MEASURING THE COLLECTIVE INTELLIGENCE EDUCATION INDEX

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Abstract.

War games and sports games always seek glory and excellence in an environment where participants enjoy what they do. Success is guaranteed in the degree of effective collaboration and coordination within the team members, as well as the strategy used by teams, such games or war strategies are generated since the birth of humanity. In this sense, the following questions emerge in the field of education: Is it possible to design learning activities that use this principle applied to collaborative work in the classroom? Which are the conditions of application of team competition strategy using ICT tools and how to measure it?

This research explores the application of a web tool called Choose the Best (CTB). CTB implements a strategy that fosters competitiveness among the teams of a class, as well as the coordination and collaboration within the same, these types of strategies contribute to the development of Collective Intelligence levels. It's measured through a group of implemented metrics.

Based on the results, we consider that the use of new forms of teaching and learning based on the emerging paradigms is necessary. Therefore, CTB is a tool that could become an effective way to measuring the group's performance according to Collective Intelligence paradigms.

Keywords: collective intelligence, ICT, education, group performance.

1 INTRODUCTION

Analysis of group performance has challenged researchers across disciplines. [14] establishes a typology of activities (circumplex model) to measure the performance of the groups by dividing it into four quadrants: Generation, selection, negotiation and execution.

Several researches have been made around the work developed by [14], one of the most outstanding and used as inspiration of the present research was the one by [18], who in his study to determine the Factor C of the participant groups used the framework designed by [14], subjecting participants to perform tasks under the four quadrants, the resulting effect of that research was Factor C. Some other authors who have reported work as reported by [14] for instance: [1], [16], [2], [5].

[18] in their study under the quadrant IV of McGrath, (1983) used several specific tasks: Typing group, video controls, art reproduction, architectural design. The common denominator of these tasks in essence was that each work team gained points in relation to coordination and individual input, it also identifies that the factors of assessment are the time and the level of accuracy of the team's responses.

[11] point out that the ideal of Collective Intelligence (CI) includes technical, economic, legal and human assessment of an intelligence that is everywhere generating a dynamics of competence mobilization. Several authors, in harmony with [11] and others have done efforts to evaluate the CI.

[15], [17] presented research about formalization of (CI). A quasi-chaotic model of calculation allows modeling CI in social structures, and defining its measure (IQS). This methodology works for bacterial colonies and social insects, as well as for human social structures. Their outcomes presented a Collective intelligence quotient (IQS), measures the probability P that after time t, a goal is reached, considering the starting point, and the inferences of the participation of N elements. IQS = P (t, N), additionally presented other metrics: Levels of collective intelligence, specialization of social structures, Individuals versus social structure, cardinal equivalence of social structures on a domain. [10] Reported some tests to identify measure and compare collective intelligence, part of basic definitions of collective intelligence using independent notions of the domain. The tests are performed by simulating ant colonies. [10] concludes that Collective Intelligence Index (CII) can be used as an CI

test to compare instances of collective intelligence. The higher values of the CII indicate that a group shows more collective intelligence. [3] proposed a approach to captures the essence of Collective Intelligence, and proposes a new quantitative measure, the Collective Intelligence Index (CII) that takes into account two factors: the "improved experience score" and the "confidence-based collaboration score", they conclude that CII of the team is defined as the linear combination of experience score and team-based collaboration score, it is maximized.

In the other hand, [9] proposed Indicators based on social networks that are predictors of team creativity and collaborative innovation. They presented three indicators Rotary Leadership (RL) & Contribution (RL), and prompt response time (PRT). [7] examined patterns of individual diversity, decentralization of sources of information, and independence of thought to estimate their contribution to the collective outcome. The pattern found was Diversity Index, it allow setting individual diversity, based on the decentralization of sources of information and independence of thought.

Related with the individual people profiles and their influence on the CI arena, [6] develop a research and proposed a list of evaluation taxonomies. These taxonomies trying of analyzing online behaviors in individual and community levels. [6] mention that the greater effectiveness of communication, and models measurement patterns to identify effective forms of interaction of individuals, taking into account their cognitive and social behaviors. The patterns found by [6] were: Mental self-government, learning; cognitive, personal, community, & online behavior; and finally CI affinity.

The successful index should be the capabilities for predict some CI environment, in this sense [13] attempts to establish a general framework of the CI system and identify some common basic problems that may prevent its success. [13] proposed three indicators : Users exportations, future state system, and system objective.

The efforts presented by several researchers allow identified a gap in the Higher Education in relation to measure the collective intelligence in the teaching learning process.

Based on the presented evidence, this research explores the application of a web tool called Choose the Best (CTB) with an academic strategy that trying to fosters competitiveness among the teams of a class, as well as the coordination and collaboration within of team.

2 METHOD & PROPOSAL MODEL

The research combines the study of the literature with the analysis of the ICT tools that have emerged in the field of the CI and RS. Design-Based Research (DBR) was used to compile and summarize collective intelligence approaches reported in the literature in the field of Higher Education as well as to incrementally adjust the tool.

The propose model is splitting in three components: On the one hand the instructional process, after that design learning activity, and finally defines the collective intelligence indexes.

2.1 Instructional process

The instructional process has been designed in two stages and some tasks by stages, as we show to follow.

Planning.- These are activities prior to the use of the activity in the classroom, in which the teacher in the development of his curriculum or syllabus should establish:

1. Defining a challenge that your objective will be finding a solution through tracks.
2. Establishing questionnaires (close questions) with respect to the analyzed challenge, where, depending on the answer (s), one or another alternative solution is possible.
3. Establishing the number of questionnaires to be applied to solve the challenge.
4. Specifying the time, the maximum score and the ratio of opportunities that a team has to solve a challenge, since the discovery of track is an automated task of synchronous character and in real time.
5. Specifying the numbers of seconds for the assigned random values by active user
6. Identifying the weighting between score and time, default is the same valuation.

Execution.- The execution consider using CTB tool. It's will be guided according to the process of Fig 1, which establishes the activities to be fulfilled by both the teacher (s), and the students by each challenge.

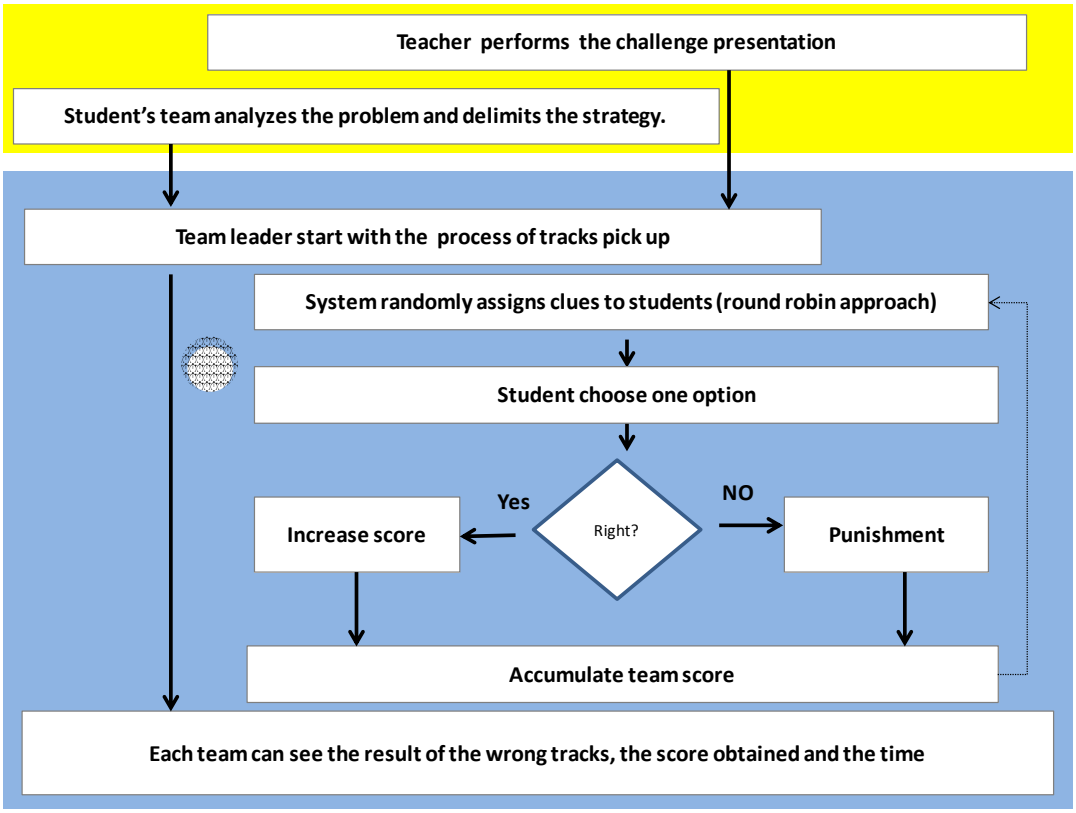

Figure 1. - Execution process.

As it is possible to see in Fig 1 the CI process involves a complete and constant collaboration & competition relationship between students inside the group and between the groups, therefore is reasonable to think of CTB as an IC tool in the class. CTB pushes to the students to competition.

2.2 Learning activity

Learning activity design is the way for implement the instructional process, in this context, it was designed how follow.

Name: Competing by the glory.
Objective: Encourage synchronized collaborative work in class in the construction of a product..
Electronics Tools: CTB, Guess the Score (GS)[19] .
Tasks:

1. Teacher prepares a challenge to meet in a 90-minute class session.
2. The beginning of the class on the day and time indicated the students in groups, each one in a computer can accede to the challenge, which will be realized until finishing the 90 minutes of classes.
3. Steps for resolve the challenge:
   - 3.1. Understand Challenge and read theory (20 min)
   - 3.2. Discovering Tracks (15 min). CTB.
   - 3.3. Preparing the presentation and upload in the cloud (20 min).
   - 3.4. Register presentation (5 min). GS
   - 3.5. Collective evaluation by experts and students (5 min). The collective evaluation doing by the teacher generate the quality score (QS).
   - 3.6. Presenting winners (5 min). The winners are given based on the points earned from their Collective Intelligence Index obtained in CTB, and the evaluation of the quality of the product in GS by teacher vote. The group that win the first position in the ranking wins 10 points for the match; the others are in decreasing order according to the number of teams, where the last one wins 1 point.
   - 3.7. The winning group performs a Start Up Pitch (5 min)
   - 3.8. Teacher feedback (5 min)

3.9. Feedback from students in the class (5 min)

2.3 Collective Intelligence Indexes.

2.3.1 Collective Intelligence index by Group (IICG)

Objective. - Determine the collective intelligence levels of a task force (swarm) on various tasks, to help experts and researchers establish factors and variables that influence the outcome of synchronous and real-time work.

Concepts & definitions.- The present indicator has been established based on the following conjectures: The execution of a task of a team involved 2 variables the time of resolution of a problem, and the points gained in that resolution, therefore, considering [10] "... the performance of a work team is defined as the quality of its solution relative to the optimal solution ...", it is concluded, that if I compare N equipment, the equipment with the highest intelligence Collective, is the one who developed his task in the shortest time and won the most points. In this sense it is determined that the Collective Intelligence Index of a work team is a function of time (t) and the score (s) CII = F (t, s).

[10] and [18] are agree that the performance of a team is given according to the difficulty of the task that can be in the resolution of the problem or in time, therefore this indicator weighs Each value of (t) and (s) with a specific weight (W1, W2) according to the difficulty considered. W1, W2 are fractional values whose sum will not exceed 1. [10] states that the CII could function as an intelligence test to compare instances of collective intelligence, which also suggests that it could be used as a forecast indicator that allows a set of variables to predict the performance of A group from the point of view Factor C defined by [18].

Assumptions.- In the execution of the practices and / or tasks, at least the level of collective intelligence of a team is within the average and a deviation of consensus of all teams**.**

Method.- Proportions and weighted average.

Unit.- [0 - 1].

Formula:

$$\mathrm{IICG} = \frac{\left[1 - \frac{\text{Time Resolution}}{\text{Maximum Time Available}} * \mathrm{W1}\right] + \left[\frac{\text{Points Earned}}{\text{Maximum Points}} * \mathrm{W2}\right]}{2}$$

Where :

Time Resolution: Time the equipment needed to solve a problem.
Maximum Time Available: Time that is assigned as a stop to solve a problem.
Points Earned: These are the points the team earns in solving a problem:
Maximum Points: It is the optimal score that a team could aspire to.
W1: Weight of difficulty in time to solve a problem.
W2: Weight of difficulty in content to solve a problem.

Interpretation: .- In the resolution of tasks over a period of time, work teams must solve problems of coordination in real time, in this type of learning activity involves two variables, the resolution time and the number of points earned. Under the premise presented each task team will have an IICG Collective Intelligence Group Index. For example: Assume a task in which students must solve a questionnaire of clues to solve a puzzle that is considered equal complexity in time and resolution, students have a maximum time of 15 minutes, and the optimal score is 15 points. The team or after completing the task has taken 15 minutes and accumulated 6 points, then your IICG will be:

IICG = 0.2

2.3.2 Collective Intelligence index by Class (IICC)

Objective. - Determining the levels of collective intelligence of a class (multitude) of work in diverse tasks, in order to help to experts and investigators of to establish potential factors and variables that influence the result of the work synchronous and in real time.

Concepts & definitions.- The present indicator has been based on the fact that a multitude (CLASS) is made up of several swarms (WORKING TEAMS), therefore the basis of the determination of the collective intelligence of a CLASS is given according to the scores of its groups, In harmony with what [10] argues, "higher values of collective intelligence indicate that a swarm shows more collective intelligence", and, "the performance of a swarm (WORK TEAM) in relation to the crowd (CLASS) is defined by its performance below a CLASS".

Following the definitions of [10], it is established that the collective intelligence of a CLASS is given according to the Group's Collective Intelligence Index, adjusted by a factor of proportion of number of students members of a team in relation to the class.

Assumptions.- In the execution of the practices and / or tasks, at least the level of collective intelligence of a class is within 50% of the expected maximum performance.

Method.- Proportions and weighted average.

Unit.- [0 - 1].

Formula:

$$\text{IICC} = \left[\sum_{\text{Team}=1}^{\text{Total Teams}} \text{Teams[Team]} * \frac{\text{Members[Team]}}{\text{Students Class}} \right]$$

Where :

Total Teams: The total number of equipment in a class

Teams: List of IICG scores

Team: Vector path index.

Members: List of number of members per team

Students Class: Total number of students in the class

Interpretation: .- In the resolution of tasks over a period of time, work teams must solve problems of coordination in real time, in this type of learning activity involves two variables the resolution time and the number of points earned. Under the premise presented each task team will have an IICG Collective Intelligence Group Index.

It is pointed out that not all teams have equal number of members therefore the score of a team could be influenced by the number of members, that's mean that for each IICG is applied an adjustment factor W (i), this factor of adjustment is a proportion of students in the team versus students in the class. For example: Assume a class with 4 work teams where the rank of number of members per team is [4-6], and it has 19 students. The teams were divided as follows: G1: 4, G2: 5, G3: 4, G4: 6, and where their IICGs respectively were 0.7, 0.8, 0.75, and 0.9. Therefore, the collective intelligence index of the CLASS will be:

IICC = (0.7 * 0.21) + (0.8 * 0.26) + (0.75 * 0.21) + (0.9 * 0.32)

IICC = 0.8

3 EMPIRICAL EXPERIENCE & RESULTS

In this section, the empirical evidence of CTB application through a web tool (Appendix I) is described. CTB was used by one group of student from the University of the Armed Forces of Ecuador ESPE in the academic year 2016-2017 in the months of December 2016 till January of 2017. The number of students were 24 (18 Masculine, 6 Feminine) the average of age was 20 years age. The students had

to resolve several topics in the subject of Social Project Manager Administration. By each task the students and teacher followed the process represented in the Fig 1, and the learning activity defined in the section 2.2.

The learning activity were applied three times in different topics, its results are presented in the Table 1. The Table 1 shows five columns:

1. *Topic* is the name of topic applied in the session class.
2. *IICC* represent the Collective Intelligence Index for the class by topic.
3. *Team* is the name the team.
4. *Participants* are the number of students in the topic.
5. *IICG* represent the Collective Intelligence Index for the group by topic.
6. *QS* is the teacher score.

Table 1. Results of indexes by topics

Topic	IICC	Team	Participants	IICG	QS
Stakeholder analysis	49%	1ProyGroup	4	11%	89%
		2ProyGroup	4	49%	78%
		3ProyGroup	4	63%	60%
		4ProyGroup	4	72%	67%
		5ProyGroup	4	20%	58%
		6ProyGroup	4	79%	64%
Analysis of problems and objectives	57%	1ProyGroup	4	53%	45%
		2ProyGroup	4	68%	33%
		3ProyGroup	4	57%	28%
		4ProyGroup	4	77%	56%
		5ProyGroup	4	18%	17%
		6ProyGroup	4	72%	61%
Strategy design and Logical Framework Matrix	47%	1ProyGroup	4	28%	45%
		2ProyGroup	4	50%	33%
		3ProyGroup	4	22%	28%
		4ProyGroup	4	85%	56%
		5ProyGroup	4	33%	17%
		6ProyGroup	4	62%	61%

The maximum value for the collective intelligence index into the group and the class is 1 or 100%, which mean discovering all the tracks without mistakes into the standard time.

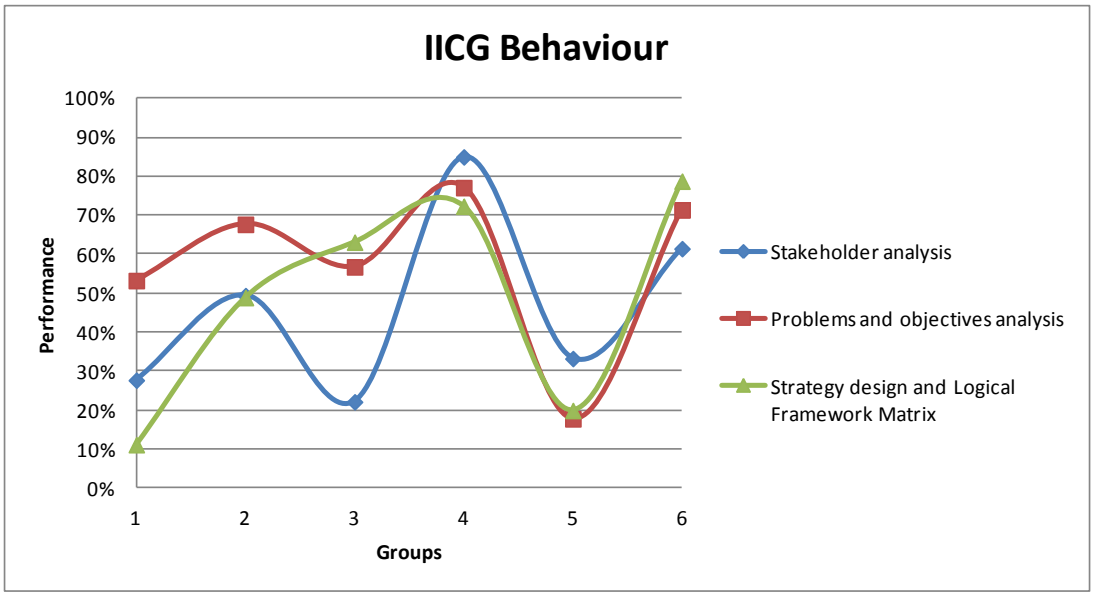

Figure 2. - Behavior of Collective Intelligence index by group

The Fig. 2 shows the IICG behavior. The IICG for all the groups was uniform inside the topic (ANOVA with p- value. 0.73), however, was different between topics (ANOVA with p-value. 0.003). This behavior is agree with [10] and [18], who point out that the collective intelligence index of a group is related to the difficulty of the task. Therefore these results allowed to the teacher reviewing the didactic strategy, and content of the resources, as so on the difficulty level by topic (Fig. 3).

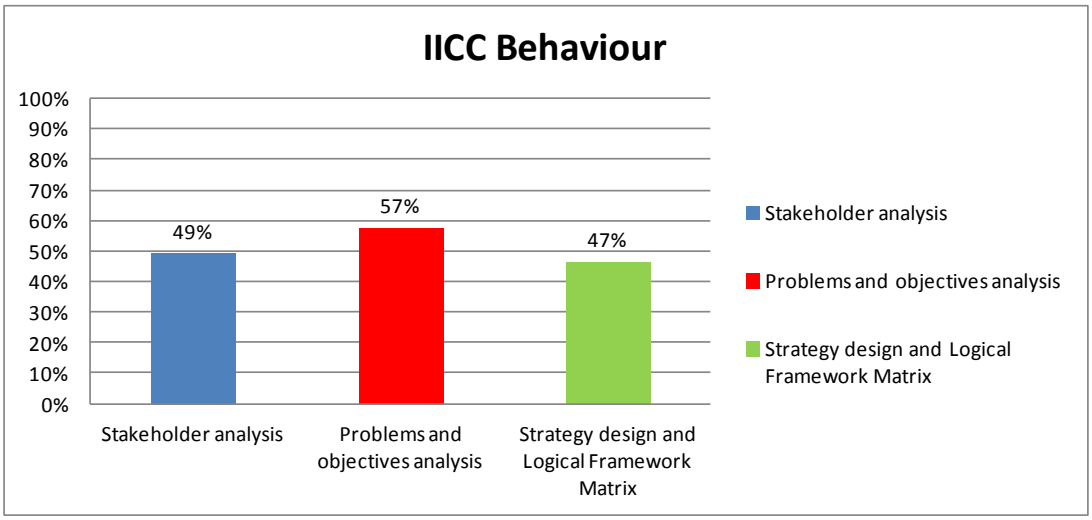

Figure 3. - Behavior of Collective Intelligence index by class

The outcomes presented in Fig 2. & Fig. 3, shown the usefulness of CTB as a support tool in making decisions into the teaching-learning process, as well as the effectiveness of the indicators for the calculation of collective intelligence into the learning environment. The collective intelligence was computed according the general criteria proposed by [18] & [10].

In the other hand, the learning activity design presented was useful for organizing each session of class. The students into the class presented engaged & motivates, moreover their dedication during the session was complete. Therefore this kind of learning activities allowed to the students explored the real collaborative work into the team, where if there is not the good coordination and participation all the team is affected in its score.

4 CONCLUSIONS

The objective of the presented work is to share the progress on a research program, which purpose to provide processes, tools and resources for fostering & increasing the collective intelligence in the class using ICT tools..

The application of CTB has shown evidence on the usefulness of the tools in the collaboration and participation into the class. The usefulness of the tool is considered because the evaluation accords to the individual contributions & collaboration increasing o decreasing the team performance. CTB also fostering the competence as a means of learning.

In the other hand, It gives the teacher the ability to generate reports of trends and behaviors of their students, and the real-time assessment of the team's performance, therefore accuracy the quality of strategy and how it could be improved.

The CTB can be applied in several fields for instance: Training courses, types of training in different modalities, investigations of group's behavior & performance in teaching-learning process.

The proposed instructional process, learning activity, and the corresponding web tool are the result of a creative combination of theoretical and practical perspectives. From this point, with a consistent instructional process, it will be possible to continue with the development of new features oriented to make recommendations on the continuous improvement to the state of art in the field of collective intelligence and its influence into the educational environment.

Future works, will focus on looking the best way to increase the collective intelligence into the groups in the class using ICT tools. This kind of exploration is planning develop long essays by complete academic periods in different groups of students and topics.

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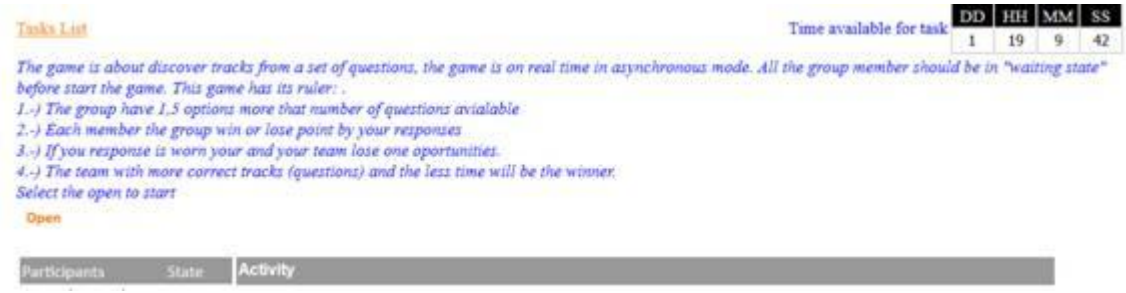
Appendix I. Web tool interfaces

Selecting task.

Initiating synchronous and synchronized execution of teamwork.



Discovering tracks in teams.

Viewing results.

Figure 4. Main interfaces of CTB.