

# Models to implement Learning Analytics: A literature review

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## Abstract

Managing Distance Education courses produces a great amount of data organized in different isolated systems. Large and preexisting databases can be an obstacle to gathering useful information for decision-making. Based on literature review, this paper presents models to implement Learning Analytics and the main challenges the managers must overcome.

**Keywords:** Learning analytics, Distance educations, Educational systems.

## INTRODUCTION

The shift from an industrial society to a society oriented by information (Castells, 2000) formed new lifestyles, consumption and learning habits. Education on the information society looks for different ways the pursuit for knowledge, (Junior, 2004) demonstrated the search for knowledge by performing a comparison between traditional education and education in the information society as can be seen in Table 1

*Table 1 - Comparison between traditional education and education in the information society (Junior, 2004)*

<b>Traditional education</b>	<b>Education in the Information Society</b>
Focus on teaching	Focus on learning
Focused on the teacher	Focused on the learner
Emphasis on the transmission of knowledge	Emphasis on developing skills and attitudes ( learning to learn )
It teaches how to do it	Student learn by doing
Works logical-mathematical and linguistic intelligence	Works multiple intelligences
Model production line	Personalized learning model
Awards submission	Awards participation
Little use of technology	Employs new media and new technologies
Little motivation	High motivation
Teacher's time nearly fully invested in the presentation of lessons	Considerable preparation of classes
Low utilization rate (classes and teacher )	High utilization rate (classes and teacher)

Thus, increasingly teaching and learning method has been supported by the Information and Communication Technologies (ICTs). Education has been using the data for the approach to teaching for years, the difference is that we now have the opportunity to efficiently capture large amounts of data; this is due to the evolution of the computer systems capability, networks and methodologies to analyze these data which provides previously unavailable insights.

In distance education, where students can build knowledge anywhere and anytime always mediated by ICT (Shin et al. 2011), the use of different systems such as academic management systems, learning management systems, among others, generate large amounts of data. The employment of these data collected from different sources, with different standards and users with different access levels allow greater support in the decision- making process that is the idea of Learning Analytics (LA).

Higher Education Institutions (HEI) are increasingly required to measure, demonstrate and improve student performance, but also have implemented predictive modeling for strategic decision-making at the institution level. (Mattingly et al. 2012)

In order to evaluate this new area, this work suggests a systemic literature review, covering the study of applications, the reference models found in the literature to implement the Learning Analytics and its forms. The work seeks to understand what types of data are analyzed, what techniques are applied, which are the actors involved and what are the goals for conducting the analysis.

## **LEARNING ANALYTICS**

This area is founded and integrates the research and methodologies that are related to data mining, social network analysis, visualization data, machine learning, learning sciences, psychology, semantics, artificial intelligence, e-learning, and educational theory and practice

(Dawson and Siemens, 2014). As happens on any new area of research, many definitions, as you can see below, were introduced to Learning Analytics.

One of the most adopted definition in the literature for Learning Analytics is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Long and Siemens 2011).

The Learning Analytics is used for teaching and learning processes and it refers to the interpretation of the data produced by the students in order to assess academic progress , to predict future performance and identify potential problems (Johnson et al . 2011) . In educational institutions, the use of LA focuses on relevant data to students and teachers, using for this purpose, analytical techniques aiming to improve the learning outcomes of students through a better learning guidance, resources and curriculum interventions (Elias, 2011; Van Barneveld et al 2012).

Learning Analytics is the third wave of development of instructional technology, as study by (Fiaidhi, 2014); the first wave began in 1991 with the appearing of Learning Management System (LMS) and the second wave integrating to the LMS a broader educational enterprise involving students in social networks, Web 2.0.

Using Learning Analytics, according to (Siemens et al 2011), improves the effectiveness of learning and its benefits include:

- Customization of the learning process and content;
- Provide students with information about their performance and of their colleagues and suggesting activities that address identified knowledge gaps;
- Provide the teacher with information of students whom need additional help, which teaching practices are having more effects that are positive.

Learning Analytics exists in various organizational levels with micro, meso and macro levels where each level gives access to a different set of data and contexts. For instance, the analysis of a classroom may include social network analysis in order to assess levels of individual engagements, whereas the institutional level analysis may be concerned with improving the operational efficiency of the university or comparing performance with other universities (Shum, 2012).

## **METHODOLOGY**

The methodology adopted, on the research results for the Learning Analytics, qualify the article as a systematic literature review (Mancini and Sampaio, 2007). So that it is possible the completion of the literature review, the research was divided into distinct phases: 1) research questions; 2) searching the literature for data collection; 3) review and evaluation of the results of research; 4) synthesis of results.

### **Research Question**

On the systematic mapping proposed in this paper the following research, question will be addressed:

RQ1 - Which are the models found in the literature to implement the Learning Analytics?

## Literature searching

To collect established studies, the search was conducted in search engines of Science Direct, Web of Knowledge and Google Scholar. To perform the searching, it was used the Boolean expression: TS = (“learning analytics” AND “model”), therefore will be selected only the items where on its terms contains the word “learning analytics ” and “model”.

To facilitate the articles selection, were defined inclusion and exclusion principles (table 2).

*Table 2 - Inclusion/ exclusion criteria*

<b>Include</b>	<b>Exclude</b>
Articles available for download	Duplicate articles
Conference papers or periodicals	Small items
Articles with four or more pages	Articles not released for download
Data from 2011 to 2016	
Most cited articles	

The inquiry on Google scholar brought numerous results, so for this searching were included only the 80 most cited work. This searching procedure, after removing duplicate files, produced 152 results on the three bases that will be analyzed, with the majority of the articles published in 2013 (figure 1 ), 60 were found in Web of Knowledge , 23 in Science Direct and 69 on Google Scholar.

Then, it was evaluated the quality of work found according to the criteria of inclusion and exclusion defined, and based on the research questions, a new classification has been made.

Throughout the process of articles evaluation, it was identified that among the 152 articles, 04 of them were considered more central to our review, answering the RQ1.

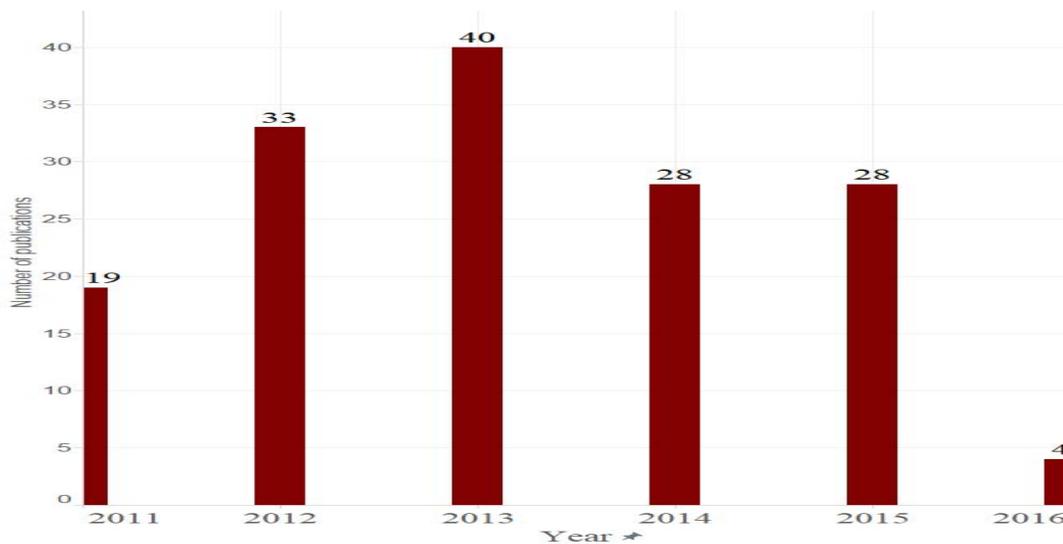


Figure 1 - Articles published per year.

## RESULTS

In this section, it will be presented the findings based on analyzes carried out in published papers and the responses on the research questions.

RQ1. Which are the models found in the literature to implement the Learning Analytics?

To facilitate the understanding and thus classify the literature on Learning Analytics, table 3 divided the key studies with the models adopted for the implementation of Learning Analytics.

Table 3 - articles that describe models for the implementation of LA.

Learning Analytics - Model	Author and year (Paper ref.)
Model based on 4 dimensions: data and environment (What?), interested party (Who?), Goals (Why?) and methods (How?)	Chatti et al. 2012
This article presents a model for Learning Analytics focused on the student, the process aims with the creation of reports, services support to students and tutors, retention of students.	Freitas et al. 2014
Using of four types of technology resources : sharing , data gathering , information processing and knowledge application	Lias and Elias, 2011.
In this model of Learning Analytics includes seven components: collection, storage, data cleaning, integration, analysis, representation and visualization, and action.	Siemens, 2013

The reference model proposed by (Chatti et al 2012), divides the application of Learning Analytics in four dimensions as shown in (Figure 2), as follows:

- **What?** What kind of data is used in the analysis? - These data can be from the academic management systems, learning environments, library systems, etc.
- **Who?** Who is the target of analysis? - It refers to who will be presented the analysis; it can be to teachers, students, coordinators, managers and other actors who are part of the process.
- **Why?** What is the objective to be achieved by analyzing the data collected? - Some of the possible goals of LA include monitoring, analysis, forecast, intervention, mentoring / guidance, assessment, feedback, adaptation, personalization, recommendation and reflection.
- **How?** What techniques will be used to perform the analysis of the data collected? - Some of the most applied techniques for detecting important patterns are statistics, information visualization (IV), data mining (DM), and social network analysis (SNA).

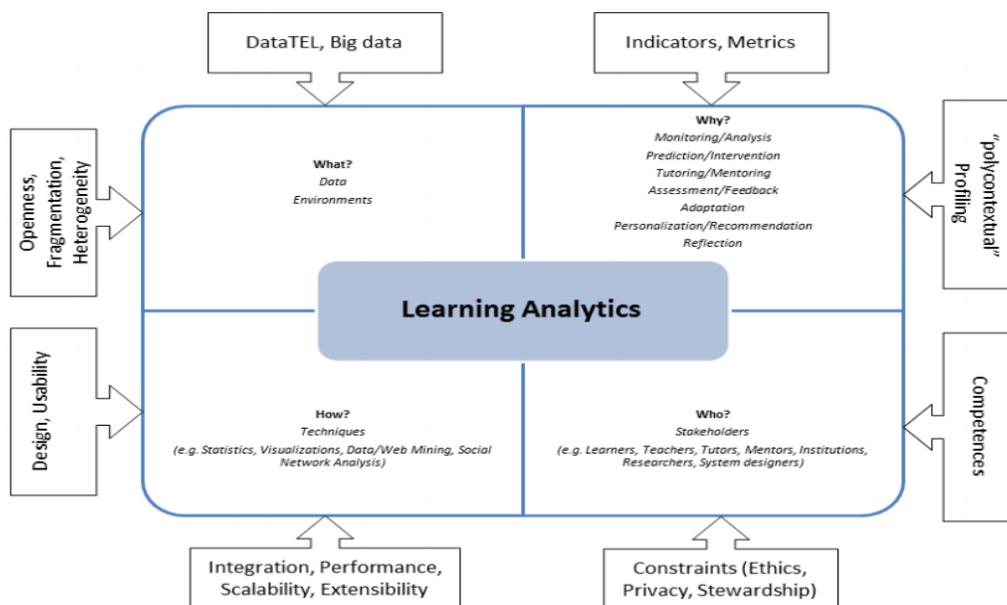


Figure 2 - Learning Analytics Reference Model (Chatti et al. 2012).

In the work of (Freitas et al. 2014), the proposed model (figure 3) is focused on the student, being an essential point that the student is seen as an element of analysis. For this purpose, a set of principles was developed shown below:

- **Develop a learning analytics strategy** - Have a single strategy analysis for the entire university.

- **Commit to create an infrastructure for big data integration** - Most Important Part of the Learning analytics is the access to information in real time. This information is derived from data integration of different systems and also from the processes of analysis.
- **Learner-centred service ethos—the unit of one** - Experience centered on the individual-student with emphasis on adaptive development and not only predictive.
- **Dynamic look at the students’ learning journey** - Systems and processes must have an approach to be followed creating a student lifecycle.
- **Adaptively model user behavior** - The intention is to apply an adaptive model for the whole University, taking into account the mission of the University
- **Linking learning analytics within a wider dynamic context** - The link of all data sources to a student will create a network analysis. To treat such large volumes of data generated by various sources, it is necessary the use of different agile methodologies
- **Qualitatively driven crowd-sourced hypotheses formation** - Qualitative informations are used, boosting changing ideas, to generate multiple hypotheses and gain greater commitment and understanding of the interested parties
- **Rigorous view of ethics and adherence to highest standards of ethical procedures** – This principle refers to ethics in the protection of data such as: anonymity of data, identity protection and safe storage
- **External as well as internal review and cross-validation processes** - On this principle, different approaches of external evaluations should be used crossing internal data and be applied in a continuous manner, for the reason that, the contexts change as the conclusions.

## Learning Analytics Model Principles

An effective analytics model ...

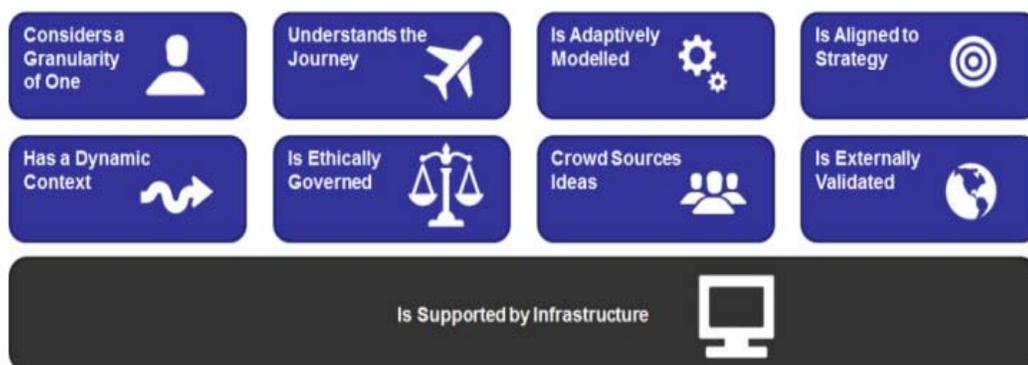


Figure 3 - The learning analytics model principles (Freitas et al. 2014)

In the model (Lias and Elias, 2011), four types of technology resources focus on the Learning Analytics: computers, people, theory and organizations. These features, along with the three phases of the cycle proposed by LA (Dron and Anderson, 2009) complete the model (figure 4).

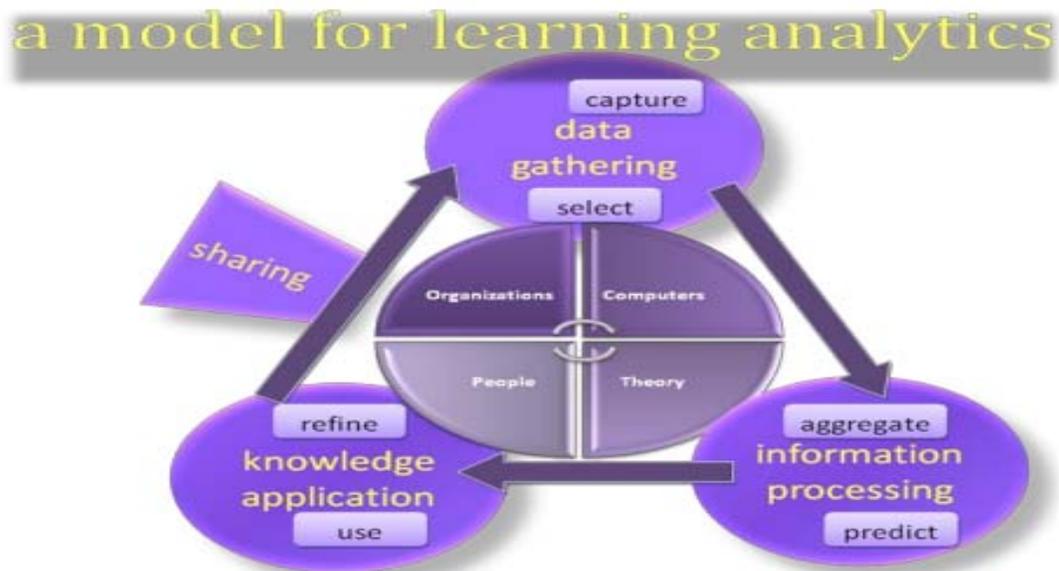


Figure 4 - Learning analytics continuous improvement cycle (Lias and Elias, 2011.)

- **Computers** - The challenge of this resource, with regard to hardware and software of data collection, is the integration of various data sources. Therefore, solutions able to gather and correlate are needed, for instance, Virtual Learning Environment data with the academic management system data.
- **Theory** - The theory for Learning Analytics includes analytical knowledge and good practices already used in other areas.
- **People** - Perhaps the most important resource, as, even in various aspects of the system, is necessary the knowledge and skills of human beings.
- **Organizations** - The social or relational resource, must be used, being essential for the analysis to know who will be involved in the project, how the decisions and actions will be supported and finally how communications and interactions will with others.)

For (Siemens, 2013), in the Learning analytics proposed model, a systematic approach ensures that all support resources are systematized so that, interventions or the creation of predictive models will only be possible with the full support of the whole education institution. This model has seven components: collection, storage, data cleaning, integration, analysis, representation and visualization, and action (figure 5).

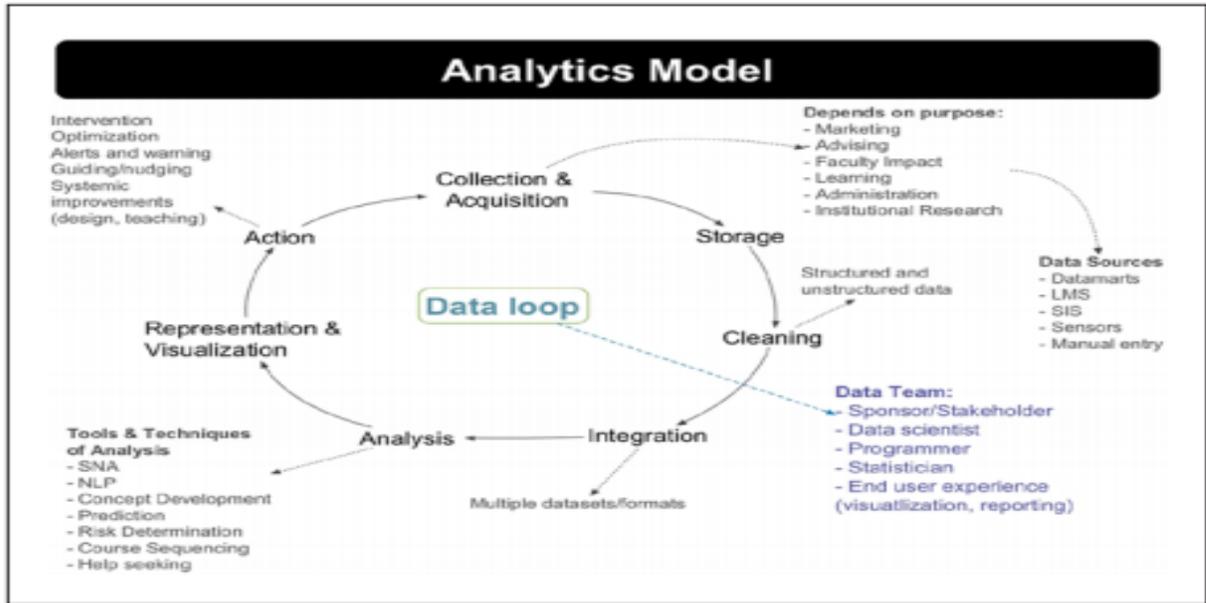


Figure 5 - Learning analytics model (Siemens, 2013)

## CONCLUSION

The aim of this study, was, through the systematic mapping carried out, verify which are the models found in the literature to implement the Learning Analytics, in order to understand its concept and possible directions.

Given the results presented, it is possible to verify that are few models of Learning Analytics and no guidelines were found to indicate whether the use of the models in an implementation of Learning Analytics, brought indicative of success.

On the models found, it is possible to realize that the most significant challenges in the Learning analytics deployment are; the introduction of the tool throughout the Institution of Higher Education and for people to get involved in the project.

We believe that as the area evolves, other models will be proposed.

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