Identifying Access Barriers to Effective Web Resource Retrieval

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Abstract—*The Web is used increasingly for informal learning which is more conversation based and learner-centred. Many intrinsic and extrinsic factors contribute towards retrieving information on demand. However, Web information retrieval (IR) has proved to be a challenging task due to the rapid increase in quantities of digitised information. Thus, retrieval time and learner attention should receive more emphasis to make Web IR more effective. This study identifies and tests an extended version of the Technology Acceptance Model (TAM) to identify the role of environment factors in effective Web resource usage. The study shows that the presence of environment factors lowers perceived access barriers, leading to more effective usage. Furthermore, the results suggest that extending the TAM to include perceived access barriers helps to explain the existence and application of intrinsic motivation factors leading to effective usage, providing key insights for website designers to re-evaluate their processes to incorporate environment factors.*

Keywords—*context awareness, web information retrieval, learning, technology acceptance model*

I. INTRODUCTION

In a learner-centred approach to education, the learner plays a pivotal role and, unlike in an instructor-centred approach, is increasingly encouraged towards self-learning. This approach towards self-learning shifts the role of instructors from being givers of information to facilitators of student learning. The Web and modern advancements in technology further create opportunities towards facilitating active learning. Today, information, especially in its digital form, can be easily accessed, shared and reused. Information is no longer a scarce resource.

The Web is a vast repository of knowledge awaiting learner access. However, many factors contribute to deflecting a learner away from an information source. Multiple distractions lead to the use of more study time spent in locating resources and allow less time to comprehend the contents presented in the selected resources. This can frustrate learners and may leave them directionless on the Web; the techniques adopted for Web information retrieval so far are not suited to the information explosion. There is no organised structure available to explore information in an inter-linked way to suit learners' different levels of cognition. Eventhough learners have a vast amount of information at their fingertips, finding Web resources on demand appears to be a challenge due to the scale of existing information resources. Therefore, retrieval time and learner attention have become scarce resources [2].

Informal learning, which includes all learning that occurs outside the curriculum, contributes moretowards a lifelong learning process. Hence, to attain higher rates of student retention and have better prepared graduates, there is a paradigm shift from an instructor-centred approach to a learner-centred one [16]. With a learner-centred approach, search engines are used to retrieve learners' on-demand information from the Web but the search results returned are either too specific or too general and, therefore, far from what a learner actually expects.

Information overload means learners struggle with extracting and satisfying their information needs. This is due to the increasing quantities of information learners need to manage on a regular basis and in a timely manner [9]. Information overload is a recognised problem as learners struggle to extract and satisfy their information needs. The overwhelming majority of information retrievals on the Web are for informational queries where learners seek information. The highest number of queries executed on search engines has been classified as informational (60%) where the user seeks information relevant to their topic of interest [20]. The techniques use by search engines varies from simple keyword indexing to semantic mapping of keywords [21]. Due to mismatches in keyword mapping between user intentions and filtering, the search results might not always be helpful to the user.

The problem with this approach is that search engines lack effectiveness because the results they generate may be too general and do not address specific information needs. Hence, the results lack personalisation. Search personalisation is a far better approach to Web IR. It bridges the mismatch by trying to interpret the user's intention and generate the results. In search personalisation, Web contents are organised and ranked according to user behaviour [22], which is tracked through recording navigation in the search space. The recorded data are then used for link selection.

However, irrespective of the advances in IR, with increased relevance less weight is given to the usability of the Web resources returned by a search engine: the extent to which a Web resource satisfies the learner's information requirement. The sheer scale of available resources on the Web makes finding the right content at the right time extremely challenging, and more often it leaves learners overloaded with information. This makes the Web less usable. Therefore, it is necessary to address this gap towards making the Web more learner friendly.

The TAM is a widely accepted model to help understand and explain user behaviour in an information system. The suitability of the TAM is well tested, as depicted in the findings by Davis [7], [8]. Accordingly, an empirical study isundertaken to understand learners' behaviour when undertaking information searches on the Web. In conducting this study, it is necessary to understand the environment factors to explain effectively learners' behavioural intentions and the use of Web resources. Previous findings in this connection revealed pedagogical usability and multiple tool support to have more influence on content personalisation in a learning environment [24]. In the study undertaken, the influences of these two factors are further extended in the context of Web resource search and use.

Pedagogical usability is associated with learning and its processes. In the study, the pedagogical usability construct is further operationalised as learning objects organisation, support of learner styles and cognitive styles [10], while multiple tool support is operationalised as availability and use of different context-aware software tools to achieve learning objectives [5]. The outcome of this empirical study is likely to help Web content designers and systems developers alike to model their environment better to satisfy learner perspectives of Web resources by incorporating these factors.

This study contributes to existing knowledge in two ways. First, pedagogical usability and multiple tool support which indirectly influence effective Web resource usage are included as external variables. Second, the TAM model is extended by adding perceived access barriers as an outcome variable in an environment that negatively impacted learners' behavioural intentions and, ultimately, effective usage of the Web resource.

The results shows that there is a positive relationship between the presence of environment factors and Web resource usage in the sense that Web resource usage can be better explain by these two predictor variables and because lack of these factors lead to poor usability of the Web resource. The outcomes of the study confirm the previous findings by Davis [7] and by Porter and Donthu [19], and the use of perceived access barriers as a third factor is also supported.

The remainder of this paper is structured as follows. Section II gives an overview of the current status of the TAM model and Web IR. Section III presents the theoretical framework with factors that influence learners' effective Web information search behaviour and the section ends with the research methodology. Section IV presents the results and analysis while Section V discusses the results of the study. Finally, Section VI concludes the work with topics for future direction.

II. RELATEDWORK

In the study, learner Web resource usage behaviour is observed. The TAM, a widely accepted model to help understand and explain user behaviour is adopted to explain learner behaviour and to test the significance of environment factors which affect it. This section presents the existing knowledge in three main areas: Web information retrieval, user acceptance and behaviour. Each section highlights the shortcomings of the current approaches.

A. Web Information Retrieval

Users use Web search engines mostly for navigational and transactional purposes. The majority, 60% of queries, are classified as informational, 25% as resource/transactional and 15% as navigational [20]. The highest number of queries is classified as informational when the user searches for information relevant to a topic of interest. Searchers may prefer to access entry pages to authoritative sites on a topic or pages that contain useful links to documents containing relevant text. Popular Web and general IR techniques vary from summing relevance to semantic mapping of context. The scores assigned to individual pages in isolation have a strong advantage in that the result is re-usable. However, a score assigned this way may substantially overestimate the actual value to a searcher.

1) Issues in Web Information Retrieval:

Techniques used by search engines vary from relating keywords to semantic mapping. A set of keywords forming a Boolean expression has limited contextualisation and usually returns too many low quality results [27]. Semantic mapping of keywords can leverage the quality of the search results [21] by increasing the relevance, but due to mismatches in mapping between user intention and filtering, the search results might not always be helpful to the user. Therefore, learners have to navigate each result and extract relevant information to cater to their needs.

Furthermore, there is no semantic relationship between Web resources. Thus, the system sees them as independent resources. Many of the retrieved Web resources are not related to the user query, which means low precision, and many relevant documents are not retrieved, which equates to low recall.

Search personalisation is an attempt to identify a user's specific need where Web contents are organised and ranked according to user behaviour, a more

relevant and accurate prediction of the user's information needs [22]. Collaborative filtering, a filtering technique based on similar needs of the Users can also be applied for Web resourcefiltering and recommendation to improve search results. SIWeb (Social Interests through Web Analysis), an approach to understand the interests the society has on a specific topic irrespective of platform can be used to cater general purpose search requests on social web sites. SIWeb uses collaborative filtering to generate the master index which understands the interests the society has on a specific topic [11].

In spite of recent development in IR techniques, there is less attention paid to usability of Web resources returned by a search engine. The usability of a Web resource influences the actual use of it. It often relates to the quality of the Web resources as well.

B. User Acceptance

The TAM as a theoretical model related to technology acceptance is well-known and frequently cited [7]. It explains and predicts user behaviour in different information system constructs, which is considered an influential extension of the Theory of Reasoned Action (TRA) [1]. The TAM is used to explain why a user accepts or rejects information systems by adapting the TRA. In the TAM, perceived usefulness and perceived ease of use determine a user's behavioural intentions towards usage. According to Davis [7], perceived usefulness (PU) is defined as the prospective user's subjective probability that using a specific application system will enhance his or her job or life performance, and perceived ease of use (PEOU) is defined as the degree to which the prospective user expects the target system to be free of effort.

The TAM provides a theoretical underpinning of how external variables influence belief, attitude and intention of actual use of an information system. Figure 1 depicts TAM constructs according to one's actual use of a technology system that is influenced by the user's behavioural intentions, attitude, perceived usefulness and perceived ease of use of the system. One of the limitations of TAM is in assuming that self-reported usage reflects actual usage.

C. User Behaviour

The TAM proposed by Davis [7] focused on extrinsic motivators, namely, PEOU and PU of user acceptance. Hoffman and Novak [13] showed that intrinsic motivating factors are also important and play a key role in the context of the Internet. They also stated that flow, the user navigation path of the system as an intrinsic motivator could affect user acceptance of the Internet.

Porter and Donthu [19] extended the TAM by addingperceived access barriers as a third belief about technology that explained a consumer's attitude towards Internet usage; their findings were statistically significant. The purpose of this study is, therefore, to extend the TAM by exploring the environmental characteristics which influence the use of Web resources in the context of Web IR. The environmental characteristics are operationalised as pedagogical usability and multiple tool support. Pedagogical usability is associated with learning and its processes, wherein the system must have provision to support elements of learning to cater to different learning styles and preferences [10]. The multiple tool support focuses on the availability of different context-aware software tools in the system to achieve learning objectives [5].

1) ***Integrating Environment Factors:***The learning process can take place formally or informally. Formal learning takes place when there is a set curriculum, whereas when learning is more conversation based, it is considered as informal. There are numerous advantages of informal education and hence, the paradigm shifts from teacher-centred to learner-centred education. Due to the advancement of devices and technology, most learners are encouraged to learn outside the classroom, hence, more informally [27]. In informal learning, a learner has more control in directing the learning process. In the long term, it prepares learners to engage in lifelong learning. Therefore, to facilitate informal education, it is necessary to identify challenges in achieving its outcomes effectively and restrict constraints that may hinder the learning process in the Web context.

Chen and Macredie [5] stated that online resource-based learning environments are most likely to be effective when they are designed to support pedagogy, and more often it is related to navigational path (flow) in the literature [4]. Tseng et al. [24] in their study found that presenting learning materials in different learning styles as being an important factor that increases user attention. Due to the sheer scale of the Internet, most users need to navigate through various sources to find the right information to suit their information need. Research into user acceptance of particular websites over others would, therefore, be equally helpful to website designers and content generators wanting to gain more user traffic through better user acceptance of these sites. This, in turn, will help users to find Web resourcesfaster.

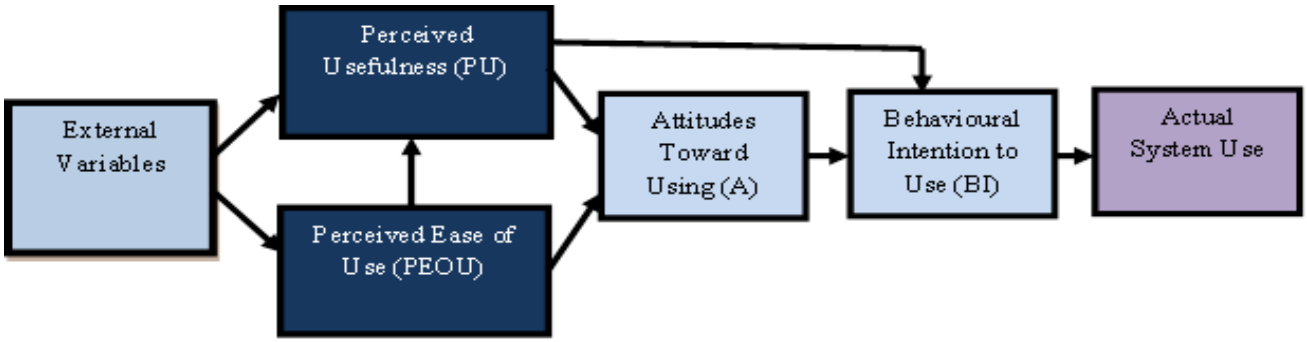

Fig.2 Technology acceptance model [6]

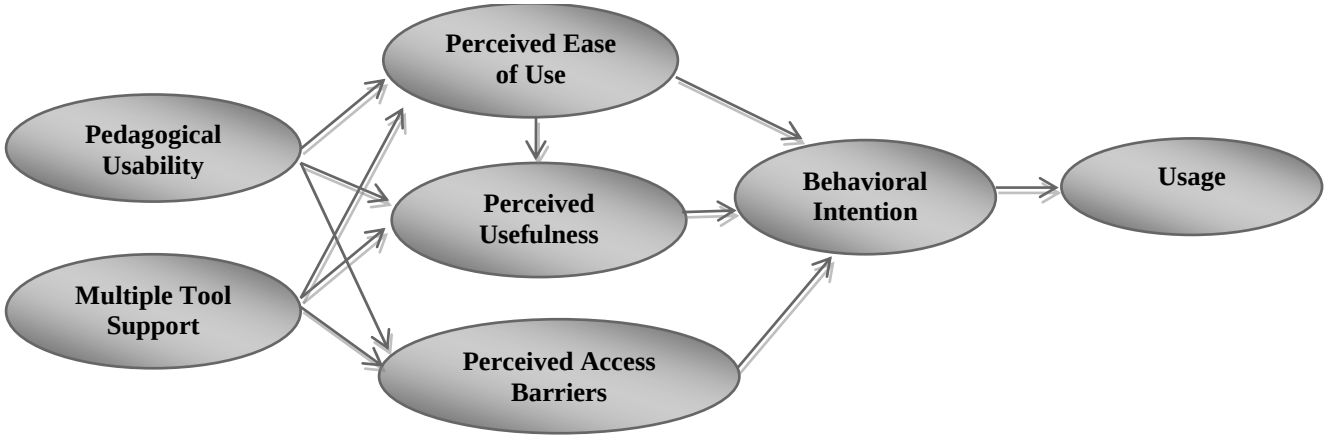

Fig.1 Theoretical framework adapted for the study [6]

Usability is defined as the extent to which a system can be used by users to achieve specified learning goals with effectiveness, efficiency and satisfaction in a particular environment or with a particular tool or learning resource, and this accessibility and usability are intrinsically linked [6]. When designing Web resource retrieval systems, attention must be paid to learners' learning objectives and Web resources generated to match their learning styles and pedagogy, since one size does not fit all information needs.

III. Research Methodology

This section outlines the theoretical framework, as shown in Figure 2. It contains predictor variables and outcome variables with their relationships to be tested for statistical significance. The section represents the details of the approach used in the study. It also defines a progressive elaboration in order to conduct this study scientifically. Further, it validates data collected and removes any biasness. The predictor variables and the outcome variables are given in Table I. Table IIrepresents a detail description of each dimension and factors under consideration. Section A and B outlines derivation of hypothesis base on usability and user acceptance of a system.

Table I: Predictor, Mediating and Outcome variables

Predictor Variables	Mediating Variables	Outcome Variables
Pedagogical Usability Multiple Tool Support	Perceived Ease of Use Perceived Usefulness Behavioral Intension of Use Perceived Access Barriers	System Use

Table II: Dimensions and factors

Dimension	Factors
Pedagogical Usability	System interactivity, content and resources, learning strategies use, feedback, learner guidance and support
Multiple Tool Support	Selection of instructional materials, individual and shared documents, viewing and dissemination methods,

	atmosphere that promotes mentoring and open exchange of ideas and discussion; ergonomically designed for optimal usability
Perceived Ease of Use	The degree to which a person believes that using a particular system would be free from effort
Perceived Usefulness	The degree to which a person believes that using a particular system would enhance his or her job performance
Behavioral Intension of Use	The degree to which a person is ready to perform a given behavior
Perceived Access Barriers	demographic-based differences in system use
System Use	It represents the actual system use

A. *Measuring System Usability*

In the literature, the term usability is often related to human and computer interaction. Usability is a qualitative attribute which cannot be directly observed. The usability of a system is its ability to be used by humans effectively and easily [23]. Be it a Web application, a mobile application, a desktop application or any user interface, the user interface design gives a sense of the quality of auser's experience. This is also known as user experience design (UXD) [25]. Usability plays a role in the development of the World Wide Web and the use of e-commerce. Nielsen [17], in his empirical study of 42 organisations, found that redesigning their websites with improved usability led to 135 percent increases in sale conversion rates and 150 percent increases in user traffic. Users will use a website when it is properly designed and allows content access quickly and efficiently with ease of use [15]. These findings show the importance of designing websites with high usability. However, neither the Shakel model nor the Nielsen model weighed the dimensions to recognise their significance on usability. To observe the impact of usability, pedagogical usability and multiple tool support are included as predictor variables in the study. The following hypotheses are derived to test usability, relationships and significance among the variables.

There is evidence that pedagogical usability directly affects system ease of use. To measure the extent of a system's pedagogical usability influence on system ease of use, hypothesis 1 is tested.

H1: There is a positive relationship between pedagogical usability and system ease of use.

There is evidence that pedagogical usability directly affects system usefulness. To measure the extent of a system's pedagogical usability influence on system usefulness, hypothesis 2 is tested.

H2: There is a positive relationship between pedagogical usability and system usefulness.

There is evidence that multiple tool support directly affects system ease of use. To measure the extent of a system's multiple tool support influence on system ease of use, hypothesis 3 is tested.

H3: There is a positive relationship between multiple tool support and system ease of use.

There is evidence that multiple tool support directly affects system usefulness. To measure the extent of a system's multiple tool support influence on system usefulness, hypothesis 4 is tested.

H4: There is a positive relationship between multiple tool support and system usefulness.

There is evidence that perceived access barriers have negative relationship with pedagogical usability and multiple tool support in a system. To measure the extent of pedagogical usability and multiple tool support on perceived access barriers, hypothesis 5 and 6 are tested.

H5: Perceived access barriers associated with using Web resources are higher in Web resources with lower pedagogical usability.

H6: Perceived access barriers associated with using Web resources are higher in Web resources with lower multiple tool support.

B. *Measuring System Acceptance*

The TAM can predict behavioural intention and the actual use of the system [7]. A user's behavioural intent towards system use depends on the PEOU and PU of the technology. The actual use of the system measures the completed actions. The model indicates that behavioural intention has a positive effect on actual use of the system [7]. PEOU is the user's belief that using the technology is free of effort [7]. In the context of a website, PEOU determines the extent to which content can be accessed easily, and plays a major role in directing user traffic. PU is the perception of the user that the website will help to achieve his or her goals. It exerts a positive relationship on actual system use. PEOU is also considered to influence the PU of the system. The following hypotheses are derived to test acceptance, relationships and significance among the variables.

There is evidence that system ease of use directly affects system usefulness. Easy to use systems are

more likely to be used than those that are difficult to use. To measure the extent of system's ease of use influence on system usefulness, hypothesis 7 is tested.

H7: There is a positive relationship between learning system ease of use and system usefulness.

There is evidence that system usefulness directly affects user's behavioural intention. Users are likely to adopt a system that they believe will help them achieve their goals. To measure the extent of system's usefulness influence on behavioural intention, hypothesis 8 and 9 are tested.

H8: There is a positive relationship between learning system usefulness and learners' behavioural intention.

H9: There is a positive relationship between learning system ease of use and learners' behavioural intention.

There is evidence that learner's perception of access barriers directly affects user's behavioural intention. Users are less likely to adopt a system that they perceive difficult to use. To measure the extent of user's perception of access barriers influence on behavioural intention, hypothesis 10 is tested.

H10: The higher the learner's perception of access barriers associated with a learning resource, the less favourable is the behaviour towards using it.

To measure the extent of user's behavioural intention influence on effective system usage, hypothesis 11 is tested.

H11: There is a positive relationship between learners' behavioural intention and effective system usage.

C. Selection of Sample Frame

A survey is conducted using a Judgment sample of undergraduate students drawn from private and public higher education institutes in Sri Lanka. All the respondents are drawn from information technology related disciplines to ensure the sample is computer-literate and experienced in the systems' operations. The aim of the survey instrument is to identify environmental needs to assist with the learning process. In the sample frame, the respondents are drawn from students (N=120) with the same educational background studying in three major state and private universities. All the respondents have some learning experience in using e-learning systems on their courses in different subject modules. Considering the time, cost, accessibility and the availability of the standard curriculum, the sample frame is further refined. The final sample frame in Table III considers the two leading state universities and a private Higher Education Institute (HEI) institute according to the government annual statistics.

Table III: The sample frame based on density

Higher Education Institute	Number of Students pursuing IT related discipline
University of Maratuwa (https://www.mrt.ac.lk)	140
Colombo School of Computing (http://www.ucsc.cmb.ac.lk/)	120
Sri Lanka Institute of Information Technology (http://www.sliit.lk/)	100

A questionnaire is designed to track user experience and to establish measures of environment characteristics, PEOU, PU, perceived access barriers, behavioural intentions and actual system use. In the online survey from Figure 3.1 to 3.5, each respondent is asked to give their opinion on a 7-point Likert scale with the end points being "strongly disagree" and "strongly agree". The 7-point Likert scale items appearingon the survey are adapted from previous researches measuring variables in a similar context [14], [16]. A total of 120 surveys were completed, and the final analysis included 100 cases after removing incomplete cases, giving a response rate of around 83%. Demographic information with respect to gender is recorded for control purposes in the analysis. Among the 100 respondents, 57% are male learners compared to 43% female. Table IV summarises the demographic profile.


A SURVEY ON LEARNERS' PERCEIVED EFFECTIVENESS OF USING WEB RESOURCES TO ACHIEVE LEARNING OBJECTIVES

Dear Participant,

Thank you very much for landing on my survey page, this questionnaire is designed to assess your approach to learning using web resources* and to assess the effectiveness of it in comparison to guided learning using structured processes in E-learning systems**. The outcome of this survey is to identify a gap to facilitate learning in the web and to close the gap to enhance learning by implementing a system in the open web. Please take 15-20 minutes to complete following questionnaires and give me your valuable feedback to furthering this research endeavor.

With kind regards,
Y. Jayaweera

* Web resources return by a Search engine
** E-learning systems can be Blackboard, E-College, Captivate, Articulate, LearnMate, Moodle and the like.

* Required

Gender *
Male
Female

Figure 3.1: Online Questionnaire -Demographic Variables

Figure 3.2: Online Questionnaire -Background Knowledge

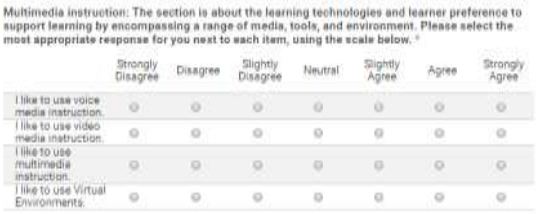

Figure 3.3: Online Questionnaire -Multimedia Tool Support

Figure 3.4: -Online Questionnaire Learner Control

Figure 3.5: Online Questionnaire -Pedagogical Usability

Table IV: The demographic profile of the respondents

Variable	Number of respondents	Percentage
Gender		
Male	57	57
Female	43	43

D. Measuring Reliability and Validity of Data

Reliability and construct validity are evaluated using Cronbach's alpha, composite reliabilities and average variance extracted measures (AVE) [18]. The Cronbach's alpha is used to measure the internal consistency. The items measuring the same construct in the questionnaire should be closely related. The generally agreed-upon criteria for scale reliability is its cut-off Cronbach alpha value of 0.7 [18], though there are findings supporting the view that Cronbach alpha values above 0.6 are generally acceptable [10]. Hair [11] stated that in a study with a small sample size, low Cronbach alpha scores such as 0.6 can be taken as an acceptable measure. Table V shows the reliability of the measurement scales and Cronbach's alpha reliability scores which are all above 0.6, which is considered to be acceptable.

Table V: Reliability measurements of each variable

Variable	Scale	Cronbach alpha	Number of questions
PEDU:- Pedagogical usability	Vocabulary and terminology used in Web resources are not appropriate (PEDU1) Abstract concepts (principles, formulas, rules, etc.) in Web resources are not illustrated hard to understand. (PEDU2) The Web resources do not have tools (taking notes, glossary, resources, table of contents etc.) that support learning. (PEDU3)	.704	3
MI:- Multiple tool support	Use of voice media instruction (MI1) Use of multimedia instruction (MI3) Use of Virtual Environments (MI4)	.774	3
AB:- Perceived access barriers	Use of Vocabulary and terminology (ABPEDU1) Use of clear concepts with proper illustrations (ABPEDU2) Support of tools to support learning (ABPEDU3) Lack of voice media instruction (ABMI1) Lack of video media instruction (ABMI2) Lack of multimedia instruction (ABMI3) Lack of Virtual Environments (ABMI4)	.676	7
PEOU:- Perceived ease of use	Web systems act as my learning assisted tool. (PEOU1) The Web systems have all the learning functions. (PEOU2) I am satisfied with Web learning contents and the guided learning processes. (PEOU3) I am more satisfied with using a search engine to retrieve Web resources as a learning assisted tool if it returns related resources. (PEOU4) I am satisfied with learning contents in Web resources which I retrieve to satisfy my learning objectives. (PEOU5)	.636	5
PU:- Perceived usefulness	I believe content on Web resources returned by a search engine are useful learning materials. (PU1) I believe contents on Web resources are informative. (PU2)	.633	2
BI:- Behavioral intention	I intend to Web resources to assist my learning. (BI1) I intend to use content on the Web resources to assist my learning objectives. (BI2) I intend to use Web resources as an autonomous (self) learning tool. (BI3)	.781	3
SE:- Effective system use	I believe Web resources can assist efficiency in my learning. (SE1) I believe Web resources can assist performance in my learning. (SE2) I believe Web resources can motivate my learning. (SE3)	.639	3

\Table VI: Factor Loading (Principal axis factoring is used with promax rotation and Kaiser normalisation, N = 100)

Item	Factor									
	1	2	3	4	5	6	7	8	9	10
PEDU1	.573									
PEDU2	.628									
PEDU3	.543									
MI1		.525								
MI3		.523								
MI4		.793								
ABPEDU1			.593							
ABPEDU2			.571							
ABPEDU3			.570							
ABM1				.716						
ABM2					.625					
ABM3				.596						
ABM4				.570						
PEOU1						.806				
PEOU2						.718				
PEOU3						.717				
PEOU4							.661			
PEOU5							.558			
PU1								.681		
PU2								.681		
BI1									.846	
BI2									.780	
BI3									.673	
SE1										.690
SE2										.646
SE3										.538
% of variance explained	35	36	35	20	45	34	15	47	60	40

The convergent validity is supported by the composite reliabilities (CR). The CR is calculated using the following formula [18].

CR = (square of the summation of the factor loadings) / {(square of the summation of the factor loadings) + (square of the summation of the error variances)}

The discriminant validity for the measures is supported by an exploratory factor analysis and AVE values as given in Table VI. The average variance is calculated as follows [18].

AVE= (summation of the square of the factor loadings) / {(summation of the square of the factor loadings) + (summation of the error variances)}

The dimensionality reduction is also carried out using exploratory factor analysis. All factor loadings given are above 0.50, showing good convergent validity [11]. The AVE for each construct exceeds 0.5, as given in Table VII. Hence, constructs are valid and serve the purpose of the measurement [11].

Table VII: AVE values

Construct	Factor Score	AVE
Pedagogical usability	Factor 1 score	0.686
Multiple tool support	Factor 1 score	0.613
Perceived access barriers	Factor 1 score	0.578
	Factor 2 score	0.628
	Factor 3 score	0.625
Perceived ease of use	Factor 1 score	0.747
	Factor 2 score	0.609
Perceived usefulness	Factor 1 score	0.681
Behavioural intention	Factor 1 score	0.766
Effective system use	Factor 1 score	0.625

IV. Results and Analysis

This section outlines the results obtained by the in-depth analysis. It is followed by a detailed discussion presented together with the outcomes. In conducting the analysis, correlation and regression analysis are carried out. The hypotheses are tested against the path coefficient. In summary, the statistical analysis reveals that there is a relationship between environment factors and perceived access barriers. Hence, the use of Web resources is influenced by its pedagogical usability and multiple tools support.

A. *Item Correlation Analysis*

The correlation coefficient r-value represents the quantitative measure of the relationship between outcome variables and predictor variables [3]. Table VIII summarises the correlations. According to the correlation analysis in Table VIII, there are moderate levels of correlation between environment factors and dependent variables: PEOU, PU and perceived access barriers. Furthermore, there is a negative correlation between environment factors and perceived access barriers. Accordingly, the higher the presence of environment factors in Web resources, the lower the perceived access barriers. The r-value between predictors is less than 0.9. However, there is no problem of multicollinearity. No significant correlation is found between participants' gender, the path coefficient or p-value greater than 0.05. Hence, it is dropped from further analysis. The path coefficient represents the weight derived from a linear regression model which determines a causal relationship between the predictor and outcome variables [3].

Table VIII: Correlations between the variables

Variable	Pedagogical Usability	Multiple Tool Support	Perceived Access Barriers	Perceived Ease of Use	Perceived Usefulness	Behavioural Intention	Effective System Use
Pedagogical Usability	1.00	0.119	-0.815	0.553	0.57	0.082	0.084
Multiple Tool Support	0.119	1.00	-0.657	0.462	0.361	0.208	0.277
Perceived Access Barriers	-0.815	-0.657	1.00	-0.101	-0.194	-0.447	-0.167
Perceived Ease of Use	0.553	0.462	-0.101	1.00	0.457	0.594	0.357
Perceived Usefulness	0.57	0.361	-0.194	0.457	1.00	0.594	0.168
Behavioural Intention	0.082	0.208	-0.447	0.594	0.594	1.00	0.428
Effective System Use	0.084	0.277	-0.167	0.357	0.168	0.428	1.00

Table IX: Regression results for H1 – H11

	Variable	β	Standard Error of β	p	R2
H1	Pedagogical usability	.338	.050	P<0.05	.306
H2	Pedagogical usability	.358	.072	P<0.05	.326
H3	Multiple tool support	.146	.068	P<0.05	.214
H4	Multiple tool support	.132	.101	.193	.131
H5	Pedagogical usability	-.465	.033	P<0.05	.664
H6	Multiple tool support	-.523	.061	P<0.05	.432
H7	Perceived ease of use	.307	.088	P<0.05	.209
H8	Perceived usefulness	.313	.083	P<0.05	.354
H9	Perceived access barriers	-.324	.056	P<0.05	.200
H10	Perceived ease of use	.331	.087	P<0.05	.308
H11	Behavioral intention	.388	0.83	P<0.05	.183

Table X: Testing of Hypotheses

Hypothesis	Relationship tested	Results
H1	Positive relationship between pedagogical usability and system ease of use.	Supported
H2	Positive relationship between pedagogical usability and system usefulness.	Supported
H3	Positive relationship between multiple tool support and system ease of use.	Supported
H4	Positive relationship between multipletool support and system usefulness.	Not Supported
H5	Perceived access barriers of using Web resources are higher with Web resources with lower pedagogical usability.	Supported
H6	Perceived access barriers associated with using Web resources are higher with Web resources with lower multiple tool support.	Supported
H7	Positive relationship between learning system ease of use and system usefulness.	Supported
H8	Positive relationship between learning system usefulness and learners' behavioural intention.	Supported
H9	The higher the learner's perception of access barriers associated with a learning resource, the less favourable the behaviour towards using it.	Supported
H10	Positive relationship between learning system ease of use and learners' behavioural intention.	Supported
H11	Positive relationship between learners' behavioural intention and effective system usage.	Supported

B. Regression Analysis

Linear regression analysis is conducted based on 100 completed surveys collected from the study. In testing hypotheses 1 to 11 (H1-H11), regression analysis is performed. Table IX summarises the regression results. Except for H4, the others are supported and are statistically significant. The relationship between multiple tool support and system usefulness is statistically insignificant: p-value is 0.193. Based on the results, Table X shows the outcomes of hypotheses testing.

V. Summary and Contributions

This empirical study examines the TAM using learner acceptance of Web resource usage in the context of Web IR using search engines. Based on data collected from 100 undergraduate students, the utility of the TAM to explain acceptance of Web IR using search engines by students is evaluated. Overall, the TAM is supported. According to the results, pedagogical usability and multiple toolsupport are associated with significant outcome variables. These factors influence learner's behavioural intention towards usage and, ultimately, effective use of Web resources. Furthermore, the perceived access barriers have a negative effect on the outcome variable of learner behavioural intention towards using a Web resource. Higher perceived access barriers in a system lowers learner behavioural intention on using a Web resource and ultimately limits the overall usage. The effect of PEOU and PU on learners' behavioural intention is also found significant, which is consistent with the previous findings [7].

The findings of this study make several theoretical contributions. First, the basic TAM is extended by adding perceived access barriers as a third factor which explains user behavioural intentions towards effective use of a system. Second, environment factors are considered as external variables due to their importance in the context of Web resource usage. Thus, modern search engines provide ease of use through navigation with the irrelevant search results that get through negatively impacting system usefulness by lowering its precision. This finding highlights the impact of perceived access barriers on overall system usage. None of the well-known search engines have provision for environment factors when they return Web resources. Hence, this might reflect limitations of the application of search engines in a learning scenario.

The findings also highlight the need for improving environment factors in Web-based IR systems. Pedagogical usability and multiple tool support are considered as the main contributors to the environment. In line with findings, the presence of environment factors in an IR system can lead to improved learning system ease of use and learning system usefulness while lowering perceived access barriers. This study also helps website designers and content generators to be more focused on pedagogical usability and supporting multiple tools.

VI. Limitations and Directions for Future Research

One of the limitations of the study concerns the sample selected for findings. The survey is conducted using a sample of learners who have moderate computer literacy. The sample covers undergraduate students of both genders who are studying in both state and private higher education institutes in Sri Lanka. Therefore, the findings may be skewed away from learners from other backgrounds.

With regard to future work, researchers need to conduct studies to explore the role of other intrinsic motivational factors that could impact learners' effective system usage by creating a better environment for informal learning to take place. However, research needs to be directed towards constructively removing barriers and paving the way for designing and developing improved Web IR systems which address the current problem of information overload and thus providing on-demand IR that satisfies user requirements. In the future, it is intended to investigate the impact of personal factors on effective system usage to make Web IR more personalised.

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