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Maximizing learning in online courses using critical thinking, project-based learning, and flipped classroom approaches

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APPENDICES

Appendix A:

Week	Learning objective	Critical thinking activities
01	To understand the course structure	In this week we presented the learning objectives, the educational approach (PBL and the flipped classroom), the course website and the forum for discussion. The students were asked to choose the project themes. Explanation of the course rules and critical thinking activities.
02	To understand the concept of System Thinking and System Archetypes	Test: Evaluation of the learning Review of the answers Workshop goal: To understand the concept of a system´ archetype by means of group modelling exercise, where the students were challenged to figure out the similarities of four institutions (prisons, orphanages, military academies). Tool used: Padlet
03	To learn about systems characteristics and systems structure	Test: Evaluation of learning Review of the answers Discussion about the readings and videos. Workshop: Understand the concept of patterns of behavior and system structure. Critical analysis of the movies “The Wave” (1981) and “Blue Eyes/Brown Eyes” (1992) (documentaries about fascisms and racism)

		Representation of the forum discussion through a mind mapping activity. Tool used: Mind Mapping (using the software Lucidchart)
04	To learn about mental models	Test: Evaluation of learning Review of the answers Discussion about the readings and videos. Workshop: Understand the concept of mental models. Critical analysis of Ceaucescu's birth control policy (Romania,1967). Tool used: Padlet
05	To learn how to represent causal links and feedback loops	Test: Evaluation of learning Review of the answers Workshop: Representing causal links and feedback loops, based on the documentary "The Social Dilemma" Tool used: Google Forms and VensimPle
06	To understand the concept of critical Thinking	Test: Evaluation of learning Review of the answers Workshop: Analyze critically the recent declarations of Brazilian President and ministers of the state Tool used: Stella Cotrell´s framework and Google Forms
07	Project presentation	Each group presented the project activities accomplished and the project´s website
08	Modelling exercises	Test: Evaluation of learning Review of the answers Workshop: Individual modelling activity, modelling the dynamics portraited in the documentary "Food Inc." Tool used: VensimPle and Google Forms
09	Modelling exercises	Test: Evaluation of learning Review of the answers Workshop: Individual modelling activity, modelling the dynamics portraited in the documentary "Food Inc." Tool used: VensimPle and Google Forms
10	Modelling exercise	Test: Evaluation of learning Review of the answers Workshop: Individual modelling activity, modelling the dynamics in the interview with an expert (Priscila Cruz) about the educational system in Brazil. Tool used: VensimPle and Google Forms
11	Project final presentation (part 1)	The first half of the groups presented their projects, the projects' websites and the videos created.
12	Project final presentation (part 2)	The second half of the groups presented the projects, the projects' website and the videos created.

Table A.1: This table present the course development, week by week, from the beginning of the course (week one) to the end of the course (week twelve). It presents the learning objective of each synchronous meetings and details the critical thinking activities accomplished during the meeting.

Appendix B:

Criteria	**Degree**
Criterion 01: Analysis of concepts under different perspectives	□ Always □ Very often □ Sometimes □ Rarely □ Never
Criterion 02: Reflection and interpretation of the content that was presented and the facts that supported them	□ Always □ Very often □ Sometimes □ Rarely □ Never
Criterion 03: Analysis and evaluation of arguments.	□ Always □ Very often □ Sometimes □ Rarely □ Never
Criterion 04: Identification of logical fallacies and contradictions	□ Always □ Very often □ Sometimes □ Rarely □ Never
Criterion 05: Evaluation of the trustworthiness and accuracy of the sources of information	□ Always □ Very often □ Sometimes □ Rarely □ Never

Table B1. This table presents the form we created to evaluate the discussion forum activities. It shows the five criteria we defined. Each criterion was evaluated under five different degrees. The degrees were specified in another form, that we used in conjunction with this one (Table B2).

Degree	**Percentage of the students that met each criterion**
Always	81% to 100%
Very often	61% to 80%
Sometimes	41% to 60%
Rarely	21% to 40%
Never	0% to 20%

Table B2. This table presents the form that we used to quantify the degree in which the students met each criterion defined previously. The degrees were based on percentage of the students that met each criterion, from the highest (80%-100%) to the lowest (0 to 20%).

Appendix C:

	Criterion 01: the quality of the group modelling processes	**Criterion 02**: the quality of the reflective learning records	**Criterion 03**: quality of the product created (videos)
Project	□ Excellent □ Good □ Fair □ Poor □ Very poor	□ Excellent □ Good □ Fair □ Poor □ Very poor	□ Excellent □ Good □ Fair □ Poor □ Very poor

Table C.1 This form was used to evaluate the team learning, following three different criteria. We evaluated the quality of the group modelling processes, the quality of the reflective learning records and the quality of the videos created by each team. Each criterion was evaluated under five degrees (excellent, good, fair, poor, very poor). The degrees were specified in another form, that we used in conjunction with this one (Table C.2).

Degree	**Students' achievement**
Excellent	The students achieved far more than expected
Good	The students achieved more than expected
Fair	The student achieved what was expected
Poor	The student achieved less than expected
Very poor	The student achieved far less than expected

Table C.2 This form was used in conjunction with the previous form. We evaluated the degrees in which the teams met each criterion. We evaluated the teams based on how we expected them to perform and what was achieved.

Group	**Project**
Project 01	The dynamics of pandemics
Project 02	The dynamics of agricultural production
Project 03	The dynamics of livestock production systems
Project 04	The dynamics of fishery
Project 05	The dynamics of recycling
Project 06	The dynamics of educational systems

Table C.3 This table presents the project themes (themes chosen by the students). Each theme addresses a systemic problem. The teams researched about each problem and created models that represent the main dynamics that drive the problems.

Appendix D:

Questionnaire sent to students:

Question 1: What did you learn from your participation in the discussion forum?
Question 2: What did you learn by working in your project?
Question 3: What did you learn from studying prior to the class (flipped classroom experience)?
Question 4: How can you evaluate our synchronous meetings?
Question 5: How can you evaluate the professor´s feedback (in video format)?
Question 6: Tell me about your experience of using critical thinking tools in your project. What did you learn from using critical thinking tools?
Question 7: Tell me about the studies of the week. How useful were the articles and documentaries to your learning?
Question 8: Tell me about your experience of creating models to represent real-life systemic problems. What did you learn from it?
Question 9: Tell me in which way you may apply what you learned in this course.
Question 10: Is there something else that you want to report?