Giving more autonomy to computer engineering students: are we ready?

Mayela Coto, Sonia Mora, Georges Alfaro
School of Informatics
Universidad Nacional
Heredia, Costa Rica

Abstract— **In higher education, and particularly in the computer engineering disciplines, enhancing the learner's autonomy has become essential to meet the needs of the industry. This article reports the results of a research study that was conducted at the Universidad Nacional of Costa Rica with the aim to produce a curriculum shift from teacher-centered approaches towards student-centered approaches. The paper explores the readiness and willingness of students to have a level of control on their learning and the readiness of teachers to share control with them. Results about student participation in setting learning activities, in collaborative learning, and in self- and peer-assessment are discussed as fundamental aspects of learners' autonomy. The results highlight the importance of guiding students and faculty in the transition to an educational model that promotes the autonomy of students.**

Keywords- autonomous learners, self-regulated learning, computer engineering, problem based learning, project based learning, curricular innovation

I. INTRODUCTION

Autonomous learners are valued by employers worldwide, who indicate that they seek for graduates who are willing to learn, have motivation to work, are effective in group work, have good communication skills, ability to solve problems and the capacity of lifelong learning [1][2][3]. They claim to need university graduates who have been educated to become autonomous and critical thinkers. Unfortunately, many students come to universities without having made any decisions about their learning because the education system tends to create very dependent students [4].

Some researchers [5][6][7] have also argued that in order to have professionals who can respond successfully to the contexts of a global economy and knowledge-oriented society, the development of autonomous learners is fundamental. Lifelong learning has been recognized as a critical skill for graduates for many decades. Being an autonomous, self-regulated learner enables a person to be highly adaptive to new situations and environments, to gather resources and learn quickly so as to solve new problems or handle new jobs or situations they encounter. These capabilities are critical in the ever changing knowledge society where the only constant is change [8]. Providing students with opportunities to engage in self-regulated processes seems the only way of preparing them to face the future at the same time as helping them develop the competencies that are currently required by society.

Many university programs, including computer science, have only partial components of activities which promote self-regulated skills and these are usually present in the final years of undergraduate programs. The Computing Science Curricula 2013 [9] also states that university study programs must prepare students for lifelong learning, so they will be able to succeed in this rapidly changing field. Under this scenario, it is clear that universities need to ensure they are contributing to graduate professionals with abilities to meet these requirements, thus the question of how a specific learning environment may support or hinder students' autonomy is relevant.

This paper introduces an exploratory research study which is conducted at the Universidad Nacional in Costa Rica. The study explores a curriculum shift from teacher-centered approaches towards student-centered approaches; specifically it investigates the feasibility and usefulness of problem- and project based learning (POPP) in a case study at the Informatics School. The case study involves an educational intervention in five programming courses, and it takes place through four semesters [10]. This paper specifically reports the results related with one of the components of the educational intervention - the learner autonomy - and discusses its implication on the development of a learner-centered approach in an engineering informatics career. The paper explores students' readiness and willingness to have a level of control on their learning, and teachers' readiness to share control with students. Results about student participation in setting learning activities, in collaborative learning, and self- and peer-assessment are discussed as fundamental aspects of learners' autonomy.

II. AUTONOMOUS LEARNERS

Autonomy is the ability to take charge of one's own learning. It means to have the responsibility for setting learning goals; identifying and developing learning strategies; developing study plans; reflecting on learning; identifying and selecting relevant resources and support; and assessing one's own progress [11].

According to [12] the autonomous learners should be curious, motivated, methodical, disciplined, analytical, reflective, flexible, confident, creative, persistent and responsible and, in addition, they should have highly developed skills for information seeking and retrieval, knowledge about the learning process, and be able to develop and use criteria for evaluating. He considers self-regulation of learning as a goal and as a process, and defines four dimensions: personal autonomy, self-management in learning, the learner control of instruction, and the independent pursuit of learning, Personal autonomy refers to independence, freedom of choice, and rational reflection. Self-management is the ability of the learners to manage their own learning. It refers to the exercise of autonomy in learning. Learner control deals with control over aspects of the instructional situation, and the independent pursuit of learning concerns learning outside formal educational settings.

In our perspective, promoting student autonomy at an initial level in a university setting involves that students develop the capacity to take at least some control over their learning; and provide a learning environment that offer them opportunities to take control of their learning. However, in our current traditional model of education and as [4] argues, faculty control most if not all of these processes. They decide the content that students learn in the course, control the speed at which that content is covered; determines assignments and tests through which the material will be mastered; establishes the conditions for learning, and assess the learning that has occurred.

According to [4], the reasons for exercising this considerable power over student learning are several: (1) teachers believe that students lack the intellectual maturity to make decisions, are not well prepared, and we cannot trust they take courses because they care about learning and not just for degrees, (2) teachers have always made decisions on student learning, and this is an unquestionable part of what being a teacher means, and (3) teachers have to be in control and exercise authority over students in order not to feel vulnerable.

It is clear that building autonomous learners represents a challenge for both, students and faculty. In one hand, students come to university from diverse social, cultural and educational backgrounds, which influence their attitude towards the learning process. This attitude, their knowledge about learning and the learning strategies that have been previously acquired affect the extent to which the learner is able to become an autonomous learner [13][14]. In particular younger students need to overcome their feelings of uncertainty. On the other hand, the traditional instructional approaches that are common on our universities in which faculty control most of the processes through and by which students learn, are not well suited to achieve this outcome [15]. The traditional deductive method of teaching affects adversely students' motivation, confidence, and enthusiasm for learning and does not develop the capacity for accepting responsibility, and the ability to take initiative [4].

Preparing teachers to reduce the amount of control they exercise and, at the same time, to use structures that promote the growth of the students and prepare them to assume more responsibility for their learning, is a slow and difficult process. Studies such as [16], conceptualized this process in phases, starting from a low level of self-regulation to the highest one. The first level is the *Incidental self-directed learning*, in which the occasional introduction of self-regulated activities into courses or programs that are otherwise teacher-directed takes place. The second level is *Teaching students to think independently* and it concerns courses or programs that emphasize the personal pursuit of meaning through exploration, problem solving and creative activity. The third level deals with *Self-managed learning*, in which courses or programs are presented through learning guides that students complete independently. In the fourth level, *Self-planned learning*, are courses or programs in which students pursue course outcomes through activities they design themselves. The higher level is *Self-directed learning* which comprises courses or programs in which students choose the outcomes, design their own activities and pursue them in their own way.

III. PROBLEM AND PROJECT BASED LEARNING: INDUCTIVES APPROACHES TO TEACHING

In order to effectively develop an autonomous learner we need to change teaching [4]. In computer engineering, teaching has traditionally been deductive [17]. However, preferable alternatives to foster in students the abilities to meet society and industry requirements are the approaches known as inductive, among them, problem-based and project-based learning [9] [17] [18]. Both approaches are student-centered, have constructivist principles, involve active learning and promote collaborative learning. Both methods strive to resemble a work based scenario, either in the exploration of a problem or a project with more than one way to solve the problem or project implementation. They also have the potential to achieve a higher motivation and greater responsibility in the learning process because students learn to be more independent in their approach instead of relying totally on teachers.

For the purpose of this study, the term POPP was taken to mean that the starting point of the learning process is a problem, but the solution takes place through a project. This form is known as the PBL model of Aalborg University (Denmark) or Project-Oriented Problem Pedagogy (POPP) [19]. The basic principles of the approach are: (1) problem-solving as the point of departure of the learning process; (2) projects as the way to address the problem; (3) integration of theory and practice; (4) students control over the selection of the problem and organization of the project; (4) collaboration in groups with feedback from peers and faculty [20] [21].

According to [22] problem-based learning and project-based learning frame the development of students' self-regulatory strategies as an explicit learning outcome. Both approaches have the potential to foster students' engagement in self-directed learning in a context that is relevant to their future professional work [15]. A study undertaken by [23] shows that the average readiness for self-directed learning increased significantly for students in problem-based learning courses. Other studies [24][25] also gave evidence that problem/project based learning are effective in facilitating the development of self-regulation. These results presents an excellent opportunity to explore the possibility of implementing POPP through the Informatics School curriculum, with the potential outcomes of improved student retention, increased motivation and improved graduate outcomes. One of the main principles of the POPP approach is that by increasing the level of control of the learner, the overall motivation and the capacity to learn autonomously will increase too [19].

As it was briefly explained in the introduction, the whole research in which this paper is framed is a project which investigates how a problem- and project-based learning approach is a useful tool to develop university students' professional qualifications needed for the Costa Rican ICT sector. Our interest in this paper is focused on students' personal autonomy and self-management in learning, both fundamental components of the proposed approach. The following sections explain the chosen methodology to approach the research and the results obtained so far.

IV. Methodology: Design-based research

When teaching is moved towards a student-centered model it is necessary to learn to share power. Teachers still need to make key decisions about learning, but not make all of them and not always without student participation. Teachers have to give up some control with the goal of creating motivated, confident and responsible students, and students need to learn that with more freedom to make decisions comes more responsibility to accept the consequences of those decisions. Indeed, power must be redistributed in amounts proportional to the ability of teachers and students to handle the situation.

Therefore, understanding that learner autonomy is achieved in a gradual way; that students of the Informatics School need to understand the benefits of autonomous learning, and we also need to convince faculty that sharing control does not mean abandoning their professional responsibility, the research study has an approach to gradually introduce levels of autonomy in a sequence of five programming courses: Introduction to Programming, Programming I, Programming II, Programming III and Programming IV. In all of them disciplinary contents play a central role, and faculty has had the total control of the learning process. Consequently, the intervention follows different approaches based on the characteristics of each specific course and on faculty openness and willingness. With this objective in mind a *design-based research* methodology was selected. The goal of design-based research is to improve and evaluate educational practices in real contexts [26] [27].

Design-based research can be seen as a model of phases [28] where participants are part of a joint and iterative process of analysis, design, development and implementation. In this case, through the phases, researches and faculty: (1) analyze the context; (2) create an initial design solution based on the principles of autonomy, the learning objectives of the programming courses and, the perspective of students and faculty;(3) undertake an iterative process of implementation and refinement of the initial design principles and; (4) make a retrospective reflection on the design and its results.

V. Preliminar analysis of the context

As a preliminary phase of the educational intervention, we aimed to explore student's attitudes towards autonomous learning, and teachers' readiness to share control with students. This exploration took place in the second semester of 2011. The participants were 14 teachers from diverse curricula levels and 68 students of the course Programming III. Two questionnaires were designed to address both target groups. The first questionnaire had 22 closed questions and one open general question. The questionnaire applied to students consisted of 23 closed and open questions. Below some of the results are shown:

A. Teachers' readiness to share control

To understand what kind of level of decision on problems and projects were given to students by teachers, a questionnaire was designed and administered to 14 teachers from diverse curricula levels. The results show that 100% of faculty provides in their courses a detailed definition of problems and projects, and 62% of them argue that students are not mature enough to choose or define a good problem to solve. As such, students have almost null level of decision on this matter. Also 90% of them assert that they provide in their courses everything students need to solve the project. The data show the perception that students are not prepared to have a level of control or choice over the content and activities. Faculty argues that students lack intellectual maturity and do not care about learning, hence is not possible to trust them with the making of decisions about learning. For teachers making decisions it is an undeniable part of what it means to be the teacher [4].

B. Students' willing to share control

In order to explore the students' attitudes towards autonomous learning, a questionnaire was applied to 68 students of the course Programming III. This course belongs to the second semester of the second year – the middle point of the study program. The students were requested to answer a number of questions regarding their level of decision on

problems and projects they solve and implement throughout the courses. The results show that 98% of them would like to have influence on the problems they solve. Additionally, only 58% state to have some level of decision on the problems posed by the faculty, while 42% state they have no power in this regard. Furthermore, 75% feel able to decide which problems and projects can be solved. These data suggest that students are more ready to be autonomous compared to what the teachers think. This students' attitude is a key aspect that needs to be fostered, no matter if they are or are not well prepared.

Having as a point of departure the above results and the premise that when students have experienced success in learning autonomously in small ways they will be able to develop more confidence at later stages, and when faculty have obtained evidence of the improvement of learning and skills in their students, they will be more willing to share the control with them; we follow a model that supports change as a process based on positive experiences for students and faculty [29], and under this scenario, during the II semester of 2012 the educational intervention was carried-out in the courses Programming I and Programming III. The implementation in both courses took place under very different conditions. At this point, it is very important to clarify that the research project does not have any mandatory approach; it means that the teachers are not required to make changes, but the project seeks to convince them to implement the proposed changes. As such, not all teachers in a specific course adopt the approach in the same manner and to the same extent. This is one of the great challenges of the project. The two cases and their results are explained below.

VI. First Case: Programming I Course

Programming I is the second programming course in the sequence. The course studies the principles of analysis, design, and object-oriented programming with focus in the relations between classes and their implementation in C++. The course consists of four hours per week, two of them for theory and two for practical work in the computer lab. In addition, the course demands six hours of independent study. Regarding evaluation, there were three main components: exams (60%), project (25%), and other learning activities such as quizzes, class work, and assignments (15%).

There were six groups with around 25 to 27 students each. Three teachers were in charge, two of them with previous experience in the course and one novice. The group showed high levels of cohesion, all teachers applied the same exams and project, and in addition, as learning and coaching strategy, a workshop was held weekly to share materials and experiences among teachers. Students enrolled in this course belong to the 50% who manage to pass the course Introduction to Programming, this might suggest that are the students who are more motivated and with better skills in programming. However, a study conducted [30] to this student population (160 students) at the beginning of the semester by the Academic Success Program attached to the Office of the Vice-president for Academic Affairs reveals that only 50.55% of them shows a high level of motivation for their studies; 42.86% have a high concentration capacity; 8.57% have adequate study habits, and 32.80% have adequate study skills.

According to [4] there are four areas of potential decision making for learners: classroom policies, course content, course activities and assignments, and evaluation activities The intervention in this course was framed in the two latter ones in particular around the project. For the first time, students were not given a detailed definition of the project; instead teachers offered them three possible scenarios to choose from: a hardware store, a restaurant and a medical clinic. The only processes previously established were billing, inventory control, and appointments. From this, the students were free to define the problem to be solved and its scope and limitations. To achieve this, the students had to search for information and interact with the context. Giving students a voice in the project they wanted to solve was aimed at increasing the ownership and motivation.

Groups of three students were formed to approach the project. This issue was discussed among teachers because groups were generally of two students. At the end, and in order to foster collaboration, negotiation and leadership, it was decided to experiment with larger groups. Furthermore, a strategy of self-evaluation and peer-evaluation was defined with the aim to move away from thinking that evaluation is exclusively a teacher activity. If we want to take another step toward the goal of self-regulated learning, it is desirable to develop the students' ability to assess their own progress and make appropriate changes. In addition, when students do peer-assessment they learn to use criteria to measure participation and the work of others.

The project and the learning process were evaluated through three partial reports, a final report and a final presentation of the project to the entire class. In each group, progress reports were discussed with the teachers who gave feedback to the proposed solution. This feedback process was done differently by teachers; two of them worked 30 minutes with each group three times during the semester and answered questions in class and on attention periods. The other teacher spent eight hours of extra time each week to monitor progress.

A. Evaluating the experience from students' perspective

Through a questionnaire the students were requested to answer a number of close questions related to their experience with their recently completed project activity and associated course as a whole. From 160 students we received 114 complete answers. In addition a focus group was carried-out with 9 students.

Regarding the project formulation, 80.7% of students stated they like to formulate the problem to solve and 94.7% of them

indicated the project allowed them to achieve the course learning objectives; in addition 83.3% of students liked to have higher levels of decision in the course (e.g. selecting the project problem). These affirmations are validated in a focus group with 9 students where all claimed that the project was the best way to show what had been learned in the course. Through the project they develop a sense of ownership of learning. At the beginning the fuzzy definition of the project created a sense of uncertainty and confusion, students wanted to give the power back to teacher, but once they faced the need to start working on the project learned to enjoy their freedom, the room for creativity, and appreciate the diverse ways of approaching the problem. They asked for the project to have a higher weight in the course evaluation.

With respect to the ability to chart their learning processes, 53.5% said they want the opportunity to investigate some issues on their own, but this contrasts with the 91.2% who said prefer the teacher explain the entire subject in classroom. In addition, and regarding practical exercises to do outside class, 99.1% said the teacher should provide them. Just 49.1% indicated they like to find by themselves the exercises to practice. Another important aspect is related with seeking help when they do not understand part of the lessons, 89.5% of the students prefer to seek help from teachers and peers instead of investigating by themselves using resources as internet, books or the virtual classroom. These high percentages indicate that most students experienced uncertainty with respect to what to learn and that they relied on their peers and given faculty resources instead of selecting resources independently.

Regarding self-planning and self-managing their time, 61.4% mention they did not use the six hours of independent study that correspond to the course; 38,6% did not establish a schedule for study and 44.7% spent less than two hours per week in the project; however 81.6% affirmed having completed all course assignments. It is interesting to notice that 86% of students indicated to need that teachers assign them tasks in order to keep them studying regularly. This data show low levels of management (external tasks and resources) and monitoring (internal process of thinking, reflection) of their own learning processes.

With respect to self-evaluation and peer-evaluation, during the focus group some students commented that evaluation is seen exclusively as a teacher activity. They also doubt their ability to self-assess and peer-assess and feel frustrated and impotent with the lack of direction on how to manage the situation when one or two members end up doing a disproportionate part of the group work. Despite of this, 71.9% stated that the effort spent on the project was properly distributed among group members, and 66.7% indicated that group work is an effective strategy to promote learning.

B. Evaluating the experience from teachers' perspective

In order to learn about teachers' perspective, a focus group was carried-out with participation of all (three) the teachers of the course. In general terms, their appreciations are congruent with the data obtained from the students. Teachers indicated that students are very passive in the classroom; most of them are not ready to identify their own learning goals, nor to identify learning tasks to achieve those goals. According to them, students are not used to critically reflect on their learning and many of them did not ask for feedback from teachers and peers to achieve their learning goals. Teachers also complain that getting students involved and participating in class is hard work; students are used to rely on them making all their decisions.

Regarding the project, they assert that the project modality of this semester generated enthusiasm and ownership in students; however they showed concern about the disciplinary content covered by the course. Because students defined the scope of the problem, the group projects had diverse levels of complexity, and most of them were simpler than those projects defined by teachers in previous semesters. Despite this, teachers agreed that there was a deeper understanding of the concepts compared with previous semesters. On the other hand, teachers feel overwhelmed by the pressure to cover content, the time-consuming process and the potential marginal quality of the projects. With respect to self and peer evaluation, teachers questioned the ability of students to be objective when there are grades involved, however they agreed that some of the groups used them as an appropriate tool to evaluate the individual contribution to group work.

VII. SECOND CASE: PROGRAMMING III COURSE

Students enroll in the Programming III course at the end of the second year of the study program, after having completed three courses in the area of programming. As in Programming I, the course consists of four hours per week, two of them for theory and two for practical work in the computer lab. In addition, the course demands six hours of independent study. Regarding evaluation, the more important learning activities are three exams (60%), quizzes (10%) and two projects (30%) where students develop applications of medium difficulty with full functionality. Since last year, Java is the programming language used in the course, previously it was C#. The course covers the basic object-oriented design patterns, as well as specific techniques such as the use of execution threads in asynchronous tasks, the use of sockets for basic network communication and the implementation of persistence using databases.

In the II semester 2012, there were six groups with 25 students each. Four teachers were in charge, two of them with previous experience in the course and two novices, but with an equivalent professional experience. Although it was not frequent among teachers to discuss academic aspects of the course, learning materials were shared and the evaluations were set in general agreement.

Following [4] the intervention in this course was framed in course activities in particular around the project. For the first time, one of the teachers, who is part of the research project, was willing to give students a level of control on deciding which kind of project they wanted to undertake. Considering students proposals, the teacher evaluated the relative difficulty of them and made a selection of projects from which students could choose. It is important to note that in previous years the projects set by teachers had an administrative orientation while this time students decided to develop game programs, in particular to work on the graphics and user interaction, aspects that have not been covered in previous courses. Unfortunately, the project failed to timely convince the other three teachers to implement a similar approach.

Groups of two students were formed to approach the project. Although the teacher tried to encourage the formation of larger groups, the students refused, saying it was more difficult for them to negotiate and reach consensus. In this case, it was decided to respect the decision of the students. There was no strategy of self-evaluation and peer-evaluation set in order not to create inequities in the evaluation with respect to the other groups. The project and the learning process were evaluated through one partial report, a final report and a final presentation to the teacher. In each group, progress reports were discussed with the teacher who gave feedback to the proposed solution. The next sections report the results obtained in a group of 25 students.

A. Evaluating the experience from students' perspective

Through a questionnaire the 25 students in the course were requested to answer a number of close questions related to their experience with the project activity and associated course as a whole. We received 18 complete answers.

With respect to project formulation, 61.1% of students stated they like to formulate the problem to solve and 88.9% of them indicated the project allowed them to achieve the course learning objectives; in addition 61.1% of students liked to have higher levels of decision in the course (e.g. selecting the kind of project to develop). The three values are lower than the correspondents in Programming I. This was unexpected as students in this level should have more intellectual maturity to set their learning goals and learning strategies.

Regarding the ability to chart their learning processes, 77.8% state they want the opportunity to investigate some issues on their own, but 88.9% mention they prefer that the teacher explains the entire subject in the classroom. In addition, and regarding practical exercises to do outside class, 100% said the teacher should provide them, but this contrast with the 72.2% who indicated they like to find by themselves the exercises to practice. Related to seeking help when they do not understand part of the lessons, 50% of the students seek help from teachers and peers and 50% preferred investigating by themselves using resources as internet and books. These values indicate that at this level, compared with Programming I, more students have learned to select resources independently.

With respect to self-planning and self-managing their time, 38.9% state they did not use the six hours of independent study that correspond to the course; this data is significantly lower than the 61.4% of Programming I, indicating that students are more conscious of using time to study. Nevertheless, in a similar rate to Programming I, 38.9% did not establish a schedule for study and 44.4% spent less than two hours per week in the project; however 77.8% affirmed completing all course assignments. It is interesting to notice that even at this level 77.8% of students indicated they need the teacher to assign them tasks in order to keep them studying regularly. As in the Programming I course, this data show low levels of management and monitoring of own learning processes.

Regarding group work, 55.6% stated that the effort spent on the project was properly distributed among group members, 77.2% indicates that group work is an effective strategy to promote learning, and 83.3% preferred to work in small groups (two persons).

B. Evaluating the experience from teachers' perspective

In order to learn about teachers' perspective, the teacher who implemented the changes was invited to the focus group carried-out with the Programming I teachers. In general terms, he also indicated that students are very passive in the classroom and getting students participating in class is hard work.

Regarding the project, he asserted that the project modality generated motivation and ownership in students, they were excited by working in a problem they chose; however he also pointed-out that only 40% of the projects were evaluated with a grade higher than 7 (out of 10). The average grading was 6. From his point of view, this suggests that the evaluations did not reflect the students' perception of the project as an effective tool to achieve the course learning objectives. In relation with the relative low number of students (61.1%) who liked to have higher level of decision in selecting the kind of project to develop, the teacher argued that many students did not accept the challenge and they did not know how to exercise this power.

With respect to group work, the teacher indicates that there is no real division of work among students, they used to work together in the solution of the problem, and perhaps this is the reason they prefer small groups where working together is simpler. Even though the data show that students at this level are more familiar with seeking and selecting resources to support their learning process, the teacher indicated that this seeking of information had as a purpose to get sample code and there was little overall effort to build a suitable model for the problem.

The teacher also stated that the feedback process on the project needs to be improved in order to have better control on the project progress and be able to identify the students' needs. He pointed-out the scarce time as a factor that prevented this monitoring, due to the work involved in understanding, analyzing and conceptualizing students' work. To conclude on the learning experience, the teacher expressed that "as long as students get a set of learning objectives, along with some sort of agenda, then they will be more prepared to be autonomous learners". This seems to indicate that students in the Programming III course still need support teacher's support to become autonomous, but with guidance and support students will be motivated to make a plan to achieve their learning needs.

VIII. Retrospective Analysis

In general terms, the data show that students in both courses need reinforcement to move forward with more confidence. The data also show that not all students in a class are at the same level of intellectual maturity, so some may be able to handle more responsibility than others. In addition, a high percentage of students fail to identify and determine their own learning goals, as well as to identify learning tasks to achieve those goals. In terms of phases [16] it can be seen that both courses still in the *Incidental Self-directed Learning* phase where a self-directed activity was introduced into courses that are primarily teacher-directed. With both interventions the courses gain in students' motivation and ownership of learning, but are still a long way from providing opportunities and control to students to set their learning goals and to manage their learning process in an effective and productive way.

In relation to the four areas of potential decision making for students established by [4], is clear that given the way the programming courses are organized, as sequencing courses, teachers cannot let students be significantly in charge of course content, and must not lose control of the major components of the assessment process. Nevertheless, and with the aim of developing the intellectual maturity, learning skills, and awareness necessary to be autonomous learners, students should be exposed to learning environments that encourage them to exercise some extra level of decision (e.g. course activities other than projects, and classroom policies). Also they should have the chance to gradually learn how to use self- and peer-assessment as an effective tool to measure learning and participation in group work.

It seems also that power sharing have had benefits for students learning [4], when they were engaged with an activity, they were motivated to work harder on it, and even to go further of what teachers requested, and this undoubtedly resulted in more learning.. However, the data show that this enthusiasm seems to be restricted to the activity in which the students had a level of control (the project), because the behavior of students in class remained passive. This suggests that the teaching methodology should be reconsidered in light of the PBL approach.

This portion of the study also indicates that the PBL approach by its own nature has the potential to increase readiness for autonomy in learning, however the changes for individual students can vary substantially, while some of them enjoy the freedom and the control that they can exercise in their learning process others feel confused and frustrated. In that sense, it is important not to give students more responsibility than they can handle.

The next step should be to move towards the second phase of [16], and teach students to think independently, through activities that emphasize the personal pursuit of meaning through exploration, and problem solving. Those activities should emphasize the skills students need as they are given more opportunities to direct their learning. However, the challenge is that teachers learn how to design a set of course activities and assignments that responsibly give students more control over the decisions that affect their learning. The educational interventions documented in this paper should be refined and implemented in the other programming courses to work incrementally on the skills developed in the Programming I and III courses. It is also necessary to persuade more teachers to embrace the opportunity to move towards a student-centered approach, in particular when the model demands extra-work and there is still uncertainty in teachers in the value of content versus development of skills. Additional studies need to be developed to analyze the impact of other factors in the results, such as continuous project feedback, greater formality in the final products and improving overall evaluation.

IX. Conclusions

In universities, traditional teacher-centered approaches prevail and it is difficult to change. The reasons for this may lie in teachers and student conceptions of teaching and learning processes and their lack of preparedness to move towards student-centered models which emphasize autonomy in learning. Both students and faculty can show resistance, they can feel confused and frustrated, and need to learn a new set of skills. Students need to develop new learning strategies and faculty needs to develop new conceptions of teaching. A commitment to autonomy requires the university to understand the value of empowering students to take responsibility for decisions related to learning and to support faculty to move from the role of knowledge expert to a role of facilitator.

The Informatics School at the Universidad Nacional is slowly incorporating PBL into its undergraduate program.

However, this transition is not an easy one. Teaching style has been traditionally focused on the discipline itself rather than on the learner. Teachers often lack the pedagogical background required to follow new didactics. Thus, some of them are reluctant to embrace the approach and those who accept it do not have the knowledge to make it work. In addition, secondary education systems still predominately adopt teacher centered learning approaches and it has contributed to the creation of students with a limited readiness to be an autonomous learner. Self-regulated aptitude is one key outcome from PBL and is also a necessary one in order to obtain higher levels of learning. Graduating students with high levels of autonomy is one of the best outcomes the Informatics School can offer to the Costa Rican ICT professional market. Thus, as hinted in this paper, the Informatics School curricula should be modified to include learning experiences that challenge students to develop self-directed learning skills. These experiences need to be carefully designed and implemented to minimize negative reactions among students and teachers.

REFERENCES

[1] OIT, "Una fuerza de trabajo provista de formación para un crecimiento sólido, sostenible y equilibrado." Ginebra.

[2] World Bank, "Higher Education in Developing Countries - Peril and Promise", 2000. [Online]. Available: www.worldbank.org/education.

[3] World Bank, "Lifelong Learning in the Global Knowledge Economy: Challenges for Developing Countries", The World Bank, Washington, D.C., 2003.

[4] M. Weimer, *Learner-centered teaching: five key changes to practice*. San Francisco, CA: Jossey- Bass, 2002.

[5] T. Bourner, "Assessing reflective learning", *Education Training*, vol. 45, n.º 5, pp. 267-271, 2003.

[6] J. S. Brown y P. Duguid, *The social life of information*. Boston: Harvard Business School Press, 2000.

[7] L. Dynan, T. Cate, y K. Rhee, "The impact of learning structure on students' readiness for self-directed learning", *Journal of Education for Business*, vol. 84, n.º 2, pp. 96-100, 2008.

[8] R. A. Stewart, "Investigating the link between self-directed learning readiness and project-based learning outcome: The case of international masters students in an engineering management course", *European Journal of Engineering Education*, vol. 32, n.º 4, pp. 453-465, 2007.

[9] ACM, "Computer Science Curricula 2013". .

[10] M. Coto, S. Mora, y M. Lykke, "Design Considerations for Introducing PBL in Computer Engineering", presented at the CLEI 2012, Medellín, Colombia, 2012.

[11] H. Holec, *Autonomy and Self-directed Learning: Present Fields of Application*, Council of Europe. Strasbourg: , 1988.

[12] Candy, P., *Self-Direction for Lifelong Learning: A Comprehensive Guide to Theory and Practice.* San Francisco, CA: Jossey Bass, 1991.

[13] V. Chan, "Readiness for Learner Autonomy: What do our learners tell us?", *Teaching in Higher Education*, vol. 6, n.º 4, pp. 505-518, 2001.

[14] J. D. Vermunt y N. Verloop, "Dissonance in students' regulation of learning processes", *European Journal of Psychology of Education*, vol. 15, n.º 1, pp. 75-89, 2000.

[15] S. L. Raidal y S. . Volet, "Preclinical students' predispositions towards social forms of instruction and self-directed learning: a challenge for the development of autonomous and collaborative learners", *Higher Education*, vol. 57, n.º 577-596, 2009.

[16] M. Gibbons, *The self-directed learning handbook: Challenging adolescent students to excel*. San Francisco, CA: Jossey- Bass, 2002.

[17] M. Prince y R. Felder, "Inductive teaching and learning methods: Definitions, comparisons, and research bases", *Journal of Engineering Education*, vol. 95, pp. 123-138, 2006.

[18] T. W. Hissey, "Enhanced Skills for Engineers", *Proceedings of the IEEE*, vol. 88, n.º 8, 2000.

[19] L. Dirckinck-Holmfeld, "Designing Virtual Learning Environments Based on Problem Oriented Project Pedagogy", in *Learning in Virtual Environments*, Frederiksberg C: Samfundslitteratur Press, 2002, pp. 31-54.

[20] S. Barge, "Principles of problem and project basic learning. The Aalborg PBL Model". Aalborg University Press, 2010.

[21] A. Kolmos, F. Fink, y L. Krogh, "The Aalborg Model - Problem-based and Project-Organized Learning", in *The Aalborg PBL model - Progress, Diversity and Challenges*, Aalborg: Aalborg University Press, 2004, pp. 9-18.

[22] S. M. Loyens, M. Joshua, y R. M. Rikers, "Self-Directed Learning in Problem-Based Learning and its Relationships with Self-Regulated Learning", *Educational Psychology Review*, vol. 20, n.º 4, pp. 411-427, 2008.

[23] T. A. Litzinger, J. C. Wise, y S. H. Lee, "Self-directed learning readiness among engineering undergraduate students", *Journal of Engineering Education*, vol. 94, n.º 2, pp. 215-221, 2005.

[24] P. Blumberg, "Evaluating the evidence that problem-based learners are self-directed learners: A review of the literature", in *Problem-based learning: A research perspective on learning interactions*, D. Evensen y C. E. Hmelo, Eds. Mahwah: Erlbaum, pp. 199-226.

[25] C. Hmelo y X. Lin, "Becoming Self-directed Learners: Strategy Development in Problem-based Learning", in *Problem-based Learning - a Research Perspective on Learning Interactions*, D. Evensen y C. Hmelo, Eds. London: Mahwah: Erlbaum., 2000, pp. 227-250.

[26] F. Wang y M. J. Hannafin, "Design-based research and technology-enhanced learning environments", *Educational Technology Research and Development*, vol. 53, pp. 5-23, 2005.
[27] Design-Based Research Collective, "Design-Based Research: An Emerging Paradigm for Educational Inquiry", *Educational Researcher*, vol. 32, pp. 5-8, 2003.
[28] T. C. Reeves, "Design Research from a Technology Perspective", in *Educational Design Research*, London: Routledge, 2006, pp. 52 -66.
[29] T. Guskey, "Professional Development and Teacher Change", *Teachers and Teaching: theory and practice*, vol. 8, pp. 381-391, 2002.
[30] L. Hernández y R. Jiménez, "Informe de aplicación del taller "Claves para el éxito académico" en la carrera de Ingeniería en Sistemas". Programa Éxito Académico. Dirección de Docencia. Vicerrectoría Académica., 2012.