competencies.		.705												

Extraction Method: Principal Component Analysis. Rotation Method: Promax with Kaiser Normalisation.

Response to Reviewers' Comments

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Reviewers' suggestions/ comments	**Our response**
Expand the discussion on how the questionnaire can be applied in real-world educational settings.	A new section titled "VI. Potential Uses in Educational Settings" has been added to elaborate on the practical application of the questionnaire in real-world contexts.
Compare the questionnaire to similar assessment tools.	A new subsection has been included under the Literature Review—2.2 Identified Gaps and 2.3 Justification for the New Tool—to compare the developed questionnaire with existing instruments.
Make the sample size justification more accessible by avoiding overly technical explanations.	The sample size justification has been revised and simplified on pages 3–4.
Provide concrete recommendations for policymakers, educators, and instructional designers.	A new section titled "Recommendations" has been added.
Include a discussion of the study's limitations. Offer suggestions for future research, such as: • Expanding the sample size. • Testing the questionnaire in different educational contexts.	A new section titled "Limitations and Future Research" has been added to address study limitations and propose directions for future research.