

## Collective Intelligence and Learning Analytics for Online Learning and Teaching Support

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**Abstract:** *Collective intelligence (CI) is the behavior performed by individuals acting as an aggregate in a social context with favorable outcomes as a group. With the support of online learning platforms and social learning tools, individual learning activities can be effectively organized and connected to generate knowledge collectively. This study discusses the use of learning analytics (LA) to acquire CI for online learning and teaching support. It explains collective intelligence learning analytics (CILA) for informed pedagogical decision-making in four aspects, including objectives setting, data collection, data analysis, and application of results. There are two levels of the usage of CILA, namely, information and insights. The temporal factors and the corresponding application areas of these two levels of usage will be further examined according to the interests of teachers and learners.*

**Keywords:** collective intelligence, learning analytics, social learning, pedagogical support, online learning and teaching

### 1. Introduction

Along with the technological advances and fast-developing digital resources, online learning and teaching has been proliferating in the globe and has become a driving force in education. With the support of online learning platforms and social learning tools, it is more and more convenient and effective to connect many individuals working collectively to produce a shared and group knowledge. Collective intelligence (CI) is featured as a group problem-solving method and ability which exhibits greater wisdom than individual expert intelligence (Heylighen, 1999; Mauboussin, 2006). The value and impact of CI has been widely recognized and adopted in recent years, with Google's PageRank and Amazon's Recommendation as popular examples in commerce. However, there is only a few existing literature on its application in the field of online learning and teaching (Recker, Yuan & Ye, 2014). Since the acquisition of CI is a process of collecting information about the behaviors of a vast quantity of people, learning analytics (LA) is thus considered as an appropriate approach to achieve this goal. In this paper, we explore the use of LA to facilitate the collection of CI so as to support online learning and teaching with informed pedagogical decisions.

### 2. Literature Review

#### 2.1. Collective Intelligence

There are many definitions of CI in the literature (Malone & Bernstein, 2015). Generally, CI is defined as the knowledge generated by groups of individuals which not only can be human beings but also animal herds or even insect colonies, working collectively with the aggregate outcome exerting greater impact than some of its parts (Singh, 2011; Malone, Laubacher, & Dellarocas, 2009). Two key words of CI must be explained. One is collective, emphasizing the diversity and richness of sources with certain interdependence, which constitute as an entity to take effect (Malone & Crowston, 1994). The ways of organizing and connecting the individuals to work as a whole may vary in different situations and cases. Another is intelligence, a kind of knowledge or ability that is embedded within societies or large communities of individuals and that can be acquired and applied to solve problems. It can be categorized into two types, explicit knowledge and implicit knowledge (New Media Consortium, 2008). Explicit knowledge is created through a series of processes including collaboration, sharing, data collection and recording by a great many people in a clear and direct approach, with millions of endeavors for a refined final version, such as Wikipedia. Implicit knowledge is revealed by analyzing patterns, correlations and flows formed by the choices and actions of lots of people over a period of time, like Amazon's Recommendation, with thousands of purchasing records to help decide a specific recommended

list to satisfy personal needs. Considered as an embedded knowledge within people’s explicit and implicit collective work, CI is hence used as a strategic suggestion in this study to guide and support online learning and teaching, in which it is of benefit to 1) provide the learners with the broad-spectrum, widely available and constantly updated information; 2) motivate the learners to self-reflect and improve their social awareness; 3) enhance the innovation capacity and productivity for novel learning and teaching methods; 4) assist the teacher in making a better prediction of the potential problems and challenges; 5) give opportunities, insights and inspirations to both teachers and learners for breakthroughs.

## 2.2. Learning Analytics

LA is the collection, analysis and reporting of data from learning activities for the purpose of optimizing learning and its corresponding environment (Siemens, 2012). It is a fast-growing research area in the age of data-based decision-making. It is essentially used to discover knowledge and intelligence from learning data. Therefore, LA is beneficial to facilitate the explication of CI. It can reveal the various perspectives, the focuses and the development tendencies of the group of learners, and then motivates individuals to reflect their differences from others in the group, which may help them to set new learning goals. Several representative models of LA (Cooper, 2012; Greller & Drachsler, 2012; Lisa & Elias, 2011; Chatti et al., 2012) have been put forward, in which data source, analytical objectives, technical methods, stakeholders and constrains are five common elements. Apart from this, there are four interesting aspects that deserve special attention: 1) Analytical orientation: Analytical questions are divided according to the focus on time into three types, past, present and future, to help decide the application context; 2) Embedded pedagogical theories: Learning theories, sound pedagogical practices, domain knowledge and perspectives should be introduced to make the analytical applications meaningful and effective; 3) Presentation strategy: Technologies should be incorporated into the design of visualizations so as to facilitate a better understanding of the analytical results and its underlining information; 4) Competence of data clients: Data clients should possess some necessary competences required for interpreting LA results and deciding the corresponding actions appropriately by themselves.

## 3. Collective Intelligence Learning Analytics for Online Learning and Teaching Support

Collective intelligence learning analytics (CILA) is put forward in this paper as a kind of learning analytics that looks into the collective behaviors performed by individuals in a social context with favorable aggregate outcomes under some special pedagogical designs. It is a new research area of evidence-based pedagogical decision-making by analyzing CI to support online learning and teaching. This study proposes a framework of CILA which includes four aspects, from objectives setting, data collection, data analysis, to application of results. In order to achieve the analytical purpose and ensure the outcome, it is fundamental to set up analytical objectives and define the right Objective/Indicator/Metric (OIM) triples (Chatti et al., 2012) before analyzing the data. When it comes to online learning and teaching, two kinds of angles (teachers’ and learners’) should be taken into the CILA framework for consideration, as shown in the Table 1: Teachers are interested to understand the focuses and cognitive tendencies, problems and undesirable behaviors of the learners and the groups, and to find out the suitable teaching approaches and the intervention points with the collective learning outputs revealed by CILA; while learners are desired to reflect their learning by being compared with their peers and the groups, and to receive personalized guidance and recommendation for learning provided by CILA.

Table 1. Interests of teachers and learners on data extracted from CI for informed pedagogical decision-making.

Teachers	Learners
1. Focuses and cognitive tendencies of the learners and the groups; 2. Problems and undesirable behaviors of the learners and the groups; 3. Suitable teaching approaches reflected by the CILA; 4. Intervention points for the learners and the groups.	1. Differences and gaps among the peers and the groups; 2. Personalized guidance and recommendation provided by CILA.

In the CILA framework, specific goals should be set in advance to determine the data needed for analysis. The data

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drawn by CILA are mainly from heterogeneous sources which are usually distributed in social learning context. Making reference to the research of Ferguson & Shum (2012), five categories of CILA for data analysis and the corresponding data types and application areas are proposed in Table 2.

Table 2. Five categories of CILA for data analysis and its corresponding data types and application areas.

Category of CILA	Data types	Application areas
Social network analytics	Ties, relations, roles & network data	Appropriate learning community
Discourse analytics	Semantic relationships & learning topics	Diverse traits of focuses & perspectives of the groups
Content analytics	Tags, ratings & content information	Special preferences & corresponding choices
Disposition analytics	Learning behaviors, processes & individual information	Suitable learning style & methods
Context analytics	Learning status & context settings	Learning conditions & requirements

With the understanding of the interests of teachers and learners, analysis can be conducted according to their different focuses on time and then be further divided into 3 kinds (past, present and future). Meanwhile, two levels of analytical services can be provided (Davenport, Harris, & Morison, 2010). One is at information level with the analysis for answering the questions, such as, “What has happened?” “What is happening?” and “What will happen?”. Another is at insight level revealing the information about reasons, processes and possible changes of the learning behaviours, and the research questions are “How and why did it happen?” and “What is the best following actions?”. Table 3 lists the orientation of temporal order, different types, contents, data clients and service levels on CILA.

Table 3. Types and contents of CILA in the temporal order of past, present and future.

Time	Type	Content	Data Client	Service Level
Past	Assessment	Comparison with learning peers	Learner	Information
	Diagnosis & Modeling	Information about pedagogic methods	Teacher	Insight
		Information about learner clustering and learning path	Teacher	Insight
Present	Reporting	Different perspectives on learning of the learners	Learner	Information
		Different focuses on learning of the learning groups	Teacher	Information
	Warning	Information about learners’ undesirable behaviors	Teacher	Information
		Warnings of isolated learners	Teacher	Information
	Recommendation	Suitable learning resources or communities	Learner	Insight
		Suggestions on more effective teaching structures	Teacher	Insight
Future	Prediction	Predictions of the potential dropouts	Teacher	Information
	Adaptation	Adaptive personalized learning	Learner	Insight

LA needs proper technical methods to detect the required analytical contents hidden in the learning data. Chatti et al. (2012) depicted four technologies that had received particular attention in the LA literature, namely, statistics, information visualization, data mining and social network analysis. Apart from the aforementioned technologies, this study especially points out the importance of the sound and appropriate pedagogical instruction to the analysis process so as to guarantee the practicability of the results. Results of CILA could be transformed as algorithm logic for the learning system. They could also be applied to support teachers and learners in self-reflection and pedagogical decision-making through the commonly used learning dashboards. In this respect, effective presentation methods and organization strategies are desired to assist both teachers and learners in understanding the meanings of the information generated from CILA. To this end, some questions related to the designs should be taken into consideration. For example, “How to show the focal points more clearly?” “What operational variables should be provided to get the best whole picture for observation?” “What are the better ways of organizing and displaying the results of analysis?”, etc. In fact, in order to help the teachers and learners to make pedagogical decisions more effectively with the results of analysis, it is of importance to follow one rule, that is, making the key points to be clearly shown and easily caught up by eyes.

#### 4. Conclusions

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This study discusses the use of CILA to support online learning and teaching and proposes a CILA framework. The framework highlights the interests of teachers and learners in CILA, which in turn helps to set goals for collecting data for pedagogical decision-making. It is suggested that there are two levels of CILA usages, information and insight, with the temporal factors and corresponding application areas analyzed. For the sake of a practical and meaningful CILA framework, future work has to deal with the following issues, which includes: (1) Define various OIM triples for different objectives in CILA, and study how to transform data into useful information and knowledge; (2) Design and develop supporting tools to make results of CILA easily interpreted by teachers and learners; and (3) Evaluate and test the effect of CILA on online learning and teaching support in real practice by experimental studies.

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