

Learning Technology Systems: issues, trends, challenges

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Abstract

This paper elaborates on a comparative analysis of contemporary LTSs. We have selected a number of the most important, commonly used, modern LTSs and put them through a thorough evaluation process, based on the services, tools, and features they support, and the usability of their hypertext user interface. The result of the evaluation is twofold: to explore the utility of LTSs and consequently discover the real nature of these systems, based on the features they support; and to delve into the usability of LTSs, a critical factor in the acceptance of these systems by the market.

Keywords

Learning technology systems, distance learning, computer-based training, hypertext, evaluation, usability.

1. Introduction

The introduction of networked technologies and especially the Internet and the World Wide Web in the fields of education and training, is not new and certainly not innovative. In fact these technologies, also known as 'Advanced Learning Technologies' [<http://csalt.lancs.ac.uk/alt/>], have been around for some years, and have been applied in the form of computer-based training, electronic performance support systems, computer assisted instruction, intelligent tutoring, collaborative, adaptive and distance learning etc. Even though the Internet and the Web are the basic low-level infrastructure for the construction of such systems, there is also a middleware in the form of **Learning Technology Systems (LTS)** that provides integrated services such as the creation and distribution of on-line learning material, the communication and collaboration between the stakeholders, the management of instructional systems and so forth. These systems incorporate fundamental Internet and Web services, provide a uniform interface to learners, tutors, learning material authors, instructional designers and administrators, and promote portability of learning resources as well as interoperability between each other.

The LTS [IEEE LTSC 2000] has been established as the basic infrastructure for supporting the technology-based instructional process in an easy-to-use, pedagogically correct and cost-efficient manner. LTSs have been used for educational and training purposes, not only because they have been advertised as the state of the art learning technology, but also because they have substantial benefits to offer. In specific, they alleviate the constraints of time and place of learning, they provide an excellent degree of flexibility concerning the way of learning, they support advanced interactivity between tutors and learners and they grant one-stop maintenance and reusability of resources.

The plethora of the LTSs available today, as well as the varying needs of instructional systems, instructors and institutions, create a need for the evaluation of these systems, so that their potential can be investigated [Alexander 1995]. The market is packed with such systems that offer different services and capabilities regarding organization and distribution of learning content, course management, student assessment, communication and collaboration tools, administration of instructional institutions and so forth. There has to be some comparative analysis and assessment of LTSs, which clearly probes their features in the context of pedagogy, open learning and instructional design. Consequently instructional designers that are called upon to solve a specific instructional problem with explicit needs and requirements will be assisted in choosing a specific LTS that fits closer to the above problem.

A number of comparative reviews are available on the World Wide Web. The most important are

- [<http://www.ctt.bc.ca/landonline>], a comprehensive presentation of technical characteristics of LTSs, and an on-line tool for automatic comparison of systems, based on certain criteria.
- [<http://www.leeds.ac.uk/educol/documents/00001237.htm>, etc], a review that provides a full framework for the evaluation of LTSs based on Pedagogy and System Organization applied on 12 systems.
- [<http://www1.umn.edu/dmc/portfolio/comparison/index.shtml>], where four LTSs are being examined against certain, high level evaluation criteria. The results are presented in textual interview reports and comparative evaluations per system and per criterion.
- [<http://www.esocrates.com/LearningResources/ComparisonChart.htm>]
<http://www.marshall.edu/it/cit/webct/compare/comparison.html>
<http://www.umanitoba.ca/ip/tools/courseware/evalmain.html>
<http://www.futureu.com/cmscomp/cmstables.html#table1>.
 These Web Sites present tables of features supported by selected LTSs.

These reviews usually focus on the mere presentation of the features supported by the LTSs being examined, as well as on the comparison between them according to specific criteria. Some times an evaluation framework is introduced, based on technical and pedagogical principles. This paper also presents an evaluation framework that is concentrated on technical specifications, as well as on usability issues. For every learning technology system assessed, there is an analytical table of features and functions categorized in groups that address the most important functions that these systems are expected to perform, as well as other features, such as standards compliance [Nielsen 200]. Also there is a classification of the LTSs under assessment, according to the features they best support and the potential need that we suggest they can address in the learning process. Finally usability criteria are adopted in order to further assess the systems functionality and efficiency in addressing the needs of different types of users accessing the systems.

The aim of this review is not a mere lining up of the different capabilities that LTSs offer at present, but also an investigation regarding the trends of the market, the worries about the problems that surface, and finally the challenges that are currently faced. The structure of the paper will be as follows: In section 2 we describe in detail the framework used for the evaluation. Section 3 presents the qualitative results of the assessment of LTSs, while section 4 continues with some conclusions deduced from the review.

2. Evaluation framework

Our approach derives from the understanding that Learning Technology Systems are introduced and widely adopted by institutions and instructional designers, in order to fulfill certain needs and requirements in a field of ever increasing demands for effective, fast and pedagogically correct education and training. Consequently the people involved in the decision-making process concerning instructional design and organization of educational institutions would use a Learning Technology System in order to:

- Create, operate and administrate an on-line course.
- Support the collaboration between students and provide motivation and resources for team building [McConnell 1994].
- Create and deliver questions and tests for student assessment
- Organize educational, financial and human resources.
- Administer virtual, distributed classes where the students are geographically scattered and communicate via the Internet.

These diverse usage scenarios of LTSs, correspond to different categories of Learning Technology Systems, which are respectively the following:

- **General systems**, which have a number of tools for creating and managing courses and do not give emphasis to any particular set of features. We call these systems ‘general’ and not, for example ‘Course Management’, because they provide a plethora of features that span many assorted areas, in order to provide fully functional on-line courses, such as communication tools, administration tools, etc.
- **Collaborative learning support systems**, which emphasize on team building, student group management and providing the synchronous and asynchronous collaboration tools to support the aforementioned activities.
- **Question and test authoring and management systems**, which facilitate the design and construction of quizzes and tests, which are published on the WWW and taken on-line. They provide tools for test creation and their on-line delivery, automatic grading, results manipulation and report generation.
- **People and Institute resources management systems**, which deal with human resources and financial management.
- **Virtual classrooms**, which establish a virtual space for live interaction between all the participants in the learning process, i.e. instructors, tutors and students.

The LTSs that fit in one of the above categories support a number of **features**, or tools or capabilities in order to carry out certain tasks. These features do not discretely belong to only one LTS category but can be shared by several categories. These features can be classified into certain groups, namely:

- **Course Management**, which contains features for the creation, customization, administration and monitoring of courses.
- **Class Management**, which contains features for user management, team building, projects assignments etc.
- **Communication Tools**, which contains features for synchronous and asynchronous communication such as e-mail, chat, discussion fora, audio/video-conferencing, announcements and synchronous collaborative facilities (desktop, file and application sharing, whiteboard).
- **Student Tools**, which provide features to support students into managing and studying the learning resources, such as private & public annotations, highlights, bookmarks, off-line studying, log of personal history, search engines etc.
- **Content Management**, which provide features for content authoring and delivery and file management.
- **Assessment Tools**, which provides features for managing on-line quizzes and tests, project deliverables, self-assessment exercises and so on.
- **School-Management**, which provide features for managing records, absences, grades, student registrations, financial administration etc.

The features in these groups are presented in the next paragraph. The first part of the evaluation framework aims at two goals: a) to discover *what* an LTS does, i.e. which features it supports and b) to classify the LTSs into the appropriate categories. The first goal is achieved by providing tables of features and ticking the suitable check-boxes for every LTS. The second goal is accomplished by identifying the groups of features that an LTS supports and deciding about which one of the LTS categories it belongs to. This decision is not taken ad hoc, but according to the mapping of Table 1. This mapping portrays the relation between the aforementioned Learning Technology Systems categories and the groups of features that we have selected in order to characterize the LTSs.

The classification of LTSs under evaluation into categories is of paramount importance since it seeks to shed some light into the real nature of these systems, as there is currently much confusion about this matter. The terms used to describe the LTSs are covered by much vagueness and fuzziness and companies or other development organizations tend to assert these systems with expressions that further augment the uncertainty. There is surely no common vocabulary that characterizes the LTSs, which results in hindering the building of consensus among various stakeholders. Our approach aims to clarify things by characterizing LTSs objectively, according to the features they support.

The evaluation framework proposed in this paper suggests that the systems under evaluation shall be tested in order to discover the supported features and consequently the supported groups of features. If the majority of the features in a group is supported by an LTS, then the whole group is considered to be supported by this LTS. The result will be to classify the LTSs into the respective categories according to which groups of features they support and the mapping of Table 1. An important issue that must be emphasized here is that it is possible for an LTS to fit into more than one category, i.e. it can be used for more than one purposes.

Table 1: Mapping between LTS categories and groups of features

LTS Categories	General Systems	Collaborative Learning Support Systems	Virtual Classrooms	Question and Test Authoring & Management Systems	People and Institute Resources Management Systems
Supported Groups of Features					
Course Management	X				X
Class Management	X	X	X		X
Communication Tools	X	X	X		
Student Tools	X	X	X	X	
Content Management	X			X	X
Assessment Tools	X			X	
School-Management	X				X

The evaluation framework so far has dealt with the utility of the LTSs by proposing the identification of features that each LTS supports, and the classification of the LTSs into the defined categories. The second part of the framework deals with the usability of the LTSs, which is not concerned with *which* features are supported by each LTS, but *how well* they are supported. This approach is based on the hypertext usability criteria proposed in [Nielsen 1993], takes under account the evaluation principles suggested in [Tessmer 1996], and elaborates on the above in order to set usability criteria especially for Learning Technology Systems.

LTSs are complicated hypertext systems having extended and complex navigation structure in order to present the learning content and tools that they provide. The intricacy of hypermedia applications has become common knowledge and there are various techniques and models used in order to manage this structural and semantic complexity [Squires & Preece, 1999, Lowe & Hall 1999]. The criteria proposed by this evaluation framework aim to address the usability issues that cover the whole of the multi-faceted hypermedia-based LTSs and are the following:

- 1) **Easy to learn and comprehend.** The users of an LTS must easily comprehend the system and learn how to use it. This concerns the navigation, the selection of tools and functions and the metaphors. It is also important that special technical skills are not required.
- 2) **Efficient in feature realization.** LTSs are designed to perform certain tasks, but it is obvious that not all LTSs perform the same tasks in the same manner (e.g. the video conferencing facility in CUSEEME and Microsoft Netmeeting). The question here is how well are the various tasks being performed.
- 3) **Efficient in navigation.** A user who is navigating through the hypermedia structure of an LTS must at all times know where he is and why he is there, where he came from and where can he go from there.
- 4) **Forgiveness from errors.** A user of an LTS often navigates himself back and forth through various paths due to an inclination to experimenting and exploration. A forgiving system allows the user to return quickly and easily to the point where he started through commands such as "undo", "back", "revert" etc.
- 5) **Pleasant to use.** An LTS must have pleasant aesthetics, which is the result of the color code in use, the graphics and animation quality, the fonts etc. An LTS is also pleasant to use when the downloading and the transition between pages of content is fast, or in other words when the user is not forced into frustrating delays.

For each of the above criteria we apply a grade from 1 to 5 where a small number means poor performance and a large one means good performance. This sort of usability evaluation is performed for each category of potential users, namely the students, the designers, the tutors and the administrators. This is important because different categories of users are provided with different kind of features, and even the features that are shared by more than one user categories have different user interfaces for each one of them. The application of this evaluation framework for 13 Learning Technology Systems is described in the following section.

3. Results

We have selected a certain number of LTSs for applying the proposed evaluation framework. The criteria for selecting the specific systems out of the entirety of the LTSs in the market are: a) the degree of adoption they have received by instructional institutions and b) the availability of resources for our evaluation (on-line documentation, white papers and demonstration versions of the systems). We concluded in 13 LTSs, that we consider being the most widely adopted in the educational market and that also offer adequate resources for their evaluation.

The proposed evaluation process begins with testing each system and checking which features it supports. These features are classified into the groups mentioned in Section 2. The results are depicted in Table 2.

Table 2: Features of Learning Technology Systems

	WebCT	VirtualU	Blackboard	CoSE	Centra	Cate	Intralearn	TopClass	LearnLinc	Saba	FirstClass	Convene	LearningSpace
Course management													
Syllabus Template	No	Yes	No	No	No	Yes	Yes	No	No	No	No	Yes	No
Calendar	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	Yes	Yes
Announcements	Yes	No	Yes	No	No	No	Yes	Yes	Yes	No	No	Yes	No
Glossary	Yes	Yes	No	No	No	No	Yes	No	No	No	No		No
Structure course access pages	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Customizable-consistent course interface	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Links to web resources	Yes		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class Management													
Create assignments	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Organize students in groups for team working on assignment projects	Yes	No	Yes	Yes	No	No	No	No	No		Yes	Yes	Yes
Assignments grading	Yes	Yes	Yes	No	No		Yes	No	No	Yes	Yes	Yes	Yes
Assignments grades statistical analysis	Yes	Yes	Yes	No	No		Yes	No	No	Yes	Yes	Yes	
Students' progress tracking	Yes	No	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Assessment tools													
Test content authoring tools/wizards	Yes	No	Yes	Yes	No	No	No	No	Yes	No	No	Yes	Yes
Test content upload	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Automatic, scheduled test delivery.	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	
Automatic test scoring	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No		Yes
Automatic generation of results' statistical analysis reports.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

Number of test types supported	5	Any	4	0			3	>4	5	5	0	>4	4
Advanced security for increased examination procedure's reliability.	Yes	No	No	No	No	No	No	No	No	Yes	No	No	Yes
Automatic generation of quizzes from a pool	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No		Yes
Adaptive and personalized quiz presentation	No	No	No	No	No	No		Yes	No	No	No		No
Communication tools													
E-mail	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Chat	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	Yes
Discussion forums	Yes	Yes	Yes	No	Yes	No	Yes	Yes		No	Yes	Yes	Yes
Video conference	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
Voice conference	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
Shared white board	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	No
Application Sharing	No	No	No	No	Yes	No	Yes	No	Yes	No	No	No	No
Sessions scheduling	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
File transfer utilities	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Student Tools													
Add Bookmarks	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes		Yes
Add Personal notes	No	No	No	Yes	No	?	Yes		No	No	Yes		Yes
Get information about study progress	Yes	Yes	Yes	No	No	Yes	Yes		No	Yes	Yes		Yes
Self-assessment quizzes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No		Yes
Adaptive/personalized quiz presentation	No	No	No	No		No	No	Yes	No	Yes	No		No
Search-in-content tools	Yes	No	No	Yes		No?	Yes	Yes	No	No	No		No
Self registration in courses	Yes	No	Yes	No	No	Yes		Yes	Yes	No	No		No
Personal web page creation	Yes	No	Yes	No	Yes		No		No	No	Yes		Yes
View his own grades	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes			Yes
Groups of students can share resources to facilitate team working.	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Content management													
Content upload	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Content authoring	Yes	No	No	Yes	No	No	No	No	No	No	Yes		No
Content structuring	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Yes		Yes

Multimedia content insertion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Other (than html) content types supported	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes		Yes
Tools for effective navigation inside content	Yes	No	No	Yes	No	Yes	Yes	Yes	No	Yes	No		Yes
No HTML knowledge required for content authoring	No	No	No	Yes	No	No	No	No	No	No	Yes		No
Tools/wizard for content authoring	No	No	No	Yes	No	No	No	No	No	No	Yes		No
Use of templates – reusability of content appearance	No	No	No	No	No	No	No	No	No	No	Yes		No
Tools/wizards for content publishing	No	No	No	Yes	No	No?	Yes	Yes	No	Yes	Yes		No
Meta-data specification.	No	No	No	Yes	No	No		Yes	Yes	Yes			Yes
School-Organization Management													
Student admissions management	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No
Human resources management	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No
School financial management support	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Student mentoring – Advising for courses selection and prerequisites	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Administration													
User Records Management	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No		Yes
Course Backups	Yes	No		No	No	No	Yes	No	No		No	Yes	No
File management support	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	No		No
Database management support	No	Yes	No	No	No	Yes	Yes		No	Yes	No		No
Other Features													
General													
Multiple language support	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No		No

Learning technology standards compliance	IMS	No	IMS	IMS	No	No	AICC, SCORM, IMS	AICC, IMS	No	AICC IMS, IEEE	No	No	AICC, IMS
Online help	Yes	Yes	Yes				Yes	Yes	Yes		No	Yes	Yes
Reliable technical support	Yes		Yes				Yes			Yes	No	Yes	Yes
Price	\$4,000 (400 Students)	\$2500 (Academic Price)	\$4000	£2495 (Unlimited package)			\$25,000						
Technical													
Web hosting /Local server installation	Local	Local	Local/Hosting	Local	Local	Local	Local		Local	Local /Hosting		Web hosting	Local
Database System Use	No	No	No	No		Yes	Yes		Yes	Yes	No		Yes
Server platform requirements	Unix/Win	Unix/Win	Unix/Win	Unix/Win	Win NT/2000	WinNT	Win NT/2000	Win/ Unix/Mac	Win	Win	Win		Win
Openness	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No
Assessment Resources													
Tested Product/Version	v.3.1.3	v.2.5	v.5				SMS		v.5	Learning Enterprise	Zebu	Izio	v.4
Method of Assessment	Full functional local installation	Full functional local installation	Full functional Online demo	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation

It is reminded that we consider a group of criteria to be supported by an LTS if the majority of features in the group is supported. In Table 2, the features mentioned as ‘Other Features’ have not been taken into account for the classification and are presented for informative reasons only. Taking into account the mapping between the categories of LTSs and the groups of Features, as shown in Table 1, we classify the systems in the categories defined in Section 2. The results are shown in Table 3.

Table 3: Learning Technology Systems Categorization Results

Name	Company	URL
General		
WebCT	University of British Columbia	http://www.webct.com
CoSE	Staffordshire University	http://www.staffs.ac.uk/COSE
Centra	Centra Software	http://www.centra.com
Cate	Cate	http://www.cate.com
Convene	Convene	http://www.convene.com
LearningSpace	Lotus	http://www.lotus.com/home.nsf/welcome/learnspace/
BlackBoard	Blackboard	http://www.blackboard.com
TopClass	WBT Systems	http://www.wbtssystem.com
VirtualU	Virtual Learning Enviroments	http://www.vlei.com
FirstClass (Zebu)	Centrinity	http://www.firstclass.com
Intralearn	Intralearn	http://www.intralearn.com
Collaborative Learning		
WebCT		
BlackBoard		
Virtual Classrooms		
LearnLinc	Mentergy	http://www.embanet.com
Question and Test		
WebCT		
Organisational Management		
Cate	Eurocom	http://www.eurocom.gr/catesite/

As we have mentioned above, some systems can be classified into more than one categories, which is rather evident in Table 3. For example, WebCT can be used both as a general purpose system, and as a system that provides a full set of tools to create and deliver Questions and Tests.

As far as the usability evaluation is concerned, we used the criteria described in the previous section to test five of the most dominant systems of the ‘General’ category: WebCT, Blackboard, VirtualU, Intralearn, LearningSpace and CoSE. We only tested systems from the ‘General’ category because of the wide adoption of this category and the extensive hypertext user interface that characterizes them. We applied our criteria for three types of users: Students (St), Instructors and Designers (ID) and Administrators (Ad). The results of the evaluation are represented in Table 4.

Table 4: Systems Usability Assessment per User

LTS	Usability Criteria														
	Easy to learn and comprehend			Efficient in feature realization			Efficient in navigation			Forgiveness from errors			Pleasant to use		
	St	ID	Ad	St	ID	Ad	St	ID	Ad	St	ID	Ad	St	ID	Ad
WebCT	5	4	3	4	5	3	5	4	3	3	2	2	5	4	3
Blackboard	5	5		4	4		5	4	3	4	3		4	4	
VirtualU	3	3	3	2	2	2	3	3	3	2	2	2	4	3	3
Intralearn	3			4			4			4			3		
LearningSpace	4			4			4			3			4		
CoSE	2			5			4			4			3		

4. Conclusions

The mere enumeration of supported features, is a good metric for the potential of LTSs, but cannot be an inclusive measure for the comparative analysis and evaluation of Web-based Learning Technology Systems [Avouris et al. 2001, Paternò, 2000]. The added value of our approach is twofold: the classification of the LTSs into categories according to specific objective criteria and the survey of the usability of these systems. The first aspect aims at clarifying the real disposition of the LTS under evaluation, as there is currently little insight, concerning what each of these systems actually represents, what it is able to perform, and what needs it can cover. The second aspect deals with an often-overlooked matter, the usability of the hypertext user interface, which is rather critical in LTSs that are extensively based on human-computer interaction.

From the tables 2 and 3 it is obvious that the most full featured and powerful systems are Blackboard and WebCT. It is not a surprise that these two systems are the most popular in the education and training market at present. Another inference from the tables is that the majority of the systems examined belong to the 'General' category, and these systems include a great variety of features that overlaps all the other categories. Systems that belong to this category are more popular than systems from the other categories, because they tend to have everything in the same price, even if they lack in efficiency compared to the specialized systems.

From Table 4 we conclude that most of the LTSs are characterized by an acceptable degree of usability as far as the student is concerned, and they are less usable for designers, instructors and administrators. This is partially justified by the fact that students are equipped with rather simple and straightforward tools, while designers, instructors and administrators deal with much more complex and dense tools and perform more challenging tasks. On the whole we reckon that the LTSs under evaluation are quite usable, especially as far the 'easy to learn and comprehend' and 'efficient in navigation' criteria are concerned.

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