Analysis of Learning Styles in Learning Objects (LSiLO) Related to Socioeconomic Stratums in a Colombian Public University

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Keywords: Learning styles, Learning objects, Socioeconomic stratums, Learning improvement.

Abstract. The Francisco de Paula Santander - UFPS is an affordable public higher education institution located on the Colombia-Venezuela border in the state of Norte de Santander. Approaching 86% of alumni entering our Computer Science program come from low income families (socioeconomic stratum 1 and 2). These students had zero knowledge of the English language and their PC knowledge is limited to office utilities and social networking, and as a consequence the Internet is seen as a means of entertainment rather than a learning tool. Additionally, we recognized that each and every student has their own learning abilities, level of knowledge and has a unique way of learning. A learning style (LS) includes every kind of learning characterized by a single person. In this study we selected a topic and built using four different learning objects (LO) corresponding to four LSs (Active, Reflexive, Pragmatic and Theoretical). This work was developed to analyze the usage level of learning styles aided by LSiLO, to generate the programming skill set required by alumni on our courses, looking at the differences between socioeconomic stratums and hence find out which of them is favored by the application of LSiLOs. To evaluate effectiveness two kinds of instruments were used. On one hand quantitative tools were designed in order to measure skill generation and knowledge appropriation. On the other hand, we developed qualitative assessment tools (Likert scale) to gain individual perception of how students interacted with the LO. The results of this study bring us to realize that considering learning styles is beneficiary for low-income students, given that it allows the student to learn in a much more comfortable way, without feeling the need to adapt to a professor's teaching style, and hence letting the student learn by themself.

1. Introduction

The Francisco de Paula Santander University - UFPS (located on the Colombia-Venezuela border in the state of Norte de Santander) is an affordable public higher education institution that is attractive for students from low-income backgrounds whom wouldn't otherwise have the chance to study post-secondary school. Each semester we received more than 200 applicants and just 60 are accepted as students into the Computer Science course, starting with the introductory Computer Programming course [1].

According to a survey conducted online, our students come from schools without computer rooms for the student to get close to such technology. Other students come from schools where they have had the chance to learn the basic concept of computer programming, and others have taken courses on programming techniques. As a consequence, students' knowledge of computers and the Internet is orientated towards social networks. Another difficult for these students is the fact they have little to no knowledge of the English language [4].

ISBN: 978-605-64453-0-9

Another problem the students recognised, in an online survey, is that they only dedicate study time to classes rather than complementing this with other means such as library books or Internet tutorials. The self-study mentality just isn't there.

Computer programming isn't an easy thing to study [5,6,7]. It requires comprehending certain abstract concepts like organizing information in a way it can be understood by the right person; however this isn't always possible to teach in a lecture due to the large and heterogeneous groups which make it difficult to design learning material which is beneficial for everyone.

It's difficult to teach students who haven't had sufficient previous contact with technology to program. Many of whom feel pushed away from technology and programming along with it. They don't see it as something they can use to learn by themselves, at their own pace. But we cannot put all the blame onto the students, as it's also the environment they have grown up in that hasn't allowed them to develop their skills and hence develop their programming abilities.

In addition to this, it becomes difficult for the professor to achieve the same level of understanding amongst every student. There's a failure of effective communication. Generally speaking, students confuse some concepts and hence misapply them, and don't worry about misunderstandings until they fail in evaluations. These students have their own learning abilities, and level of knowledge. Logan [2] supports this by shown how people exhibit important differences when it comes to problem solving. This makes it especially difficult for a professor who can't teach 30 different ways [3]. These difficulties cause students frustration, depression and hence demotivation with the course [5,6], provoking high desertion levels.

Within the Computer Science program we want to focus in two issues, the heterogeneity of students and the lack of initiative to learn by themselves. In the CS program we think these issues can be solved by creating a better way for the student to get a feel for this knowledge, so we'll focus on two aspects: i) Using LOs to present topics identified by students and ii) Including Learning Styles in Learning Objects - LSiLO.

To face the first issue we need to arrange all material related to key topics identified by students. This material will be made both textual and graphic content, examples and evidence. We can then create LOs and share them with other professors and students. The aim of this is to keep a Learning Object Repository (LOR) covering all programming subjects to be used by professors in their lectures, as well as students to facilitate the learning process, thus giving them a sense of self-learning.

For the second issue we need to realize that each and every student has a unique way of learning, and that a professor cannot teach a class thirty different ways. That's why each LO must be designed following the four learning styles proposed by Peter Honey and Alan Mumford [8]. Logan [2] supports this by establishing that individuals with a very visual memory but a weaker one for verbal processing are going to find textual material more difficult to process compared to students with strong verbal abilities. This way a professor can use these LSiLOs to teach a heterogeneous classroom whilst aiming at a multitude of different levelled students, without the need to slow down the pace of others [3].

With the application of these two aspects we look to analyze the impact of LSiLO use on alumni from different socioeconomic stratums, and then using this analysis we aim to establish a starting point for the group getting the best use out of them and hence design strategies that allow us to alter their use depending on stratum. As well as this we're closely following both the development of programming skills and that of a consciousness of self-learning, giving alumni the ability to take their own initiative in the knowledge acquirement process.

To achieve this, we employs a series of tests, surveys and interviews to measure LSiLO use within the constraints of the classroom to develop new knowledge.

The organization of the article is as follows. Section 2 contains a concept review. Section 3 contains an overview of the related literature. Methodology and the analysis of the results will be

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introduced in Section 4. Discussion of results will be shown in Section 5. The conclusions will be presented in Section 6.

2. Background

2.1 Learning objects

In recent years global interest in online learning has been focused on LOs [9]. According to Wiley [10] LOs are "any digital resource that can be reused to support learning", however this definition is quite broad. Polsani's [11] definition has a more educational intention: "A media asset or a digital object can become a LO only when it is incorporated into a form and provides a relation to itself as LO in order to facilitate the understanding of that object". In [12] Noppamas establishes that los learning objects can be educational components presented in any format. Adamchik [13] defines a learning object (LO) as an integrated module containing the core text, code examples, review questions, supplementary material, and programming labs.

Despite these definitions on what an LO is, there's still no globally accepted definition. So for the purpose of this investigation we decided to use the definition proposed by Ünal [9], who established that "LOs can be united in order to be used in different areas, can be reused, and can be arranged easily". This definition would only be improved by saying they are also available online. This means students with different learning needs may benefit from LOs, being able to study them at their own pace wherever they may be, autonomously.

A LO looks to provide class material within a course, not an entire course. It also looks to be an instructional aid thanks to its flexibility, accessibility, durability, interoperability and reusability [14]. Kaiser [15] establishes that LOs must be the size of an activity in order to be used in line with a module or lecture. Examples include simulations, data, tests, surveys, texts and according to [12] could include adaptable learning modules.

Robin Kay [16] has analysed different studies on the perception of LOs taking faculty and student perspectives, as well as performance, into account. In this compilation he show three obstacles from the POV of the faculty, that's also been seen at UFPS: i) Not enough knowledge of LOs to determine their effectiveness, ii) Time required to integrate LOs into the curriculum is too demanding, and iii) Time required to construct good quality LOs would be extensive. Before attempting to solve any issue, effectiveness must be checked. This study will convince our teaching community that LOs and more specifically LSiLOs are worth looking into as they allow students to improve their learning process. This will give us the institutional support needed to create interdisciplinary groups for the construction of LOs.

Be that as it may, having many loose LOs is not advantageous, that's why they are arranged into Learning Objects Repository (LOR), allowing them to be located and used. UFPS has an LO repository where students can consult and use them, unfortunately this project is still at an early stage and hence incomplete.

In an academic environment, LOs offer unique capacities and within the reach of every student so that they can work at their own pace, through personalized tutorials along with feedback. With this, the professor can easily work in heterogeneous classes facing different levels without having the need of slowing the pace of other students [3].

In this day and age, a person's ability to create and consolidate the knowledge required to do so age is more important than ever, rather than just accumulating knowledge. This allows the development of skills such as critical thinking, problem solving, decision-making and technological understanding [13].

2.2 Learning styles

Learning Style is an important criterion for personalization because it has a strong influence on the

ISBN: 978-605-64453-0-9

learning process [18]. Learning styles are considered one of the most important factors and influence the competition of e-learning. A learning style includes every kind of learning characterized by a single person, such as a concrete way of solving an activity, or strategies used to complete a task.

The concept of learning style suggests everyone is different in respect to the way they follow instructions or study more efficiently [18,2]. Keefe [19] defines learning style as the characteristic cognitive, affective and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with and respond to learning environments. Looking at this definition you can say that learning styles are reflected on preferences and individual choices and encompass a broad range of factors including that of cognitive styles.

Some researchers have argued that learning style is also a useful indicator for potential learning success on the grounds that it already shares information on individual differences in terms of preferences and information processing [18].

As Griggs [20] points out, it's important to recognise the fact that learning styles have no relation whatsoever to IQ, mental capacity, or actual learning performance nor can it be said that one style is better than another. The best learning style for an individual is specific to that individual and depends on cognitive capacity and current learning situation of said individual [2].

In this study we used the four learning styles developed by Peter Honey and Alan Mumford [21] based on the work of Kolb [22], those being: Active, Theorist, Pragmatic and Reflector.

To identify student's particular learning style Honey and Mumford have developed a Learning Style Questionnaire (LSQ). According to Honey: "Improve your learning skills and processes. Increased awareness of how you learn, opens up the whole process to self-scrutiny and improvement. Learning to learn is your most important capability since it provides the gateway to everything else you want to develop". This questionnaire shows a good grade of validity and reliability / internal consistency as well as sharing precise learning style evaluations [12].

3. Literature review

Our starting point was the work of Essi Lahtinen [7] who studied the difficulties in learning programming in more than 500 students to support developing learning materials for basic programming courses.

In [23] Sajaniemi applied a metaphor approach to object-oriented programming by presenting new metaphors for such concepts as class, object, object instantiation, method invocation, parameter passing, object reference, and garbage collection.

For improve students' motivation in [24] Molins-Ruano used game design as a test-bed for an experience involving Computer Science and History students: interdisciplinary teams have cooperated in the design of a video-game on an historical theme.

About learning styles, in [25] Feldman proposed a novel approach to detect the perception style of a student by analyzing his/her interaction with puzzle games. They tracked how students play a puzzle game and extract information about this interaction. Also, in [18] Shaw studied the relationships among learning styles, participation types, and learning performance for programming language learning supported by an online forum.

In Colombia there is an approach to teaching programming using an active learning approach. Villalobos [26] presents an Interactive Learning Objects (ILOs) as one of the components that reinforce their pedagogical model, by supporting the generation of high-level programming skills.

4. Methodology

This experiment was designed to analyze LSiLO usage levels amongst different socioeconomic stratums in generating the required programming skills.

Most of our students hadn't had proper schooling giving them the ability of self-learning, meaning they don't feel able to learn by themselves nor develop an individual conception of a subject.

ISBN: 978-605-64453-0-9

Therefore upon beginning the course they face the problem of developing the required skills and moreover, doing it alone.

At present, 87% of students who signed up for the 2013-II period come from low income families (socioeconomic stratum 1 and 2), and per semester pay the equivalent of around half the Colombian minimum wage, or about US$140. Distribution for our students can be seen in Fig. 1.

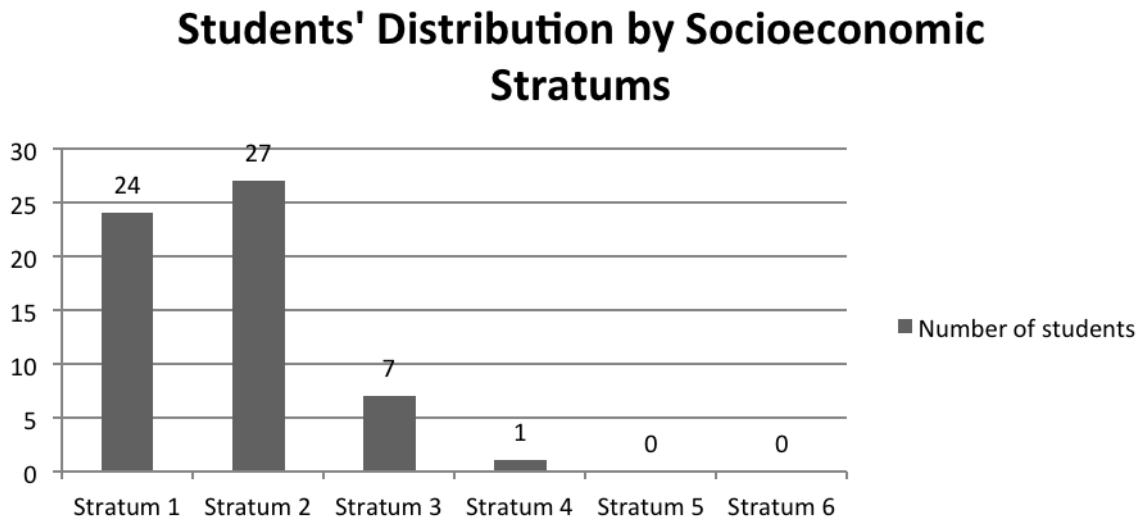

Fig. 1. Students' Distribution by Socioeconomic Stratums

The design of this project emphasizes the need to listen to students, enabling them to articulate the ways they work with digital materials.

4.1 Sample

The study was designed for first semester students taking the Computer Programming (CP) course, which last for a whole semester and covers object-oriented programming towards Java. The course in its entirety covers object-oriented concepts, java swing, arrays and matrixes, collections amongst others. This study wasn't developed over the whole semester, but instead the students' toughest topic was established and we went from there. This study seeks to show the supports benefits e-learning has for traditional teaching.

The subject for which the LOs were developed is List. This was identified using online surveys taken by students of previous semesters. We can now clearly establish that it currently may not be the new students' toughest, though historically speaking, it has always been.

The population surveyed composed of 59 students split up into two groups (CP-B and CP-C), using a sample of 30 (CP-C). The sample was divided into two evenly split groups, one for comparison and the other for intervention (Table 1). The comparison group will get to the subject through an LO which follows one path to get to the content, and the intervention group will use the LSiLOs. To achieve equity between the two groups an evaluation instrument allowing us to see the current state of students' knowledge of the study subject was designed.

An LSQ (Learning Style Questionnaire) [21] composing of 40 questions to be answered according to acceptance score was given to both groups. The sum of each answer allows us to identify Learning Styles. The questionnaire identified four types of learners (activists, reflectors, theorists, pragmatists). The LSQ measures a learner's preferred learning approach and the degree to which he or she is likely to learn.

With the application of the questionnaire we managed to categorise the 30 students needed for the sample, it is also important to mention that the questionnaire was given without informing the

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students what would be done with it afterwards, but just asked for their cooperation for some statistics to be used in applying learning. Students showed interest in the test.

Table 1 shows student distribution according to LS.

Table 1. Student Classification by Learning Style

Group	N	Activist	Reflector	Theorists	Pragmatist
Comparison	15	5	2	3	5
Intervention	15	3	5	4	3

Despite finding learning styles within the comparison group, all group members will use an LO obtained by LOR from UFPS.

4.2 Learning objects

Intervention Group material involved the designing of four LOs, one for each learning style: active, theorist, pragmatic and reflector. Every new LO responds to different needs, therefore how to address the topic of study is different.

According to Rodríguez [27], UFPS LOs will include the following: Contextualization elements, (introduction/presentation, objectives, and methods), Topics (subtopics), Prior knowledge, Tasks, Recommended materials (videos and texts), Practical cases, Data sheets, and Bibliography.

Moreover, every LS will include a knowledge path based on particular characteristics from each style [27]. This knowledge path has to include the aforementioned LO elements.

For each and every knowledge path a proposal for designing distribution schemes in response to each one was raised to be used in the construction of LOs within UFPS. The active style knowledge path can be seen in Fig. 2.

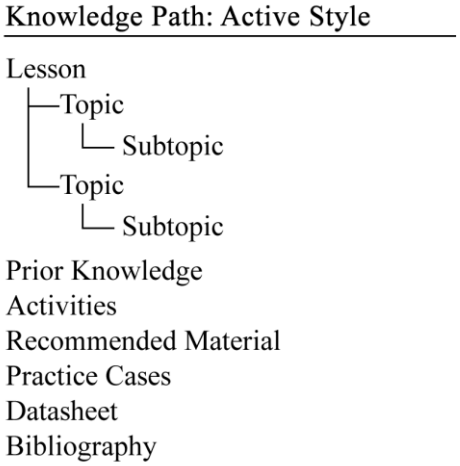

Fig. 2. Knowledge Path of Active LS

4.3 Research tools

To evaluate effectiveness two kinds of instruments were used. On one hand quantitative tools were designed in order to measure skill generation and knowledge appropriation. On the other hand, we developed qualitative assessment tools (Likert scale) to gain individual perception of how students interacted with the LO.

4.4 Study

In this study professor participation was reduced to avoid teaching skills becoming an uncontrollable variable.

The study was done on a normal day. Students were not warned about the class being given using LOs beforehand so as not to encourage the checking of repository materials available. The aim was to

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get to know students perception without prior knowledge of LO use.

The class was arranged into three stages. In the first, the professor explained how to access the LO repository in order to find and use LOs. The intervention group students used a private repository, where according to LSQ results, each student accessed the section where they'd material corresponding to their LS.

Throughout this first stage, which lasted a total of 40 minutes, we encouraged students to really get to know the LO.

It must be mentioned that classes are held in rooms where each student has access to a desktop pc, allowing them to perform at their own pace in the learning process. This has been proven by Omit Spektor-Levy [3] in an analysis of studies and research suggesting positive 1:1 computer initiatives, including increased student participation, decreased discipline problems and an increased use of computers for word processing, analysis and research. This initiative has shown significant performance differences in favour of using computers in class.

Continuing with the study, the second stage was characterized by the checking of concepts learned. For this stage exercises similar to the examples given in the first stage were put into place with the objective of generating and reinforcing students programming skills, and regarding the study we focussed on the concept, declaration, instantiations assignations and array paths.

And in the third and final step, students from both groups are evaluated. In this stage both quantitative and qualitative tools were applied to students.

The quantitative assessment composed of fifteen questions, each of them with four possible answers. This allows the assigned grade to be isolated. The maximum score is five, and minimum zero, the assessment was done online in a controlled environment.

A summary of the assessment results can be seen below in Table 2 and Table 3.

Table 2. Quantitative Assessment Results

Group	N	Lowest Grade	Highest Grade	Mean (SD)
Comparison	15	1.0	4.0	2.9 (0.71)
Intervention	15	2.0	4.3	3.3 (0.64)

Table 3. Quantitative Assessment Averages by Socioeconomic Stratums

Group	Stratum 1	Stratum 2	Stratum 3	Stratum 4
Comparison	2.5	3.4	3.1	2.5
Intervention	3.0	3.6	3.2	

The average grade for students from the comparison group was 2.9, with a minimum of 1.0 and a maximum of 4.0. The intervention group did a little better with an average of 3.3, with a low of 2.0, and high of 4.3.

Table 3 shows the average results organized by socioeconomic stratum. From this we can see that alumni from stratum 2 were the best of the two groups. In addition, we can see that the intervention group did better overall.

These results suggest the objective was met; effectively showing that providing content based LS can improve a student's performance. Nonetheless, the result didn't generate the expected level of improvement. This is analysed in Section 5.

In general, the intervention group grades were better than those of the comparison group though they should be analysed further to get a more accurate conclusion applicable to our study context.

Additionally, a qualitative tool was applied to the students with the means of measuring the benefits of LOs from their perspective. To do this we used the codification plan proposed in [16] for the qualifying and receipt of student comments regarding LOs.

This plan assessed the LO from the perspective of learning interest and quality and consisted of 16

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questions, each one being scored using a four point Likert scale (TA-totally agree, A-agree, D-disagree, TD-totally disagree).

Table 4 shows the results of some of the questions in the qualitative tool.

This qualitative assessment was applied to students from both comparison and intervention groups, this is to say that each student evaluated the LO from their own perspective. The Active students assessed it using an Active LS. The Reflector students assessed it using a Reflector LS.

Table 4. Partial Qualitative Assessment Results

Question	TA	A	D	TD
Working with the learning object helped me learn	33%	35%	21%	11%
The learning object helped teach me a new concept	46%	49%	5%	0%
The learning object was easy to use	11%	23%	50%	16%
The learning object was well organized	24%	66%	8%	2%
I found the learning object motivating	24%	31%	30%	15%

These results are accompanied by comments assisting in enriching the LO design process.

Many students agreed that such learning tools help have a deeper understanding as well as developing their knowledge better, although content quality is fundamental.

A lot of students favoured the visual characteristics of the LO's, however, many felt they weren't challenging enough in motivating them to keep on learning. LO quality was seen well, together with a good use of colours and presentation.

5. Discussion

The idea of this study was to analyze LSiLO impact on our alumni from different stratums. To do this we had to build our LOs using the four LSs proposed by Honey and Mumford [14]. Two data sources were examined, the quantitative qualification of the revised topic and the qualitative qualification of LO perception and assessment.

Our analysis indicated alumni performance improved thanks to LSiLOs, and those of stratum 2 took the best advantage of them. However, many students expressed they could have done better but were afraid to prepare the study subjects alone, this fear caused frustration and hence brought on a feeling of inability to learn. This shows us that there are still students who haven't the ability take the initiative of learning by themselves. Bringing us to the conclusion that these students have a low capacity for self-directed learning.

Analysing the results it's clear to see that even if the use of LSiLOs doesn't considerably improve student performance, its use will help improve their learning. Regardless to say, it's important to clarify that LOs alone are not responsible for student improvement, as the teaching strategies employed must be take into account.

Student comments also allow us to understand why they like using LOs or not. The students who enjoyed using them found them easy to use with good visual, graphical and other aids. They don't like them when they're challenging enough, when help is poor and full of too much text.

6. Conclusions

This article describes a proposal to assess the effectiveness of learning styles in learning objects (LSiLO) designed according to learning styles described by Honey and Mumford and compared to LOs with only one way of presenting content. This study took place within the fundamentals of computer programming course, for new UFPS students.

The results obtained showed that if there is any improvement, it isn't conclusive and should be followed up with semesterly evaluations.

Students showed they were satisfied with content and activities completed; however many expressed fear of taking charge of their own learning. This could be blamed on the way they are

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prepared at school, and that self-directed learning can be seen as a somewhat radical change in the learning process.

Another cause we analysed could be the fact students can review subject items in any order, without necessarily following the one suggested by the LS. This is a result of students in a rush to get as much knowledge as they can in as little time as possible.

It's hard to say if the structure proposed for each style is what the students really need, or if rather just one LO could be developed with the student being able to navigate any way possible. Later studies will give us the chance to come this conclusion.

Likewise, it must be asked whether a mixed strategy combining LOs with traditional classes could also be an adequate solution for computer programming courses. This idea was proposed by Eugenia Y. Huang [28].

To conclude, this technology has the potential of being powerful enough to improve access to learning opportunities and a broader information society. With accurate design and planning we can take education to students everywhere, including the smallest towns and villages in the world [29].

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