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Collaborative Learning Evaluation (CLE) Framework

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Abstract: - Collaborative Learning is an effective activity-based, constructivism-based and experience-based learning method. Recently, various computer and network supported educational environments are incorporating collaborative learning activities. In order to design, develop and select effective collaborative learning systems it is necessary to consider quality requirements. This paper presents the CLE (Collaborative Learning Evaluation) framework for evaluating the quality of collaborative learning systems. This CLE framework consists of three quality dimensions: educational, economical, and technical. The educational dimension consists of three sub-dimensions: i) content & activities, ii) pedagogy & abilities, and iii) interaction & communication. The economical dimension consists of three sub-dimensions: i) costs, ii) contracts & licenses, and iii) cost-effectiveness. The technical dimension consists of eight sub-dimensions: i) user interface, ii) reliability, iii) maintainability, iv) performance, v) functionality, vi) adaptation, vii) connectivity, and viii) security. This CLE framework may help designers, developers and evaluators of collaborative learning systems to make right decisions.

Key-Words: - collaborative learning, cooperation, evaluation, human-computer interaction, pedagogy, quality requirements, usability.

1 Introduction

Learners working in small groups tend to learn more of what is taught and retain it longer than working independently. They are also more satisfied with their educational activities. Collaborative Learning (CL) has great potential in facilitating active, constructive and experiential learning. In a collaborative learning environment the learners collaborate to perform educational tasks, activities, projects, etc. Recently, many computer and network based CL systems are being developed to enhance learning [1-4]. A CL system consists of the learners' devices, the networks interconnecting them, the software that manages all activities and participants, other hardware and software resources. The CL system manages all these so that the learners learn successfully. The virtual room metaphor is used in [1] to develop a cooperative learning system. The virtual institute metaphor is used in [2]. Cooperative hypermedia are used to represent both shared learning spaces and shared information spaces as shared hyper-documents. An infrastructure for collaborative lifelong learning is described in [3]. It is based on integrated collaboration functionality, transitions between different learning modes and a scalable standards-based architecture.

It is important to evaluate the quality of CL systems in various contexts of use. Quality includes the characteristics of the system that ensure its ability to satisfy the user needs. For example, does the CL system support collaborative and active learning? Does it adapt to the learner? Is it easy to use? Is it secure? Is it cost effective?

Usability and user satisfaction are extremely important for effective CL [4]. Evaluation of CL systems is needed to justify the investment and select the most appropriate ones [5]. A collaborative virtual learning environment that uses avatars in a virtual world is developed and evaluated in [6]. The evaluation is performed at four levels: pedagogical-psychological, technical-functional, organizational-economical, and social-cultural. An observation method, an inspection method, a usability design method and a hierarchical task analysis of collaboration in collaborative virtual environments are presented in [7]. A context-oriented communication model that focuses on the dialogical communication and mediation of context is described in [8]. The evaluation of a prototype shows that the concept of annotations is well received. A collaborative learning platform to support the implementation of a variety of learning environments is developed in [9]. Initial experience indicates its applicability. A web-based consultation space is evaluated by a non-deterministic qualitative, utilisation-focused approach in [10]. The student's perceptions on the usability, usefulness, group work and international collaboration of a collaborative virtual learning environment are shown in [11].

The lack of a generally accepted evaluation framework makes difficult the evaluation of a CL system and the comparison among various CL systems. In this paper, we propose such a framework. We hope to develop an effective evaluation methodology, and increase the CL systems comparability attempts. The proposed CLE framework consists of three dimensions: i) educational, ii) economical, and iii) technical. For the technical dimension, we are inspired by the ISO 9126 quality standard [10]. However, we do not closely adhere to it. We extend it to best suit CL systems. The ISO/IEC 9126 standard for software evaluation defines six software quality characteristics: Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability. In this paper, for the technical dimension, we consider eight sub-dimensions: 1) User Interface, 2) Reliability, 3) Maintainability, 4) Performance, 5) Functionality, 6) Connectivity, 7) Security, and 8) Adaptation (Diagram 1). For the educational dimension, we consider three sub-dimensions: 1) Content & Activities, 2) Pedagogy & Abilities, and 3) Interaction & Communication. Finally, for the economical dimension, we consider three sub-dimensions: 1) Costs, 2) Contracts and Licenses, and 3) Cost-Effectiveness.

2 CLE Framework

In this Section, we propose the CLE framework for evaluating CL system. It consists of the following three dimensions: A) Educational, B) Economical, and C) Technical (Diagram 1).

2.1 Educational dimension

The Educational dimension consists of the following sub-dimensions: 1) Content & Activities, 2) Pedagogy & Abilities, and 3) Interaction & Communication.

2.1.1 Content & Activities

The content and the educational activities of the CL system (Table 1) should be personalized based to each learner's and educator's personal characteristics. They should be accurate, valid and bias-free presenting all points of view objectively without discriminating. They should be comprehensive and complete covering all main ideas and key points at the right quantity.

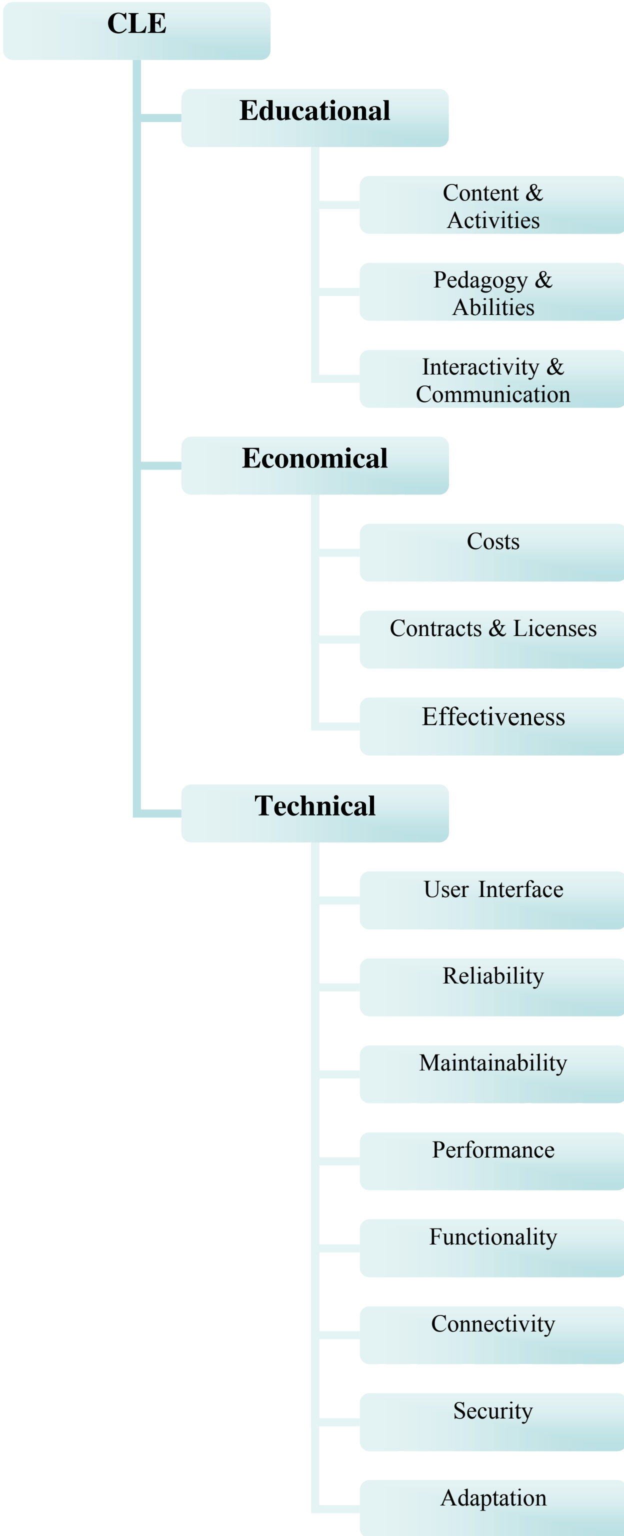

Diagram 1. CLE framework.

Their presentation should be clear and simple with minimum cognitive overload. They should be suitable for collaborative learning, meaningful for the participants and appropriate for the expected educational outcomes. They should present the state of the art, currently acceptable knowledge that will be valid for long time.

Content & Activities	*Description*
Personalization	Content & Activities (C&A) based on learner's personal characteristics.
Accuracy & Validity	Accurate, reliable, valid, credible, authoritative, and certified C&A.
Objectivity & Bias-free	Objective, bias-free, fair and non-discriminating.
Comprehensiveness & Completeness	Complete and comprehensive C&A without missing key concepts, and at the right quantity.
Clear & Simple	Clear and simple C&A.
Presentation & Media	Right and attractive presentation, format and use of multimedia.
Appropriateness, Suitability & Meaningfulness	C&A appropriate and relevant to the expected educational outcomes, suitable for collaboration, meaningful for the participants.
Currency	Current, modern & updated C&A.
Stability & Durability	Acceptable and stable ideas, concepts, methods, technologies, etc.
Usefulness & Effectiveness	Useful and beneficial for the learners, and effective for collaborative learning.
Organization & Structure	Right and logical organization and structure
Educator's Easiness	C&A easy for the educator to manage, author, teach, tutor, support, assess, grade, etc.
Learner's Easiness	C&A easy for the learner to study, learn, act, exchange work, etc.

Table 1. Content & Activities criteria of CL systems.

They should be useful and effective for CL. Their organization and structure should be right. They should be easy, time and cost efficient for the educators to author, develop, manage and teach it, as well as to create and assign assignments, projects, exams and tests, to grade them and report on the results. Also, they should be easy, time and cost efficient for the learners to manipulate and study them, to do the assignments, projects, exams and tests, to exchange work and cooperate among themselves, to know their progress.

2.1.2 Pedagogy & Abilities

The CL system should be based on effective pedagogical theories (e.g. constructivism, active learning, collaborative learning) and should support and improve the learner's abilities (Table 2). It should improve the learner's communication (written, oral, kinaesthetic, etc.) abilities with the other learners and educators. It should enrich the learner's interpersonal and social abilities. It should strengthen the learner's openness, tolerance to the difference and acceptance of others' capriccio. It should enhance the learner's flexibility, adaptability, compatibility with the others as well as her adjustability to various situations. It should enrich the learner's cooperation, collaboration, sharing, caring and altruism. However, it should also amplify the learner's leadership, coordinating and managerial abilities. It should enhance the learner's knowledge acquisition and retention. It should enhance her higher order and critical thinking. It should enhance her creativity, innovativeness and exploration. It should strengthen her responsibility, trustworthiness, reliability, credibility, accountability, loyalty to others and to the CL. It should increase her commitment and persistency to the CL. It should enhance her motivation. Finally, it should augment her confidence and self-efficacy.

Pedagogy & Abilities	*Description*
Personalization	Pedagogical theory based on learner's personal characteristics and expected educational outcomes.
Pedagogical theories	Using effective and valid pedagogical theory, such as constructivism, active learning, etc.
Communication	Enhancing written, oral, kinaesthetic, emotional, etc. learner's communication.
Interpersonal & Social	Enhancing learner's interpersonal and social abilities.
Openness, Tolerance & Acceptance	Enhancing learner's openness, tolerance and acceptance of difference.
Flexibility, Adaptability, Compatibility &	Enhancing learner's flexibility, compatibility with others, adjustability to various

Adjustability	situations.
Cooperation, Sharing & Caring	Enhancing learner's ability to cooperate, share and care for others.
Leadership	Enhancing learner's ability to lead & guide others.
Management & Coordination	Enhancing learner's ability to manage and coordinate others.
Knowledge Retention	Enhancing learner's knowledge acquisition and retention.
Critical Thinking	Enhancing learner's high order and critical thinking.
Creativity & Innovation	Enhancing learner's creativity, innovativeness and exploration
Responsibility & Trustworthiness	Enhancing learner's responsibility, trustworthiness, reliability, credibility and accountability.
Participation, Involvement	Enhancing learner's participation and involvement in CL activities
Commitment, Persistency	Enhancing learner's commitment and persistency to CL activities.
Motivation	Enhancing learner's motivation to success.
Confidence, Self-Efficacy	Enhancing learner's confidence and self-efficacy.

Table 2. Pedagogy & Abilities criteria of CL systems.

2.1.3 Interaction & Communication

The CL system should support personalized interaction and communication among the participants that are based on the individuals' characteristics (Table 3). It should be easy, time and cost efficient for the participants to interact, communicate, monitor, cooperate, negotiate, argue, agree, advise, reward and penalize among themselves. It should try to achieve non-discriminating, balanced or prioritizing participation. It should establish team building, trust and cohesion. It should define clear roles and relationships among participants. It should support a large number of concurrent participants and activities. It should be easy for a participant to search and find another participant, activity or resource. A participant should be aware of all interaction, communication and activities that concern her and other participants who are related to her. It should provide a variety of interaction and communication tools, such as i) synchronous communication: chat, shared spaces, whiteboards, web-cast, telephony, videoconferencing, games, simulations, etc. and ii) synchronous communication: email, e-lists, newsgroups, bulletin boards, news boards, file exchange, forums, wikis, blogs, etc. It should provide a variety of interaction and communication modes and forms, such as formal or informal, explicit or implicit, cooperation or competition, friendly or hostile, defensive or aggressive, etc. It should support efficient scheduling among activities or participants. For example, it should queue participants during a discussion or debate. It should keep synchronization and limit interference among participants or activities. It should keep the consistency of interaction and communication among participants.

Interaction & Communication	*Description*
Personalization	Participation, Interaction & Communication (PI&C) based on learner's personal characteristics.
Easiness, Time & Cost Efficiency	Easy, time & cost efficient for participants to interact & communicate, participate, monitor & attend, cooperate, compete, confirm, negotiate, argue, agree, advice & guide, praise, criticize, reward, penalize.
Fairness & Non-discrimination	Fair & non-discrimination of PI&C.
Balancing	Balanced PI&C, no-monopoly by some participants.
Prioritizing	Priority-based PI&C based on some criteria.
Team Building, Trust & Cohesion	Developing team building, trust & cohesion.
Clear Roles & Relationships	Defining clear roles & relationships among the participants.
Number of participants	Appropriate number of participants in the CL.
Number of concurrent activities	Appropriate number of concurrent activities.
Search participant or activity	Ability to search and find a participant or an activity.
Awareness	Ability to be aware of related participants, interactions, communications and activities.
Tools & Modes	Appropriate variety and

Comprehensive ness	comprehensiveness of available interaction & communication tools, modes & forms.
Synchronous - Asynchronous	Variety of synchronous and asynchronous communication tools.
Efficient Scheduling	Efficient and appropriate scheduling of PI&C among activities or participants
Synchronization & Coordination	Accurate synchronization & coordination among media (text, voice, video, etc.), activities or participants.
No interference	Limited interference
Consistency	Consistency of interaction & communication among participants. Similar causes produce similar results.

Table 3. Interaction & Communication criteria of CL systems.

2.2 Economical dimension

The Economical dimension consists of the following sub-dimensions: 1) Costs, 2) Contracts & Licensing, and 3) Cost Effectiveness.

2.2.1 Costs

The various costs should be considered together. There are costs in planning, buying, operating, maintaining, upgrading and terminating the devices, the networks, and the CL system (Table 4). There also possible health and environmental costs.

Costs & Expenses	*Description*
Planning	Cost for planning the introduction of the CL system.
Buying or Building	Cost for buying or building it.
Operating	Cost for operating it.
Overhead	Overhead for those using it (e.g. learners, teachers, administrators).
Maintaining	Cost for maintaining it.
Upgrading	Cost for upgrading, revising & extending it.
Terminating	Cost for withdrawing it minus the selling income.
Health	Cost for health (e.g. electromagnetic waves)
Environmental	Cost for environment (e.g. pollution)

Table 4. Costs criteria of CL systems.

Finally, the cost-effectiveness is related to the achieved learner's satisfaction, learning with respect to the fees and the costs.

2.2.2. Contracts & Licensing

The CL system should offer a large variety of contracts and licenses for using it (Table 5). For example, there should be alternative contracts or licenses with respect to the number of subjects, the number of participants, the number of activities, the collaborative activities duration, the traffic, the network quality, etc. The school should either buy or lease (rent) the CL system. Each participant may pay (or not) some fees. So, the administrator and the participants should choose the most appropriate contract or license. The duration of the contract & license is another important parameter. For example, it may be for a single day or for the whole academic year. Also, it may be from 9am to 11am every working day or from sunrise to sunset every Tuesday. They should be aware of the various costs and fees which should be visually available at any time. For example, the participants should be aware and know exactly the fees for every video-mail sent or received. The discounts (e.g. with respect to the number of participants, activities) and guarantees are also important parameters.

Contracts & Licenses	*Description*
Variety	Variety of alternative contract & license types
Flexibility & Adjustability	Flexibility and adjustability of the contract & license to the special needs of the educational activities.
Duration & Timing	Duration (long and short term) & timing of the contract & license.
Visibility & Awareness	The current costs & fees are visible at any time at any situation.
Discounts	Generous discounts with respect to many aspects.
Guarantees	Comprehensiveness of guarantees covering all parts of the CL system.

Table 5. Contracts & Licenses criteria of CL systems.

2.2.3. Cost Effectiveness

Considering on one side the costs and expenses of the CL and on the other side the learning outcomes, the learner's satisfaction, fees and other incoming parameters (e.g. school reputation for using the CL system), the CL system should be cost-effective (Table 6).

Cost Effectiveness	*Description*
Incomings & Fees	The incomings & fees that the school is gaining.
Learner's Satisfaction	Satisfaction of the learners with the CL system.
Learner's Learning	Effectiveness of the CL system to increase the learner's learning.
Cost-Effectiveness, Feasibility	The relationship between costs & expenses versus incomings, learner's satisfaction & learning

Table 6. Cost Effectiveness criteria of CL systems.

2.3. Technical dimension

The Technical dimension consists of the following sub-dimensions: 1) User Interface, 2) Reliability, 3) Maintainability, 4) Performance, 5) Functionality, 6) Adaptation, 7) Connectivity, and 8) Security.

2.3.1. User Interface

The user interface should be personalized (Table 7). It should be easy, time and cost efficient to understand, learn, remember and use. It should be simple and convenient to use (e.g. minimum number of clicks to find and display information, minimum number of scrolls to display information). It should facilitate communication and collaboration. It should support the learner's focus and attention, avoiding her distraction, boring and tiredness due to cognitive load. Its features and operation should be appropriate, convenient, meaningful, self-evident, and rational. It should be uniform and consistent. Under the same conditions similar results should be produced (e.g. messages, colours, menus). Its operation should be correct, accurate, precise and effective. Its layout, organization and structure (e.g. frames, menus, and buttons) should be simple, intuitive, rational and effective. Its design should be aesthetic, attractive, pleasant and fun to use it. It should support many languages and media types (e.g. text, audio, video, immersion) of high fidelity at the right mix and position on the user interface.

It should support a variety of rich and of high quality interactivity and multimedia communication (e.g. one-to-one, one-to-many, many-to-many, synchronous, asynchronous). The interactivity and the multimedia communication should be at the right quantity at the right moment without producing cognitive overload. Its navigation should be easy, simple, intuitive and rational. There should be alternative ways of navigation with proper number of levels. It should offer many navigation facilities (e.g. sitemap, next, previous, home, exit, undo, redo, shortcuts, history, save, print). It should provide quality orientation and help (e.g. documentation dictionaries, FAQ, search engine) in a consistent way. The responses to any learner's action should be immediate and effective. It should consider learners with disabilities and do not discriminate. It should treat all fairly.

User Interface	*Description*
Personalization	User Interface based on learner's characteristics.
Easiness of use	Easy, time & cost efficient to understand, learn, remember and use it.
Quality	Simple, accurate, supportive, effective, and distraction-free.
Layout & Presentation	Intuitive, rational, simple, consistent and effective layout, organization & structure of it. Aesthetic design, attractive, pleasant and fun to use it.
Media	Variety and quality of media at the right proportion and position.
Multilingualism	Variety of languages supported
Interactivity	Variety, right proportion, suitable fidelity, proper timing, of interactivity.
Navigability	Easy, simple, consistent, intuitive, and rational navigation. Variety of alternatives and facilities.
Orientation & Help	Easy, appropriate, consistent, rational, and useful orientation & help.
Accessibility	Accommodating all people fairly and efficiently without discrimination.

Table 7. User Interface criteria of CL systems.

2.3.2. Reliability

Reliability is related to the capability of the CL to maintain its level of performance under stated conditions for a stated period of time (Table 8). The CL system should be error-free. It should prevent errors that may occur, for example measurement errors. It should be easy and fast to be monitored and tested. If an error or fault happens, it should recognize its existence and its source. It should also make correct diagnosis of the error. The error should be easily repaired by the system or by external intervention with minimum effort and resources at the minimum time. No data or other useful resources should be lost in case of error. The repair should be transparent to the learners. No data discrepancies should occur due to hardware faults (e.g. power off, communication disconnection). The duration and the cost of the interruption should be minimal. The CL should handle any unexpected case and should resist to malicious attacks. It should not be stacked in a deadlock situation. Its operation should be stable and consistent with minimal transient phenomena. It should always be available.

Its operation should be correct and accurate. It should do what is supposed to do, for example alerting learners about deadlines. Its operation should be consistent and similar states should be treated similarly. It should keep on back of all data, interactions, communications, achievements, statistics, etc. The perceived reliability of the system increases with the reputation and the brand name of the manufacturer, as well as with awards, certifications and guarantees that are given to it.

Reliability	*Description*
Error Free	The CL system is free of errors & faults.
Error Prevention	It prevents errors to occur.
Error Recognition	It recognizes errors and their sources.
Error Recovery	It recovers from errors with minimum effort, resources, losses, at the minimum time.
Stability	Stable operation.
Correctness	Correct & accurate operation.
Consistency	Consistent operation.
Backup	Keeping back up of all data, transactions, interactions, communications, results, etc.
Reputation & Guarantees	Awards, certifications, reputation, brand name of manufacturer. Valid and advantageous guarantees.

Table 8. Reliability criteria of CL systems.

2.3.3. Maintainability

Maintainability is related to the effort needed to maintain the CL and make specific modifications (Table 9). Initially, the installation of the CL should be easy and fast. The CL should need minimal effort and time to maintain its efficient operation. In case of changes in its scope and operation, its reconfiguration should be easy, unproblematic and fast. In case of faults, the repair or replace of the faulty parts should be fast and easy. It should be easy and fast to be revised and upgraded. Its integrity, resistance and survival from attacks should be guaranteed. Its efficient operation should be supported by the manufacturer. The guarantees should be for long time and take care of any possible case.

Maintainability	*Description*
Installability	Easy and fast installation.
Easiness of Maintenance	Easy, minimum effort and time to maintain the CL system.
Reconfigurability & Modifiability	Easy, fast and efficient CL system reconfiguration.
Replaceability	Easy and fast to repair or replace faulty parts.
Survivability	Easy and fast to successfully survive from failures.
Upgradeability	Easy and fast to upgrade it.
Supportability	Certified and guaranteed survival from faults and attacks. Advanced support.

Table 9. Maintainability criteria of CL systems.

2.3.4. Performance

Performance is related to the achieved performance and efficiency of the CL (Table 10). The CL system should operate fast enough to facilitate collaboration. The communication bandwidth (both for uploading and downloading) should be high enough to support any possible communication. The memory capacity should be large enough to store all possible data, transactions, communications, etc. The quality and the fidelity of the input (e.g. camera, handwritten recognizer, speech recognizer) and output (e.g. screen, speakers) should be appropriate. For example, the quality of the displayed, stored and transmitted images should be the best possible given the constraints (bandwidth, delay etc.). So, the camera and screen resolution, the screen size, the ergonomic keyboard are important factors. The energy consumption should be small. Finally, the effectiveness and efficiency of the system should be high.

Performance	*Description*
Responsiveness	Fast operation, minimum delay.
Memory	Large available memory.
Input & Output	High quality and fidelity of input & output.
Resource Utilization	Minimum energy consumption, memory requirements, used bandwidth, etc.

Effectiveness	Effective operation.

Table 10. Performance criteria of CL systems.

2.3.5. Functionality

Functionality is related to the available functions, features, tools, and applications in the CL (Table 11). Examples of tools include: editor, drawing, audio recorder, photo camera, video recorder, fingerprint reader, handwriting recognition, speech recognition, face recognition, multimedia processing, etc. Examples of features and applications include: multimedia mail, alerting and reminding, chat, telephony, videoconference, etc. These features and applications should be of high quality, simple, self-explanatory, intuitive and rational to use them. Each feature or application should function autonomously and be self-contained. There should be no need for extra plug-ins. Multiple features and applications should function concurrently synchronized with no interference among them. The technology used to implement the system should be not only current and innovative, but also mature and stable.

Functionality	*Description*
Comprehensi-veness	Variety of available functions, features, tools and applications.
Quality	High quality & fidelity functions etc.
Educator's Support	Functions etc. to support the educator in planning, managing, authoring, educational activities developing, teaching tutoring, examining, grading etc.
Learner's Support	Function etc. to support the learner in attending, comprehending, learning, problem solving, test taking etc.
Simplicity	Simple, self-explanatory and intuitive functions etc.
Usefulness	Useful and effective functions
Suitability	Suitable and appropriate for the learners and the educational activities functions etc.
Timeliness	Right reaction timing of the functions etc.
Synchroniza-tion	Harmonious, concurrent and synchronized functions etc. No interference among them
Autonomy	Autonomous and self-contained functions etc. No need for extra plug-ins etc.
Innovativeness	Innovative and modern technology, functions etc.
Maturity	Mature and stable technology, functions etc.

Table 11. Functionality criteria of CL systems.

2.3.6. Connectivity

Connectivity is related to the ability of the CL system to be connected to other software and hardware systems (Table 12). The CL system should provide as much connectivity (inside and outside of the system) as possible. Tools, applications, resources, learners and teachers should be smoothly interconnected. It should follow open architectures, comply with international standards and be compatible to as many software and hardware devices as possible. It should easily import and export data, transactions, communications, statistics, etc. All parts should be seamlessly integrated to construct the whole CL. The integration of the parts should be transparent to the learner. All interconnections should be done in harmony with minimum learner's effort. Also, parts of the CL system may be reused by multiple systems. Also, it should be easy and fast to connect or disconnect as many concurrent activities and participants as possible. It should support multiple platforms, databases, collaboration types, multimedia format, etc. Finally, it should be autonomous not required additional plug-ins.

Connectivity	*Description*
Openness	Use of publicly and freely available parts.
Standards Conformance, Compliance & Compatibility	The CL system complies with international standards and is compatible to many other systems.
Interoperability	Accurate data exchange, sharing and use between it and other systems. Harmonious communication, cooperation between it and other systems.
Reusability	Easy and efficient reuse of all parts in various situations and systems.
Portability	Easy to import and export data, communications, parts of the CL system.
Modularization	It is composed from modules.
Integration	Smooth, easy and harmonious integration of all parts.
Transparency	Seamless and transparent to the learner interconnection of all parts.
Scalability & Extensibility	Easy, simple and efficient scalability.
Comprehensive	Variety of systems that can

ness	work together with it.

Table 12. Connectivity criteria of CL systems.

2.3.7. Security

CL should support current, updated security technologies (e.g. firewalls, access control, authorization, authentication, certification, encryption, cryptography, tunnelling, anti-virus, anti-spam, anti-spy) to protect the interactions, communications, data, transactions, results, etc. (Table 13). It should protect both the storage and the communications. It should support multiple levels of security for different learners and resources. It should prevent unauthorized access to resources, tools, data or unauthorized communications and collaboration. It should support the learner's confidentiality, anonymity, privacy and trust. The learner should have control of what personal information should be available to others. All data, activities, decisions and applications that concern a learner should be visible and available to her whenever she requests them. For example, there should be no secret monitoring and recording of the learner's transactions. High prestige security organizations should certify and guarantee its security.

Security	*Description*
Completeness	Complete security coverage using current and updated security technologies.
Levels	Various levels of security to protect the communications, storage, resources etc.
Confidentiality & Privacy	Respect to the learner's confidentiality, anonymity, and privacy.
Trust	Enhanced learner's trust on the CL system.

Table 13. Security criteria of CL systems.

2.3.8. Adaptation

The CL system should adapt its educational parameters (e.g. content, activities, presentation, communication), its technological parameters (e.g. user interface, security), and its economical parameters to the learner and the teacher (Table 14). It should be personalized. For example, it should adapt the communication to the learner according to her network connection. It should adapt the content to the screen size. It should adapt the resolution of an image to the available transmission bandwidth. The adaptations should be transparent to the learner. They should be correct, accurate, precise, and error free. They should be useful, appropriate and effective. They should also be timely. They should be consistent and uniform, similar results should appear for similar reasons. They should be flexible and adjustable, i.e. if an exact match cannot be found an approximation should be given. Also, there should be prioritization among the parameters importance in case of constraints or conflicts.

Adaptation	*Description*
Control	Control of adaptation either by the learner, or the teacher, or the CL system.
Comprehensive-ness	Variety of adaptation areas.
Transparency	Transparent adaptations.
Correctness	Correct, accurate and precise adaptation.
Usefulness	Useful, effective, appropriate and meaningful adaptations.
Timeliness	Right timing of adaptation.
Consistency	Consistent and uniform adaptation.
Flexibility & Adjustability	Flexible and adjustable adaptation.
Prioritization	Prioritization of the adaptation decisions

Table 14. Adaptation criteria of CL systems.

4 Conclusion

The learner is at the core of the Collaborative Learning (CL). Every effort should be made to support the learner. The learner should participate in the collaborative activities being satisfied and using the resources efficiently. We provide insights on the characteristics, attributes or criteria that a CL system should have in order to satisfy the learner's requirements for successful CL. We propose the CLE framework that consists of educational, economical and technical characteristics. Designers, developers and evaluators of CL systems may consider this CLE framework to make appropriate decisions.

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