Curriculum Integration by Projects: Opportunities and Constraints

A Case Study in Systems Engineering

Sonia Mora
Escuela de Informática
Universidad Nacional
Heredia, Costa Rica
sonia.mora.rivera@una.cr

and

Mayela Coto
Escuela de Informática
Universidad Nacional
Heredia, Costa Rica
mcoto@una.cr

Abstract

The Universidad Nacional in Costa Rica is making significant efforts to improve the professional performance of graduates in order to respond to society and industry needs. In particular, the School of Informatics has been exploring the opportunities to implement, through the use of a pedagogy oriented to problems and projects, a curricular integration between diverse areas of knowledge in the curriculum.

From this perspective and with the aim of integrating the areas of programming, databases and systems engineering, an initial exploratory study was carried out with faculty members and a group of students from the fourth level of the curriculum. The findings show several limitations, such as mismatches between the course contents, lack of faculty commitment to collaborative work and student resistance. They also show the need of establishing strategies to create, from the early years of the curriculum, the necessary conditions to promote a positive attitude towards curricular integration processes and therefore overcome, at least partially, the identified limitations.

Keywords*: curricular integration, project based learning, pedagogical approaches, systems engineering curriculum*

~~1.~~ Introduction

Curriculum integration is an approach to teaching and learning that intentionally brings together knowledge, perspectives, and skills from diverse disciplines to develop a more powerful understanding of central ideas [1]. It occurs when components of the curriculum are connected and related in meaningful ways for both, students and faculty. Advocates of the curriculum integration argue that the best way to teach and learn is comprehensive and non-fragmented. Establishing links between knowledge from different disciplines or subjects give students a wider range of experiences, create a less fragmented learning approach, and create better connections to the real world.

The role of interdisciplinary collaboration and the exchange of experience and knowledge are growing every day [2]. Increasingly often to solve problems in any contexts, whether government, industry, or medicine, it is necessary to have a group of people from different fields who work together in a viable solution.

Unfortunately many higher education curriculums are disjointed, contributing to a series of ruptures that are evident in the pedagogical level, such as the repetition of themes in courses, fragmented knowledge, double effort to fulfill courses assignments, and the loss of opportunities to provide students with situations in which they could integrate diverse subject knowledge to solve a given problem. This is the case of the study program of Systems Engineering at the Universidad Nacional of Costa Rica (UNA), where each area is defined as an independent course of study without considering the interrelationship with other courses in the curriculum.

The current structure of the study program, the predominant traditional teaching approach, and the trend towards individualism of faculty staff are just some of the aspects that make difficult to achieve a proper curriculum integration which, as stated by [3] can provide students the interconnectedness of existing knowledge with new skills and experience, so they can better respond to the actual society needs. In addition, having the opportunity to use knowledge and skills from several disciplines increase the opportunities for making the curriculum relevant.

This paper presents an exploratory experience about curriculum integration on three related subject areas: Programming, Databases and System Engineering. The study aimed to analyze the opportunities for these areas of knowledge to be integrated by the modality of projects [4] with the intention of making students learning more meaningful and linked to their future professional work. The section 2 of the paper introduces the relevant theoretical framework, while section 3 explains the context in which the study is conducted and faculty and students perspectives about the process. Section 4 present and discuss the limitations. Section 5 proposes some possible alternatives and the paper will end with concluding remarks in section 6.

2. Theoretical framework

Higher education is often a set of fragmented knowledge and experiences that do not prepare students to face the real world in a proper way. Most real world problems are multidisciplinary in nature. Promote the student's ability to integrate the learning acquired through their studies with their academic and personal life is a major challenge of higher education [5] because as [6] states, the integration of knowledge and multidisciplinary perspectives are high priority requirements for current practitioners.

It is well know that fragmented teaching often leads to fragmented learning. At the higher education context, it is usually taken for granted that students will be capable of seeing for themselves how knowledge is integrated. In general, in their courses, the faculty staff tend to cover as much content as possible, creating few opportunities for students to work on and make decisions about complex problems that involve several areas of knowledge [2], i.e. subject content is approached as an encapsulated entity within one discipline and not as an integrated body of knowledge.

An integrated curriculum is one who encourages students to see interconnectedness and interrelationships. According to [7] the objectives of an integrated curriculum is to develop in students skills such as: effective communication; capability of working in groups; grounded approach to problem solving; a broad repertoire of theoretical knowledge and skills; independent responsibility for learning; critical evaluation of literature; and sharing information and knowledge with peers.

Curriculum integration involves active participation from students. The approach uses problems and issues of importance to them to develop a curriculum that is not restricted to independent content subjects, however, preserving the integrity of those areas [8] [9]. That is, curriculum integration is an approach that aims to overcome the confines between learning areas, making learning functional [1], and helping students to make sense of the whole picture of knowledge.

In this sense it is important to clarify that curriculum integration is not a summation of content subjects. It does not imply to join content from several courses and faculty staff as the responsible for making the connection between knowledge [10]. Curriculum integration involves students and faculty negotiating the curriculum, and the faculty role is scaffold students' learning to make connections rather than directing them [8]. It must contribute to develop students' strategies in establishing their own relationships between diverse content, thus generating significant learning in a broad spectrum of situations [5] [1]. In this sense, faculty staff have the responsibility to construct learning experiences that are both intellectually and creatively demanding, and support students in the knowledge integrating process [11].

Furthermore, according to [12], an integrated curriculum learning is related to making connections between learning experiences, which occurs in childhood and continues throughout life. At the university level this process involves: 1) the ability to use skills and knowledge from different disciplines, 2) combine theory and practice, 3) to consider multiple perspectives to solve problems, 4) transfer the skills learned in one situation to another and finally, 5) to reflect on their learning experiences and transfer them into a report or essay.

Curriculum integration implies work. Students play a key role, but the success of the initiatives depends largely on the commitment and creativity of faculty and administration [5]. Even though each faculty staff can contribute to

strengthen curriculum integration through the design of their course, the pedagogical approach and the proposed learning activities [13], these individual efforts by themselves cannot provide sustainability to an integration strategy in a higher education curriculum. For this to happen, a joint collaborative effort between all stakeholders (authorities, faculty staff and students) is needed. It is also vital that leaders of the curriculum integration initiative are clear that integration is a long and gradual process; strive to design a clear integration strategy; and obtain management support [5].

In [8] [14] some of the obstacles that curricular integration processes face are identified. One of them is the common reaction to new approaches. As with any new initiative, there is faculty staff that is not willing to commit, either because of lack of interest or because they feel that experimentation can harm their academic careers.

Another obstacle is related to the dependence on leadership. Many times new curriculum integration efforts depend on a single leader, who needs to have the energy and power required to the process to be successful. For example, the leader should have the energy to build positive and effective relationships between participants, and should have the power to allow faculty staff to attend meetings and training sessions.

Other barriers to effective curriculum integration include the pressure to cover content, faculty staff workload, and effective collaboration among them [14]. The increase in the workload of faculty is one of the biggest obstacles, while some are willing to invest more time preparing to address the approach, for others it is not within their priorities. Furthermore, it is difficult for institutions to acknowledge the invested time or provide the necessary incentives for faculty staff who want to venture into integration initiatives curriculum. Another drawback is related to the curriculum itself, as there are faculty members who feel that the time to cover content is less due to the need to teach students new skills or time consumed by group work. In this sense, faculty may feel that the integrity and level of courses are weakened. Some critics also claim that the quality of education can be lower because of its emphasis on the practical more than on the theoretical [14].

Other obstacles arise about faculty staff collaboration. Some difficulties may emerge when they have different perspectives on students, or different standards to evaluate the same work (e.g. content vs. clarity or quality of the writing). The latter may also cause confusion among students who expect some kind of uniformity from faculty.

Given this scenario, it is vital to ensure timely and open communication channels between faculty staff who are involved in any process of curriculum integration. This coordination also helps to ensure that content is not repeated and rather it is complemented by each subject course [13].

According to [4], there are different forms of curriculum integration: by generating topics, by stories, by themes and by projects:

- The generating topic is a strategy with a point of departure in the formulation of a complex problem common to several disciplines or to various knowledge areas that are articulated among them. The fundamental aspect of this strategy relies in the problem. It should provoke a cognitive imbalance, it should be meaningful to student's life, motivate them to learn, and it must trigger the need to research and use all the knowledge areas involved in order to solve the problem [15].

- The integration by stories is performed around a narrative that articulates the chosen issues and problems from the different disciplines. It is based on the text to facilitate understanding and meaning construction, provoking all kinds of exchanges between faculty and student with the aim of contextualizing the problem [16].

- The integration by themes, arise from the agreement between groups of faculty who jointly select a topic that must be addressed from each of the knowledge areas involved. Its main objective is to show that knowledge has practical applicability and is consistent with the daily life and the environment in which student live [17]. In this kind of integration, each faculty member develops their course contents around the identified theme and may approach it using different educational activities. In an advanced version of the strategy, students are who select the themes according to their interests.

- The integration by projects is related to elements such as active learning, collaborative work, interaction faculty-student, students' autonomy, the development of a creative and research capacity, and a close relation with real life in order to link theory with practice [4]. Because of this, projects are an excellent option for integrating courses at the same level of the curriculum.

The study proposed in this paper uses projects as strategy for curriculum integration, i.e. it uses projects as the tool which allows the articulation among courses at the same level [18]. Specifically, we use the approach known as the Aalborg PBL model or Project-Oriented Problem Pedagogy (POPP) [19]. The basic principles of this approach are: problem solving as the point of departure of the learning process, projects as the way to address the problem, and integration of theory and practice. In addition, it is important to remark that in this approach the students have a level of influence on the selection of the problem, and how to organize the project, and they collaborate in groups of three or more members supported by feedback from peers and faculty [20] [19].

These characteristics are particular useful for computer related careers. According to [21] project-based learning is an appropriate approach for computer engineers because it reflects the professional behavior of a computer engineer. The ability to solve problems is vital in computer engineering, and many of the activities of professionals in computer engineering are framed in the development of projects. In the same vein, [19] mentions that the approach facilitates the development of competences on project management and collaboration, both of them essential for computer engineers. Furthermore, [22] identifies a set of skills that future graduates must have, among them, problem solving, effective communication, effective group work, professional responsibility and the capacity of lifelong learning.

In the POPP approach, students are faced with a real problem as a starting point for the acquisition and integration of new knowledge. The learning process begins with real-life questions to be answered, a realistic case study or a complex problem that must be solved in the real world. When students analyze the information and try to solve the problem, they create and see a need to know the theory, principles, facts, rules and procedures. This need has a strong impact on motivation for learning, because students can understand the purpose of what they are learning.

In general, the model is aimed at solving problems as the basis of the learning process. The problem is addressed by conducting a project that integrates theory and practice. The search for viable solutions to the problem is performed collaboratively by groups of students who receive ongoing feedback from peers and tutors. Additionally, students have a level of autonomy in selecting the problem and in organizing the project, which aims to achieve from them greater commitment and motivation to learn [23].

The use of projects as part of teaching and learning is well known in the area of computer engineering. Usually, they focus on the application of knowledge and, occasionally, on the integration of previously acquired knowledge [21]. However, it is important to be aware that project-based learning presupposes an integral educational strategy and not just a complement in the learning process. When a curriculum is organized in projects, most of the courses are linked with the development of a specific project. There are few examples of study programs where the entire curriculum is organized in projects. The Aalborg POPP model is one of them.

In the Aalborg model each study program consists of a number of orientation courses, study courses, and project related courses which support the project work. Depending on the nature of the study program and its objectives, the project work may comprise from 50% to 75% of the students' total semester credits [20] [21]. Each semester is organized around a central theme which serves as the context in which both project courses and projects achieve the learning objectives. These themes may vary from one semester to another or may be fixed through the curriculum. Each group work has a supervisor who is responsible to ensure that the students' problem formulations are aligned with the theme and provides an adequate context for achieving the learning objectives. The students' learning process is facilitated by peers, faculty members, supervisors and assessment activities. The university encourages students to collaborate with organizations in order to extend their learning into the labor market.

From the administrative point of view, the supervisors have hours within their workload to make the supervision [20]. An important element to notice is the supervisors' role. They are in charge of facilitating students' learning through the project work, but they do not take decisions for the students or direct them [8]. Clearly this implies neglecting traditional teaching and takes an interest in an approach that promotes and encourages student-centered collaborative learning through the solution of real life problems which integrate in a natural way different areas of knowledge.

3. Context description

The Universidad Nacional (UNA) has since 2008 a pedagogical model that understands teaching and learning as a social, historical and cultural process that goes beyond the simple transmission of knowledge [24]. The model is based on constructivist principles where the student is seen as the center of the learning process. Further, it proposes an active and meaningful learning environment. However, as model, it does not identify any specific teaching strategy, which entails that it is implemented in classrooms in a diversity of ways, depending on factors such as the nature of the subject content, faculty staff perspective on teaching and learning and their ability to apply different teaching strategies.

In the particular case of the School of Informatics, the application of the pedagogical model depends on the nature of the courses and on the pedagogical knowledge of the faculty who taught the course.

In this study, POPP is understood as one possible concretization of the UNA pedagogical model [18]. Both models are aimed at student centered teaching and learning, where the main role of faculty is the facilitation of the learning process. In both, teaching is understood as a complex and multidirectional process through which knowledge is constructed and shared.

For purposes of this paper, we want to focus on the curriculum integration of a group of courses that are taught in the fifth, sixth and seventh levels in the curriculum and in the way these courses organize the learning process. The

initiative aims to integrate three knowledge areas: systems engineering, programming and databases. The strategy suggested is integration by projects. Table 1 shows the courses in these semesters.

TABLE 1. CURRICULUM OF SYSTEMS ENGINEERING

Fifth semester	*Sixth semester*	*Seventh semester*
Systems Engineering I	Systems Engineering II	Systems Engineering III
Programing IV	Programing Paradigms	Design and programming of mobile platforms
Design and implementation of databases	Data Bases Management	Research methods in informatics
Operating Systems	Operational research	Elective course
Communications and network computers	Leadership and Organizations	Elective course

Source: Curriculum of Engineering in Information Systems, 2012

During these three semesters students must develop a computer system in a company. This experience, in addition to promoting meaningful learning, allow them to know the national reality and discover their potential as future professionals [25]. This process is organized and coordinated by the faculty participating on the courses Systems Engineering I, II and III. Students are supported by them during the whole process. At the same time that students are working in this computer system they are taking courses in Programming and Databases areas. In the following paragraphs we will explain how each of these areas organizes the learning process.

In all the courses belonging to the Systems Engineering, Programming and Databases areas, the learning process relies heavily around projects; however they are very different in nature. In the Systems Engineering area, students work with a single big project throughout the three courses. Students must identify an organization with a specific need in the area of information systems and along the courses they develop a computer system to satisfy those needs. From the point of view of coordination, faculty involved in this sequence of courses, are highly organized and have high cohesion, each of them have taught the three courses to get a better understanding of them. In addition, students are organized in groups who are guided by a tutor. The group of faculty members also unifies the themes, and it provides material for all students through a virtual classroom. The project has the highest weight (50% to 60%) within the learning activities of the courses [25].

In the Programming area, the faculty staff proposes specific projects for each course. The project has very concrete objectives and covers very specific topic of the course. With regard to coordination, in this area it has been very difficult to achieve a vertical coordination within different curriculum levels. At the horizontal level, in most cases, there is a good coordination level among the faculty who teach the same course. They apply the same assessments and projects, and many efforts have been made to use the same didactic materials for all groups in the same course. In this disciplinary area, projects usually represent 20% to 30% of total course learning activities.

The faculty in the database area initially considered the implementation of a specific project in an organization; however this idea faced many problems mainly because of the students' workload in the fifth and sixth semesters. For this reason, this didactic strategy is no longer implemented and instead students currently develop small projects in each of the courses. From the point of view of coordination, all the courses have the same projects and assessment strategies; however each faculty member prepares and uses its own class materials.

The above information shows us that each disciplinary area has different levels of internal organization and cohesion.

As shown in Table 1, the students' workload during these three semesters is very heavy. At any given time students may be developing three projects of very different nature. Students complain about the lack of coordination between faculty staff who teaches courses at the same level of the curriculum. They argue that the systems engineering project is a comprehensive project which undoubtedly requires strong programming and database components. In addition, students feel they receive very little support in these latter areas, because the faculty staff from the systems engineering discipline is not expert in programming or databases, and there is a lack of collaboration and coordination among the three disciplines. In this sense the curriculum does not allow students to experience the learning process in an integrated and more meaningful way. Moreover, each faculty member is focused on developing projects for their own course and not on integrating knowledge. In this situation, integrating the three thematic areas in one single project could improve students' learning experience and also contribute to lighten their workload.

Given the above context, the analysis of the literature, successful experiences in other countries and considering that the faculty members of the Systems Engineering area have incorporated into their teaching some principles of

POPP [25], it was considered important to conduct an exploratory study to determine the feasibility of using the POPP approach as the mean by which to achieve a curricular integration between the areas of Systems Engineering, Programming and Databases. Given the natural interrelation between those three areas of knowledge, it was considered that the fifth, sixth and seventh levels of the curriculum offered the best conditions for a first initiative on curriculum integration. This selection was important, because as [26] suggests, faculty are willing to make a significant change in attitudes and beliefs mainly after positive experiences and after obtaining evidence of improved learning outcomes of their students. In this sense, the study supports the curriculum integration initiative as a process based on positive learning experiences for faculty and students.

The initial integration process proposes to present students with a real life problem which needs to be solved through a project that adequately reflects the interrelationship between the three areas of knowledge (programming, databases and systems engineering), and where each of the faculty from those areas may support students from their area of expertise and knowledge.

The initiative considers that faculty members who are experts in their areas and have a deep understanding of their courses are in the best position to decide the type and level of integration feasible among the three knowledge areas. Following this principle, the study used a participatory methodology where faculty staff and students were the main actors. The nature of the study was qualitative because it aimed to achieve a better understanding of the faculty staff perspectives and students' opinion on curriculum integration and the current conditions of the School of Informatics for such kind of initiatives.

Starting from the premise that the curriculum integration is a gradual process that takes time, the study proposed an exploratory process with the following steps: (1) faculty staff awareness; (2) analysis of possible common ground aspects between the courses - objectives, content, methodology, teaching and learning activities-; (3) design of a pilot proposal to guide the implementation of the curriculum integration initiative on fifth level; (4) monitoring / assessment the students at level fifth in the development of an integrated project; and (5) retrospective analysis of the experience obtained on the level fifth. At this point the above steps start again for the sixth and seventh levels of the curriculum, considering as input the results obtained in the previous level. The whole process is complemented by a faculty training program which enables them to develop appropriate skills to implement the integration process. This is consistent with [27] who suggest that when faculty staff engage with the new changes is more likely that these will be sustainable over time.

As part of the process it was considered important to properly assess the context in which the initiative is framed (some previous results in [18], [28]). The study was interested in understand faculty and students perspective on curriculum integration, as well as the limitations or obstacles that the initiative may confront. The results are presented in the following section.

3.1. Faculty members perspective

The phase of faculty staff's increasing awareness took place from July to October 2011. A series of sessions were carried out with faculty from the three knowledge areas in order to introduce them to the POPP approach. In addition, each area explained how they understand projects and their main learning objectives. From the point of view of the study was very important to analyze faculty's willingness to plan a single joint project which integrates effectively knowledge of the three disciplinary areas.

The first session was a workshop where the 8 participants were divided in 3 groups. Each group had the task to identify some key elements. The first group aimed to identify potential limitations, the second group thought about the goals to get with the curriculum integration process, and the third group reflected on activities to reduce these limitations and achieve the goals. The results were grouped by similarities and are shown in Table 2.

The first group identified a number of barriers for the curriculum integration process. These barriers revolve around three areas: administration, faculty and students. With respect to the administration, the participants point to obstacles in administrative and curricular aspects, low motivation in the work environment, and the diverse ways to understand, implement and evaluate students' projects in the three areas. With regard to the faculty staff, the participants considered that most of them have a rigid mindset where pedagogy is not understood as a way of improving teaching and learning. They also complained that their work is not properly valued and on the lack of supervision over it. Additionally, they find difficult to collaborate and work together. Finally, in relation with students, participants pointed as barriers a low level of commitment and motivation, as well as a weak ability of abstraction and poor writing skills.

The second group of participants stated some goals that were interested in achieve through curriculum integration. Their overall interests revolved around a more rewarding work environment where a culture of sharing and learning is promoted. They also expressed the need of improving the link between university and industry, and as result having a curriculum better aligned with society's needs.

The last group reflected on aspects that could contribute to reduce barriers. Among the suggested actions were: a strategy to promote a gradual process of change, have an open mind to curricular changes, and improve relationships and the process of knowledge construction between faculty and students.

TABLE 2. FACULTY PERSPECTIVES ABOUT CHANGE TOWARDS PBL

BARRIERS
A rigid curriculum administration
Little possibility of collaborative work among faculty
Students have low motivation
Low motivation at work
The pedagogy is not conceptualized as a fundamental vehicle to improve students' learning.
GOALS
Improve the organizational climate
Training faculty in formulating and solving problems
Have a curriculum aligned with society's needs
Promote a working environment more geared to common goals, collaborative work and the pursuit of excellence
Improve the link university - industry
ACTIONS
A gradual strategy for change that will be able to anticipate future requirements
Design a continuous pedagogical training that allows the development of faculty relevant teaching skills
Improve the curriculum

Source: Faculty 1st workshop, 2011

In sum, from a faculty perspective, the curriculum integration initiative should consider a rigid curricular administration and the existence of a group of staff who do not fully believe in pedagogy as a vehicle to improve faculty performance and student learning. This leads to promoting a gradual change with successful experiences to motivate faculty to introduce small changes and to share their knowledge and experience, in such a way that contributes to improving the communication and learning processes among them. It is also important to monitor students' learning in order to obtain information that leads to an improvement in the curriculum.

After this first workshop and once there were clarity about the faculty expectations, a series of meetings were held with the participants to discuss possible common ground between courses, at level of learning objectives, content and methodology. In these sessions the participating faculty continued to express some concerns for collaborative work. They also feel distrusting of opening their own courses to other colleagues. Each group of participants belonging to a knowledge area considered themselves experts in its field, most of them expressed that while their courses are likely to improve, the way in which courses are taught is appropriate and achieves the learning objectives they have set. As it can be seen, this attitude is to some extent, not consistent with the desire that participants expressed in the first workshop about promoting a culture of sharing and learning.

Similarly, faculty pointed out a mismatch between contents of the courses in the same level. At the level of content and learning objectives, the courses do not complement each other. In their opinion, this situation makes not viable the effective integration of the three areas through a single integrated project. Furthermore, the working sessions allowed the identification of different levels of understanding and willingness towards the POPP approach. The faculty from the Systems Engineering area argued having experience in implementing some of the principles of POPP, and having make significant progress in organizing and planning the curriculum according to the approach. For faculty from the Programming and Database areas, the POPP approach at the level of the learning process organization, is something entirely new, however they feel familiar with the use of projects in their courses.

Additionally, the faculty staff of the Systems Engineering area expressed that the project which students develop through three semesters in an organization demands a lot of effort and planning among them, thus it is unlikely they will have time to closer coordinate with faculty from other knowledge areas. Getting involved in a possible integration with courses in other areas means for them greater workload, as well as the ability to rethink issues, times and joint tasks. According to them, this could have a counter-productive effect or even a drawback in the progress made by them to date.

After several additional meetings where discussions become recurrent and virtually no progress was achieved, the participating faculty affirmed that there is no time to plan, organize and coordinate the implementation of a single project which integrated the three subject areas. In their opinion, a strategy of curriculum integration by projects is not feasible in the actual conditions of the curriculum neither in the current working environment in the School. In this sense, faculty suggested make internally changes towards POPP in each of the three areas of knowledge before considering integrating them.

3.2. Students perspective

Regarding the student perspective, the study considered 68 students who were taking courses in the fourth level of the curriculum. This student population has experience in project development, usually around problems simulating real-life situations. It is also the group of students who are closer to start the sequence of courses in Systems Engineering, where the best conditions exist for carrying out a project oriented to genuine problems. Due to these characteristics it was considered that the perspective and expectations of this population would allow the analysis of the students' disposition toward curriculum integration by projects. In order to learn the student perspective, a questionnaire composed of open and closed questions was designed.

Table 3 shows three items of the questionnaire. As it can be seen, 79% of students think that the main course contents are adequately integrated in the projects; 72% of them believe that the course projects are effective in integrating diverse knowledge areas. However, only 46 % showed a positive attitude towards the integration of the contents of various courses -in the same level of the curriculum- into a single project.

TABLE 3. STUDENTS PERSPECTIVE ON PROJECTS AND CURRICULUM INTEGRATION

Questions	*YES*		*NO*	
	N	**%**	**N**	**%**
1. ¿Do you consider that the main theoretical concepts taught in the curriculum are often well integrated in the course projects?	54	0,79	14	0,21
2. ¿Do you consider that course projects are effective in integrating diverse knowledge areas of the curriculum?	49	0,72	19	0,28
3. ¿Would you like that the main contents taught in the courses belonging to the same level of the curriculum will be integrated into a single project?	31	0,46	37	0,54

Source: Questionnaire to students in the fourth level of the curriculum, 2011

Regarding the question #3, students were asked to explain their choice. Table 4 shows the main categories on their answers; 23 students gave arguments in favor and 32 against the integration by projects.

The 23 students who agree with the curriculum integration by projects, have mentioned as positive factors: (1) a better balance of their workload since they can focus in one project instead of distributing the time between three different projects; and (2) better integration of knowledge which allows them to have a more comprehensive and realistic view of problems. With respect to the 32 students who expressed their opinion against the curriculum integration by projects, they argue aspects such as: (1) students do not always are enrolled in all the courses belonging to one curriculum level; (2) the project will have greater level of complexity and as such will be more difficult to solve; (3) a bad grade in the project would adversely affect the evaluation of all the courses involved. Moreover, they also have concerns about faculty staff' ability to find consensus and organize in a coordinated way the project. These results are consistent with [29] who stated that students can initially resist curriculum integration efforts, showing attitudes of skepticism and indifference.

From the above data, it seems that students' reluctance to the curriculum integration initiative is not directly related to the integration by itself, but with the consequences it could have on their assessment and workload. It is clear, as the students themselves point out, that an initiative like this requires great coordination among faculty involved.

TABLE 4. STUDENTS ARGUMENTS FOR AND AGAINST CURRICULUM INTEGRATION BY PROJECTS

Arguments in pro the curriculum integration by projects	*N*	*%*

Easier courses and lower workload	8	35
Better overall understanding	7	30
Better integration between theory and practice	5	22
Better learning	3	13
TOTAL	23	100

Arguments against the curriculum integration by projects	***N***	**%**
It would be more difficult, more work and more complicated	12	38
Students do not always enroll in all the courses in one level	6	19
Practice is more important than theory	4	13
Faculty staff often advance at different pace in the courses, there will be disorganization	4	13
It would be boring	2	6
The assessment would be very strong, the project grade will have a major impact	2	6
No need to change what is right	1	13
It is better to understand each knowledge area in a separated way	1	3
TOTAL	32	100

Source: Questionnaire to students in the fourth level of the curriculum, 2011

An interesting point that emerges from the study was to know that many students (65%) do not feel able to conduct real projects in an organization. The reasons they argued are related with a lack of proper skills. They expressed that the kind of hypothetical projects carried out during most of the courses in the curriculum have not prepared them to face real life projects. This situation reinforce the importance of using an approach as POPP to offering students, since the first years of the curriculum, the opportunity to work on real life projects which trains them for future employment. The POPP approach in turn can be an excellent means to facilitate the integration between diverse knowledge areas.

From the perspectives of faculty and students, it can be concluded that before to carry out curriculum integration initiatives there are some aspects that need further work and reflection. It seems important increasing students' awareness on the benefits and opportunities that curriculum integration could provide to their learning process. They also need skills to deal with the limitations or obstacles that they have identified in the process. Complementary to this, it is clear that the same process should be done with the faculty staff in order to achieve positive attitudes towards curriculum integration processes. In particular, these initiatives must be accompanied by the support of the authorities of the School of Informatics, who are the most suitable people to establish policies at the department level.

4. Identified Constraints

As a result of the process of joint work with faculty and students, the study determined that currently there not exist good conditions at the administrative, faculty and student level, for implementing an initiative of curriculum integration in the fifth, sixth and seventh level of the Systems Engineering curriculum. The constraints mainly revolved around the current organization of the curriculum and the lack of a strong culture of collaboration, as explained below:

4.1 Current organization of the curriculum

When proposing a curricular integration, it is important to ensure that each of the courses involved in the initiative can achieve their own goals for learning through the joint project.

As it can be seen in Table 1, the fifth level of the curriculum has in theory the ideal conditions for curricular integration of the three knowledge areas (systems engineering, programming and databases). However, in the course of Systems Engineering I, is where students identify the organization in which they will develop their project. In this semester they will have the first contact with the organization and the problem to be solved. Following the methodology of the course, the students deal with the analysis of requirements and the design of a conceptual framework, but with no need of programming or design of databases. This situation generates a mismatch between the learning objectives of the Systems Engineering I course and the learning objectives of the courses Programing IV and Design and Implementation of Databases.

A similar situation occurs in the sixth level. Even though in this semester there are courses of the three areas of knowledge, the topics taught in each course are not closely related. Finally, in the seventh level of the curriculum, is where students in the Systems Engineering III course have to develop the final computer application for the organization and precisely in this semester students do not have any support in programming or databases. Even more, the faculty staff from each knowledge area have determined that their courses has particular contents and very concrete learning objectives which are not susceptible of being integrated in one single project because the above

mentioned discrepancy in time. They also argued that, under the current conditions, pursuing the integration could compromise the achievement of the learning objectives of each course.

Further, students can enroll in each course independently. In this sense planning a single project to put in practice and assess the knowledge of the three subjects courses forming part of the integration initiative could be complicated from the administration point of view.

In sum, it can be concluded that in the current context there is not appropriate to go further with the curriculum integration initiative without affecting the curriculum structure (order and contents of the courses in the fifth, sixth and seventh semesters).

4.2 Collaborative culture

When proposing the implementation of a single project which will integrate three of the courses in the same curriculum level, it was clear the vital role of collaboration among faculty staff. Planning for integrated curriculum is a collaborative venture. Faculty staff needs to follow a backward design approach, beginning by exploring expectations and determining what is most important to know, do and be, and how to assess student outcomes [30]. The curriculum integration by projects is a process that demands effort, commitment, extra work and a lot of organization and planning between the faculty members belonging to the diverse knowledge areas. They are key actors in the success of the initiative [5].

However, when analyzing the current context, the study found a lack of trust, collaboration and openness between the faculty members participating in this initiative. There are evidence of "islands" which difficult the exchange and sharing with other areas of knowledge. In addition, and consistent with those results reported by [14], the multiple occupations of faculty also prevent them from participating in a training process which may foster a more healthy and collaborative working environment.

~~5.~~ Possible alternatives

Although the study identified constraints, similar to those identified by [14], which does not enable the implementation of the initiative of curricular integration by projects, it is considered that opportunities still exist, and that there are actions that could contribute to reduce the limitations.

Regarding the mismatch in the courses, it is possible to make a partial redesign of the curriculum, modifying the level at which some of the courses are taught and adjust the content in the programming and databases courses. Also, it is possible to ask that the three courses should be simultaneously taken for the students.

Having in mind that the sequence of Systems Engineering courses are the central column of those semesters and that the main aim of these courses are the analysis, design and implementation of a computer application in an organization, the changes can be summarized as:

- At the fifth level: teach the courses Programming Paradigms and Systems Engineering I. This will enable students to complement the analysis of the organization and the definition of the computer application to be developed with the analysis of the more appropriated programming paradigm.
- At the sixth level: teach the courses Programming IV, Design and Implementation of databases, and Systems Engineering II. By following a POPP approach these courses can complement each other in the process of design and develop the computer application for the organization.
- At the seventh level: teach the courses Data Bases Management and Systems Engineering III. Both courses can complement each other in the process of delivering a functional computer application to the organization.

A more aggressive approach is to fully redesign the curriculum, considering curriculum integration as a central component, and considering the POPP pedagogical approach as the means to achieve the integration. In this line, a similar approach to the University of Aalborg could be implemented with project courses and subject courses around a theme or a generating topic [15]. This approach would require establishing the role of supervisors and their respective workload.

The limited openness of the faculty staff to work together with other areas of knowledge requires more work in changing beliefs and attitudes. This ongoing process can be achieved through forming working groups following the recommendations of [31] who establishes as success criteria for curriculum integration: (1) have a good

understanding of the participants; (2) provide them with clear information about what is to be achieved; and (3) generate an atmosphere of collaboration. These conditions are necessary in order to enable participants to establish common objectives, to be committed to the initiative and to be more open to the changes necessary in the process. Additionally, as noted by [14], it is important to identify leaders who can promote motivation and engagement between their colleagues. Another fundamental aspect is to have a well-defined institutional support.

6. Concluding remarks

It is important to understand that curriculum integration allows building meaningful and relevant knowledge to meet current society demands [5] [6]. This pedagogical strategy allows the creation of opportunities for students to work on and make decisions about complex problems that involve several areas of knowledge [2]; and contributes to develop in students skills such as: effective communication; group work; problem solving; theoretical knowledge and skills; independent responsibility for learning; critical thinking; and sharing information and knowledge with peers [7], all of them valuable skills for computer engineering professionals.

As with any approach to curriculum, the skill and attitude of the faculty is the crucial factor. Without their willingness and commitment could not be possible to have successful experiences of curriculum integration [8] [14].

Curriculum integration requires a shift in the traditional role of the faculty members; as such some of them may feel threatened by the approach. According to [8], some of the reasons for this attitude are: faculty reluctance to share decision making and their preference for having activities carefully planned well ahead of time. Another barrier for some of them is the concern that they will not be covering what the curriculum requires in terms of content. In this context, any initiative on curriculum integration should be aware of the importance of convince and prepare faculty to embrace it. They need training and opportunities to learn in and about collaboration. They also need skills to plan and organize the curriculum beyond the confines of their knowledge areas [1] [5] [8].

In the exploratory phase of this study, it was determined that, under the current conditions of the Informatics School, it is not viable to propose a curriculum integration by projects in the fifth, sixth and seventh levels of the System Engineering curriculum. The results obtained in the processes of increasing awareness and analysis of the common ground between knowledge areas show that the actual organization and structure of the curriculum does not facilitate the integration of content and learning objectives. Moreover, faculty is not yet ready for collaborative work and has no openness to share "their" courses and projects. In this sense, it was also evident the need to create safe spaces where faculty can learn about curriculum integration and gain a more global vision of the curriculum beyond their disciplinary area. This process can start internally in each area where faculty feel confident and comfortable, and then design a strategy to gradually spread it to related areas.

This first initiative of curriculum integration at the Informatics School managed to identify a set of constraints to the process. Some of them are administrative and could be overcome with some changes in the curriculum such as moving courses between levels, change the contents of some courses or establish requisites for some of them. Another constraints are cultural, and as such more difficult to overcome. In this aspect, the faculty willingness and the support from the authorities of the School of Informatics are key issues in order to achieve a good understanding and successful implementation of curricular integration initiatives.

However, this study shows the importance, the need and the potential of the POPP approach to facilitate curriculum integration. An important number of students understood the objectives of the curriculum integration initiative, and their reluctance to it is not directly related to the integration by itself, but with the consequences it could have on their assessment and workload, and with the problems in organization and coordination among faculty involved.

An aspect that should be considered seriously is the students' perception of not being prepared to conduct real projects in an organization. They argue that hypothetical projects carried out during most of the courses in the curriculum have not prepared them to face real life projects. In this point, is important to reinforce the role of POPP as pedagogical approach, since it can offering students the opportunity to work on real life projects which trains them for future employment. In turn, the POPP approach can be a valuable means to facilitate the integration between diverse knowledge areas.

In this vein, it is important to provide learning experiences that enable faculty and students to recognize the value of solving a complex problem which by one hand resemble more the real-life, and by other hand force students to integrate in a formal way the knowledge from diverse areas. This latter experience with the support from faculty would contribute to prepare students better for their future professional work. It is clear that aspects like workload and the content integrity should be carefully planned and organized.

From this study it is undeniable the need of establishing strategies to create, from the early years of the curriculum, the necessary conditions to promote a positive attitude towards curricular integration processes and therefore overcome, at least partially, the identified constraints. As such we would suggest to apply the POPP pedagogical approach since the first levels of the curriculum [18]. In this way the process of building trust between faculty and their openness to collaborative work will grow smoothly, and on the time both faculty members and students will be ready to participate in future curriculum integration initiatives which in turn will prepare students to better face their future work.

Finally, it should be noted that for holistic learning to be truly effective, curriculum integration should not be considered as an independent event, but a regular activity in the curriculum [6], so it must be assumed by the institutional authorities and have the commitment of the authorities of the School of Informatics.

Acknowledgment

This study was supported by the School of Informatics through the research project 0294-11: "Curricular Innovation of Study Plans in the disciplinary area of System Engineering at the Universidad Nacional, considering the POPP (problem-oriented project pedagogy) as a methodological approach".

We thank the faculty staff at the School of Informatics at Universidad Nacional, Costa Rica mainly those from the System Engineering, Programming and Databases knowledge areas. We would thank all the participating students in the fourth level of the curriculum during 2011.

References

[1] R. Aguila, B. Behnan, R. W. Burniske, C. Cerda, R. D. Valle, and M. Gonzalez, "Fase III: Integración de Tecnología y Currículum.," World Links, Washington, D.C., 2002.
[2] M. T. Huber, P. Hutchings, and R. Gale, "Integrative Learning for Liberal Education," in *Integrative Learning*, vol. 7, 4 vols., Asociation of America Colleges and Universities., 2005.
[3] S. Johnson, *Integrative Learning*, vol. 7, 4 vols. Asociation of America Colleges and Universities., 2005.
[4] *Reorganización curricular por ciclos: Referentes conceptuales y metodológicos*. Colombia: Secretaría de Educación de Bogotá, 2012.
[5] Association of American Colleges and Universities (AAC&U), "A statement on integrative learning," 2004.
[6] D. Humphreys, "Why Integrative Learning? Why now?.," in *Integrative Learning*, vol. 7, 4 vols., Asociation of America Colleges and Universities, 2005, pp. 30–31.
[7] R. Hill, "An Integrated Curriculum: The Monash MBBS," Monash University, 2005.
[8] D. Fraser, "Curriculum integration: What it is and is not,set:," *Res. Inf. Teach. 3 34-37*, vol. 3, pp. 34–37, 2000.
[9] R. Vásquez and G. Urías, "Una Nueva Episteme de la Pedagogía Universitaria: La Integración Curricular de Los Procesos Académicos Universitarios," *Práxis Educacional*, vol. 8, no. 13, pp. 11–29, 2012.
[10] A. Camilloni, "Modalidades y proyectos de cambio curricular. Aportes para un cambio curricular en Argentina. Facultad de Medicina.," OMS, UBA-OPPS, 2001.
[11] R. Gibson and R. Ewing, *Transforming the curriculum through the arts*. South Yarra, VIC: Palgrave Macmillan, 2011.
[12] R. Miller, "Integrate learning and Assessment," in *Integrative Learning*, vol. 7, 4 vols., Asociation of America Colleges and Universities., 2005.
[13] A. Chaves, D. Hernández, J. León, Z. Pereira, and M. Vargas, "La integración curricular: Una experiencia en el primer nivel de diplomado de la carrera de Licenciatura en Pedagogía con énfasis en Educación Preescolar," *Rev. Electrónica Educ.*, vol. 15, no. 2, pp. 63–86, 2011.
[14] D. Perin, *Curriculum and Pedagogy to Integrate Occupational and Academic Instruction in the Community College: Implications for Faculty Development*, vol. 8. CCRC Brief, 2000.
[15] C. Vasco, A. Bermúdez, H. Escobedo, J. C. Negret, and T. León, "El concepto de tópico generador," in *El saber tiene sentido. una propuesta de integración curricular*, 2000: CINEP.
[16] J. Negret, *Proyectos y relatos. Herramientas para el diseño de proyectos pedagógicos*. Bogotá: H&G, 2007.
[17] L. Y. Aguilar, J. M. Carreño, A. Galeano, G. Preciado, and O. Espinoza, "Acerca del rediseño curricular por ciclos," *Itinerario Educativo*, vol. 55, pp. 213–237, 2010.
[18] M. Coto, S. Mora, and M. Lykke, "Design considerations for introducing PBL in Computer Engineering," *Informática CLEI 2012 XXXVIII Conf. Latinoam.*, pp. 1–10, 2012.
[19] A. Kolmos, F. Fink, and L. Krogh, "The Aalborg Model - Problem-based and Project-Organized Learning," in *The Aalborg PBL model - Progress, Diversity and Challenges*, A. Kolmos, F. Fink, and L. Krogh, Eds. Aalborg: Aalborg University Press, 2004, pp. 9–18.
[20] S. Barge, "Principles of problem and project basic learning. The Aalborg PBL Model," Aalborg University., Aalborg, 2010.
[21] J. Mills and D. Treagust, "Engineering Education - Is Problem-Based or Project-Based Learning the Answer?," *Australas. J. Eng. Educ.*, vol. 4, 2003.
[22] ACM, "Computer Science Curricula 2013," ACM, 2011.
[23] E. De Graaff and A. Kolmos, "Characteristics of problem-based learning.," *Int. J. Eng. Educ.*, vol. 19, pp. 657–662, 2003.
[24] Universidad Nacional, "Modelo Pedagógico," 2007.
[25] M. . Sandoval and R. Cortés, "Proyecto: Análisis del impacto de proyectos desarrollados por los estudiantes de la Cátedra de Ingeniería de Sistemas de la UNA del 2006 al 2010," Universidad Nacional, 2011.
[26] T. Guskey, "Professional Development and Teacher Change," *Teach. Teach. Theory Pr.*, vol. 8, pp. 381–391, 2002.
[27] T. Guskey, "What Makes Professional Development Effective?," *Phi Delta Kappa Int.*, vol. 84, pp. 748–750, 2003.

[28] M. Coto, S. Mora, and M. Lykke, “Developing the Qualifications of the ICT Workforce through Problem-Based Learning,” in *Changing Education through ICT in Developing Countries*, M. Georgsen and P. Zander, Eds. Aalborg University Press, 2013, pp. 33–60.
[29] P. A. Bishop and K. Brinegar, “Student learning and engagement in the context of curriculum integration.,” *Middle Grades Res. J.*, vol. 6, no. 4, pp. 207–220.
[30] G. Wiggins and J. McTighe, *Understanding by design*, 2nd ed. Alexandria, VA: Association for Supervision and Curriculum Development, 2005.
[31] L. Esquivel, G. Induni, V. Madrigal, Z. Pereira, J. Solano, and W. Umaña, “Conformación de un equipo de investigadores: Una experiencia concreta,” *Revista Electrónica EDUCARE*, vol. 6, pp. 193–204, 2004.