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Analyzing the Non-Functional Features of Web Conferencing Tools for Synchronous Online Tertiary Education in Sri Lanka

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ABSTRACT

A selection of a web conferencing tool often focuses on functional requirements. However, nonfunctional requirements play a critical role in ensuring the overall effectiveness and usability of a tool, especially for developing countries like Sri Lanka. This study aims to provide a detail discussion on the nonfunctional requirements discovered in a previous study on "Expert opinion on selecting a web conferencing tool for synchronous online tertiary education in Sri Lanka." The study conducted semi-structured interviews with twenty selected experts, including educational specialists, educational psychologists, and IT specialists who are directly in touch with the online tertiary education sector of the country. The data is analysed using a thematic analysis approach to identify the sub-factors attributed to each non-functional requirement and content analysis to quantify the identified sub-factors. The findings revealed a total of 66 subfactors across nine key categories: pricing, compatibility, performance, security, user-friendliness, customer support, user training and setting standards, admin functionality, and value-added services. The study provides a comprehensive overview of the non-functional requirements essential for web conferencing tools to be effective in the Sri Lankan context, where internet connectivity can be unreliable, devices may be limited, and cultural sensitivities need to be considered. The findings of the study can be used by educational institutions in Sri Lanka to make informed decisions about the selection of web conferencing tools and to ensure a robust synchronous online learning environment for teachers and students by minimising the limitations of being a developing country.

Keywords: Content Analysis; Non-Functional Requirements; Synchronous Online Education; Thematic Analysis; Web Conferencing Tools

Background

The increasing reliance on online tertiary education has made web conferencing tools essential for creating effective learning environments. Selecting the most appropriate tool requires evaluating functional and non-functional requirements, particularly in resource-constrained settings like Sri Lanka. As a lower-middle-income country, Sri Lanka faces challenges such as unstable internet, frequent power outages, limited access to devices, economic constraints, and varying levels of technological readiness (Hayashi *et al*., 2022; Senevirathne *et al*., 2021). These issues emphasise the importance of non-functional requirements, such as usability, reliability, affordability, and scalability, in selecting suitable web conferencing tools (Mathrani, Sarvesh, & Umer, 2021).

Studies suggest that prioritising non-functional requirements can significantly alleviate these limitations and enhance the usability and accessibility of online learning tools in developing countries (Sife, Lwoga, & Sanga, 2007; Raturi, 2014). Building on the findings of De Zoysa, Mohomad, & Abeygunawardane, (2023), which focus on expert opinions regarding web conferencing tools for synchronous online education, this paper offers detailed guidelines for Sri Lankan tertiary institutions. By addressing non-functional requirements effectively, institutions can overcome resource and infrastructure barriers, enabling a smoother online learning experience for educators and students alike. These efforts are critical for promoting equitable and effective online education in Sri Lanka.

The study provides guidelines for Sri Lankan tertiary education institutes to select web conferencing tools by identifying non-functional requirements and their sub-factors to improve synchronous online education.

- **Objectives:**

1. Determine non-functional requirements based on 13 factors by De Zoysa, Mohomad, & Abeygunawardane (2023).
2. Explore sub-factors contributing to these requirements.

- **Research Questions:**

a. Key non-functional requirements for web conferencing tools?
b. Sub-factors contributing to these requirements?

Literature Review

In the existing literature, it is identified that there are connectivity bottlenecks, diverse technological expertise, resource disparities, social conditions, and economic disparities as challenges for online tertiary education in Sri Lanka (Hayashi et al., 2022; Udayanga et al., 2021; Senevirathne et al., 2021; Hettiarachchi et al., 2021; Hayashi et al., 2020; Yang et al., 2022; Khashunika, Yatigammana, & Lakmal, 2021; De Alwis, 2022; Madhuwanthi, L. A. P., Muthulingam, A., & Madusha, 2021; Jayasinghe, 2022)

Many of the nonfunctional requirements suggested in this study can be utilised to minimise the said challenges. Performance ensures smooth communication even with connectivity bottlenecks, including limited internet bandwidth. Supporting a wide range of devices and operating systems to bridge the digital divide will minimise the issues with resource disparity. Security Features helps to protect sensitive information and ensure a safe learning environment even if the user is not technology savvy. User-friendliness caters to users with varying levels of technological skills and cultural backgrounds. Customer Supporting like readily accessible technical support and troubleshooting technical issues will help users with low technical skills to use the tool effectively. Implementation of flexible and affordable pricing

models considering the economic realities of the Sri Lankan context will promote inclusivity and accessibility to online education.

User training and setting standards offering comprehensive training and establishing clear guidelines for online communication will facilitate smooth adaptation and address social challenges. Though the admin functionality and value-added services do not directly link with the challenges discovered from the literature, these two nonfunctional requirements will help to establish effective online learning environments for the tertiary education sector of Sri Lanka.

Methods

The study employed qualitative research methodology via semi-structured interviews with experts.

The study, based on De Zoysa, Mohomad, & Abeygunawardane (2023), developed a framework for selecting web conferencing tools in Sri Lankan tertiary education by identifying non-functional requirements. Semi-structured interviews with 20 experts (educational specialists, psychologists, and IT specialists) were analysed using thematic and content analysis to identify and quantify sub-factors. Experts were chosen via judgemental sampling to represent pedagogical, psychological, and technical perspectives. This framework offers a comprehensive approach tailored to the sector's needs.

Table 1: Selection Criteria for Experts

Participant Category	Characteristics
Educational Specialist	Top-ranking individuals of the public and private sector tertiary educational institutes of Sri Lanka. (University professors, Department heads, Directors, and heads of the institutes) Actively engaged in synchronous online education Holds a minimum of a master's degree in their field of expertise.
Educational psychologists	Senior counselors with a bachelor's degree in psychology or doctors who have studied psychology as a subject. Have experience working with parents, students, and teachers to improve the educational, social, and emotional outcomes of the youth. Actively engaged in synchronous online tertiary education in Sri Lanka.
IT specialists	Those who are in the senior level of the Sri Lankan IT industry. Involved in the customization or development of web conferencing tools for higher educational institutes. Actively engaged in synchronous online tertiary education in Sri Lanka either by providing lectures or by following online courses.

Source: Expert opinion on selecting web conferencing tools for online tertiary education in Sri Lanka

International Journal of Education and Technology, 18(2), 123–145, De Zoysa, Mohomad, & Abeygunawardane, (2023)

The interview questions for the semi-structured interviews were adapted from a previous study by the authors. Out of the 5 questions provided in Table 2, the last question applies to this study.

Table 2: Description of Interview Questions

Question	Purpose
Have you ever participated in synchronous online teaching/learning activities?	To identify the participants' awareness of the synchronous online education
What web conferencing tool are you most associated with?	To identify the tools that are commonly used for online education in Sri Lanka

Do you think that the below eight criteria are important to consider when selecting a web conferencing tool for tertiary education in Sri Lanka?	To confirm the criteria identified from the literature in the Sri Lankan context
Other than the above eight criteria, are there any other criteria to be considered in the Sri Lankan context?	To find out any other criteria that are important for tertiary education in Sri Lanka
What are the sub-features you think should be considered under each main criterion in the Sri Lankan context?	To identify the sub-features of each main criterion that is to be considered in the Sri Lankan context.

Source: Expert opinion on selecting web conferencing tools for online tertiary education in Sri Lanka

International Journal of Education and Technology, 18(2), 123–145, De Zoysa, Mohomad, & Abeygunawardane, (2023). The semi-structured interviews were conducted online via Zoom or MS Teams applications on pre-agreed date and time. These meetings were digitally recorded with the permission of the respondents. Once the data is collected sub-factors for each non-functional requirement are detected via a thematic analysis approach and the identified sub-factors are quantified using content analysis.

Results & Discussion

Identification of Non-functional Requirements.

Out of the thirteen main factors discovered in the study by De Zoysa, Mohomad, & Abeygunawardane, (2023), this study first filtered the non-functional requirements. Functional requirements are defined as what the system must do. And non-functional requirements explain how the system should work. If non-functional requirements are not met, users may become frustrated (Gorbachenko, 2021). The following table details the non-functional requirements derived from the said previous study based on the above definition.

Table 3: Functional and Non-functional Requirements of Web Conferencing Tools

Theme	Definition	Description
Performance	The ability of the tool to achieve its tasks concerning time constraints and allocation of resources	Defines how well the tool should do its tasks. Not what the tool must do to execute its main duties
Compatibility	The ability of the tool to execute its functions well on different hardware or Software platforms.	Tells how well the tool should interact with other hardware and software systems. Not what the tool must do to execute its main duties
Security features	Features necessary to ensure that only authorized individuals get access to the system and its data.	This tells how well the tool should protect data and prevent unauthorized access. Not what the tool must do to execute its main duties
User-friendliness	Whether the tool can be easy to use or understand by people who are not experts.	Describe how easily the tool can be used. Not what the tool must do to execute its main duties
Customer support	Type of help that is available for the users when they have trouble with the tool.	Tells how the vendors or developers should help users in troublesome situations. Not what the tool must do to execute its main duties
Pricing	Fixing the value of the tool for its buyers.	This does not specify what the tool must do but how it should be priced
User training and setting standards	Established user training for the customer before using the tool on a set of standards to be followed while using the tool to obtain the best of the online sessions.	This does not specify what the tool must do but tells how the users of the tool should be trained and what standards are required to be established for the better use of the tool.
Admin functionality	A special set of facilities available only to the administrator which includes total control over the tool	This does not specify what the tool must do to execute its main duties, but a set of special features to the administrator.

	and is not available for ordinary users.	
Value added services	Some special functionalities can be made available on additional payment for special user categories like top managers or directors (not for the general users like lecturers and students).	This does not specify what the tool must do to execute its main duties, but some special features for special user categories like managers.

Identification of the Sub-factors for Non-functional Requirements.

This section presents the results of thematic and content analysis on the nine non-functional requirements. It details the sub-factors, expert categories, and endorsement rates for each.

Table 4: Performance Sub-features

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
P1	High-quality audio	7	100	7	100	6	100	100
P2	High-quality video	7	100	7	100	6	100	100
P3	Low bandwidth requirements	7	100	5	71	6	100	90
P4	Provide the user to select the required bandwidth	2	29	3	43	1	17	30
P5	Image quality	1	14	3	43	1	17	25
P6	Low resource usage on low-end devices	0	0	2	29	1	17	15
P7	High-speed retrieval of audio, video, and still images	1	14	1	14	0	0	10
P8	Run on top of the web browser without installing the application	0	0	1	14	0	0	5

Table 4 lists performance sub-features for web conferencing tools in Sri Lanka. Results show strong agreement on P1 and P2, moderate agreement on P3, and varying agreement on P4-P8.

Table 5: Compatibility Sub-features

No	Sub feature	% ES	% IT	% EP	Total %
C1	Web browser compatibility	100	100	100	100
C2	OS support	100	100	100	100
C3	Mobile Support	100	100	100	100
C4	Compatible with other SW systems	57	71	17	50
C5	Compatible with other supportive equipment	43	43	33	40

Table 5 lists five sub-features for compatibility. All experts agreed on C1-C3, while C4 and C5 were suggested by many but not all.

Table 6: Security Sub-features

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
SE1	User authentication for all participants	7	100	7	100	6	100	100
SE2	Detect and manage disruptive activities	7	100	7	100	6	100	100
SE3	Enables the lecturer to remove students from the session if required	7	100	7	100	6	100	100

SE4	Set how attendees should act	7	100	7	100	6	100	100
SE5	Local storage	7	100	7	100	6	100	100
SE6	Server storage	7	100	7	100	6	100	100
SE7	Enables the lecturer to decide how the students should access the recordings and other session artifacts	3	43	2	29	1	17	30
SE8	Enables users to sign in via social networking sites (Facebook, Instagram)	1	14	3	43	1	17	25
SE9	Facilitates Lecturer to decide who should access the class (open access via a sharable link, invitees only)	2	29	2	29	1	17	25
SE10	Facilitates Lecturer to decide how the participants should access the class	2	29	1	14	2	33	25
SE11	Notifies the lecturer when changing between windows especially when the desktop is shared	2	29	1	14	2	33	25
SE12	Automatically remove a participant after observing a set misbehave for the third time	1	14	0	0	0	0	5
SE13	Communication link should be encrypted	1	14	0	0	0	0	5
SE14	Give anonymous access. Allow them to access through the browser without creating an account in the system	0	0	1	14	0	0	5
SE15	Provide restrictions on the use of the tool	0	0	0	0	1	17	5
SE16	Facility to accept the attendees to the class	0	0	0	0	1	17	5

Table 6 lists 16 security sub-factors for web conferencing tools. SE1-SE6 were fully endorsed, SE7-SE11 were partially endorsed, and SE12-SE16 had low endorsement rates.

Table 7: Customer Support

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
CS1	Frequently ask questions	7	100	7	100	6	100	100
CS2	Phone, e-mail or live chat support	7	100	7	100	6	100	100
CS3	Online documentation and user guide	7	100	7	100	6	100	100
CS4	Discussion boards and knowledge base	7	100	7	100	6	100	100
CS5	Demo	7	100	7	100	6	100	100
CS6	Provide support on different versions	1	14	3	43	1	17	25
CS7	Q and A with video	1	14	0	0	0	0	5
CS8	Video tutorials	0	0	1	14	0	0	5
CS9	Online chatting support	0	0	0	0	1	17	5

Table 7 lists nine customer support sub-factors. CS1-CS5 were fully endorsed, CS6 was partially endorsed, and CS7-CS9 had low endorsement rates.

Table 8: User Friendliness Sub-factors

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
UF1	Easy to understand, learn, and use	7	100	7	100	6	100	100
UF2	Short and simple steps to get things done	7	100	7	100	6	100	100
UF3	Support local languages	4	57	3	43	2	33	45

UF4	Display subtitles in English and local languages	3	43	4	57	1	17	40
UF5	Ability to join a session via a web browser simply by clicking on a link without having an account	2	29	3	43	1	17	30
UF6	Not to have many options to achieve one thing	4	57	0	0	1	17	25
UF7	Simple and easy-to-handle interface	1	14	1	14	2	33	20
UF8	No additional training should be required	0	0	2	29	0	0	10
UF9	The learning curve should be less	0	0	1	14	1	17	10
UF10	Easy navigation between options	0	0	0	0	2	33	10
UF11	Make it more graphical steps than the text	1	14	0	0	0	0	5
UF12	Provide tool tips in local languages	1	14	0	0	0	0	5
UF13	Fully tough enable	1	14	0	0	0	0	5
UF14	Record sessions and export to the cloud easily	0	0	1	14	0	0	5

Table 8 lists 14 user-friendliness sub-factors. UF1 and UF2 were fully endorsed, UF3-UF7 were partially endorsed, and UF8-UF16 had low endorsement rates.

Table 9: Pricing Sub-features

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
PR1	Pay in LKR	4	57	2	29	2	33	40
PR2	Provide free features	4	57	1	14	1	17	30
PR3	Payment plan	3	43	2	29	1	17	30
PR4	All compulsory features at an affordable price	2	29	2	29	1	17	25
PR5	Open source	2	29	2	29	0	0	20
PR6	Make available via a free platform	0	0	1	14	0	0	5
PR7	Payment gateway	1	14	0	0	0	0	5
PR8	Usage concessions	0	0	0	0	1	17	5

Eight pricing sub-factors were identified for web conferencing tools in Sri Lanka. PR1-PR4 received moderate to strong support from experts, while PR5-PR8 had limited support.

Table 10: Admin Functionalities Sub-features

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
AF1	Admin should have overall control over the tool	0	0	1	14	0	0	5

The admin functionality was suggested by one IT specialist and there was only one sub-feature contributing to it.

Table 11: Value-added Services Sub-features

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
VS1	Archiving	0	0	1	14	0	0	5

VS2	User insight reports	0	0	1	14	0	0	5

Table 11 identifies two sub-features contributing to value-added services, and both were suggested by a single IT specialist.

Table 12: User Training and Setting Standards

No	Sub feature	ES		IT		EP		Total %
		No	%	No	%	No	%	
UT1	Provide a proper understanding of the online learning environment to the users	0	0	1	14	0	0	5
UT2	Inform the importance of active communication during an online session (to encourage switching on the camera and microphone and speaking out)	0	0	1	14	0	0	5
UT3	Acknowledge the teachers and students about the facilities available so that they can conduct online sessions more like a physical class	0	0	1	14	0	0	5

Three sub-features were identified for user training and setting standards, each endorsed by a single IT specialist as shown in Table 12.

Based on expert opinions, the following framework is proposed outlining key non-functional requirements and their sub-functionalities for selecting web conferencing tools in Sri Lankan tertiary education.

Table 13: Non-functional Web Conferencing Requirements for Online Education in Sri Lanka

Non-Functional Requirement	Sub-feature	Expert categories supported	Total response rate
Performance	High-quality audio	ES, IT, EP	100%
	High-quality video	ES, IT, EP	100%
	Low bandwidth requirements	ES, IT, EP	90%
	Provide the user to select the required bandwidth	ES, IT, EP	30%
	Image quality	ES, IT, EP	25%
	Low resource usage on low-end devices	IT, EP	15%
	High-speed retrieval of audio, video, and still images	ES, IT	10%
	Run on top of the web browser without installing the application	IT	5%
Compatibility	Web browser compatibility	ES, IT, EP	100%
	OS support	ES, IT, EP	100%
	Mobile Support	ES, IT, EP	100%
	Compatible with other SW systems	ES, IT, EP	50%
	Compatible with other supportive equipment	ES, IT, EP	40%
Security	User authentication for all participants	ES, IT, EP	100%
	Detect and manage disruptive activities	ES, IT, EP	100%
	Enables the lecturer to remove students from the session if required	ES, IT, EP	100%
	Set how attendees should act	ES, IT, EP	100%
	Local storage	ES, IT, EP	100%
	Server storage	ES, IT, EP	100%
	Enables the lecturer to decide how the students should access the recordings and other session artifacts	ES, IT, EP	30%
	Enables users to sign in via social networking sites	ES, IT, EP	25%
	Facilitates Lecturer to decide who should access the class	ES, IT, EP	25%

	Facilitates Lecturer to decide how the participants should access the class	ES, IT, EP	25%
	Notifies the lecturer when changing between windows especially when the desktop is shared	ES, IT, EP	25%
	Automatically remove a participant after observing a set misbehave for the third time	ES	5%
	Communication link should be encrypted	ES	5%
	Give anonymous access. Allow them to access through the browser without creating an account in the system	IT	5%
	Provide restrictions on the use of the tool	EP	5%
	Facility to accept the attendees to the class	EP	5%
Customer Support	Frequently ask questions	ES, IT, EP	100%
	Phone or e-mail or live chat support	ES, IT, EP	100%
	Online documentation and user guide	ES, IT, EP	100%
	Discussion boards and knowledge base	ES, IT, EP	100%
	Demo	ES, IT, EP	100%
	Provide support on different versions (HW & SW)	ES, IT, EP	25%
	Q and A with video	ES	5%
	Video tutorials	IT	5%
	Online chatting support	EP	5%
User-friendliness	Easy to understand, learn, and use	ES, IT, EP	100%
	Short and simple steps to get things done	ES, IT, EP	100%
	Support local languages	ES, IT, EP	45%
	Display subtitles in English and local languages	ES, IT, EP	40%
	Ability to join a session via a web browser simply by clicking on a link without having an account	ES, IT, EP	30%
	Not to have many options to achieve one thing	ES, IT, EP	25%
	Simple and easy-to-handle interface	ES, IT, EP	20%
	The learning curve should be less	IT, EP	10%
	No additional training should be required	IT	10%
	Easy navigation between options	EP	10%
	Make it more graphical steps than the text	ES	5%
	Provide tool tips in local languages	ES	5%
	Fully tough enable	ES	5%
	Record sessions and export to the cloud easily	IT	5%
Pricing	Pay in LKR	ES, IT, EP	40%
	Provide free features	ES, IT, EP	30%
	Payment plan	ES, IT, EP	30%
	All compulsory features at an affordable price	ES, IT, EP	25%
	Open source	ES, IT	20%
	Make available via a free platform	IT	5%
	Payment gateway	ES	5%
	Usage concessions	EP	5%
Admin functionality	Admin should have overall control over the tool	IT	5%
Value-added services	Archiving	IT	5%
	User insight reports	IT	5%
User training and setting standards	Provide a proper understanding of the online learning environment to the users	IT	5%
	Inform the importance of active communication during an online session	IT	5%
	Acknowledge the teachers and students about the facilities available so that they can conduct online sessions more like a physical class	IT	5%

The results of this study offer valuable awareness of the desired nonfunctional requirements for a web conferencing tool to mitigate the challenges associated with synchronous online tertiary education in Sri

Lanka. There were nine nonfunctional requirements discussed in detail. These included performance, compatibility, security features, user-friendliness, customer support, pricing, user training and setting, admin, and value-added services.

Admin functionality: Help the educational institutes manage user accounts, monitor usage, and configure settings to suit their specific needs. Value-added services Facilitate special user groups like directors and managers to revisit past events for evaluation and improvement. As well as comprehensive user insight reports, provide valuable data on audience engagement, participation patterns, and areas for optimisation, and will empower informed decision-making for future improvements in the country's online education. While these nonfunctional requirements present a valuable framework, the study has not prioritised them, therefore further research can be adopted to prioritise these nonfunctional requirements in the context of online tertiary education in Sri Lanka. Also, the study has considered only three categories of experts, teachers, students, and other relevant stakeholders that could be included in future research to ensure a more comprehensive understanding of the necessary nonfunctional requirements. This study focused on only the nonfunctional aspects of web conferencing tools, including a detailed analysis of the functional requirements identified in the previous study by De Zoysa, Mohomad, & Abeygunawardane (2023), would provide a complete picture of the ideal web conferencing for synchronous online tertiary education in Sri Lanka.

Conclusion

The successful implementation of online learning platforms in Sri Lanka is essential for addressing the growing demands of tertiary education. By prioritising non-functional requirements, web conferencing tools can significantly mitigate the challenges associated with synchronous online learning in the country. The study identified nine key non-functional requirements, including performance, compatibility, security, user-friendliness, customer support, pricing, user training, admin functionality, and value-added services. Addressing these requirements is crucial for creating a seamless and effective learning experience for both teachers and students, regardless of their socioeconomic background or technological expertise. Tertiary education institutions in Sri Lanka are strongly encouraged to focus on these non-functional requirements when selecting web conferencing tools for synchronous online learning activities. By doing so, they can establish a robust and inclusive learning environment that benefits all students.

Declarations

Ethics Approval and Consent to Participate: Not applicable

Conflicts of Interest: The authors declare that they have no conflict of interest.

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