Following Up On the Examination of Accesses to Educational Resources in a Blended Learning Flipped Classroom Controls Course

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Abstract: This work addresses the accesses to abundant and varied courseware in a Controls Course taught in Blended Learning with flipped classroom. The time spam is the three terms 2021.1, 2021.2 and 2022.1. The course in mandatory in two Engineering curricula. The courseware had respectively 135, 165 and 158 items of different natures and digital formats; many interactive. Results are available as raw data for each students, each courseware item and date/time of access. In this work data are presented in aggregated form so that privacy is respected. The course was taught by the authors – one author in 2021.1, the other author in 2021.2 and jointly in 2022.1 The results have some common characteristics and other that are quite different.

Keywords: courseware, accesses, b-learning, flipped classroom

1. Introduction

The pandemic has had different impacts on the teaching/learning of Institutions of Higher Education (IHE). This is due to the fact that they had varied levels of use of ICT-Information and Communication Technology tools. This also happened in different areas/departments within institutions – some had been heavy users of ICT supported learning while others had been very traditional.

Faculty who were used to ICT supported teaching/learning had an opportunity to enhance their practices; this included offering additional courseware and relying more on communication functions offered by the Maxwell System (www.maxwell.vrac.puc-rio.br). This system is an integrated platform hosting a Learning Management System (LMS) [1], an Institutional Repository (IR) [2] and a Service Broker for Remote Labs [3]. This integrated platform is presented and discussed in [4, 5]. Different models for assessing student's results were implemented too.

This work addresses a specific aspect in the Controls and Servomechanisms course at Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio). The aspect to be discussed is how students have been using educational resources during the pandemic.

This work is divided in 4 sections besides this introduction. Section 2 introduces the course, Section 3 presents the resources available and refers to the first set of results in 2020 – first year of the pandemic [6]. Section 4 is devoted to presenting and interpreting usage data that were gathered from the platform and Section 5 comments the results.

2. The Controls and Servomechanisms Course

The Controls and Servomechanisms course is mandatory in two curricula of the university – Control and Automation Engineering (CAE), and Electrical Engineering (EE). When taught in the Traditional Face-to-face mode, it had 6h/week of lectures plus 2h/week of traditional brick-and-mortar lab activities. According to the Brazilian credit count, the course is a 6 credit course for the lecture part and 2 credit for the laboratory. The option to switch it to this learning mode was to make it closer to the definitions of credit units both in the European Community (http://ec.europa.eu/education/tools/docs/ects-guide_en.pdf) and the United States (https://www2.ed.gov/about/offices/list/ous/international/usnei/us/credits.doc).
This means putting more responsibilities on the students by making them active players in the process.

The course had been taught in the Blended Learning (b-learning) mode with flipped classroom for some semesters before returning to Traditional and finally switching back. B-learning follows the definition in page 5 of [7] which is presented in Table 1.

Table 1 – Prototypical Course Classification – page 5 [7]

Proportion of Content Delivered Online	Type of Course	Typical Description
0%	Traditional	(1)
1 – 29%	Web facilitated	(2)
30 – 79%	Blended / hybrid	(3)
80+%	Online	(4)

(1) Course with no online technology used – content is delivered in writing or orally.

(2) Course that uses web-based technology to facilitate what is essentially a face-to-face course. May use a course management system (CMS) or web pages to post the syllabus and assignments.
(3) Course that blends online and face-to-face delivery. Substantial proportion of the content is delivered online, typically uses online discussions, and typically has a reduced number of face-to-face meetings.
(4) A course where most or all of the content is delivered online. Typically has no face-to-face meetings

Flipped Classroom uses the definition found at The University of Texas at Austin Faculty Innovation Center webpage (https://facultyinnovate.utexas.edu/instructional-strategies/flipped-classroom).

"A flipped class is one that inverts the typical cycle of content acquisition and application so that:

- Students gain necessary knowledge before class, and
- Instructors guide students to actively and interactively clarify and apply that knowledge during class."

In March 2020, the course was ready to switch back to b-learning with flipped classroom. For this reason, it was very easy to move to remote learning when the university decided to do so due to the COVID-19 Pandemic – the synchronous sessions started being held on the Zoom Platform (zoom.us). There was abundant courseware though new materials started being developed and the synchronous sessions were recorded and made available to students.

In [6], the characteristics of the use of educational resources in 2020 were addressed. This work is a follow up of [6] so the characteristics of the classes in 2021.1, 2021.2 and 2022.1 must be presented. Table 2 contains the numbers of students and their overall results in the three terms 2021.1, 2021.2 and 2022.2.

Table 2 – Students in the classes in 2021.1, 2021.2 and 2022.1

Term	Enrolled	Dropped off	Failed	Passed
2021.1	33 (19 EE/14CAE)	6 (18.18%)	0 (0.00%)	27 (81.82%)
2021.2	16 (12EE/4CAE)	3 (18.75%)	2 (12.50%)	11 (68.75%)
2022.1	14 (11 EE/2CAE/1Int)	4 (28.57%)	1 (7.14%)	9 (64.29%)

CAE – Control & Automation Eng; EE – Electrical Engineering; Int – International Student.

Since 2020.1, the course has been taught with 3h/week of synchronous Zoom sessions and the equivalent of 3h/week of individual or group work solving assignments and using the courseware that is available from the platform. The characteristics of the courseware are described in the next section.

3. Available Courseware

Courseware started being developed in 1995 when ICT tools were very limited and the speed of the Internet very low. Very little is left from the first items of

courseware. But the development has never stopped – faculty, students (both graduate and undergraduate) and technical staff have been working hard all these years.

As time went by, ICT tools have been enhanced and the team has grown more experienced. For this reason, the number of items is constantly growing. The repository side of the platform manages all courseware that is classified as ER – Educational Resource. In 2018, an aggregator to facilitate the access to OER – Open Educational Resources was launched. It is named Open Educational Resources @PUC-Rio (www.maxwell.vrac.puc-rio.br/projetosEspeciais/OER/Home.php). Currently, there are 4,144 ER on the platform and 1,432 are in OA – Open Access.

The courseware for the Control and Servomechanisms course is made of both OA and restricted items. The items are: texts (classnotes, class annotations, sets of exercises to solve, study guides), interactive objects (hypermedia, simulators, course guide) and software code developed for specific activities (Cmap Tools, MATLAB® and Simulink®).

One very special item is the Course Guide. It is a large hypermedia file that outlines all the topics of the syllabus in the order they are addressed during the school term. It presents the main definitions and methods, suggests activities and has 23 short videos (no longer than 15 minutes) explaining some topics.

Every term, the course schedule is defined based on the Course Guide – the use of b-learning with flipped classroom requires the students to study before coming to the synchronous sessions; for each week the topics of the Guide are assigned in the Course Schedule on the platform. This is a very important characteristic of the course that will be mentioned when accesses are presented and analyzed.

Table 3 shows the types and numbers of courseware items in the three terms.

Table 3 – Courseware items in 2021.1, 2021.2 and 2022.1

Type		**2021.1**	**2021.2**	**2022.1**
Collection	Online Exercises (220)	1	1	1
Interactive content	Simulators	44	28	46
	Online Course Guide	1	1	1
	Hypermedia Objects	45	43	46
Video	Presentations	1	0	1
	Zoom Synchronous Sessions	29	28	28
Software	Cmap Tools	1	0	2
	MATLAB® / Simulink®	0	15	6
Text	Sets of Presentation Slides	2	8	5
	Study Cases and Guides	2	1	2
	Sets of Exercises to Solve	3	10	7
	Class Notes and Annotations	6	29	11
TOTAL		**135**	**165**	**158**

In 2020.1 and 2020.2, the total numbers were respectively 106 and 143 [7].

Section 4 presents data on the usage of the courseware. The data were gathered from the platform that manages students and contents in an integrated form. The platform offers many programs that yield data to faculty and administrators.

4. Accesses to Courseware

The objective of this section is to present and discuss the way courseware was used by the students in the three terms. The focus is on the Controls and Servomechanisms course.

The platform logs all accesses – even to courseware of other courses, to articles, to theses/dissertations, etc. These contents are available because it is an IR too. Data presented and discussed in this section are from accesses of courseware in Table 3; the system filters accesses to courseware of the course or presents all accesses – it is a decision of the user to examine either one or both.

Access data are presented in statistical numbers – averages and percentages to protect the privacy of information on students. When students' performances (grades) are addressed, the students are grouped in grade intervals and the averages of both grades and accesses are used.

In order to understand the numbers, it is important to mention that the grading system at the university is from 0.0 (zero) to 10.0 (ten), with one decimal place. The minimum passing grade is 5.0.

The importance of the Course Guide comes from the fact that the course schedule is based on it. The course schedule is structured on a weekly basis, so it is expected that each student accesses the Guide, at least, once a week. The term has 15 weeks.

Another characteristic that must be mentioned is that online sets of exercises are offered for students to solve. They have automatic grading and the average of the grades in such exercises are 20% of the final grade; two exams add 80%.

4.1 Accesses in 2021.1

In 2021.1, six students dropped the course (18.18%) as shown in Table 2. The ones who remained all passed the course and the lowest final grade was 6.2.

Table 4 shows average accesses and average grades computed for the 27 students. The intervals in the first column were defined by the students' grades while the third column is the average of the grades in the interval.

Table 4 – Accesses to courseware and grades by grade interval in 2021.1

Grade Interval	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
9.1 to 10.0	10	9.60	13.60	61.70	24.50	10.40	10.60	0.20	121.70	12.17
8.1 to 9.0	6	8.52	3.50	54.83	13.50	7.83	5.67	0.00	85.33	14.22
7.1 to 8.0	8	7.40	11.90	41.90	12.70	7.40	7.10	0.00	81.30	10.16
6.1 to 7.0	3	6.40	0.67	57.00	9.67	4.67	4.67	0.00	76.67	25.56

(1) Number of students.
(2) Average final grade.
(3) Average accesses to videos of the Zoom synchronous sessions.

(4) Average accesses to courseware in text format – PDF files of class notes, slides of video presentations, sets of problems to solve, etc.
(5) Average accesses to the Course Guide.
(6) Average accesses to Interactive Simulator Courseware.
(7) Average accesses to Interactive Hypermedia Courseware.
(8) Average accesses to software.
(9) Average accesses to all courseware.
(10) Average accesses to all courseware per student.

For this semester, the instructor chose to rely on the interactive simulators available at Maxwell to present and discuss the behavior of dynamic systems, rather than running simulations using a numeric software, such as MATLAB® or Scilab. This explains why there was barely any access to software material.

Note that the average number of accesses to all courseware was higher for the students with higher grades, showing the importance of the available materials for the learning process. In general, the students referred mostly to the Course Guide and PDF files (class notes, annotations and exercises) as source of material for studying, followed by the videos from the synchronous sessions and the interactive simulators.

The final grade for the course is composed of weekly assignments throughout the semester, worth 20% of the grade, and two exams, worth 80% of the grade. The number of average accesses to all materials per students (last column) was fairly similar, but it is interesting to note that the number of average accesses per student is higher for the students with the lower grades. One reason for this behavior is that these students generally received a lower grade at the first exam and had to increase the study workload to get a sufficient grade to pass in the second exam.

4.2 Accesses in 2021.2

In 2021.2, the term started with approximately half the number of students if compared to 2021.1. The percentage of students who dropped off was similar, but two students failed.

Table 5 shows average accesses and average grades computed for the 13 students who did not drop off. The meanings of the columns are the same. The grade intervals are different due to the grades that students got. The lowest passing grade was 5.6.

The software material was quite different in terms of offer. While in 2021.1 the software recommended to students was only Cmap Tools (https://cmap.ihmc.us/), in 2021.2, 15 pieces of MATLAB®/Simulink® code were offered for students to download and use.

Table 5 – Accesses to courseware and grades by grade interval in 2021.2

Grade Interval	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
8.1 to 9.0	2	8.65	68.50	87.00	2.50	5.50	6.00	20.00	189.50	94.75
7.1 to 8.0	3	7.33	19.00	81.00	6.67	3.67	7.33	1.67	119.33	39.78
5.0 to 7.0	6	6.28	57.00	100.50	6.33	6.67	6.67	20.67	197.83	32.97
< 5.0	2	4.25	56.00	95.00	7.50	3.00	3.00	6.50	171.00	85.50

In 2021.2, there were a few changes in methodology in relation to the previous semester. A digital drawing table was introduced. It allowed the instructor to save the class annotations in PDF files, similarly to a whiteboard, and make them available for the students. Figure 1 at the end of the subsection shows an example of an annotation.

In the flipped classroom mode, the students are expected to have studied the correspondent chapters of the week's topics in advance and the synchronous classes are mainly for solving exercises and clarifying students' questions about the topic. The drawing table allowed the students access to the step-by-step solution of exercises performed by the instructor during classes. This caused a significant increase in the number of accesses to the PDF materials and Zoom class videos. Furthermore, the instructor also used numeric software, such as MATLAB®, for solving exercises and carrying out simulations to illustrate real-world applications. The software code was also made available for the students, which explains the increased number of accesses to software material and slightly reduced accesses to interactive simulators.

In 2021.2, for the students that passed the class, the average number of accesses to all courseware per student was proportional to the students' grades, with the number of accesses significantly higher (over twice as many) for the students with the higher grades. Again, the PDF courseware and Zoom videos were the primary source of material for studying. There is also a similar behavior of increased accesses for students that failed the class, hoping to get a sufficient grade to pass in the second term.

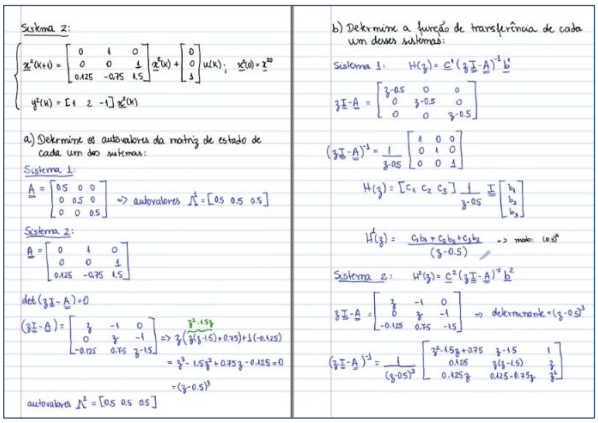

Figure 1. Example of an annotation.

4.3 Accesses in 2022.1

In 2022.1, the number of students when the term started was even lower than in 2021.2 and the percentage of students who dropped off was much higher (28.47%).

Table 6 shows average accesses and average grades computed for the 10 students who did not drop off. The meanings of the columns are the same.

Software was quite different from the other two terms if offer is considered. Cmap Tools (https://cmap.ihmc.us/) was recommended and six pieces of MATLAB®/Simulink® code were offered for students to download and use. A presentation in video was used too.

Cmap Tools was used because there is a Knowledge Map (KMap) of the course for students to track their (nonlinear) progress on the topics of the syllabus that are available on the platform. A KMap [8] is a Concept Map (CMap) [9] to which learning topics are added – in the case of this course the learning topics are instanced by digital courseware. Figure 2 shows a segment of the course KMap and implemented on the platform (not using Cmap Tools).

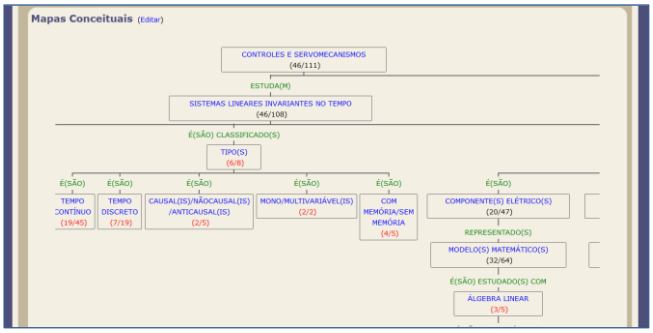

Figure 2. Segment of the course KMap.

Table 6 – Accesses to courseware and grades by grade interval in 2022.1

Grade Inteval	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
8.1-9.0	4	8.80	38.75	71.00	10.75	2.00	4.50	5.75	132.75	66.38
7.1-8.0	3	7.33	41.00	101.33	25.00	7.67	6.00	13.00	194.00	64.67
5.0-7.0	2	5.25	23.00	82.50	12.25	4.00	6.50	7.50	133.75	67.88
<5.0	1	0.50	0.00	10.00	0.00	3.00	4.00	0.00	17.00	17.00

This term had a special characteristic – it was jointly taught by the two instructors of 2021.1 and 2021.2. For this reason, Kmaps were used as well as annotations and pieces of MATLAB® code. Comments

The first comment to be made is that inspite the differences in types of courseware and performances of students, courseware is accessed.

The accesses to the videos of the Zoom sessions are quite different in the two terms – in 2021.2 the numbers are much higher. In this term, the instructor solved the problems in the sessions and made the PDF files of the solutions available on

the platform, Does this mean that students prefer to be taught than to learn by themselves? The accesses to Class Notes & Annotations show the same pattern and reinforce this perception.

Accesses to the Course Guide in the two terms were very different too. In 2021.1 students who scored 9.1 to 10.0 had and average number of accesses of 24.50 while the lowest tier (grades 6.1 to 7.0) had the average of accesses equal to 9.67. Does this mean that in 2021.2 students decided not to study before the classes because they knew the instructor would solve the problems? Does this explain the lower grades?

Accesses to software in 2021.2 yielded a positive result. They indicated that students use the code that is offered. This is an indication that investing time in this type of courseware is important.

5. Comments

In general, the average access to all courseware per student was similar in all grade intervals, except for the one student that failed the class. The PDF courseware and Zoom videos were the primary sources of material for studying, but there is a slight increase in access to the Course Guide in comparison to 2021.2. Approximately two-thirds of the synchronous lectures were mainly given by the instructor of 2021.1 that did not make available the exercises' solutions during the classes and focused more on discussing the students' questions and the activities of the Course Guide, which may explain this difference. For the last third of the semester, the synchronous lectures were mainly given by the instructor of 2021.2 that solved the exercises and used numeric software for dynamic simulations, which was reflected in the number of accesses to software material and the number of access to Zoom videos compared to 2021.1.

Another platform that is also available for professors at PUC-Rio is Moodle, a free online Learning Management System (LMS) that allows teachers to upload the class courseware, create forums for questions, track the students' access statistics, release test grades, among other features. Moodle is widely employed by several institutions and its interface is generally easy to use. Maxwell, on the other hand, is a platform fully developed in Brazil, at PUC-Rio, and it is not only a LMS, but it hosts the repository of all academic production of the university, and several other educational resources. Both systems have similar features, but the main difference is that the courseware material hosted by Maxwell is not contained to a specific classroom, but it can be made available to everyone that has access to the platform, including other students and professors. Also, it is easier and more intuitive to visualize statistics on the students' accesses to the available materials. The professor can easily access an interactive table with the number of accesses of each student, material, or both. One downside is that every new file has to be uploaded on the system by one of the Maxwell librarians, not by the professors themselves, since all the material needs to be described according to the international metadata standards.

Furthermore, Maxwell provides a tool for students to monitor their own progress on the course using Concept Maps [9].

A final comment is related to b-learning – it can be used for training in the corporate world. B-learning was one of the modes used to train professional teams [10].

References

1. Wright, C.R., Lopes, V., Montgomery, T.C., Reju, S.A., Schmoller, S. (2014) Selecting a Learning Management System: Advice from an Academic Perspective, EDUCAUSEReview (https://er.educause.edu/articles/2014/4/selecting-a-learning-management-system-advice-from-an-academic-perspective), USA.
2. Lynch, C. (2003) Institutional Repositories: an essential infrastructure for scholarship in3. the digital age. ARL Bimonthly Report, no. 226, USA, ARL.
3. Heradio, R., Torre, L., Galan, D., Cabrerizo, F.J., Herrera-Viedma, E., Dormido, S. (2016) Virtual and Remote Labs in Education: a Bibliometric Analysis. Computer & Education (98), pp. 14-38.
4. Pavani, A.M.B., Barbosa, W.S., Calliari, F., Pereira, D.B.C., Lima, V.A.P.,Cardoso, G.P. (2017) Integration of an LMS, an IR and a Remote Lab. In: Auer, M., Zutin, D. (eds.) Proceedings of Remote Engineering and Virtual Instrumentation 2017 (REV2017), USA, pp. 957-972. Springer, Heilderberg.
5. Temporão, G.P., Pavani, A.M.B. (2019) The Integration of na Institutional Repository and a Learning Management System: a case Study. In: Chova, L.G, Martínez, A.L., Torres, I.C (eds.) Proceedings of International Technology, Education and Development Conference (IATED2019), pp. 3314-3320, IATED Academy, Spain.
6. Pavani, A.M.B. (2022). Examining Accesses to Educational Resources in a Blended Learning Flipped Classroom Controls Course in 2020. In: Auer, M.E., Hortsch, H., Michler, O., Köhler, T. (eds) Mobility for Smart Cities and Regional Development - Challenges for Higher Education. ICL 2021. Lecture Notes in Networks and Systems, vol 389. Springer, Cham. https://doi.org/10.1007/978-3-030-93904-5_91.
7. Allen, I. E., Seaman, J. (2010) Class Differences: Online Education in the United States, 2010, The 8th Annual Report on the State of Online Learning in U.S. Higher Education, Babson Survey Research Group, retrieved from https://files.eric.ed.gov/fulltext/ED529952.pdf in March 2019.
8. Castles, R, Lohani, V. K., Kachroo, P. (2008) Knowledge Maps and Their Application to Student and Faculty Assessment, Proceedings of the 38th ASEE/IEEE Frontiers in Education Conference, United States, October 2008, pp. S4A-9-15. Available https://dx.doi.org/10.1109/FIE.2008.4720666.
9. Novak, J. D., Cañas, A. J. (2008) The Theory Underlying Concept Maps and How to Construct and Use Them, Technical Report IHMC Cmap Tools 2006-1 Rev 01-2008, Florida Institute for Human and Machine Cognition, United States, 2008. Available https://cmap.ihmc.us/docs/theory-of-concept-maps. Last accessed July 2022.
10. Samaka, M., Ally, M. (2015) Work in Progress: Use of Mobile Technology to Deliver Training in Blended Learning and Independent Study Formats, Proceedings of The 2015 IEEE Conference on Teaching Assessment and Learning Engineering (TALE), China, December 2015, pp. 122-126.