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Collaborative Teaching and Learning Strategies for Communication Networks*

FREDERICO NOGUEIRA LEITE
Federal Institute of Brasília, Campus Taguatinga, Brasília, DF, Brazil. E-mail: frederico.nogueira@ifb.edu.br

EDUARDO SHIGUEO HOJI
Federal Institute of Education, Science and Technology of São Paulo, Campus Birigui, Birigui, SP, Brazil. E-mail: shigueo@ifsp.edu.br

HUMBERTO ABDALA JÚNIOR
University of Brasília, Department of Electrical Engineering, School of Technology, Brasília, DF Brazil. E-mail: abdalla@ene.unb.br

Traditional lectures are not effective for teaching practical subjects. Therefore, it is important to develop a sufficient methodology to provide the conceptual and practical aspects of a course to the students. In this paper, we describe the challenges faced in the implementation of active learning methods in the subject of Data Communication & Computer Network in vocational education at the Federal Institute of Brasília. The experiences resulted in a blended methodology, which combines collaborative and problem-based learning with a learning management system. The flipped classroom was also applied in order to enhance the quality of the references used by the students in the solutions. In addition, traditional apps and social networks were used to improve the communication between students and teachers. The practical activities were applied in a small computer network laboratory, but in the first semester of 2016 it was improved, and a new high performance Datacentre was built. Thus, interdisciplinary aspects and research were explored including the relationship between vocational and graduate courses. Moreover, transversal skills, such as teamwork, leadership, self-confidence and autonomy in decision-making were developed. The research was conducted from 2011 to 2016, and 147 students were enrolled with an average of 14 students per class. Such features demonstrate that the learning methodology must be fit for the course and the educational level in order to become effective.

Keywords: problem based learning; flipped classroom; learning management systems; blended learning

1. Introduction

In most conventional learning environment, the teachers use the limited class time to deliver new contents and concepts. However, it is not always enough to clear the students' doubts [1, 2]. Besides the time limitation, many students do not feel involved in the learning process in Traditional Teaching Lecture (TTL) and their roles come down to transcribe the content presented by the teacher [3, 4].

Since students are not engaged in the teaching/learning process, some harmful aspects may rise, such as their dependence on teacher for developing practical activities and the lack of interdisciplinary aspects during the course [5, 6].

An alternative to TTL is the Active Learning (AL), in which the students are assigned for learning, reading, writing, discussing and engaging in problem solving process [3]. Under this responsibility, they can develop professional skills, like teamwork, leadership and self-confidence with the practical activities adopted in active methodologies [7, 8].

However, the AL methods by themselves are not enough to grab students' attention and ensure that practical activities represent actual labor market activities. All the structure, equipment and laboratory applications must be fit to the methodology and are essential to the learning process [4].

The problem is that building and equipping a lab focused on current technology is expensive. Moreover, new technologies render some equipment obsolete very quickly, making it difficult for educational institutions to have up-to-date labs. Some alternatives nowadays are based on virtual laboratories and cloud computer. Other way is to establish partnerships with private enterprises.

The computer network laboratory at the Taguatinga campus of the Federal Institute of Brasília (IFB) was assembled in a partnership with Huawei and utilizes the resources provided by cloud computer and virtualization. The laboratory was structured and configured to support, as a priority, the academic demands of the Technical Course on Computer Maintenance and Support (CMS) and Bachelor Degree in Computer Science.

In this paper, the evolution and relevant aspects of active learning methodologies applied to Computer Communication Network (CCN) subject in the CMS vocational course are presented. We describe the main challenges found in the development of a hybrid method based on Problem Based Learning (PBL) and Flipped Classroom (FC) and

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highlight the importance of a well-structured laboratory for performing collaborative activities in the course. The students' performance during the development stages of the method and their perception about these paradigm change were evaluated and provided relevant information to adjust the method to the course.

2. Overview of the CCN subject

The objective of the MSI course is to train professionals to work with computer maintenance and telecommunication network. The course is split in three modules, one per semester, and has a total of 1181 credit hours, among which 160 regards to supervised practices.

The CCN subject is taught in the third and last module of the MSI course and takes 120 credit hours. It is a key discipline in the course, addressing the necessary concepts students must know to setup and maintain computer networks.

The TTL method was used for teaching the CCN subject from the second semester of 2011 to the second semester of 2012, for three semesters in a row. During this time, the students' performance was below expected and two main weaknesses in the teaching/learning process were identified:

- The CCN classes were focused on theoretical issues and did not prioritize practical activities;
- The students were not engaged in the learning process and were only concerned about the approval.

Then, a chain reaction was started. The students became non-autonomous agents and had only the professor as a reference, expecting to know what to study for the assessments. In that way, practical activities only were reproduced by the students, who were not concerned about how or why something happened and what the consequences of that. As a consequence, most students did not understand the relationship between the subject and the labor market and many of them failed the subject.

In view of these problems, changing the teaching method adopted in the CCN subject in order to make classes more interesting and motivating was of paramount importance. The new approach might not only prioritize practical activities, but also lure the students into the classes.

In this context, active learning methodologies seemed to be suitable to promote the necessary changes in the CCN subject. The activities developed in AL are important to motivate the students engaged in learning process, including study groups and research practices [10, 11]. In addition, students can have improved interdisciplinary aspects and transversal skills, such as self-confidence, teamwork, leadership and autonomy [2, 5, 12].

In these methodologies, the teacher plays the role of facilitator and promotes a self-directed learning environment [6, 7]. Students, in turn, became responsible for learning and are trained to find the necessary information to solve the presented problems and to figure out if the proposed solutions lead to satisfactory results [9, 10].

Then, in 2013 the Problem Based Learning (PBL) was applied. The activities developed in PBL promote a collaborative environment with poorly structured real problems, which presents a starting point where students need to find the solution [9]. This methodology was evaluated for three consecutive semesters and the CCN subject became more practical and interesting to the students, who could put into practice theoretical issues addressed in classes based on common activities from the labor market.

This simple change made the students feels responsible for their learning process. However, there is a plenty of unreliable information on the Internet and it is possible to find ready-made solutions that are, sometimes, kludges. Even worse, some students only reproduced such solutions without understanding how they were built.

Therefore, it was necessary to verify the materials used by the students and to keep up with their solutions development. It was a hard task, especially because students were free to find their references, what might lead to a huge number of sources to be checked. Because of that, the teacher started to prepare the students' material, as a way to minimize the problems related to unreliable sources.

In order to keep on with the students' responsibility reached under the PBL and to not backslide to their dependence on teacher as it was under TTL, Flipped Classroom (FC) [13, 14] was adopted in CCN subject from the second semester of 2014 on.

The FC is a broad education model that includes direct education, research, practice and formative assessment. [15]. This learning model was named ''flipped classroom'' because the activities presented in regular classes are intended to be performed at home, and the exercises, which used to be the homework, are now settled in the classroom [16]. In other words, students learn the theoretical content outside the classroom and use the face-to-face meetings to apply the concepts they studied and clear their doubts.

The teacher is in charge of preparing, selecting and assembling the classroom materials, which can be composed, for example, of video lectures, books and handouts. The material is delivered to the students throw a Learning Management System (LMS) [17]. The LMS is defined in [18] as any digital

resource that aids the educator in the construction of knowledge and have specific functions and a cognitive style adapted for each learner.

The LMS adopted in CCN subject was the Moodle (Modular Object-Oriented Dynamic Learning Environment) [19, 20]. In addition, popular communication tools such as WhatsApp, YouTube and Google Apps were used to construct and share the subject contents and promote the communication between the teacher and the students

3. The CCN subject structure

Applying AL methods goes beyond changing the way the subject content is delivered to the students. It is necessary to adapt the course to the new learning environment, the appropriate teaching materials need to be created, and all didactic support resources must be available. In this way, the subject of CCN programmatic content was divided into three phases. The proposed blended learning method, where the PBL and FC were used, can be seen in Fig. 1.

The phase 1 is based on the TL environment and prepares the students for the transition to active learning method. The activities in this phase must be completed within 24 hours and it aims to review former studied issues, to make the student understand the differences between network equipment, and to show how the computer network devices are organized in a real computer network structure. Students performance was evaluated by means of exercises and tests applied at the end of phase 1.

Static and dynamic routing techniques are addressed in phase 2 and the practices are based on simulations. The Moodle and popular apps start to be used at this phase, including for evaluation activities. The Moodle was used as repository and assessment environment. However, its communication tools, such as chat and forum were underused, as students spent days without accessing the platform, considering that some of them do not have an Internet access or a computer at home.

Therefore, the communication between the teacher and the students needed to be improved. The solution found was to adopt the WhatsApp, since every student had a mobile phone with Internet access. This application was used for information sharing and data swap.

WhatsApp enabled the learning process to be more dynamic. An example of it occurred when a group had doubts about the network service implementation. The students sent a photo including a screen error and, immediately, the teacher explained what had happened and indicated a related video that would help them. Then, the students were able to solve the problem before the face-to-face class.

The solutions proposed by the students in phase 2 were recorded in a video lecture and uploaded to YouTube. An example of a student produced video can be found at https://www.youtube.com/watch?v=XlYQPC_x7dI. Also, the students must present their works in a poster workshop in the end of the phase, which takes 42 hours and it was based on PBL from 2013/1 to 2014/1. From 2014/2 to 2016 the FC was adopted due to the reasons former stated.

In phase 3, the practices move from network simulation to training with physical equipment, such as switches, routers and servers, which are used to install and configure network services. So, after the proposed solution is simulated, students had to setup the physical network. At this point, some failures in the network are intentionally provoked by the teacher and the students have to diagnose and correct the problem.

The activities in phase 3 take 54 hours and the PBL was the only methodology used in this phase. Unlike phase 2, the PBL worked well in phase 3. The use of physical equipment common in the labor market stimulated students' curiosity and, for this

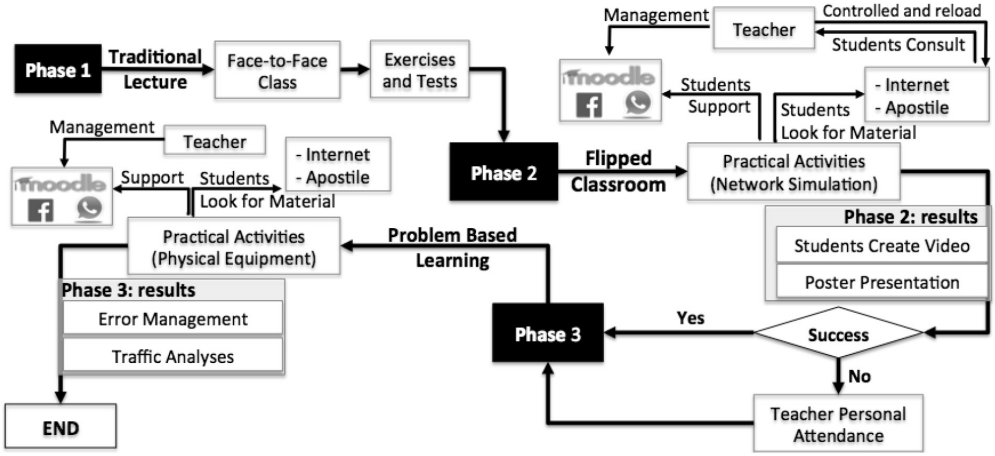

Fig. 1. The CCN activities flow.

reason, they were engaged in solving the activities. In addition, the reference materials were generally limited to manuals and official websites of equipment manufacturers. Furthermore, the ready-made solutions, easily found on Internet, did not fit the proposed problems. Thus, the difficulties noticed in previous phase were minimized.

4. The CCN laboratory

The academic laboratory is an important environment in the learning process. At the lab, students can perform hands-on activities, applying the theory in practice and fastening the knowledge. The first laboratory used in the classes, from 2013 to 2015, includes equipment donated by Huawei: four routers, five switches and two firewalls. These devices were installed in a rack in the academic laboratory.

The equipment available for the students covers the demands related to layers 2 and 3 of the reference model Open Systems Interconnect (OSI) protocols. For layer 7 service setup it was necessary to configure the lab computers. However, these machines were under responsibility of the IT department and had to follow the corporate network security roles, which limited many practical activities, for example, to accomplish traffic analysis using promiscuous application to sniff the institutional network. Moreover, their utilization required a prior authorization from the IT department. Because of that, students used to spend their time solving hardware problems instead of devoting their efforts to specific activities expected at the CCN subject.

4.1 New academic datacenter

Despite these limitations, the academic laboratory was fundamental for the learning process. Without the donated equipment, practical activities would be performed only based on simulation. For this reason, in the second semester of 2015, a new process of equipment donation was accomplished, and many switches, routers and excellent computer network servers were available to improve the academic laboratory.

Then, a new academic Datacenter was assembled. It had a dedicated Internet link with Brazilian National Research and Educational Network (RNP). The firewalls were used for Virtual Private Network (VPN) configuration, and were separated into trusted and untrusted networks. The servers were organized into clusters to ensure higher performance. The hard discs were set in Redundant Array of Independent Disks (RAID) 5 structure.

The data management and storage were located in Network Attached Storage (NAS) and Storage Area Network (SAN). This operational environment was built with Software Defined Networking (SDN) [21]. The OpenContrail [22] was used for Datacenter virtualization. Practical network simulations were based on the OMNET++ [23] and the Zabbix [24] was used for services and equipment management.

In order to improve the use of Datacenter and isolate the equipment from the corporation network, the academic laboratory was physically separated. With this change, the lab was not in charge of IT department anymore and former restricted activities could be performed, such as hardware configuration and software installation. Also, the corporate network security against to malicious attack was not affected.

The new academic Datacenter structure is shown in Fig. 2. It was divided into three layers: infrastructure, control and application. The infrastructure layer addresses the physical network structure. At this layer students deal with switches, routers, firewall, servers and network services. The Control layer is responsible for the services management and equipment available in infrastructure. In addition, the Application layer was responsible for cloud computing and virtualization of resources.

In 2016, the students of the CCN subject developed activities in infrastructure and control layer. They configured the routers, switches, installed several network services, and created a practical manual for installation and configuration of Zabbix server.

After that, the work developed by CCN students has been used in three currently running research projects regarding ''High Academic Datacenter

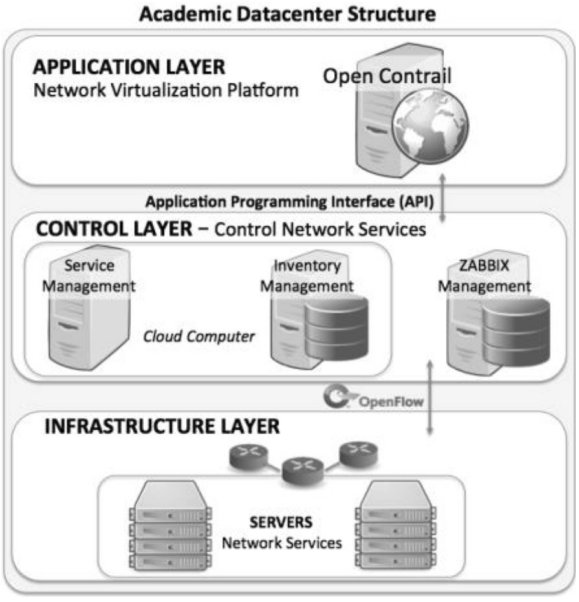

Fig. 2. Description of Software Defined Networking (SDN) Framework in Academic Datacenter.

Implementation'', ''SDN Management Network in Academic Datacenter'', and ''Cloud Computing''. All projects started in first semester of 2016 and will finish in 2018 and include technical and undergraduate students.

5. Students' performance and results

The CCN subject was taught from 2011 to 2016 and 146 students were enrolled with an average of 14 students per class. The number of students who flunked and dropped out in the first three semesters (2011/2–2012) was high, approximately 53% flunked. In addition, the number of dropouts was also high (~42%), it is happened because the students had difficulty to assimilate the taught content, and became discouraged due to obstacles encountered in the discipline. In the period between 2013 and 2016, when the active learning was adopted, these numbers and students score improved. General information about the subject can be seen in Table 1.

The students' average scores are shown in Fig 3. The standard deviation (sd) hybrid method in 2014/2 to 2015 was 1.61 and 1.82 in 2016. It is lower when compared with PBL methodology (sd = 2.43) and TTL (sd = 4.13). The lower sd in hybrid method indicates that the students' knowledge of the subject was more levelled and steady.

In 2016, some adjusts were made in the CCN subject to utilize the Datacenter equipment. However, many students had difficulty to understand and to develop the new proposed activities, such as installing the Zabbix application. To accomplish that, they needed an advanced knowledge of Linux and Simple Network Management Protocol (SNMP). However, they learnt about traffic analyses using the TCPDump (free application) and, therefore, they had an extra topic to study.

It led to an average score lower than the previous

Table 1. General Information for CCN Subject

	Methods									
	Traditional Lecture			**Problem Based Learning (PBL)**			**HYBRID (Flipped Classroom + PBL)**			**HYBRID Using Academic Datacenter**
Analysed Items	**2011/2**	**2012/1**	**2012/2**	**2013/1**	**2013/2**	**2014/1**	**2014/2**	**2015/1**	**2015/2**	**2016/1**
Students	12	19	9	17	22	12	13	17	12	14
Average Score	5.0	3.8	5.9	7.0	6.5	7.8	7.8	7.1	8.6	7.2
Approved (%)	56	42	43	85	80	78	82	85	88	79
General Score		4.9			7.1			7.8		7.2

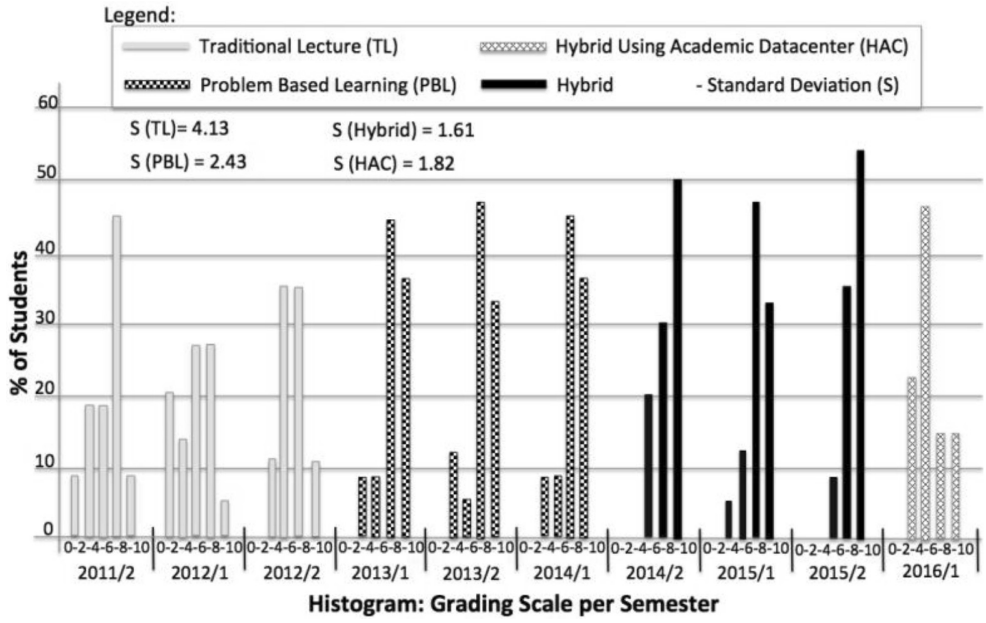

Fig. 3. Histogram of students' average score per semester.

semesters that used active learning. The class was composed of 14 students, and eleven of them (79%) were approved. The general students score was 7.2.

6. Questionnaire analysis

The active learning efficacy was assessed by means of an objective and a discursive questionnaire, in order to provide the students' perception regarding the learning method and the Datacenter utilization. The questionaries are applied in the last class of the course and it takes around 15 minutes to be answered. A total of 74 students joined the research, among which 34 were evaluated under the PBL methodology and 40 under the hybrid method.

6.1 Objective questionnaire analyses

The objective questionnaire is focus on eight big areas: I—general questions about the CCN subject; II—subject contents available for student consultation; III—the efficacy of LMS tools, and teacher/student communication; IV—information about network simulation; V—the quality and utilization of physical equipment; VI—exercises and tests relevance; VII—transversal skills evidence; and VIII—self-evaluation. The answers follow the Likert scale [25]: 1—strongly disagree; 2—disagree; 3—indifferent; 4—agree; 5—strongly agree.

Students' answers to items I, IV, V, VI, VII and VIII provided their feedback regarding the active learning methods. In general, they approved the active methods and suggested that it could be expanded to other subjects (item I). Moreover, students felt that the network simulation and physical equipment were useful in learning process (item VI and V) and the exercises and activities were in agreement with subject programming (VI). Also, they could perceive that transversal skills, such as leadership, self confidence and teamwork were developed under active methods (item VII). At least but not last, they considered themselves good students, feeling the importance of their engagement in the learning process (item VIII).

A divergence between the PBL and the hybrid method happened regarding items II and III. According to the questionaries answers, students who attended the course under the PBL method felt that the subject issues could be more specific and the teacher support did not help them to solve the proposed activities. Such features were improved in the hybrid method, mainly because of the more effective communication established between students and the teacher.

6.2 Qualitative questionnaire analyses—students' view

In addition to the objective questions, a discursive questionnaire was applied and intended to provide students a space to write their comments. Their verbalizations were grouped according to the semantics, following the Bardin [26] principles, and some of them about the PBL and the hybrid methods are presented in Tables II and III, respectively. The students were identified by the word "E" and a number in order to preserve their identity.

The students' perception, related to Hybrid method, was presented in Table III. Five categories emerged.

Under Hybrid method, several students demonstrated enthusiasm about activities that simulated

Table 2. Qualitative Result: Category and Verbalization (PBL)

Category	Verbalization
"The PBL activities"	(...) "The team spent a lot of time to solve the PBL activities." *E7*
	(...) "I need to study and work, therefore, meet with team members to solve the proposed activities was not easy for me." *E10*
"Learning with PBL"	(...) "I did activities that I thought were impossible, because I had difficulties to understand the CCN contents." *E19*
	(...) "The work developed with my team and accomplishing the problems solution, without teacher's help, allowed me to consolidate the theoretical contents and practical activities." *E22*
"Professional Experience"	(...) "I had difficulty to complete the exercises and tests proposed by the teacher, but this activities prepared me for labor market." *E1*
	(...) "I will look for a network job opportunity, because I feel confident in solving network challenges." *E26*
"Moodle tools"	(...) "The Moodle was a good interaction tool. I could sent the activities and receive a subject content." *E11*
	(...) "I had difficulty to understand the Moodle, but the teacher cleared my doubts and I noticed that this platform was dynamic and easy to learn." *E15*
"Practical Activities"	(...) "The network simulation was important to prepare the students for real practical activities." *E6*
	(...) "The users' guides were essential to configure the equipment." *E21*
	(...) "I got a new job post because I learned the practical activities in CCN subject." *E29*

Table 3. Qualitative Result: Category and Verbalization (Hybrid)

Category	Verbalization
"Students' behaviour outside face-to-face classroom"	(...) "I am working hard and my family needs my attention. Thus, study outside a classroom was difficult for me." *E36*
	(...) "The video-lecture made by teacher helped me to understand the subject contents." *E43*
	(...) "When I needed to solve some doubts related to homework activities, I used WhatsApp groups and the teacher always helped me. It was very important to my learning process." *E51*
	(...) "My performance improved when I studied the subject content at home before the face- to- face classes." *E57*
"Activities solution"	(...) "The teacher always spent twenty minutes in face- to- face classes to review the content studied by the students at home. It was relevant to solving the doubts." *E47*
	(...) "I liked to study the CCN theoretical contents at home, but the proposed activities were not easy to solve." *E48*
"Moodle activities"	(...) "The clearly organized mode of the Moodle helped me find all the content that I needed." *E43*
	(...) "The Moodle activities were always available on time." *E61*
"Change of methodology"	(...) "I think that the Hybrid Method was more productive than pure PBL methodology. I learned so much at home that I did not have difficulties solving the phase 3 activities." *E7*
	(...) "The activities developed into academic Datacenter were exciting and I enjoyed working with graduate students. In the next semester I will try to join the Computer Science course." *E71*
"In the follow of Labor Market"	(...) "I was an intern at a company focused on the network support and I will probably be hired. The activities developed in Datacenter were essential for me." *E42*
	(...) "I am motivated to continue studying the computer network issues because I want to work in this area." *E49*

the network practices common in labor market. They reported that these activities were important to get a good post at the companies.

The category "Change of methodology" emerged from the comments of students who former attended the subject under the PBL method and failed. These students demonstrated to be more engaged with Hybrid method than with PBL and stated that the FC helped them to create the habit to study at home. As a consequence, they presented to be more prepared for practical activities developed in phase 3.

In first semester of 2016 the academic Datacenter was included in CCN programming and the students could confirm the relevance of high performance equipment in their learning process. Furthermore, they highlighted the importance of interdisciplinary aspects and considered the possibility of joining graduate computer courses.

Other students noticed that TL was limited and suggested that other subjects in vocational courses should explore the proposed hybrid method. They said that the learning process was improved and the activities developed using this method were developed with more enthusiasm and efficacy.

7. Discussion

The process of paradigm change requires dedication, planning and conducting periodic adjustments into the subject. As former stated, we passed through two periods of changes. The first one happened from 2011/2 to 2014/1, when the CCN subject was being adapted to PBL. When the active learning was introduced in CCN subject many challenges were found. The first semester of 2013 there was a critical scenery because the traditional lecture paradigm broke. The teacher needed to spend a lot of time to develop the students' materials and organize the course in the Moodle.

After that, the challenges became smaller. Passed a first experience with active learning, the teacher was more confident and few changes were needed in the CCN materials. We could notice that within this period the PBL methodology improved the CCN subject. However, it was not indicated for network simulation activities because many students copied solutions from the Internet without understanding what they implemented and, sometimes, the source of research was not reliable. The main challenges found in this period and the respective solutions are presented in a chronological order in Table 4.

In the second semester of 2014 a new hybrid learning method was developed for the CCN subject. The utilization of popular apps allowed a better communication between the teacher and students. For example, the WhatsApp helped the teacher to monitor the students' participation in proposed activities, and provided information swap. Thus, the subject communication became effective and the solutions to the doubts were found more quickly. The Hybrid method remained stable in 2015, but little changes were conduced to the time of video lectures.

In the first semester of 2016 the computer network laboratory was improved, with new equipment

being included to the academic Datacenter. Despite the fact that the students' grade was lower, when compared to the other previous semesters, students highlighted that the academic Datacenter was important for their professional careers and for their self-confidence to find a job in computer network and telecommunication area. The challenges and solutions in Hybrid method were presented in Table 5.

The proposed hybrid method was adequate for

Table 4. The main challenges and solutions for the implementation of the CCN with TL and PBL methodology

Year	Challenges	Problems Solution
2011/2 – 2012	In TL the main problems noticed were: (i) teacher dependence during the activities and the focus of the subject on theoretical content; (ii) the students only reproduced practical activities without thinking about the essence of the problem; (iii) the students were not motivated to solve the exercises proposed by teacher; (iv) most students did not grab the relationship between the subject and the labor market; (v) many students failed the subject.	The solutions were developed in 2013 under PBL methodology and presented the following features: (i) the students did not feel motivated to learn a lot of theoretical content of the subject. Therefore, simple practical activities started to be prioritized. Since the difficulty of exercises increased gradually, the students focused their attention and managed to solve the challenges in the items (i, ii and iii); (ii) the practical activities were developed according to labor market practices; (iii) the percentage of students who failed dropped because they felt more motivated to learn.
2013/1	(i) the teacher had to allocate a lot of time, including weekends, to develop active learning environment appropriate to perform practical activities; (ii) the didactic lab was not prepared for PBL activities; (iii) aspects related to interdisciplinary communication needed to be introduced in the course; (iv) students inquired about the efficacy of the proposed methodology.	(i) the teacher was motivated to improve the CCN subject and the time spent to prepare the materials was a need for change. (ii) the network lab was assembled with the help of technical staff of the campus; (iii) the interdisciplinary communication was introduced in the course through successive meetings with the teachers of their subjects that were correlated with CCN; (iv) the students' resistance and distrust related to PBL were minimized with frequent dialogues and the appearance of relevant results produced in practice.
2013/2 – 2014/1	(i) many students had difficulties to understand how the Moodle worked; (ii) students criticized the PBL excess of activities, because they had difficulties to complete them; (iii) in phase 2, many students copied solutions from the Internet without understanding what they implemented and, sometimes, the source of research was not reliable.	(i) the teacher conducted a Moodle training, in order to reduce doubts about the platform; (ii) the number of PBL activities was decreased by nearly 20%, but the essential content was kept; (iii) some materials used by the students needed to be controlled. The teacher decided to prepare the students' material as a way to minimize the problems related to unreliable sources.

Table 5. The main challenges and solutions for the implementation of the CCN with Hybrid methodology

Year	Challenges	Problems Solution
2014/2 – 2015	The introduction of the new hybrid method presented the following aspects: (i) the dynamics of face-to-face class depended on students, i.e. they needed to study at home; (ii) the teacher had to monitor the students' activities inside and outside the classroom and an effective communication was necessary; (iii) extensive video-lectures presented, at times, to be ineffective, because students felt discouraged to watch it until the end.	(i) the flipped classroom method was introduced and the teacher had to explain the importance of the students' participation in order to support self-learning process; (ii) the popular applications helped the teacher monitor the students' participation in proposed activities and provided information swap. Thus, the communication became effective and the solution to the doubts were found more quickly; (iii) the video lecture length was reduced to 5 minutes at most because smaller recordings increased the probability that the students would watch the videos until the end. In addition, the transmission of the content was less tiring for them.
2016/1	(i) The laboratory had to be improved and to install and setup the academic Datacenter spent a lot of researchers' time; (ii) the energy power structure used in Datacenter was not enough to support all equipment simultaneously connected; (iii) the activities developed by graduate students depended on activities accomplished by vocational students.	(i) the students were included in organization of the lab, thus, they learned to install and configure the equipment, analogously to labor market; (ii) some network services were rationalized. There are ongoing projects to improve the energy power structure; (iii) the teacher needed to control the activities developed by vocational students and keep up with students communication at all times, using the popular tools.

vocational course. The students' evolution was dynamic, the learning process accelerated, and the activities developed in this method were improved compared with the PBL. Transversal skills were reinforced from the use of FC and PBL applied at different phases. The Moodle provided a dynamic and organized practical learning environment.

The proposed method can be expanded to other courses that involve practical activities. Adaptations of this method were introduced in the undergraduate course on Computer Science in the second semester of 2015 and in the first semester of 2016, for the subjects "Operational Systems" and "Computers Networks I", respectively. The Hybrid method needs to be consolidated in graduate courses, but the previous results indicate that this method can be applied in vocational and other practical courses.

8. Conclusion

The delivery and outcome of the Computer Communication Networks Course (CNN) were improved when the active learning was used in learning process. The new Hybrid method proved to be preferably recommended for vocational learning. However, it could be extended to undergraduate courses.

The hybrid method is indicated for small groups such as 20 students, because the teacher needs to guide the teamwork, motivate students, monitor the activities using Moodle, and provide individualized attendance, in order to minimize conflicts and clarify doubts.

The academic Datacenter changed the way the CCN was presented, and students were able to develop new practical activities common in labor market, such as: management of the network environment with specific software, and learn the basics of traffic analyses. The teachers created research groups, using the academic Datacenter, and promoted the interdisciplinary aspects between vocational and graduate students.

The students enrolled in this research approved the proposed method, and they developed transversal skills, such as self-confidence, teamwork, leadership, and presented more autonomy in decision-making. The Moodle and WhatsApp were excellent tools in learning process.

In the next semester, the CCN curriculum will be changed, i.e., more time will be allocated to practical activities in phase 3, and the time for simulation network shall decrease.

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Frederico Nogueira Leite is professor at The Federal Institute of Brasilia (IFB). He graduated in Computer Science from the Catholic University of Goiás (2004), obtained Master's (2006) and PhD (2017) in Electrical Engineering from the University of Brasilia (UNB). He has the experience in computer networks area, operation systems, image processing and engineering education.

Eduardo Shigueo Hoji received his BS in Electrical Engineering, his MSc and his Ph.D. from the UNESP—Ilha Solteira, Brazil, in 2004, 2006 and 2011, respectively. He is currently a professor at Federal Institute of São Paulo (IFSP)—Campus Birigui, SP, Brazil. In 2007, he was a visiting researcher at the University of Castilla-La Mancha, Ciudad Real, Spain. His main interests are in power systems analysis, operation and control and engineering education.

Huberto Abdalla Júnior is a professor at The University of Brasilia. Graduated in Electrical Engineering from the Federal University of Pernambuco (1972), holds a Master's degree in electrical engineering from the Pontifical Catholic University of Rio de Janeiro (1976), PhD in Telecommunications from Universuté Limoges (1982), post-doctorate from the Centre National D Etudes Des Telecommunications (1993) and post-doctorate from the Centre National D Etudes des Telecommunications (1989). He has experience in network telecommunications, working on the following topics: Linear Phase, Non-Minimum Phase, Polinomio Bessel and Engineering Education.