Online Teaching and Active Learning:
Flipping the Classroom

Patrizia Busato
Remigio Berruto
Angelica Nicholson
Fedro Zazueta

Office of Academic Technology
UF Information Technology
University of Florida, Gainesville FL
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About the Workshop Conductors:

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Dr. Patrizia Busato is a Research Associate at the University of Turin, Italy. Dr. Busato is conducting research on the student preference and performance under instruction using active learning pedagogies when compared to traditional face-to-face delivery. Member of INFITA, ASABE and CIGR.

Dr. Remigio Berruto is an Associate Professor at the University of Turin, Italy. Dr. Berruto is an early adopter of Flipped Classroom pedagogy applied to the instruction of agricultural and biosystems engineers on the logistics of the agro-food chain. Member of INFITA, ASABE and CIGR.

Ms. Angelica Nicholson is a Senior Instructional Designer at the Center for Instructional Technology and Training at the University of Florida. She consults and provides assistance to faculty related to the use of best practices in online learning, with a particular focus on active learning and the flipped classroom. Member of the Online Learning Consortium.

Dr. Fedro Zazueta is Director of Academic Technology, Office of Information Technology, and professor at the University of Florida. He is charged with providing all services related to creation and delivery of online courses. Member of INFITA, Fellow of ASABE and CIGR, Member of the International Academy of Agricultural and Biosystems Engineering.

Online Learning

Online learning has been broadly recognized as strategically important to address global needs of education. As early as 1998 UNESCO articulated a vision and framework for priority action for change and development in higher education (UNESCO, 1998). As information technology (IT) made access to information ubiquitous, its importance to support and enable strategic actions at national levels became evident. The US National Technology Plan (US Department of Education, 2010) presented a model for learning powered by technology based on the premise that advances in learning sciences and understanding how people learn coupled with rapidly evolving developments in technology create new challenges and opportunities for higher education. The European Commission (2010) articulated the importance of the innovation and modernization as fundamental to transform Europe into a competitive and inclusive economy. In a similar manner, other countries such as Italy (MIUR, 2013) and China (World Bank, 2007) have incorporated IT into their education strategy as well as programs enabled by IT to improve outcomes of research and education institutions.

The Italian Ministry of Education launched their 2007 National Plan for Digital Schools (Piano Nazionale Scuola Digitale). However, a review of the plan commissioned to the Organization for Economic Co-operation and Development (OECD) by the Ministry found that Italy lags behind other European countries in the adoption of IT in education (Avvisati et al., 2013). The report adjudicates the lack of progress towards the desired outcomes to current budgetary constraints. This general state of use of IT in education is also reflected in agricultural and biological engineering programs. It is thus necessary that investments in IT in education not only improve learning outcomes, but also reduce the cost of instruction. Past experience demonstrated that this is achievable given the right investments and adoption of IT in education. A review of 156 redesigned courses involving 195 institutions and ~250,000 students showed that in 72% of the courses learning outcomes were improved, while in 28% there were no improvements. In addition, the cost of instruction was reduced on the average by 34% instruction (NCAT, 2014). Online delivery is now common place in strategic plans related to teaching and learning in higher education for top-ranked universities. This is often associated to improving learning outcomes, reducing the cost of instruction and innovation in teaching/learning (Williams et al., 2012).

It is clear that online teaching/learning works. Online teaching/learning is generally accepted as a direction for higher education institutions as an opportunity to modernize their work and create new channels that improve creative, entrepreneurial and critical thinking skills of students. The issues that remain are related to finding the most effective and efficient ways to deliver this form of instruction (Bateman & Davies, 2014). For higher education in agricultural and biological engineering programs, challenges remain as a result of scarce budgetary resources for initial investments and the disruptive nature of the technology stemming from the cultural, historic and economic context.

Passive and Active Learning

Passive learning occurs when students are engaged solely in taking in information. Examples of this include: Reading materials, listening to a lecture, watching a video, and looking at photos, diagrams or PowerPoints. Passive learning is primarily an individual activity in which students learn by assimilating the information presented. The traditional college classroom is primarily passive.

Active learning occurs when the students are focused on doing, with the course content and activities designed to increase and enhance their understanding of a topic. Some examples of activities that encourage active learning are: Online discussions/debates, group projects, concept mapping, role playing, content related games, and problem solving. Active learning includes activities that encourage the application, deeper understanding, and discovery of new knowledge. In engineering, for example, this may take the form of providing a solution to an engineering problem or designing a system.

Social activities are particularly suited for active learning. Where students critique, collaborate and generate a deep understanding of the knowledge acquired. In this context, the role of the instructor is one of directing and supporting. This puts the responsibility of learning on the shoulders of the students, with instructor as support.

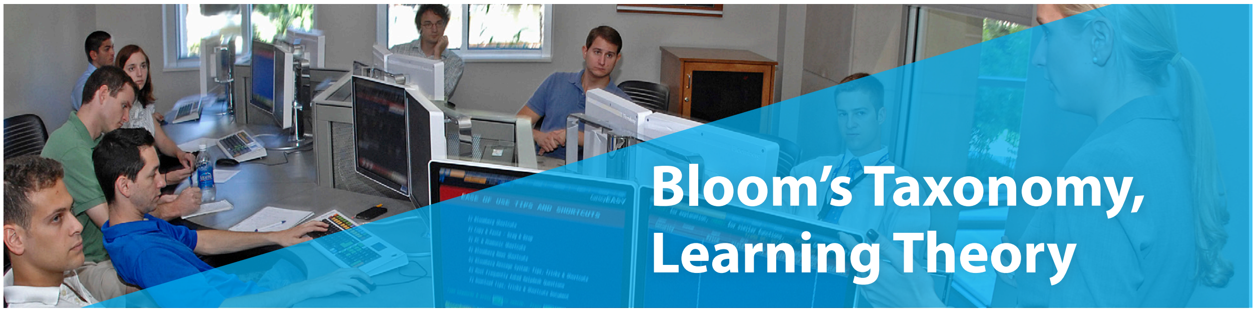
Best Practices

- Focus on the student, make learning student-centered
- Create an environment where students are thinking about what they are learning
- Ask meaningful questions that focus on the deeper meaning instead of the minor details
- Give students opportunities to collaborate and learn from each other
- Create meaningful activities that give students the opportunity to apply new knowledge
- Create multiple ways of interacting with students. Be available to guide and assist as students work through the coursework

Resources

- *http://web.calstatela.edu/dept/chem/chem2/Active/main.htm*
- *http://josotl.indiana.edu/article/view/1744*
- *http://www.icte.org/T01_Library/T01_245.PDF*
- *http://www.league.org/gettingresults/web/module3/active/index.html*
- *https://odee.osu.edu/active-learning*

[1] See: *http://citt.ufl.edu/online-teaching-resources/*



Bloom’s Taxonomy, Learning Theory

Bloom’s Taxonomy

To promote higher forms of thinking in education a taxonomy was created (Bloom, et al., 1956) in three domains of educational activity:

1. Cognitive: Mental skills (knowledge).
2. Affective: Growth in feelings or emotional areas (attitude or self).
3. Psychomotor: manual or physical skills (skills) used.

Over time, Bloom’s cognitive taxonomy was revised into its current form (Anderson et. Al, 2001):

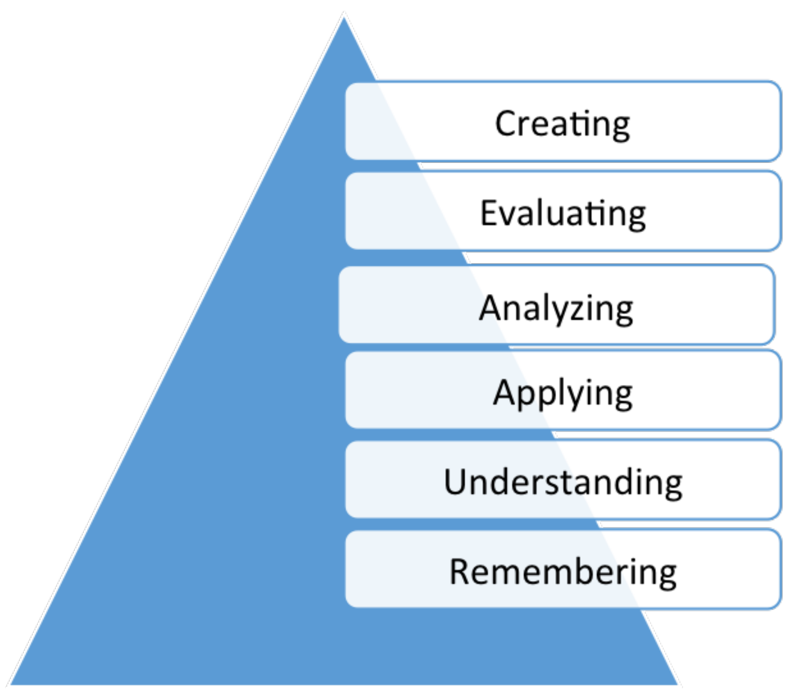


Figure 1: Revised Bloom’s Taxonomy in the Cognitive domain

A description of each level of the taxonomy and examples of related behavior follows below:

Remembering: Recall or retrieve previous learned information. (The student defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states).

Understanding: Comprehending the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words. (The student comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates).

Applying: Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place. (The student applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses).

Analyzing: Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences. (The student analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates).

Evaluating: Make judgments about the value of ideas or materials. (The student appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports).

Creating: Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure. (The student categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes).

Bloom's revised Taxonomy also added the concept of a knowledge matrix to add a cognitive dimension (**Table 1**):

Knowledge Dimension	Levels of Knowledge Remember	Understand	Apply	Analyze	Evaluate	Create
Facts	*List*					
Concepts		*Explain*				
Processes			*Solve*			
Procedures						*Develop*
Principles				*Rank*	*Justify*	
Metacognitive			*Use*			*Create*

Table 1

Cognitive Processes and Knowledge Level Matrix *(examples)*

Where:

Facts: A specific and unique data or instance.

Concepts: A class of items, words, or ideas that are known by a common name, includes multiple specific examples, shares common features. There are two types of concepts: concrete and abstract. It includes knowledge of terminology and of specific details and elements.

Processes: A flow of events or activities that describe how things work rather than how to do things. There are normally two types: business processes that describe work flows and technical processes that describe how things work in equipment or nature. They may be thought of as the big picture, of how something works. It includes knowledge of classifications and categories, principles and generalizations, theories, models and structures.

Procedures: A series of step-by-step actions and decisions that result in the achievement of a task. There are two types of actions: linear and branched. It includes knowledge of subject-specific skills and algorithms, techniques and methods, and the criteria for determining when to use appropriate procedures.

Principles: Guidelines, rules, and parameters that govern. It includes not only what should be done, but also what should not be done. Principles allow one to make predictions and draw implications. Given an effect, one can infer the cause of a phenomena. Principles are the basic building blocks of causal models or theoretical models (theories).

Metacognition: Includes strategic knowledge, knowledge about cognitive tasks including appropriate contextual and conditional knowledge, self-knowledge.

Action Words for Bloom's Taxonomy					
Knowledge	Understand	Apply	Analyze	Evaluate	Create
Define	Explain	Solve	Analyze	Reframe	Design
Identify	Describe	Apply	Compare	Criticize	Compose
Describe	Interpret	Illustrate	Classify	Evaluate	Create
Label	Paraphrase	Modify	Contrast	Order	Plan
List	Summarize	use	Distinguish	Appraise	Combine
Name	Classify	Calculate	Infer	Judge support	Formulate
State	Compare	Change	Separate	Compare	Invent
match	Differentiate	Choose	Explain	Decide	Hypothesize
Recognize	Discuss	Demonstrate	Select	Discriminate	Substitute
Select Examine	Distinguish	Discover	Categorize	Recommend	Write
Locate	Extend	Experiment	Connect	Summarize	Compile
Memorize	Predict	Relate	Differentiate	Access	Construct
Quote	Associate	Show	Discriminate	Choose	Develop
Recall	Contrast	Sketch	Divide	Convince	Generalize
Reproduce	Convert	Complete	Order	Defend	Integrate
Tabulate	Demonstrate	Construct	Point Out	Estimate	Modify
Tell	Estimate	Dramatize	Prioritize	Find Errors	Organize
Copy	Express	Interpret	Subdivide	Grade	Prepare
Discover	Identify	Manipulate	Survey	Measure	Produce
Duplicate	Indicate	Paint	Advertise	Predict	Rearrange
Enumerate	Infer	Prepare	Appraise	Rank	Rewrite
Listen	Relate	Produce	Break Down	Score	Adapt
Observe	Restate	Report	Calculate	Select	Anticipate
Omit	Select	Teach	Conclude	Test	Arrange
Read	Translate	Act	Correlate	Argue	Assemble
Recite	Ask	Administer	Criticize	Conclude	Choose
Record	Cite	Articulate	Deduce	Consider	Collaborate
Repeat	Discover	Chart	Devise	Critique	Collect
Retell	Generalize	Collect	Diagram	Debate	Devise
Visualize	Give Examples	Compute	Dissect	Distinguish	Facilitate
	Group	Determine	Estimate	Editorialize	Imagine
	Illustrate	Develop	Evaluate	Justify	Infer
	Judge	Employ	Experiment	Persuade	Intervene
	Observe	Establish	Focus	Rate	Justify
	Order	Examine	Illustrate	Weigh	Make
	Report	Explain	Organize		Manage
	Represent	Interview	Outline		Negotiate
	Research	Judge	Plan		Originate
	Review	List	Question		Propose
	Rewrite	Operate	Test		Reorganize
	Show	Practice			Report
	Trace	Predict			Revise
	Transform	Record			Schematize
		Schedule			Simulate
		Simulate			Solve
		Transfer			Speculate
		write			Structure
					Support
					Test
					Validate

Figure 2: Bloom Taxonomy's verbs

http://www.teachthought.com/learning/249-blooms-taxonomy-verbs-for-critical-thinking/

Learning Theory

This workshop is not intended to review learning theory. However, it is important for the practitioner to have some basic understanding of it. The three most prominent learning theories are known as behaviorism, cognitivism and constructionism.

Behaviorism is a world-view that operates on a principle of "stimulus-response". It assumes that a learner is essentially passive and responds to external stimuli. The learner starts as a "tabula rasa" and behavior is shaped through positive or negative reinforcement. Learning is defined as a change of behavior in the learner.

Cognitivism is a paradigm where the learner is viewed as an information processor. Knowledge is seen as a schema, or symbolic mental construction. Learning is a change in in a learner's schemata. Cognitivism responds to behaviorism by recognizing that people require active participation in order to learn and changes in behavior are an indication of what occurs within the learner's brain.

Constructivism postulates that learning is an active and constructive process in which the learner is the information constructor. (An individual constructs his/her own subjective reality linked to prior knowledge). It views learning as an active and contextualized process in which knowledge is constructed (as opposed to acquired). This construction is based on the learner's personal experience and hypothesis about the environment, bringing past experiences and cultural factors into a learning situation.

The takeaway from these learning theories as it relates to pedagogy in engineering is that behaviorism helps in understanding and articulating learning expectations in terms of conduct. Constructivism, on the other hand, helps understand how higher levels of learning can be achieved through social interaction.

Instructional Design in a Nutshell

Instructional design is a methodology used to produce learning materials. In contrast to curriculum design which focuses on what the student will learn, Instructional design focuses on how the student will learn. Instructional design is systematic and uses learning theory and best pedagogical practice to ensure the quality of learning.

The Development Team

In applying this methodology for an engineering course, it is important for the instructor to understand what his/her role is in the process. In particular, that formal development of a course is done by a team of individuals with different competencies that contribute to a successful product. There are three primary roles:

1. **Instructor.** The instructor is a subject matter expert knowledgeable of the curriculum, responsible for articulating the learning objectives, assessment items and learning activities that compose the course. The role of the instructor is to define what is to be learned and work with the instructional designer on the best way on how this can be done. In addition, to engage in a process of continuous improvement of the course.

2. **Instructional designer.** The instructional designer is an expert in education, skilled in educational technology, pedagogy, and project management. Responsible for management of the project, ensuring the quality of the content and assisting the instructor in developing high quality learning objectives, suitable assessments, learning assets, and pedagogically sound delivery of the course. A competent and experienced instructional designer is key to the success of a course in producing the desired outcomes.

3. **Support staff.** Depending on the specifics of the pedagogy selected and the type of learning assets used in the course, the team may require web developers, programmers, graphic artists, videographers, transcribers, etc.

The ADDIE Methodology

ADDIE is a common methodology for instructional design. This methodology is well tested and is composed of the five phases shown in Fig. 3.

The major activities that take place during each of the phases of ADDIE are:

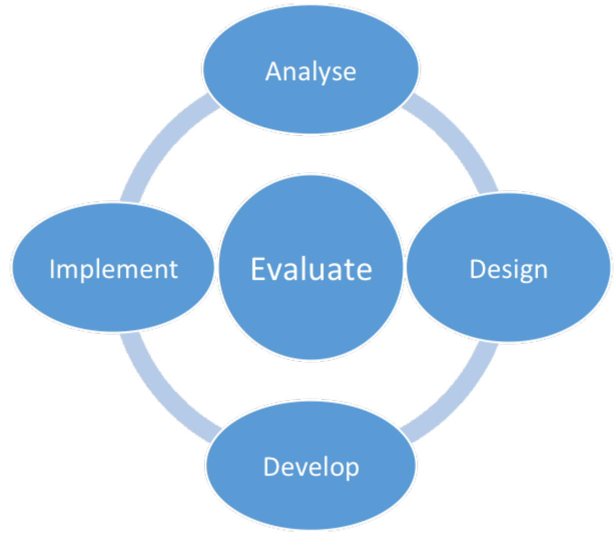


Figure 3: The ADDIE methodology

1. **Analysis.** The primary purpose is to articulate clearly what the instructional problem is. Instructional goals and objectives are established at this level, as well as identifying learner knowledge and skills.

2. **Design.** This stage focuses on developing learning objectives, assessment items, and learning assets. It follows a logical and orderly method for identifying, developing and evaluating strategies to attain the course's goals. This stage requires great attention to detail.

3. **Development.** In this stage the instructional designer works with the staff to create and assemble the learning assets that were designed in the previous phase. Includes testing and debugging. In general, this process will move forwards quickly if the design phase is executed carefully.

4. **Implementation.** During the implementation phase all functional components of the course are assembled. Also, training for the instructor is provided. It is a good practice to develop a manual that covers course curriculum, learning outcomes, methods of delivery and student assessment procedures. It may also be required to conduct training for the learners.

5. **Evaluation.** Performance methods are used to measure how well the objectives were achieved. That is, the level of success the learner reaches in retaining and demonstrating acquired skills and understanding. As a general guideline, the evaluation focus can be on understanding of the material, long term retention, and critical thinking skills. Also important at this stage, is to measure how well the course materials facilitate effective learning by the student.

Tip

- The instructional designer knows better. Let him/her do his/her job.

Resources

- 37 Great Resources on Instructional Design
- Instructional Design Resources for Assessment
- The ADDIE Model

The Flipped Classroom

Advances in technology and learning theory and practice have created new directions and opportunities for pedagogy in engineering education. A pedagogy currently receiving much attention is the flipped classroom. The flipped classroom is unique in its combination of active, problem-based learning constructivist ideas and direct instruction methods based on behaviorist principles (Bishop & Verleger, 2013). This pedagogical approach is enabled by technological advances that permit the transmission and duplication of information at very low cost and various means, and the trend in education to make learning student centered.

Consensus on a flipped classroom definition is lacking (Chen et al., 2014). A simple definition of inverted classroom is given by Lage (2000). By this definition, activities that traditionally take place in the classroom, take place outside the classroom in a flipped classroom, and vice versa. In this this workshop, a definition of flipped classroom will be used that accommodates theoretical frameworks by defining the flipped classroom not in terms of what is done in the traditional classroom, but in terms of human interaction. Thus, a flipped classroom is one in which learning activities not requiring human interaction take place outside the classroom (enabled by technology) and learning activities requiring human interaction take place in the classroom (virtual or physical). Figure 4 illustrates this definition of the flipped classroom. Note that by this definition of a flipped classroom activities requiring human interaction may occur face-to-face or virtually and in synchronous and asynchronous manners.

In this work, the focus of activities not requiring human interaction is for the student to understand and apply basic concepts related to the subject matter of the course in preparation for activities requiring human interaction that focus on higher levels of learning in Bloom's taxonomy (Krathwohl, 2002).

Some activities that do not require human interaction are readings , video, closed-problem solving and quizzes. Early studies show that quality video lectures outperform traditional lectures (Cohen et al., 1981). Also, online homework is equally effective as paper and pencil (Bonham et al., 2003; Fynewever, 2008). These, coupled with quizzes for self-evaluation (Stallings & Tascoine, 1996) provide a solid basis for the student to engage in activities requiring human interaction focused on higher level skills such as communicate effectively; identify, formulate and solve engineering problems; and, work in teams.

Specific activities requiring human interaction include the use of face-to-face and online discussion boards used to post and answer questions (students and faculty alike) and carefully crafted open-ended problems. This approach provides an opportunity to develop activities for active learning (Michael, 2006), cooperative learning (Foot & Howe, 1998), peer-assisted- learning (Topping & Ehly, 1998), and problem based learning (Barrows, 1996).

It is important to note that activities are not limited to those shown in Fig. 4. The number and type of activities can be diverse provided they focus on efficiently achieving a learning outcome and the learning style of the students (Zimmerman et al., 2006).

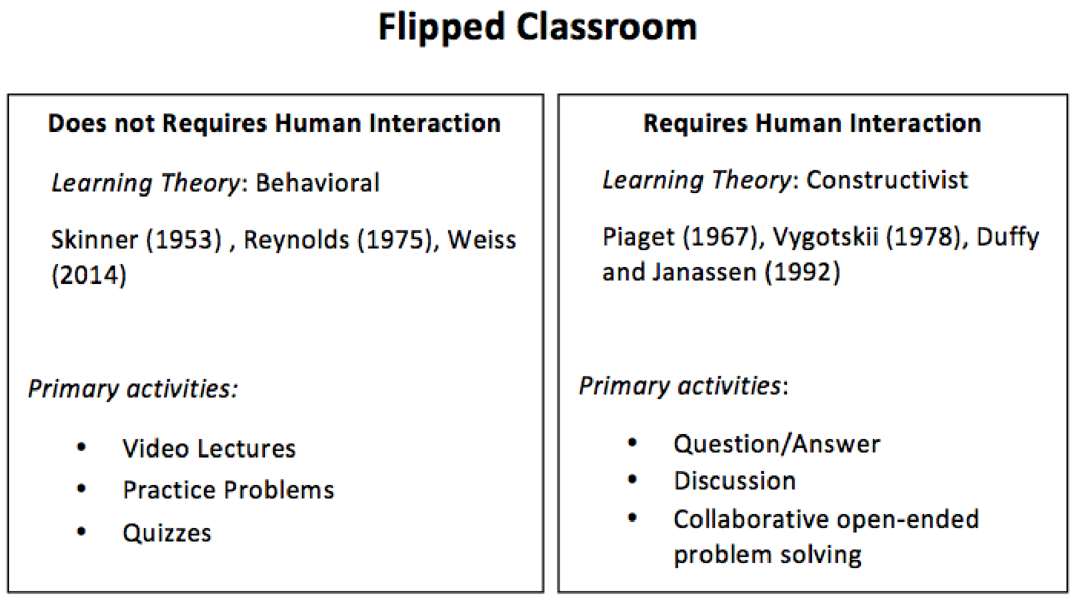


Figure 4: Definition and theoretical framework of a flipped classroom.

Research Findings on the use of the Flipped Classroom

There is abundant literature on use of the flipped classroom mode of instruction. However, little work has been done in using this approach in agricultural engineering education. Research carried out by the workshop conductors focused on evaluating preference and performance of students in a Flipped-Classroom mode of instruction when compared to traditional face-to-face. Students in an Agro-food Chain Logistics course where subjected to both forms of instruction. After completion, students were asked to fill a survey on questions related to their perception and preference about the modality of the course. The survey used a Likert scale and the results are shown in **Fig. 5**.

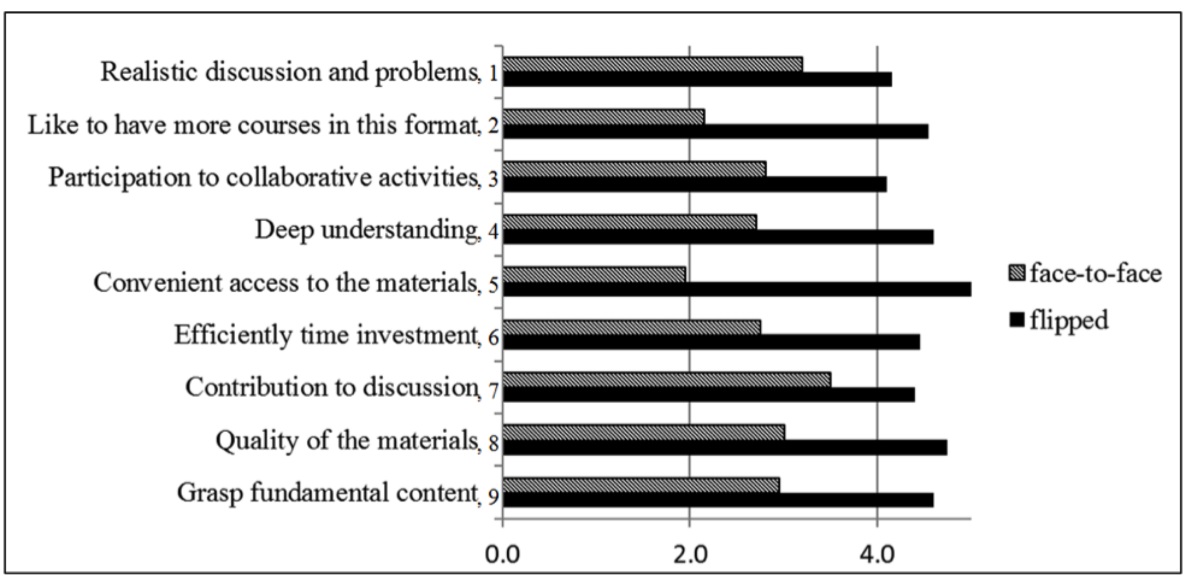


Figure 5: Comparison of answers to student preference between flipped-classroom and face-to-face instruction.

In addition, students in both modes of instruction were subjects of the same high stakes assessment. Their performance is shown in **Table 2**.

Table 2
Student performance (grades) in high-stakes tests*.

	Module 1			Module 2			Wicoxon Signed Rank Test		
	Mean	Median	Standard deviation	Mean	Median	Standard Deviation	N	Standardized Test Statistic	P-Value
Group A	100	100	0	78.47	93.75	25.9	6	-2.226	0.026
Group B	62.38	66.67	20.2	97.62	95.83	2.2	7	2.205	0.027

*Highlighted cells correspond to student's test scores for the Flipped Classroom modality of instruction.

The relevant conclusions of the study are:

1. Students show a strong preference for the flipped-classroom over the face-to-face delivery of the course.
2. Students performed better in a high stakes assessment when learning the course materials in the flipped-classroom mode of instruction.

It is also notable, that the students learning under the flipped classroom format performed, not only at a higher level, but also more uniformly as is shown by the standard deviation of the grade scores.

Best Practice

- Create quality pre-recorded lectures that relay the course content effectively (substantial pre-planning and prep work required before pilot semester)
- Reduce lectures to manageable segments (about 15 minutes)
- Develop classroom activities that promote Active Learning. Students should be applying the knowledge gained from lectures and readings. (i.e., case studies, debates, discussions, group projects, problem solving, presentations, individual assignments, educational games)
- Avoid "busy work" to simply fill the time
- Be available during class time to assist and facilitate. Circulate, be prepared to guide and encourage active learning in a student-centered environment. Interact with the class
- Provide printable transcripts where possible

Resources

- *http://educationnext.org/the-flipped-classroom/*
- *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2665262/*
- *http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6481483*

[2] See: *http://citt.ufl.edu/online-teaching-resources/*

Group Exercise:
Creating a Learning Objective

A learning objective is a clear statement describing what a student is expected to learn from a lesson. It provides details of what the student will do after completing the instruction process. A learning objective is composed of the following:

1. An action verb that identifies a measurable behavior of the student.
2. A description of the condition under which the behavior is to be performed
3. A criteria or standard defining acceptable performance by the student.

The importance of learning objectives goes well beyond indicating to the learners what they will know and be able to do at the successful completion of some learning activity; well-crafted learning objectives guide the rest of the course development process. Course materials, assignments or activities, and assessments should all be selected to align the learning objectives.

A question to consider when building a course from learning objectives is: How any element of the course (video, discussion, project, etc.) relates back to one or more of the learning objectives? Learners should not be asked to read or review material that is not relevant to one of the objectives. Nor should they be assessed on skills or knowledge which is not in one or more of the objectives.

When writing a learning objective it is important for the instructor and the instructional designer to have a clear understanding of what level of performance is required from the student in the cognitive and knowledge domains. **Figure 6** provides useful examples.

Examples:

After completing this activity the student will be able to solve a system of linear equation using matrix inverse and matrix calculations.

After completing this activity the student will be able to calculate the pressure distribution in single pipe systems using the modified Bernoulli equation.

For the purposes of this exercise and strictly in the sequence below:

1. Select a topic for one of the courses you teach.
2. Write a learning objective clearly identifying the three components listed above. You may find Fig.s 2 and 6 useful.
3. Develop three questions that the student can use to determine if they achieved the desired performance capacity.
4. Create an outline that defines the resources and a path that the student will use to achieve the learning objective.
5. Be prepared to present to the group your results.

Figure 6: Example of action verbs in the cognitive and knowledge domains.

Group Exercise:

Creating a Engaging Activity

Implementation of the Flipped classroom requires carefully designed activities that are associated to the human interactive component. This task is more difficult that it appears at first hand. It is essential to keep the following in mind when designing an activity:

1. The activity must be closely associated to one or more learning objectives.
2. Student engagement is important to ensure that students remain focused and interested in the learning tasks. Activities should be entertaining, interactive, and meaningful for the learner.
3. The activity must be presented to the learners in such a way that they see its value (metacognition).

Defining an activity that meets the three criteria above is a task that requires careful thought and attention to detail. It is important to ensure that the learner is given the opportunity to reflect about the problem (with self and with others) and to establish an open dialogue with other students and instructors.

For the purpose of this exercise follow the steps below to create an activity associated to the learning object you previously created:

1. Make a list of significant problems that drive your discipline.
2. Identify some open ended problems that are central to the course you are teaching. Problems where the instructor has served as a consultant can be of high interest to students.
3. Make a list of ideas that are engaging problems that will drive the students into the content related to the learning objective.
4. Select the idea that best meets the three criteria listed above.
5. Define the type of activity that would best achieve the intended results (group discussion, design problem, etc.).
6. Draft a statement of the problem as it would be presented to the students. A context should be included so the student understands the value of resolution of the problem.

Table 3
Example Activities for Different Levels of Blooms Taxonomy

Remembering	Understanding	Applying
Analogies Examples Illustrations Lecture Multiple Choice Test Poster Presentation Short Answer Test Visuals/Audio	Comparisson Diagram Cartoon Outline Discussion Board Implication from an Idea Match Model Multiple Choice Test Oral Report Own Statement Photograph Poster Presentation Short Answer Test Speech Summary Written Report	Build/Create Demonstrations Diagram Drama Follow an Outline Forecast Illustrate List Map Project Propose Questions/Solutions Role Play Simulations Sketches

Analyzing	Evaluating	Creating
Argument Case Studies Critical Incidents Discussion Graphs Problem Exercises Propaganda Questionnaire Survey Syllogism Breakdown	Appraisals Case Study Critiques Project Self-Evaluation Simulation Standard Compared/Standard Established Survey Valuing Writing Conclusions	Alternative Action Plans Articles Case Study Construct Simulation Consulting Creative Exercises Develop Plans Experiment Formulation of Standards Games Hypothesis Invent Problem Project Set of Rules

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