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A general framework for Learning Analytic in a Smart Classroom

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Abstract: In this paper we propose the utilization of the Learning Analytics paradigm in a Smart Classroom. Learning Analytics can extract knowledge from a Smart Classroom platform to better understand students and his/her learning processes. In this way, a Smart Classroom can understanding and optimizing the learning process and the teaching environments proposed. The smart classroom can adapt its components to improve students' performance, among others. Particularly, this paper proposes a framework about how Learning Analytics paradigm can be used in a Smart Classroom, in order to provide knowledge about the activities taking place within it. The framework is defined like a closed cycle of Learning Analytics tasks, which generate metrics used like feedback to optimize the pedagogical model proposed by the smart Classroom. The metrics evaluate the learning process and pedagogical practice provided by the smart Classroom.
Keywords: Learning Analytics, Smart Classroom.

1. INTRODUCTION

Ambient Intelligence (AmI) is an environment where the advances in information technology, mainly in ubiquitous and pervasive computing, allow the interaction with all computation devices as a whole. This idea is being used in the educational domain, and it is used into spaces where ubiquitous technology helps the learning process in an unobtrusive manner. A smart classroom is an expression of this, where a traditional classroom is redefined, integrating sensor technology, communication technology, artificial intelligence, etc. into classroom. But, a smart classroom can generate enormous volumes of data about the educational process, which must be exploited by it, in order to improve the educational experiences of its users (students, teachers, etc.).

In previous works has been defined a smart classroom based on the multiagents paradigm, called SaCI (Salón de Clase Inteligente, for its acronym in Spanish) (Valdiviezo, Cordero, Aguilar, Sánchez, 2015a). SaCI proposes two types of agents (frameworks), one to characterize its software components and the other to define its hardware components. Particularly, the components of SaCI generate a lot of information about the learning processes. This information must be exploited in order to reach its main challenge: to cover the actual needs of the learners. Due to different learning patterns of students, it is vital for SaCI to understand each student. For that, SaCI can obtain a proper understanding of a student based on the information that he or she has generated through its platform. To exploit this information, SaCI must use the Learning Analytics (LA) paradigm to identify the different learning capacities of the students, in order to provide them the necessary guidance to improve their capabilities. In this way, to improve the learning capabilities of the students, SaCI should be capable of monitoring the overall performance of each student, separately, and dynamically adjust their teaching methodologies and to take decisions about the learning resources to use, among other things, in order to improve learning of students.

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LA extracts knowledge from SaCI platform to better understand students and the way they learn. The utilization of LA paradigm allows the knowledge discovering, from the data generated by the SaCI components. This knowledge allows response to question like: How can SaCI adapt its components to improve students' performance? How can SaCI exploit usefully its different components? among others. Thus, in this paper we propose a framework about how LA paradigm can be used in SaCI in order to improve its performance. Particularly, the framework defines the cycle of LA tasks to be implemented, in order to generate useful information for the learning process provided by SaCI. This framework combines different LA tasks with a global goal, improve the learning experiences inside SaCI, where each task provides an essential knowledge that can be used individual or globally.

The aim of the utilization of LA in SaCI is generate knowledge about learners and their learning contexts, for the purpose of understanding and optimizing the learning process and the teaching environments proposed by SaCI. LA leverages data from SaCI to provide insight into the activities taking place within it. The metrics derived are used like feedback to optimize the pedagogical model proposed by SaCI. In particular, the application of LA in SaCI allows the evaluation of the learning process and pedagogical practice provided by it, in order to improve them. This paper mainly focuses on the presentation of the framework.

2. LEARNING ANALYTICS

2.1 Concepts of base

The concept of LA has the attention in several communities that work at the intersection of learning and information technology, as the designers of educational platforms, educational administrators, etc. The main idea is that the large amount of data available about learners' activities and interests, from educational institutions (for example, according to recent statistics, over 85% of educational Britannic institutions by 2003 is using VLE), has a potential to be used to improve learning processes. The roots of LA are in several fields, particularly (Buckingham, Ferguson, 2011):

- Data mining: the classical LA is based on the analysis of extracted learning data from online courses. However, the LA has been extended in different educational domains, and is defined like the use of data mining in educational data sources to understand or identify the learning patterns of the students, the learning models in a course, etc., with the ultimate goal of helping the students to learn rather helping them to pass. Overall, data mining is a field of computing that applies a variety of techniques (for example, decision tree construction, rule induction, artificial neural networks, instance-based learning, Bayesian learning, logic programming and statistical algorithms) to databases in order to discover and display previously unknown, and potentially useful, data patterns.
- Business Intelligence (BI) focuses on computational tools to improve decision-making in educational organizational through more effective fusion of data collected from different transactional database from different academic departments.

- Web Mining: analysis log files from website, behavior of the students on Internet, websites to which one does not have internal access, but for which there is available metadata (e.g. its traffic and connections).
- Action Analytics seek to build a culture that values the insights that analytics provide for organizational strategic planning, and improved learner outcomes. Several universities are implementing data warehouse infrastructures, integrating student and learning resource data sources, in order to develop predictive models about different aspect as to identify potentially 'at risk' students. In general, action analytics is very important to define and calculate educational index.
- eScience Is a term to define the power of distributed data sharing and analysis over the internet by research professionals. In this case, it is in the domain of learning and the application of different technologies (particularly IT) in order to study the cognitive sciences from the knowledge generated by these technologies.
- Recommender systems: they are techniques to provide suggestions of items to user. In this case, we can combine LA with recommender systems to determine learning resources to recommend to student, among other thing.

LA encompasses a range of cutting-edge educational technologies, algorithms, models, techniques, methods, and best practices to analyze the trajectory of a student's learning. LA is an emerging and promising field and defines an IT-supported learning process. LA formally can be 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'' (Ferguson, 2012).

Particularly, LA proposes tools for the optimization of learning processes based on the retrieve of useful information and knowledge about learning dynamics, and on the transformation of the data gathered in knowledge for educational decision making. The virtual learning environments (VLEs) (also known as learning management systems, LMSs, such as Moodle), the academic systems, among others, are the main educational data sources that educational institutions must deal. These systems amass amounts of academic information, interaction data, personal data, etc. In addition, significant amounts of learner activities take place externally, and so records are distributed across a variety of different websites. LA searches extract value from these big sets of learning-related data. In this way, LA tries to optimize learning processes.

Pardo suggests five phases of design and execution of a LA solution (Pardo, 2014): The first stage, "capture," corresponds to the earliest collection of student data. The second stage, "report," delivers that data to a specifically defined set of stakeholders. The third stage, "prediction," deploys any of a number of techniques to provide non-intuitive answers to educational questions, such as general LA specified by us more below. The "act" stage offers the possibility of issuing automated solutions or implementing manual ones that have the potential to reverse the consequences of the earlier prediction. In the final stage, "refinement," the efficacy of the resulting actions is assessed anew so that the long-term viability of the analysis can itself be modified as need be. Some questions to answer in each phase are:

- Capture: What data is being collected?, How frequently is the data collected? Where is the data going to be stored? Are the observations securely stored? Which format is going to be used to represent all events?
- Report: What kind of information needs to be reported? will receive the reports? How frequently? How will the reports be accessed?
- Predict What need to be predicted? • Which factors can be used as input for the prediction algorithms? How is the accuracy of the prediction going to be measured? Are the prediction algorithms adequate?
- Act: What actions are considered? How are the actions deployed in the learning environment?
- Refine: Are the data sources appropriate? Are the storage and access requirements for the data appropriate? Are the produced reports useful? Are they reaching the appropriate stakeholders? Are the predictions useful? Is the accuracy appropriate? Should the set of actions be revised? Are the actions properly deployed?

(Aguilar, Riofrio Encalada, Guamán, 2015) defines a business intelligence (BI) methodology to implement LA tasks, which is composed by the next steps:

1. Defining target situations. In this case the main questions that should answer BI project are defined. Normally, the target situations are strategic questions that the organization should respond. These target situations justify the BI project, and define the needs and business opportunities identified. Typically, the extraction of hidden knowledge in the organization operational data is required, by using data/semantic mining tasks. The target situations are very important because they define the indicators looking to get. The main objective at this stage is to define the target situations, describing different types of states in an organization: strengths, weaknesses, opportunities and threats (SWOT).
2. Data Model of the BI project: in this phase are prepared the data to use in order to calculate the indicators. Normally, at this stage the data warehouse that contains both, historical and current data, optimized for consultations and rapid analysis, is designed. Data warehouses are based on the design of multidimensional data models, in order to take into account the main data needed to meet the targets situations. Traditional relational Database cannot normally handle target situations. Data warehouses require the extraction, transformation, processing, integration and high-level analysis. For these reasons, at this stage these tasks are defined.
3. The knowledge extraction (indicators): in this stage different types of models or statistical metrics are calculated for the interpretation and analysis of the target situations, using the respective indicators. At this level, technologies such as OLAP, data mining, etc. are used. The OLAP engine is a query builder to explore and analyze detailed information summarized in the multidimensional databases. OLAP tools provide analysis to find trends in the data, but do not discover hidden relationships or patterns. These tasks require more powerful tools such as semantic/data mining technics.

In special, LA is distinguished of other educational analytic domains, like academic analytics, because this last is focused on the definition of political/economic decisions to improve learning opportunities and educational results at national or international levels. Overlaps between them remain, but LA is focused in the benefices of the learners and faculty (courses and departments), and academic analytics is focused in the benefices of the administrators and marketing at institutional or regional level; and governments and education authorities.

2.2 Taxonomy and Challengers in learning analytics

Some authors identify five types of Learning Analytics (Ranbaduge, 2013) (Duval, 2011)):

- Learning network analysis: involves the use of ICT to promote connections between one learner and other learners, between learners and tutors, and between learning communities and learning resources. These networks are made up of actors (both people and resources) and the relations between them. Social network analysis is an emerging perspective that has been developed to investigate the network processes and properties of ties, relations, roles and network formations, and to understand how people develop and maintain these relations to support learning.
- Learning discourse analysis: Discourse analysis is the collective term for a wide variety of approaches to the analysis of series of communicative events. Some of these approaches cannot easily be employed as online social learning discourse analytics because they focus on face-to-face or spoken interactions and may require intensive examination of semiotic events from a qualitative perspective. Typically, it is more used to understand the large amounts of text generated in online courses, etc.
- Learning content analysis: it defines the variety of automated methods to examine, index and filter online contents, with the intention of guiding learners through the ocean of potential resources available. Content analytics may be used to provide recommendations of resources. The resources can be textual, or multimedia (e.g. images, video, music), and can exploit features of images such as color, texture and shape in order to improve the recommendations. These elements can be used to provide novel methods of suggesting, browsing or finding educational media.
- Learning dispositions analysis: they provide a way of identifying and naming the qualities of a good learner. They can be used to assess and characterize the complex mixture of experience, motivation and intelligences that a learning opportunity evokes for a specific learner. Learning dispositions comprise the seven dimensions of 'learning power': changing & learning, critical curiosity, meaning making, dependence & fragility, creativity, relationships/interdependence and strategic awareness.
- Learning context analysis: LA can be applied to a wide variety of contexts. They can be used in formal settings such as schools, colleges and universities, in informal contexts in which learners choose both, the process and the goal of their learning and by mobile learners in a variety of situations. In some cases, learners are in synchronous environments, structured on the basis that participants are present in time, and at others they are in asynchronous environments. Context analytics can be used to mine readily available data such as profile information, timestamps, operating system and location. Such analytics support recommendations that are appropriate for learners' situation, the time they have available, the devices they can access, their current role and their future goals. Context analytics can also be used to highlight the activity of other learners in a community or network.

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In general, there are a lot of proposition of LA for different type of problems on the domain of educational environment. A set of problems which are solved by LA are:

- To predict the student overall performance
- To discover the relationship of tutors with their students
- To discover the different learning patterns of each student
- To help tutors to identify the students who need more attention among a larger set of students
- To prevent student dropouts in distance education university
- To classify the students
- To provide the instructors with appropriate advising
- To build eParticipation
- To analyze collaboration and interaction in learning environment
- To analyze the effectiveness of students with educational resources
- To investigate student motivation in the context of a learning process
- To assess the suitability of student interactions from VLE

Some future challenges in LA defined in (Ferguson, 2012) are:

- Establish a bridge among LA and the learning sciences (cognition, metacognition and pedagogy). In order to optimize learning processes, it is required a good understanding of how learning takes place, how it can be supported, among other things.
- Exploit a wide range of data around learning environments, including not only the VLE or LMS data, but also from informal or blended learning environment, behavior of the students in Internet, academic information, etc. That is, it is required combinations of datasets, including mobile data, biometric data and mood data.
- Focus on the perspectives of learners, in order to analyses the necessities of the students rather than to the needs of institutions. Such a perspective must include aspect like enjoyment, confidence, motivation, satisfaction, etc. It can improve the understood of the learning process of the learners
- Must be transparent, enabling learners to respond with feedback naturally that can be used to refine the analytics, and see how their data are being used.
- Must provide knowledge with pedagogical and ethical integrity. A LA process must answer to: who is defining the measures? what ends?, what is being measured?, and who gets to see what data? The challenge for learning analytics is complex, because it uses data generated by users as a by-product of online activity (e.g. social networks), not as an intentional form. It must provide results in the form of feedback to learners, modifications to the content that is displayed based on the model of the learner, or suggestions about what to focus on next. It must provide learning indicators that genuinely promote meaningful learning.
- Must revalue the role of teachers/mentors, who have unique skills, which will never be replicated by machine intelligence.

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3. SaCI

SaCI is a smart classroom proposed in (Valdiviezo et al., 2015), where its deployment environment (middleware), called AmICL, was proposed in (Sánchez, Aguilar, Cordero, & Valdiviezo, 2015a), (Sánchez, Aguilar, Cordero, & Valdiviezo, 2015b). SaCI proposes a smart student-centered classroom, which supports the learning process, through collaborative devices and applications that facilitate self-training. To do this, the smart classrooms have different types of components: hardware (such as smart boards, projectors, cameras, etc.) and software (Intelligent Tutoring Systems (ITS), Virtual Learning Environments (VLE), among others). They have proposed the SaCI model that characterizes a smart classroom, using the paradigm of Multiagent Systems (MAS). The reflective middleware for smart learning environments, called AmCL, is shown in Figure 1.

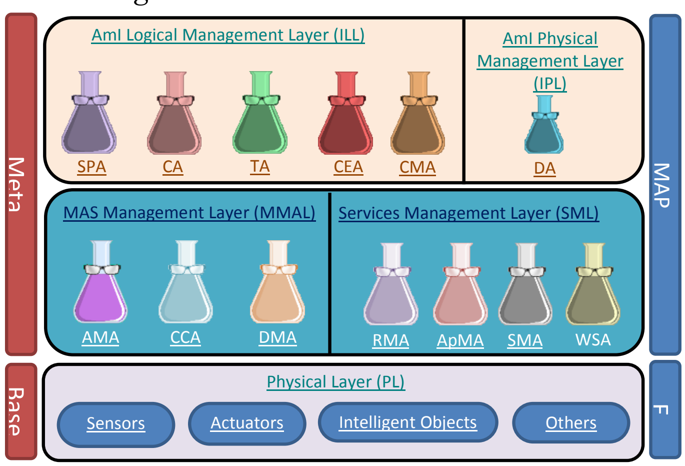

Figure 1. Middleware AmICL.

The proposed middleware AmICL has six levels. A physical layer with components that interconnect the elements of an intelligent ambient (software or hardware), such as APIs, libraries, etc. That level works directly with the operating system. The SMA management level consists of the classic multi-agent community, defined by FIPA to support the implementation of multi-agent applications (allows the deployment of MAS). The service management layer has the responsibility to seek the required services in the cloud, particularly educational. AmI physical layer represents the various devices in the environment, represented as agents. AmI logical layer represents the different software applications used in the educational platform, also represented as agents. The last two layers are those that define SaCI. Finally, in the real classroom of AmICL is where the devices (sensors, smart cameras, etc.) and software (VLE, etc.) of SaCI are deployed. Particularly, the layer "IE Logical Layer Management" (ILL) specifics all applications (software) and individuals present at SaCI as agents, which contain metadata that defines them. One of the key softwares, in order to give the adaptive capability to SaCI, is the recommender system of learning resources. In our model, it is defined like an agent, belonging to ILL. In our case, our IRS will be this agent recommender of learning resources for SaCI.

4. OUR GENERAL PROPOSITION OF LA ON SaCI

4.1 LA on SaCI

The works in LA give an idea of the variety of researches in this domain. They show how the knowledge generated can be used to solve educational problems, support educational decision making, but at the same time they pose new research questions. One of them is the goal of this work, how can be used LA in the context of SaCI?

Current, learning and teaching in a virtual classroom environment depends on the way in which the information is used by the users of the system. In modern e-learning environments, teachers and students dependent on the course module outline and how these activities are arranged using the functionalities available in LMS. Due to the different learning capabilities of the students, these course activities are performed in dissimilar fashion by the students. Nevertheless, SaCI can overcome this problem, by applying LA tasks to define the teaching principles or the teaching methodologies on the students in SaCI in different manners. In this way, SaCI tries to exploit the different learning patterns of students in a much more detailed manner. For that, SaCI require a proper understanding of the students overall performance, using the information that SaCI has gathered, in order to identify the different learning capacities of the students and to provide the necessary guidance to the students to improve their capabilities.

Using LA in SaCI to understand the student behavior becomes a new relative area of practice and research. The tasks of collection of data, of preparation of this data for LA tasks, the utilization of the knowledge generated (p.e, to discover patterns and trends) by the LA tasks by the different component of SaCI (intelligent tutoring systems, etc.), the actions derived by the LA tasks (like games and simulation programs), open a very large domain of research. In our case, we need to understand how to use LA tasks in SaC.

LA in SaCI must attempt to leverage all data present in SaCI to provide insight into the activities taking place within the classroom. Particularly, the metrics derived are a vital feedback into SaCI, in specific, to define the pedagogical model to apply in the classroom. LA must evaluate all the aspects of the learning process in SaCI. LA seeks to understand entire systems and to support SaCI in the decision making.

Thus, in the case of SaCI must be analyzed its components in order to determine the source of data, how exploit the metrics generated by the LA tasks, among others things. Particularly, like the idea is to improve the learning process, we must determine the components with more influence on it.

Particularly, the knowledge generated by the LA tasks must be exploit by SaCI. We need to give it information to help it. In special, one of the main goals of SaCI is “to understand the student behavior and how students can be motivated on learning in order to self-adapt". To reach that, there are SaCI aspects which must be analyzed by the LA tasks (see figure 2):

- To observe the learning process: in this case, LA must generate indicators to understand the current learning process (paradigm, methods, tools, etc.)
- To observe the student behavior: in this case, the LA tasks must generate indicators about the performance of each student.

Figure 2. Relationship among the aspect to analyze of SaCI

With the data provide by SaCI, we can produce a large amount of knowledge which is distributed around SaCI. Sharing and manipulation this knowledge in real time, is an enormous achievement of SaCI, in order to improve its behavior. It can be used to define the learning methodologies in an accurate manner. This problem has not been solve in the current e-learning systems. Virtual LMSs enable the teachers and tutors to manage diverse educational materials manually. The LMSs provide mechanisms that can be used by teachers to view the outline performance of each student and see the final marks that the student has gained in the given activity on the course, but manually. But the differences among the students, the large quantity of different data about the learning process, is very bad used to define the learning resources, study materials, etc. Additionally, the utilization of the performance of each student to parameterize SaCI in accordance with the behavior of the student has not been studied.

Our approach attack two of the main reasons for student's dropping out the school (Aguilar et al. 2015): Lack of educational support, or student with special needs (they require specific attention to a certain need). The lack of educational support and the special needs can be easily managed using LA tasks, like a predictive analysis approach since student who are at risk of failing can be identified at an early stage by analysing their historical data of learning behavior. The utilization of LA, as an early warning system, is a useful and effective tool. Particularly, LA in our SACI must:

- Accurately define and uncover students' problems and needs
- Successfully identify interventions and improvement strategies
- Effectively target and initiate programs and reforms
- Monitor the ongoing efforts and progress of the 'at-risk' students

We can exploit the knowledge hide in SaCI for three different interest groups: governments, educational institutions and teachers/learners. Each one requires LA on different scales and at different granularities. In this work we choice as target audience teachers/learners, but in future works we will analyze the rest of groups. Depending of the groups, the conceptualization of the problem is different, and equally the capture of data, the reports, the models, etc. In this case, the goal is 'turning learners into effective better learners'. The research focused on LA task techniques that could be used by SaCI to better understand the learning process (Zaïane, 2001). In this way, SaCI can use this information to improve teaching, learning and success of the students, and to customize learning paths or provide personalized instruction to specific learning needs.

4.2 General Architecture

If we want to apply LA in SaCI, then it is imperative that we define the architecture to support the LA tools like services in SaCI (see figure 3). Such an infrastructure need consider the different components to be used in order to develop LA task. In this way, we propose a general architecture based on the BI paradigm compose by three levels: a first question that answers the architecture is how to model the relevant data. According to our early work about BI methodology, requires the definition of the Conceptual data (CAM) [ref] that means a model with the data that need the LA tasks. This is the *data storage level*, and is the classical data warehouse generated from the transactional databases of the educational institutions. But in our case, it is extended with semantic information generated by the LA tasks. For this reason, all this level is called semantic knowledge level, because it describes additionally the knowledge generated for the LA tasks. This level guarantees that the information follow standards to describe the different aspects of SaCI, like for the case of learning resources to use the Learning Object Metadata (LOM). The next one defines the different tasks to prepare the data. This level, called *data preparation level*, has the different mechanisms to prepare the data, according to the techniques used by the LA tasks. For example, if the LA tasks are based on data mining mechanisms in this level there are three steps, the ETL (Extract, Transform and Load) operations; otherwise, if the LA tasks are based on big data and semantic mining the main tasks are collection and curation of data (CCA). Finally, the last level has a set of services linked, among others, to the LA tasks. Additionally, in this level there are other services linked to tools and applications of machine learning, data visualization, etc. In this way, our architecture can exploit the data from the organizational database, and data outside of the organization (using big data paradigm).

Our architecture, by collecting data about learning process, can be mined for different tasks: recommendations of resources, activities or people, turn the abundance of learning resources into an asset, etc. We can remark that the different components of SaCI participate in the LA tasks, like sources of data and information (like the students, the institutional Learning Management System (LMS), Virtual Learning Environment (VLE), etc.) or like users of the knowledge generated, like the students, tutor agents, recommender systems, etc. Other important remarks are that our architecture can execute data and semantic mining tasks, it can store information from SaCI (its different components), but additionally can include other information outside of SaCI (for example, from internet), and can use different type of knowledge representations: ontologies, cognitive maps, etc. Additionally, it is transparent to the techniques of data processing.

In this study only are considered the components of the general architecture to carry out LA tasks for the BI project defined in the section 4.1. That is, the LA tasks are based on data mining mechanism and a data warehouse from the operational database of the organization. The information outside of the organization, which requires big data and semantic mining mechanisms in order to be exploited, are not studied in this paper. In this way, the type of information that can be exploit are, for example, the total time spent on the courses, the average performance on the courses, the number and type of learning resources used in a course and for a specific student, etc.

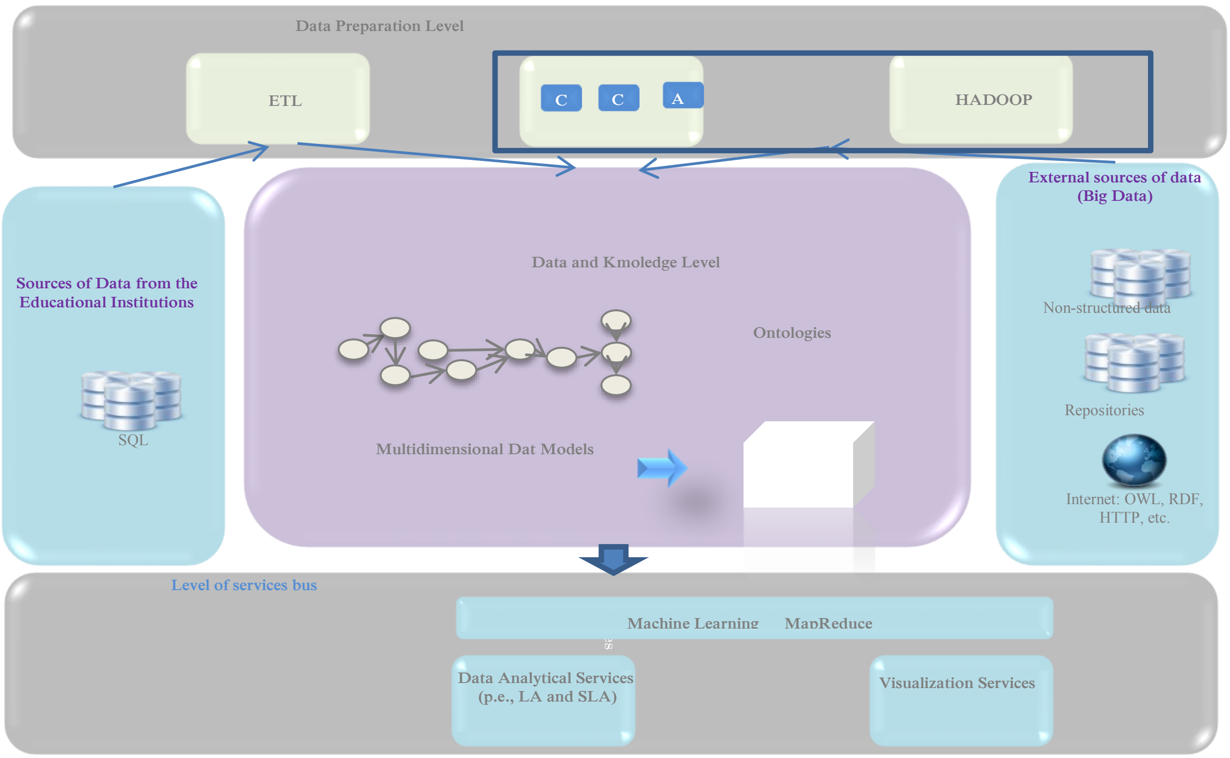

Figure 3. Our general architecture for LA tasks in SaCI

4.3. Type of tasks of LA on SaCI

Now, it is very important to define how are organized the LA tasks. In the literature there are a lot of LA tasks (see section 3). We propose use for SaCI a closed loop of LA tasks, in order to guarantee an autonomic behavior for SaCI. That is, the knowledge generated by each LA task is chained with the input to the next one, in order to allow an adaptive process in SaCI. Particularly, because the goal of SaCI is to adapt it to the needs of the students, the LA tasks must allow observe the learning process and student behavior. In this way, the LA must be:

- Focused on the learning process: some of the LA tasks that requires SaCI to analysis the learning process are
  a. Monitor efforts and progress of the students: in this case is necessary to generate knowledge about the behavior and performance of the students. Some of the knowledge generated is about the aspects learned, its level of contribution on the learning process, the learning resources used, etc.
  b. Analyze the evaluation process: in this case are studies the aspects evaluated, the average performance of the student, etc. There are two types of evaluation to consider: diagnostic and

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formative evaluation. A main element here is the pattern generate of the evaluation. The patterns allow determine weaknesses, approval rates, if the student has appropriated the issue, the types of questions that the student cannot answer (for example, if the student does not answer application questions means you cannot apply the concepts acquired)

c. Search resources and activities to recommend: in this case, based on the knowledge about the student profile, about the performance of the students in previous activities or resources, the recommender system can exploit that to recommend new items.

- Focused on the students: some of the LA tasks that requires SaCI to analysis the behavior of the students are:
  a. Discover learning styles: in this case the idea is to discover the learning styles of a student, of a group of students (for example, during a course). The idea is (re)build the student profiles based on what the student does, for that must be used learning style models like the Felder-Silverman model, with information available about the tools, learning strategies, evaluation methods, used by the students.
  b. Determine how the performance of each student varies according to the learning patterns of the courses. For that, the LA tasks must analysis the student´s participation against the learning style of the course, etc.
  c. Identify uncover students' problems and needs: in this case are used the LA tasks in order to discover the subjects not covered in assessments, identify topics that students need more attention, which questions students fail more, etc.

But, these set of tasks which observes the learning process and student behavior, must reach the next goals of the control loop (defined again like LA tasks, which use the knowledge generate for the previous tasks):

a. Determine reforms on the learning processes: in this case, the LA task must determine the changes of methods of teaching, proposing learning paradigm shifts, etc.
b. Identify interventions and improvement strategies in a given moment: in order to be introduced in the dynamics of activities to be proposed inside of SaCI during a learning process.

In this way, this loop is defined as a feedback loop in order to optimize the learning process provide by SaCI. Figure 4 show the LA control loop for SaCI. It is important remark that this LA tasks can be exploited individually by SaCI, in order to adapt specific aspects of its architecture.

5. Conclusions

In this paper we propose a LA architecture for SaCI, in order to exploit the large amount of knowledge which is diverse and distributed around SaCI. LA tasks allow an autonomic behavior of SaCI in order to manage a diversity of situations, educational materials, student styles, in a much easier manner. In this way, SaCI can carry out a correct adaptation of its components.

The learning process in SaCI, using this feedback loop, depends on the way in which the knowledge flowing through the different agents of SaCI, in order to adapt theirs behaviors. SaCI does not dependent on the course module or professor, it has an autonomic behavior based on the knowledge generated by the LA tasks. They can determine the activities to be used in VLE, the functionalities to be available in LMS, etc., considering the different learning styles of the students, the knowledge level which they have gathered in each activity, among other aspects. That mean, SaCI proposes an ecosystem of learning where different students with different learning style can share a same learning environment, different with the classical learning environment where is used the same teaching methodologies on all the students in the same manner.

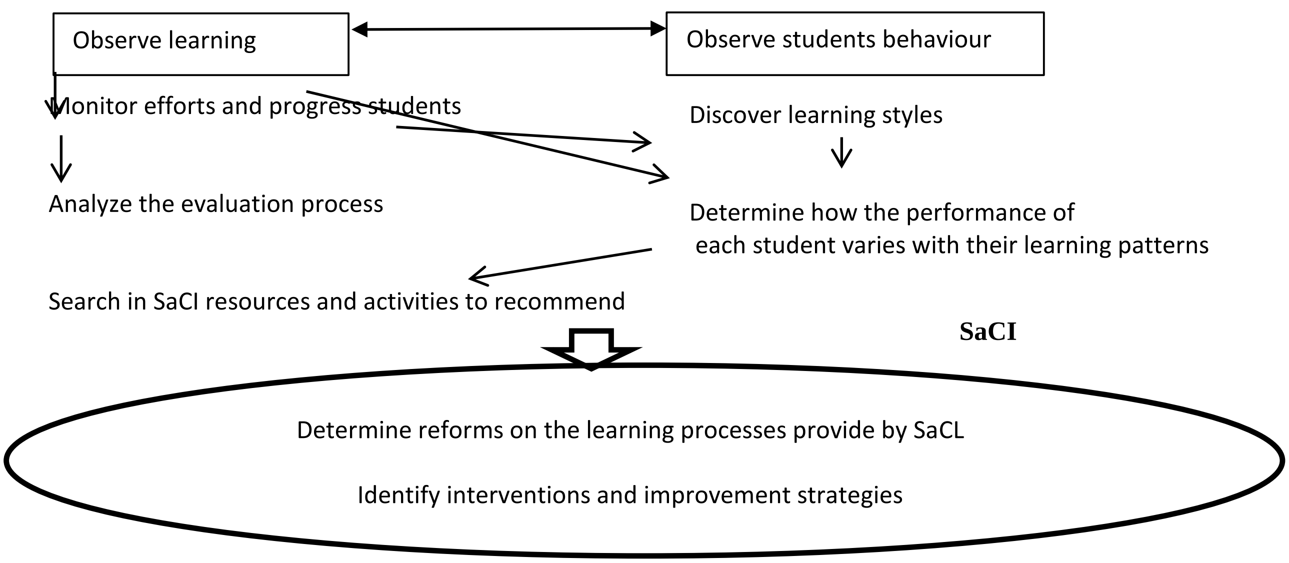

Figure 4. The Autonomic Control Loop based on LA tasks for SaCI

The autonomic loop is the framework of the LA tasks in SaCI. The systematic collection and analysis of data that identifies the patterns of the students can be used in envisioned way by SaCI. The manner in which this can effect and alter SaCI is undeniable, for that is necessary an autonomic loop where SaCI determines the best way to self-adaptation in order to guide the students. It facilitates the services and resources to offer to students.

In this paper we have only studied LA in the context of SaCI, not SLA. Particularly, the architecture that we have proposed in this paper, can be used for SLA. Next work need to test this possibilities. This is a significant advances because the integration of Social Network Analysis (SNA) within SaCI will consider the knowledge constructed through social negotiation. In the context of learning, SNA can be used to investigate and promote collaborative and cooperative connections between learners, tutors and resources, helping them to extend and develop their capabilities. Particularly, that allows to research about the process of learning through individual participation in social interactions, in order to generate a collaborative knowledge construction. We need to test all the feedback loop in other to prove the adaptive capabilities that defines this loop for SaCI.

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