Approaches to Managing Organizational Diversity and Innovation

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Chapter 13
Access within the Classroom through Universal Design for Learning and Key Learning Elements[1]

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ABSTRACT

Much has been done to assure that social justice is achieved by providing equal opportunity for access to education, but less has been done to provide equal opportunity for learning success. This chapter addresses how an organizational trainer/faculty (instructor) may become an Equal Opportunity Instructor for Learning Success (EOILS). In particular, it provides guidance for how Universal Design for Learning (UDL) and Elements of Learning may be combined in an innovative manner to design and implement classes that will provide equal opportunity for learning success. This is accomplished by presenting the UDL Principles and Elements of Learning while showing how course improvements may be made. There are three examples resulting in the final implementation that incorporates significant use of UDL Principles and Elements of Learning. Faculty and organizational trainers (training and development) around the world would likely benefit from the use of UDL.

INTRODUCTION

Social justice can be achieved by creating a pedagogy that matches individual learning needs. Social justice can be advanced for all global learners by creating a classroom environment that aims to meet the needs of the greatest number. The teacher's goal is to motivate and excite learning. The planned classroom experience should not be one of simply imparting information to the learners but to motivate and assist them as they perform their own learning.

Education is becoming more necessary for employment in our contemporary technologically diverse society and it continues in most organiza-

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tions for a lifetime. Learners can be left behind if they learn differently than the prescribed ways of a narrowly taught curriculum, and once behind, it becomes difficult to proceed.

Here we try to explain principles involved in creating a curriculum for learners who have different learning preferences, who need extra materials and resources, who do better with a different method of evaluating their learning, or who require a different mechanism to become more fully engaged in the learning process. This chapter will provide suggested general solutions and some specific examples of implementations of the solution

BACKGROUND

The primary author, Joe Grimes, is a university faculty member of computer engineering, who founded and administered a university faculty development center for ten years. He has published faculty development material, presented at conferences, kept up-to-date with trends in educational literature and best practices of education. Early in his career, he also taught in a high school, and coached basketball, golf and soccer teams. Much of this chapter is the formulation of his ideas that are a reflection of all of these experiences.

SOCIAL JUSTICE IN EDUCATION

Social justice in education can come in multiple forms such as making education more accessible, creating healthy and safe environments for learners and organizational employees, and educating instructors and learners about social justice. This chapter is about a form of social justice in which every instructor can participate by focusing on how she/he can create an environment that maximizes the number of learners in her/his classroom who are targeted for learning success. Creating greater access to educational attainment within the classroom can do this.

Access to education often refers to learners trying to get *into* a course, school, or organization by overcoming physical, historic, or other barriers. But what happens when a learner overcomes those barriers and enters into a course at a school or within another organization? The concern of *access to education* becomes replaced by the concern of *access to successful learning within the classroom*. While many organizations, especially schools, have systems in place to make educational materials accessible to those with physical and/or mental limitations, a gap often remains for learners with different learning and study preferences. Often those with the greatest ability for recognizing these differences in learners and accommodating for these differences are the instructors.

Instructors who try to improve all of their learners' potentials for learning success could be described as *Equal Opportunity Instructors for Learning Success (EOILS).* An *EOILS* does not discriminate based on race, age, sex, other personal characteristics, or learning preferences. *EOILS* will also do whatever they reasonably can to accommodate for variation in how learners learn and study.

An *EOILS* must consider each individual who enters the course. Learners come to courses with a high variation of prior knowledge and experiences (Bransford, Brown, & Cocking, 2000). Because each individual constructs his/her own knowledge, equivalent backgrounds might not mean equivalent knowledge construction (Bruner, 1996). Although learners learn best when information is presented according to highly researched principles (Mayer, 2005; Mayer, 2009) and study strategies (Weinstein & Mayer, 1985; Mulcahy-Ernt & Caverly, 2009; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013) they may need different varieties of learning activities and starting points (Rose, 2006; Rose & Meyer, 2006). Providing learners with choices of where to start and how to learn helps to advance the abilities of those who might not otherwise be able to succeed.

UNIVERSAL DESIGN FOR LEARNING

UDL Overview

UDL provides principles for developing and implementing instructional goals, methods, materials, and assessments that maximize learning paths for learners in class. UDL is not a single implementation to fit all, but rather, it is an adaptable approach that can be tailored and attuned for individual requirements. This section addresses principles and practices of course transformation planning and implementation using UDL principles and strategies. These can boost the learning environment for both instructors and learners thus enabling all learners to gain knowledge, skills, and enthusiasm for learning. It is based on explicit acknowledgement that all learners learn and demonstrate achievement differently. This results in diverse material type, presentation style, activity structure, and assessment bases and methods.

UDL strategies provide a way for instructors to increase learner engagement, improve retention of learning materials, progress further in learning, and improve assessment of learning outcomes. Learners in UDL designed courses are given the opportunity to more clearly understand course materials due to diverse delivery methods. UDL also has the potential to promote empowerment and active participation in one's own learning. In the best sense, a UDL environment fosters learner-driven learning while enhancing rigor. UDL should provide benefits to both the instructors and learners.

A UDL course aims to increase the potential that more learners will achieve the desired learning outcomes for the course and the potential of an increased course completion rate with greater learner satisfaction. A highly developed UDL course should also require fewer adjustments for learners with special needs. A UDL course is primed for learners to become more passionate about whatever they are studying, and in the end, the instructor should find the experience to have been motivating. She/he will be better informed about the teaching/learning process.

Although technology is an excellent resource for efficiently implementing UDL, there is absolutely no requirement to use expensive, advanced, or uncommon technology to implement its principles. At one time the implementation of UDL was a daunting task. However, today the availability of resources such as Learning Management Systems (LMS), the World Wide Web, Social Media, and adaptive technologies make the process a much more manageable possibility. There is no silver bullet UDL solution since all courses are different and iterations of the same course will have learners with different backgrounds.

UDL originated from the advance in architectural design and related developed products that call for design adjustments such as curb cuts in streets and automated doors to better accommodate a vast variety of users. Initially, these architectural accommodations were achieved through retrofits, But experience shows that all such flexible designs at the start of development are less expensive and less cumbersome than costly retrofits later that may not be as accommodating. In the field of education, UDL has been a part of the K-12 teaching methodology for some time but relatively new beyond K-12.

Like architecture, in the case where the course is being newly developed, it is much more efficient to incorporate UDL from the beginning of its planning and implementation. Much of UDL advancements have been provided as a result of research and development by the nonprofit CAST organization at the Web site of http://www.cast.org/index.html.

Three Guiding Principles of UDL: What, How, Why

UDL provides a small set of three main adaptable principles that can be used for classes in possibly all subject-types. Underlying the principles is the

idea that providing more opportunities for access will allow for more learners to do very well in a course.

1. **Provide Multiple Means of Representation:** Provide learning material and other resources to learners by multiple enablers of learning. This is the "what" of learning (CAST_2013).
2. **Provide Multiple Means of Action and Expression:** Give learners the opportunity to demonstrate what they know in multiple ways. This is the "how" of learning (CAST_2013).
3. **Provide Multiple Means of Engagement:** Give learners alternative paths so they may chose the one that is most motivating and enabling for them to traverse during the learning process. This is the "why" of learning (CAST_2013).

These principles lay the foundation of UDL. For an instructor they provide a roadmap for defining instructional learning outcomes, resources to be provided, strategies for teaching and for creating enthusiasm for learning, and evaluation of learner success. When UDL principles are used appropriately to develop a teaching strategy for the unique set of learners in the class, the resulting activities should be beneficial to all learners. Unless all learners have the same process for learning (but they won't), the instructional strategy should be a flexible approach that will accommodate the unique needs of individuals.

In the following is a more detailed description of each of the three principles. These descriptions expand on the statements above and summarize each of the principles.

Provide Multiple Means of Representation

Information should be presented to the learners in a manner that will make it possible for all to use it effectively. This will usually require the information to be presented by multiple means (formats) so a learner with a given learning preference and/or knowledge background will find some combination of the multiple means of representation to be suited for her/him. Presentations often would require varied modalities of images, text, and audio under the general strategy of multimedia. This is intended to improve learner recognition of elements of learning by gathering facts through reading, hearing, and seeing.

The information should be provided so the learner has flexibility to traverse it by skipping some things or by taking variable paths through it. If done well, the multiple means of representation will allow all learners to be effective learners. The bottom line is that knowledge and subject matter should be presented in different ways. The choice of the "what" of learning should be developed after the learning outcome(s) have been determined.

Provide Multiple Means of Action and Expression

Evaluation of the success of learners should be carried out in multiple manners in order to allow them to demonstrate what they actually know. Learners should be allowed to traverse th e learning process (including the evaluation of their learning) in different ways. Assessment variations include timing, method (written in class, written out of class, oral, physical demonstration, team project, or debate), and flexibility in importance (grading) given to a particular assessment. Variety may overcome writing difficulties, oral communication difficulties, organizational limitations, language barriers, or learning or physical disability. It is crucial that options for demonstrating accomplishment and conveying thoughts be given. This is basically about "how" individuals organize and express their ideas and is based on individuality of planning and performing tasks.

The bottom line is to find ways to make a distinction of the different ways that learners can express their knowledge. Prior to making decisions on the assessment process, which is the "how" of learning, the learning outcome(s) and the choice of

the "what" of learning should be established along with a grading scheme/rubric to be used in the assessment process. It is usually in the best interest of everyone to give a grading scheme/rubric to the learner before they do their work. Flexibility should never be intended or allowed to denigrate the level of quality of learner work. Thus all the variations of flexible assessment should have the level of standards that the instructor expects from passing learners.

Provide Multiple Means of Engagement

Enthusiasm in their engagement process is important to learner achievement of the desired learning outcomes. There are major differences between learners in what way to involve or stimulate them. Factors that have significant influence on the feeling associated with learner actions include: culture, biological processes, belief in personal relevance, prior experience, the subject being studied, working individually vs. working in teams, and maturity level. If the engagement is either beyond their grasp or is extremely boring, the learners may lose enthusiasm and possibly disengage themselves. It is often valuable and motivating for the better learners to assist (but not give answers to) those who are struggling. A single means of engagement that is ideal for all learners does not exist. Freshness and impulsiveness will motivate engagement in some but not all. Thus, varying potentials for interaction can be beneficial.

Some learners enjoy working with their fellow learners while others prefer to work independently and sometimes it is possible to accommodate both preferences in the same class. Prior to making decisions regarding engagement of learners, the "why" of learning, the learning outcome(s), and the choice of the "what" and "how" learning should be established. The engagement and maintenance of motivation are affective aspects that influence challenge, enthusiasm, and curiosity.

Possible Methods of Implementation

Table 1 provides examples of how to implement the three principles of UDL. These examples are just some ideas but do not represent all possibilities.

Table 1. Example means of implementation

	Principles		
	Provide Multiple Means of Representation	**Provide Multiple Means of Action and Expression**	**Provide Multiple Means of Engagement**
Possible Means of Implementation	Seven possible means of representation 1. Written material 2. Simulation (by instructor or technology module) 3. Classroom discussion 4. Guided research 5. Picture(s) 6. Instructor modeling 7. Lecture	Six possible means of action and expression 1. Oral vs. written 2. Team activity 3. In class vs. out of class 4. Text vs. Visual vs. Combination 5. Allow reference during assessment process 6. Allow second chances	Seven possible engaging suggestions 1. Learner-centered activities* 2. Questioning 3. Group work 4. Variety in Course 5. Meaningful activities 6. Contemporary vs. Traditional 7. Non-divisive activities

*Learner-centered learning concentrates on the educational requirements of the learners as apposed to concentrating on needs of the instructor.

Implementation of UDI Principles In The Classroom

Important considerations:

1. The implementation of UDL principles can be difficult since adding components to a course can radically alter the class dynamics. Even a small change can have a broad impact.
2. A draft comprehensive plan for the course's desired end result will allow staged implementation so successful initial changes will not need to be altered to allow for future course development. In order to gauge the impacts of change, an instructor may begin slowly with changes that are manageable. Adjustments and additions can be made later.
3. Communicating changes to colleagues and learners is critical especially if the planned changes are different than the current approach being used to facilitate learning.
4. If at all possible, it would be helpfully positive to approach change with a community of other instructors who have an interest in adapting UDL principles. It would be ideal to have an instructors' community facilitator who has instructors' development leadership expertise.
5. Ideally, UDL should increase the standards for the course while making it more pleasant for both instructors and learners.

Process for Including UDL in a Course

There is no one single path that is ideal for implementing UDL. An instructor has to approach the course in a manner that is tailored to her/his unique teaching method and to the nature of the course itself. This section provides a series of phases that may be used. It is important to keep in mind that it may be necessary to step back to prior phase(s) if difficulties are encountered at a later given stage.

Phase I: Be Prepared

It is important to prepare for the UDL process by understanding learning elements (to be presented later) and how they may be used to implement the UDL principles. It is not possible to become a complete expert but starting the process should not be put off because of concerns that mistakes will be made. Mistakes will occur but can be translated into valuable experience for learners and instructor. It is important to keep communication open with learners so that when problems do happen, they let the instructor know and the instructor can work with the learners on solutions. Understanding UDL and planning for the next phases will help the implementation run smoothly.

Phase II: Determine Which Course(s) will Benefit from Implementation

Those in charge of instructional decision-making must consider the order of transforming courses to UDL. Several factors must be considered, such as which courses will not only benefit most from change but also be most easily changed. Some may be more conducive to change depending on how they relate to other courses that the typical learner will have taken previously or will take in the future. Through instructor communication, learners need to know how the course and the UDL strategy will bring them closer to being the more complete person they want to become. It is best that instructors choose a course that they have taught previously, unless of course it is new. If it is a candidate for revision, it is key to begin with a good strategy. If the changes needed are extensive, it is important to make them as a series of steps beginning as soon as possible during the next offering of the course so that the process of change maximizes opportunities for feedback and continuous improvement.

Phase III: Develop Insights About the Learners

Before strategizing about how to change a curriculum, an instructor should determine where the greatest needs were during prior iteration(s) of the course. Consider all potential learners and to the extent possible determine learning previously achieved, characteristics of the learners, plans of the learners, and any special needs. It should be kept in mind that the goal should be to help the struggling learners become more efficient. Often changes will help even more successful learners have an improved learning experience.

Phase IV: Engage Learners and Other Instructors

It is important to bring learners and instructors into decision making process and UDL implementation. Past learners will be able to critique the three UDL areas of prior versions of the course and/or be able to analyze draft ideas. Surveying learners while they are in the modified course, or at its end will provide information that may be used to tweak the active course with an ending result of greater success. The results of course assessments can provide some information about difficulties in achieving certain learning outcomes. Instructor peers can be invaluable in reviewing of planned changes, provide answers to background questions, and/or providing assistance as the course progresses. There are a number of published resources that are available showing classroom tactics (Grimes, & Desrochers, 2009; Grimes, Victorino, Stuart, et. al., 2010). Learning outcome assessment before and after the changes is valuable to establishing the credibility of UDL changes.

Phase V: Develop Instructional Tactic

In this phase the instructor will decide how to change the course to implement UDL principles. The consideration of the special circumstances for this instance of the class and the learning outcomes should be established first. Additional learning outcomes may be possible because UDL is being used. It will be possible to integrate the UDL principle of provisions of multiple means of representation, multiple means of action and expression, and multiple means of engagement.

Scaffolding is an approach that may be used to give the learners the support they require in order to overcome prerequisite shortfalls and may be used throughout the term. A scaffolding tactic should be provided, when necessary, so all learners will have the opportunity to have the background to meaningfully participate in the class. Educational scaffolding is analogous to the scaffolding that is used to allow construction workers to reach a level higher than the ground. Scaffolding provides supplementary learning opportunity that will potentially bring learners to the appropriate level when they start the learning module. It may include definitions and assumptions that learners are expected to use. It is the provision of satisfactory support to prop up learning when new material is presented to learners. These props comprise such things as:

1. Supplemental material
2. A task or set of tasks
3. Guidelines
4. Assistance to the learner in gaining learning acquisition and interpersonal skills

Framework for using instructional scaffolding include:

1. Demonstrating how to perform an analogous task.
2. Providing advice
3. Being a guide on the side

The planned tactic should consider alternatives in case changes are needed. Before an actual implementation occurs, the reality check of the next phase should be performed.

Phase VI: Perform a Reality Check

The instructor should determine whether or not the tactic and implementation could be realized and without undue overload. The UDL approach should make coursework less complicated but will not make a course perfect. This design evaluation should include a consideration of the target population of learners, process prediction-assessments, and all costs and benefits. For example, some UDL changes may cause tremendous work and realize little improvement. In other cases, planned changes could theoretically benefit some people but not the target learners. Instructional changes in which the cost is high and benefits are minimal should be avoided. Additionally, the instructor should assess whether the process of implementing the tactic will actually work. Instances in which implementation is likely to fail should be reconsidered and possibly redesigned.

Phase VII: Implement the Tactic

Once the reality check has been made, the tactic can or may be implemented. It should be realized that it is subject to change until substantiation of its effectiveness is determined. Implementation can feel frightening since the tactic can move the course into unknown and unpredictable scenarios. However, an approach that includes administrative support and takes a continuous improvement philosophy can make a difficult experience feel less challenging. The UDL implementation in a computer architecture course that was taught recently in the Winter Quarter of 2013 was an excellent experience that will be explained in detail later.

Phase VIII: Evaluate the UDL Experience

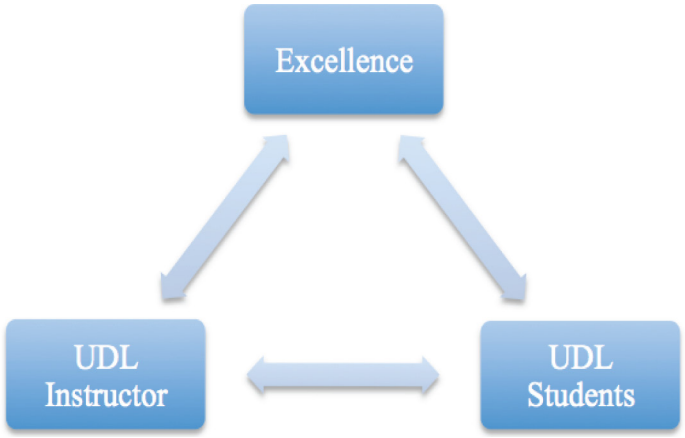
Evaluating the UDL experience can help the instructor understand if the tactic was implemented correctly, if it worked in helping learners, and if it can aid in the instructional decision-making in future iterations of instruction. Achieving the learning outcomes of the instructional experience more efficiently and with better results is not the sum of what is desired. All elements of the UDL implementation should be evaluated at all levels and at appropriate times throughout instruction. Below are some actions that can be taken to help with the evaluation of UDL implementation:

- Determine the learning outcomes of a course ahead of implementation.
- Determine what will indicate successful implementation before changes are made.
- Run evaluations of previous presentation of the course ahead of implementation in order to gather baseline course comparison data.
- Develop a feedback mechanism (such as a bi-weekly survey or summative survey) in which learners will be able to communicate strengths and weaknesses of the revised course.

A logic model (Figure 2) helps explain this idea further. In this logic model, the inputs are learners, instructor, development time, and the UDL curriculum. This leads to positive outcomes for more learners and there is greater satisfaction since they were able to complete the assignments that better suited them.

Changing a course to incorporate UDL principles does not have to be extensive. The following example shows how a course with very little UDL implementation can be modified to increase means of representation, expression, and engagement. This is a required course for Computer Engineering and for Computer Science learners with approximately an equal number of each enrolled in the class. Table 2 is based on a computer architecture course that was on the way to having a highly developed UDL course design. Table 2 illustrates the computer architecture course setup that has not implemented UDL design principles.

Figure 1. Represents the result of the ideal UDL experience. Learners and instructor would be contributors and as a result be fully participatory in the classroom with multiple means of representation, action and expression, and engagement. With the bidirectional arrows, the diagram signals that a UDL classroom is dependent on this process in which learners and instructor synergistically create a more dynamic environment that moves the class toward excellence.



This example has a basic setup with few means of representation, expression, and engagement.

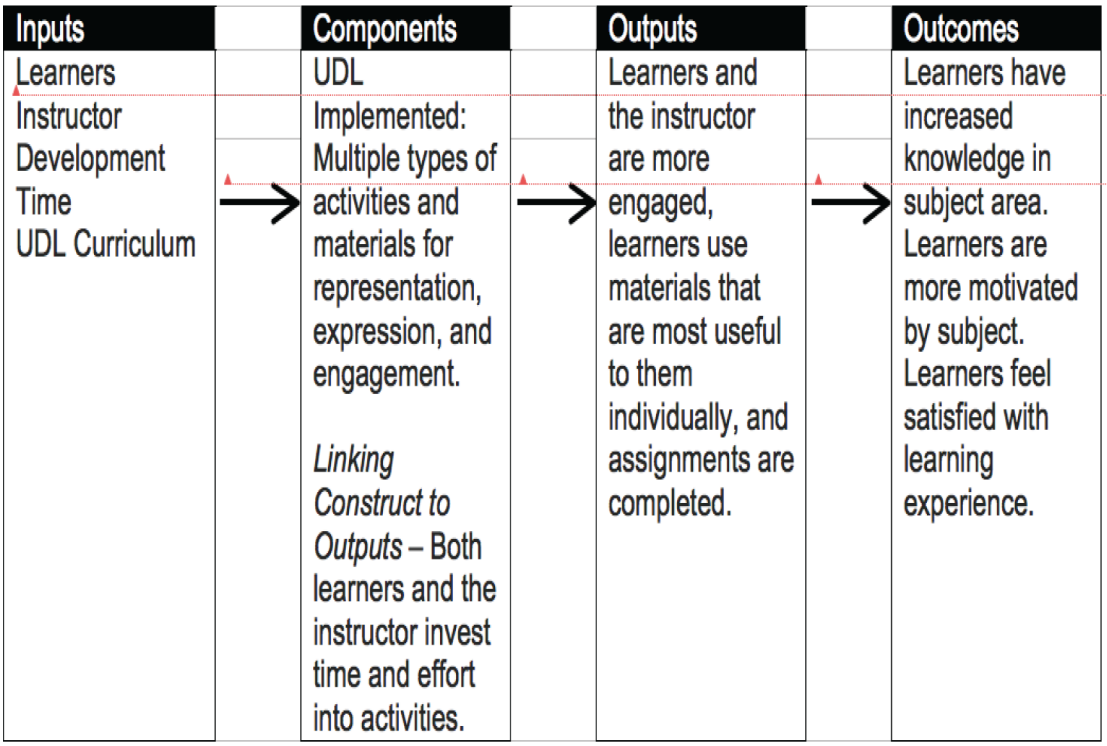
Table 2 demonstrates very little UDL being implemented. The components for the course include readings, lectures, homework assignments, and a midterm and final exam. There are only two forms of representation (readings and lectures), two activities that promote engagement (laboratory exercises and homework assignments), and three components used for expression (homework assignments, laboratory exercises, and a final exam). In this example, UDL principles have minimal implementation and would not be considered a course with UDL design. However, even this basic setup has the potential for UDL growth. Table 3 shows how this course could be expanded in a way that approaches UDL by adding additional complementary course components.

As Table 3 illustrates, the course has undergone UDL additions by adding components with still more UDL improvement possible. In this example, there are additional methods for representation (lecture slides were added to the lectures and readings), more means for engagement (laboratory discussion, weekly quizzes, a capstone project, and a presentation were added to the laboratory exercises and homework sets), and more means of expression (laboratory discussions, a capstone project, weekly quizzes, and a midterm exam were added to laboratory exercises, homework problem sets, and final exam). It is important that the course designer ensures that all new components are closely aligned with the other components. Just adding new components could make the course a confusing learning experience if they do not complement the other components in the course.

Key Teaching and Learning Elements

Teaching and learning are multifaceted human experiences. The first part of this section is designed to present the complexity that can exist in teaching and learning and the problems that can arise for instructors if they are not adequately prepared. Instructors who are well prepared will find their experience to be exciting, challenging, and rewarding. An instructor who reaches for teaching excellence is in the process of improving teaching with progressive fine-tuning. Because instructor improvement is achieved through learn-

Figure 2. Logic model for UDL implementation



ing, the mechanism for doing this is enlightened by the same learning elements that apply to any learner seeking to acquire knowledge. For the highest quality of self-learning and improvement, learning processes should be well understood by the instructor.

A good facilitator of learning (instructor) will use an innovative hybrid form of being a lecturer and patient tutor. At times this dual-role can seem conflicting. A set of skills that can help make the hybrid form less daunting is:

- Deep understanding of course content.
- A repertoire of pedagogical and content-based instructional strategies.
- A repertoire of instructional interaction strategies.
- Ability to make quick decisions about pedagogical and interaction skills.

Table 2. Components for a computer architecture course with little UDL

Component	Component Type	UDL Principle
Readings	Activity; Materials	Representation
Lectures	Activity	Representation
Laboratory Exercises	Activity	Expression and Engagement
Homework Problem Sets	Activity; Formative and Summative Assessment	Expression; Engagement
Final Exam	Summative Assessment	Expression

Table 3. Components for UDL emergent computer architecture course

Component	Component Type	UDL Principle
Readings	Activity; Materials	Representation
Lecture Slides	Activity; Materials	Representation
Lectures	Activity	Representation
Laboratory Exercises	Activity	Expression and Engagement
Laboratory Discussion	Activity	Expression and Engagement
Homework Problem Sets	Activity; Formative Assessment	Expression and Engagement
Weekly Quiz	Activity; Formative Assessment	Expression and Engagement
Capstone Project	Activity; Summative Assessment	Expression and Engagement
Presentation	Activity; Summative Assessment	Expression and Engagement
Midterm Exam	Summative Assessment	Expression
Final Exam	Summative Assessment	Expression

- Ability to design a course that facilitates good teaching and learning interactions.

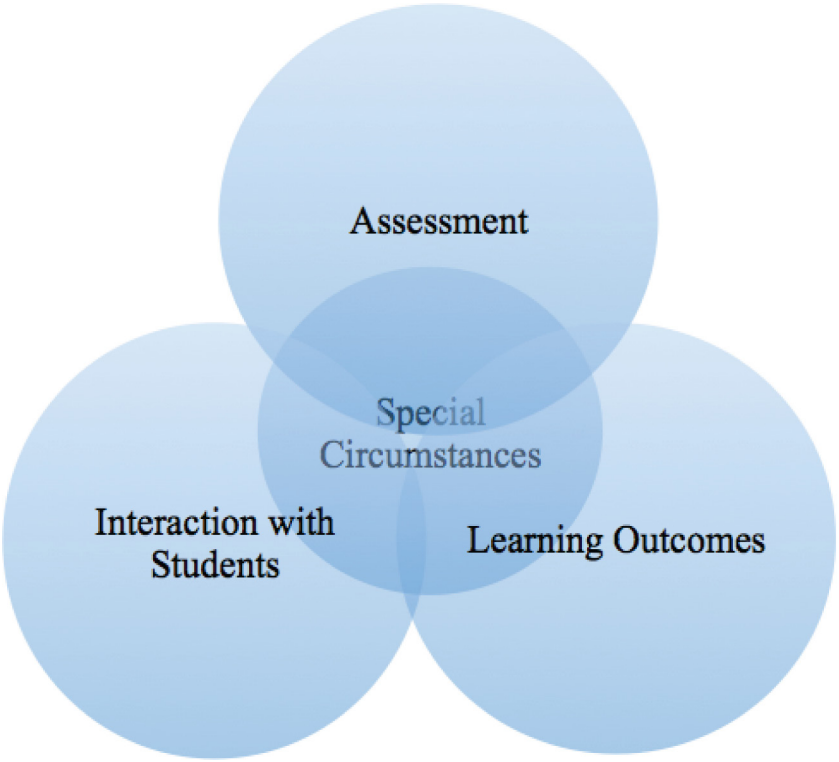
As a beginning to defining a learning experience, the *special circumstances* of a course should be considered. Special circumstances are the variables that make each repetition of instruction unique. For example, the background of learners, such as demographics, upbringing, prior learning experiences, can make the learner dynamics unique to the instructional iteration. Other special circumstances can include environmental variables, such as, time-of-the-day, time-of-the-year, place of instruction, and technologies used. Defining facilitation of learning should start with an analysis of special circumstances. Using this analysis then: a) make choices regarding the *learning outcomes*, b) choose an *assessment* method for learners and instructor to determine when the learning outcomes have been achieved, and c) then determine the ways in which the teacher and learners will need to *interact* in order to accomplish the desired outcomes. The elements of the previous sentence should be developed together as illustrated in Figure 3 and should not be developed as isolated individual solutions.

As this integrated process unfolds, it is important that the instructor deploy diverse pedagogical methods to meet the needs of the diverse learning preferences of learners. Much has been done to try to understand learner motivation, learning retention, and emotion; however, these processes are complex and vary in complexity from person-to-person and from one situation to the next.

Since learners approach content with different backgrounds and learning skills, the learning process requires creativity on the part of both the instructor and the learner. The blend of techniques used in facilitation of learning itself constantly changes for each individual learner due to countless variables in play at any instant in the life of the learner. A good summary of the available research is provided by the National Center on Universal Design for Learning (NCUDL, 2013).

Figure 4 is a concise listing of learning elements that should be considered before addressing the UDL approach. The eight elements of learning discussed in this section are related to learning guidelines and principles presented elsewhere (Bransford, Brown, & Cocking, 2000; Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). They are extended to incorporate UDL and are rewritten here by the author based on experience

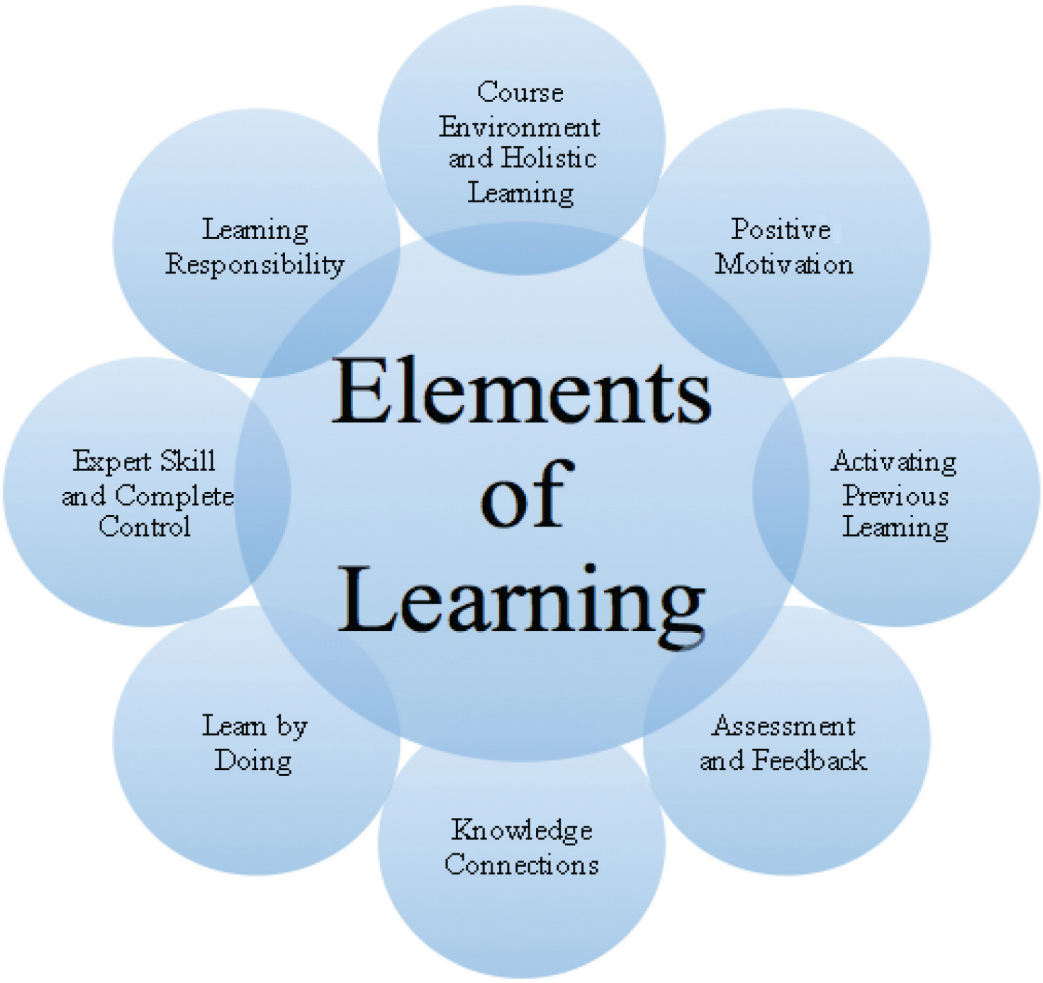
Figure 3. Facilitating learning



and to demonstrate the implications they have for a redesigned computer architecture course. Taken together, UDL and these key teaching and learning elements offer an opportunity for greater access for learner success in instructional experiences. They provide more points of entry into understanding course material and they provide a stronger foundation for mastering it and transferring it into professional practice. For each of the key teaching and learning elements described below, an example of how it could be incorporated into the above computer architecture course is discussed. The presentation of these learning elements references the highly developed computer architecture course discussed after this section.

1. **Course Environment and Holistic Learning:** Course environment and learner holistic growth development (emotional, social, and intellectual) are important to the learning process. It is vital to recognize that learner emotions and social elements can prop up or set hurdles for the learning performance. If not addressed, these elements may create difficulty, if not a crisis, for a learner or learners in the class. If a learner is expected to work within a team, good communications skills are important for the team to function well. A method to employ here might be to provide team member contracts that spell out team skill and what constitutes good communication. Observance of team dynamics during class provides an opportunity for the instructor to provide guidance. In addition to the disciplinary specific learning, the curriculum of learning should include understanding of themselves and others, learning how to be a lifelong learner, and addressing values, concentrations, and emotions.

Figure 4. Elements of learning



A key consideration of the instructor is to observe the activity of each individual learner and proactively intervene if problems appear. Also, many opportunities should exist for learners to seek assistance when they are struggling. This learning element as implemented in the course is primarily focused on the UDL multiple means of engagement principle but does contribute to the others indirectly.

Three fundamental changes to the computer architecture course were 1) the introduction of team assignments, 2) the change from a *pure lecture* to a *class meeting (flipped classroom)*, and 3) the use of an online discussion board. These three changes were meant to bring about a classroom environment that promoted positive interaction with others. How to interact with others was communicated at the beginning class so that learners had a reference for what was acceptable interaction. Teams of students were formed to promote interpersonal skills and collegial interaction and coordination on projects. Before each class meeting learners were expected to review slides, complete readings, answer homework questions, and do other assignments. During the meeting, learners were expected to discuss the work they did prior to the class without an instructor lecture (flipped classroom). The discussion board was

used primarily as a place for question and answer (Q&A); however, not only were the learners asking the questions, they were also the ones doing most of the answering. The instructor promoted this type of learner ownership of the Q&A as part of learner grading. All non-personal questions were to be asked on the discussion board. These three components (team work, interactive class meetings, and a learner-owned discussion board) helped to promote a learning-friendly environment that allowed learners to express where they were lacking an understanding. This type of an environment is crucial for learning success.

2. **Positive Motivation:** Positive motivation is a key to prolonged attention and learner achievement. Because learners have many distractions, it can be a challenge to keep their attention at premier level. Probably the best motivator is the instructor's excellent communication with the learners regarding the planned learning process and why it provides a good experience. The focus of instructional learner conversations ought to be aimed at sparking intrinsic interest in the area of study. Because most instructors come from a background in which they were highly motivated as learners, they sometimes struggle in relation to and dealing with those who lack motivation. Setting predictable parameters within which learners can freely operate allows them to pursue the learning outcomes with excitement.

Another source of motivation is to seek pre-instructional perception by asking learners to anonymously state what they have heard about the training/course. Then, after some instruction, ask learners for opinions of their experience and for advice concerning instructional improvement. It is important to limit the advice to areas where it might be used. Learners relish having input into the way learning is conducted, but it is essential to make them aware of how the information is used.

In the computer architecture course, each team had at least one person with leadership skills who worked to help learners to stay on task and maintain motivation. The team project and some laboratory projects had multiple deliverable dates that required incremental delivery of the end product. A rubric was provided for every deliverable and this motivated learners. Better understanding was their responsibility as was whether or not they achieved their goals. The inclusion of more forms of engagement had the dual role of increasing positive motivation and to stay on task. Quizzes, daily classroom discussion, and other ongoing responsibilities were meant to increase this positive motivation as they consistently allowed learners to express what they learned. These multiple means of expression created a much greater interest in achieving the course goals.

3. **Activating Previous Learning:** Previous learning and knowledge construction influence new learning. Learners who have been well prepared in their prerequisite knowledge and study skills will be better able to transition through new material. Since all learners do not enter a course with the same background not the same level, recognizing and accommodating these differences will be important toward achieving successful learning the instructor desires.

However, there will be more challenges if:

- Prerequisites have not been adequately achieved.
- Learners have developed poor learning skills.
- Learners cannot comprehend or adapt to the process of learning that is being used for the course.

In the case of prerequisite problems, learners will have to garner the prerequisite learning on their own, use available scaffolding, or struggle to

some degree if they cannot achieve the prerequisite learning. If this is a problem with approximately half of the learners, teamwork may provide the scaffolding. One method for bringing all learners to the same level would be to guide them through a process analogous to one they will have to perform later. Software testing or case studies are possible activities in which this approach could be used.

Quizzes, laboratory work, and classroom discussions may be used to determine whether or not the learners are able to bring prior learning into this course and use it appropriately. If there are difficulties seen, remedies may be attempted within the course or by recommending that learners attend learning skills workshops on test taking, time management, note taking, or other topics provided by the university.

A critical factor is that instructors and learners often view things differently.

In the computer architecture class approximately half of the learners have a better software development experience and the other half has better experience in computer hardware. Since both backgrounds are important in the course, learners can provide scaffolding for each other because of team assignments. Those with the prior skill will strengthen their understanding by explaining the concepts to others.

4. **Assessment and Feedback:** Well-timed assessment and feedback will provide learners with the opportunity to focus learning efforts and adjust knowledge. This is usually achieved by providing learners with practice and by either allowing them to determine their success or by providing the instructor with an evaluation of their learning. Feedback will allow them to better understand their achievements, deficiencies, and erroneous understanding.

Learning during the course is built on earlier knowledge, and without well-developed understanding continued learning will be problematic. Erroneous knowledge is usually more dangerous than deficiencies because it is harder to remedy and often results in future learning errors. If not remedied any shortfalls can snowball and lead to an avalanche of problems.

Formative and summative assessment techniques are commonly used during a term with varying definitions of each type of assessment. Formative is used for improvement purposes. Summative assessment is used to determine if learning outcomes have been achieved and is usually used as a part of the determination of the term grade or certification. Multiple assessment devices can be used for these purposes. For example, homework, ungraded quizzes, and self-report surveys can be used for formative assessment purposes, while exams, essays, and final projects can be used for summative purposes. However, the device is not necessarily exclusive as either formative or summative assessment. Also, an assessment device could be used simultaneously as both formative and summative. For example, a quiz could be used for grading purposes that also will contribute to the final grade; however, the instructor and the learner can also use the experience as an opportunity for improvement. Instructors can give feedback to learners so they can improve, while a learner can think about what she/he got wrong and what can be done better the next time such an assessment occurs.

A questioning assessment for a learning module might be used by giving the learners questions that are interspersed in the module or at the end followed by the in-class discussion of the questions and/or new questions. Cold calling on learners during class is a good approach and encourages engagement. Both forms of questioning may be used as formative or summative assessments. To see examples of questioning techniques refer to activity in the videos of "Creating a Positive and Engaged Classroom" (Grimes, Victorino, Stuart, et. al., 2010). Many educators recommend that feedback be provided at least weekly if not daily. Creation of an assessment doesn't have to involve

the instructor at the time of assessment because the assessment tool(s) could be created at any time.

For the computer architecture class, review, quizzes, tests, laboratory activities, interspersed questions on the slides, homework questions, classroom discussions, and the discussion board provided an opportunity for learner assessment. All of these may be used for formative self-assessment of learning. Most may also be used by the instructor to check learner achievement of outcomes and provide feedback so learners may make adjustments.

5. **Knowledge Connection:** Knowledge connection is the level to which newly learned material is meaningfully connected to relevant prior knowledge. Knowledge connection starts with how an individual recognizes and signifies perception and then facilitates and produces connections of understanding in order to make rational choices. If learners have proper knowledge connections, they will be more efficient in the way they learn and/or have a better understanding of what they know. Good knowledge connections will expand learning and the learner's ability to remember what has been learned. It is not just the collection of knowledge that is important but also organization of what is known that is essential to the learning process and efficiency. An example of this would be the following:

If learners are asked to choose between A and B and justify their answer with A as the correct choice, then a choice of A based on memorization without the ability to justify the choice is a less adequate answer than a choice of B with a solid set of reasoning. In this case, the choice of B with good justification shows a solid ability to go through the process of making a choice and explaining rationale. The person who has the ability to develop a choice based on reasoning will be able to use that reasoning skill in the future to make choices, whereas the person who memorized a single answer without reasoning skills will not be able to draw solid conclusions in the future.

Example: In computer science class, give the learners a problem that must be handled by a computer design and give them computer designs A and B. Ask them to choose between the two designs.

1. If they choose the correct design based on a prior class discussion, the choice could be based on memorization. If the instructor requires nothing further, reasoning skill is not tested.
2. If they choose a design and must justify the choice, then their reasoning skills will be tested.

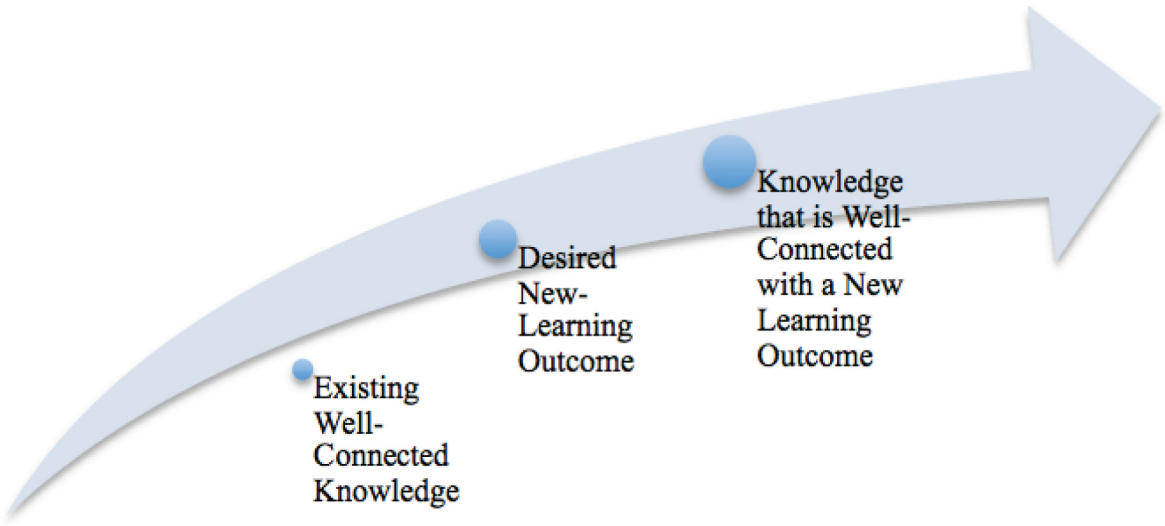
Figure 5 illustrates the positive ascension of learning when knowledge is connected with new knowledge in the achievement of new learning.

If the existing knowledge is not well connected or if the result of the new learning outcome is not connected, it is possible that the result will be a negative learning experience. Connected knowledge will allow a learner to make innovative decisions that will serve them well throughout life.

In the computer architecture class, learners were required to justify any decision that they made. These justifications required the learners to connect prior knowledge to new learning of the course. In a test, a learner with an incorrect conclusion but an excellent justification often received more points than a learner who gave the right conclusion but lacked a good justification.

6. **Learn-By-Doing:** Learn-by-doing is the process of working toward achieving the goal of "practice makes perfect," or "good practice creates improvement." Experiential learning facilitates learning through real world situations. By moving out of the purely conceptual and into a hands-on approach, a learning experience becomes a

Figure 5. Connected learning



"learn-by-doing" adventure. The goal of learning-by-doing is to provide learners with application experience that helps move the conceptual ideas of instruction into realized alignment with praxis. This is realized with either guidance throughout the practice or feedback after practice has been completed. The instructor in a laboratory type environment may provide guidance throughout the practice or as a part of a module that provides automated feedback throughout the practice or a combination of both. The learn-by-doing activity may be an activity such as developing a solution to any problem. An example in computer science would be to study the concept of implementing a computer network and then practice what has been studied by implementing a network to a certain specification encountering and remedying problems that arise.

In the computer architecture class, learn-by-doing occurred through the development of a computer architecture learning module by learner teams. This resulted in the development of: a) extended knowledge of computer architecture: b) team skills, developing their team project; and c) lifelong learning skills. In the laboratory, they developed computer designs. Also, they made justified decisions.

7. **Mastery:** Mastery within a specific area is often a necessity in certain areas of learning before learners can extend their learning to a new outcome. People can develop their knowledge and skills in a subject area over time and this development can be seen as the gateway to new knowledge and understanding. Gagné (1985) described the need for mastery before moving onto new areas, more difficult or advanced content, or more complex understandings. Often, the teacher understands this mastery of the content in an area and guides the learner as she/he works to move toward the teacher's conception of mastery. An example of this is the following:

Children learning to play soccer will learn how to gauge the power with which they are kicking. As they learn to gauge that power, they will understand how to kick the ball close or far. After they have learned to gauge the power of

their kick, they may take on more advanced skills like forecasting where to kick the ball to pass it to their running teammate or learning how to dribble while running. A coach can facilitate this process by breaking up these skills into smaller lessons or practice sessions. As a team member learns these skills, she/he begins to approach the level of mastery that the coach had intended for the players.

It is not necessary that a learner master everything in their discipline. For example, it is important that a computer scientist master specific areas of that discipline but it is not necessary that they become an expert in every aspect of this vast field. Certainly it is not necessary that a non-computer scientist master any aspect of computer science unless the computer skill is required in the chosen discipline. Learning and developing skills takes time and practice: thus, one must choose his/her educational battles.

In regard to the computer architecture class, students should have had a solid understanding of the basic building blocks of a computer *before* enrolling in the class since it required the students to *build* the internals of a computer by using basic building blocks. Because sometimes the students had not developed a mastery of these building blocks, and because student backgrounds were highly variable, scaffolding was possible by: a) team member(s); b) additional material; c) extra slides and reading material; and d) extra instructor assistance during laboratory period, during office hours, and through answers to questions posted on an online discussion board.

8. **Learning Responsibility:** Learners should develop responsibility for learning by having the skill to efficiently manage and evaluate their own process and outcomes of learning. In order to do this, they should be able to determine the requirements of accomplishing a learning outcome, plan the method to be used, analyze their progress, make adjustments as appropriate, be able to appraise their learning skills, and determine their success in achieving a learning outcome. It is expected that learners will begin to develop these difficult self-regulation skills during the K-12 years. However, many times learners are able to succeed in high school by just reciting facts and completing assignments. Because they are not given tasks that require self-reflection of understanding, they may struggle to reorient themselves when their learning assignments become more complex. Instructors who encounter learners with low self-regulation skills may need to find alternative teaching methods that will develop these skills in learners. An example might be a project that requires learner involvement in developing these skills with deliverables at multiple times during the term and the instructor providing feedback regarding their success.

By making the computer architecture course learner-centered, students were better prepared to become life-long learners with learning responsibility. In an effort to make the course more learner-centered, the capstone team project was added. In this project, the students assumed the role of the instructor and created an instructional module that would teach material beyond the scope of the course. This made students reach beyond what they were taught and made them empathize with those who are in learning situations. This experience helped the students learn how to learn and because of this, they will be better at learning important new material as well.

Students were also asked to sign-in at the beginning of each class as to whether or not they had completed the outside assignment prior to the class meeting. This sign-in promoted greater learner responsibility for their learning. The result is classroom discussion that was more meaningful. The idea motivating this outcome is that learners should have understanding of the material prior to class rather than have material introduced to them

in class. This created a more advanced learning experience during meetings. Through the communication of standards, learners realized they are responsible for their learning.

Example Course with UDL Implementation

One way to understand how UDL can be used to improve the outcomes of a class for more learners is to see an example. What follows is a more thorough description of the computer architecture course as it was last taught. In the example that follows, the course had undergone a major revision and included highly developed UDL practices as well as the extensive use of the key teaching and learning elements explained in the sections above.

The following is a list of learning outcomes of the computer architecture course that was taken primarily by junior, senior, and graduate students. From these outcomes, one can begin to get a sense of expected learner achievement of outcomes. In the paragraphs following the learning outcomes, a description is provided of how UDL was integrated into the course.

1. Know instruction set architecture (ISA) and hardware design of a specific CPU (MIPS). Know and be able to use the principles of ISA design.
2. Be able to make and defend design decisions regarding:
    a. **ISA:** Control/Datapath
    b. **Pipelining:** Memory Hierarchy
    c. **Multi-Processors:** Computers
3. Be able to determine the performance of a computer system and use computer performance measures and information to make decisions about the choice of a computer to be used for a specific purpose.
4. Be able to make decisions about computer architecture design and defend those decisions.
5. Be able to continue to learn necessary principles of computer architecture.
6. Be able to work more effectively in teams (groups).

Primary Course Outcome: Be able to Design and Implement Datapath and Control for MIPS ISA.

The above learning outcomes are specific to the course and discipline. The following is a restatement of these outcomes in a generic manner that is applicable to many courses. More specifically, the learning outcomes below capture the cognitive processes and behaviors that are being targeted by the learning outcomes above. The difference is that the specific content has been replaced with a more generic terminology.

1. Remember processes related to the content
2. Remember facts about the content
3. Remember principles about the content
4. Make complex decisions in the field
5. Solve problems in the content area
6. Work effectively in groups
7. Be prepared to continue learning in the future

The following describes the course with high UDL implementation and key teaching and learning elements in place. Course components can contribute to multiple UDL principles and key teaching and learning elements (see Table 4). Also, the design of some of the components magnified the effect on the redesign. For example, the lecture slides were redesigned to contain multiple forms of representation and engagement. Table 4 is not rigid so depending on how the reader frames her/his instruction, the primary purpose of her/his course components could change. Note in Table 4 how each of the components is mapped to primary function of the UDL principles and key teaching and learning elements. However, the components of the course are not limited to these primary purposes.

When this course was implemented, a significant amount of effort both through text and discussions was spent explaining to students how

the course was different from the previous version of the course. Also, peer faculty members were made aware of planned changes. The primary element of change was to provide additional learning opportunities and flexibility that would meet individual needs in their learning preference. This modified course included use of UDL principles and attempted to make it an equal opportunity learning experience for all students enrolled in the course.

Readings, Lecture Slides, External Links, Supplementary Materials

Readings and synchronized lecture slides with additional supplemental materials, such as external links were assigned daily. The lecture slides were dynamic with text and picture representation and contained simulations, questions of the day, open questions (without an answer), and capstone questions at the end of the slides that tied together the material of the module and as appropriate tied the module material with prior learning. The lecture slides were often-highlighted references to content that was already covered in the course. By helping the students remember what they had learned and where it came from, the lecture slides aided them to activate previous learning. They were also provided with links to additional Websites and given supplementary material. These multiple forms of representation were complementary and highly related so they made learning easier rather than more difficult. These components were meant to increase the means of representation and engagement as well as knowledge connection and activation of previous learning.

Learner Self-Reporting of Completed Activities

As a way of promoting learner responsibility, management, and mastery for their learning, students were asked to self-report when they had completed the assignments. At the beginning of each class, they signed-in as to whether or not they had completed the assigned readings, slide review, and if they had answered questions. They were then better prepared for participation in the class meetings. Participation included being able to volunteer answers or be cold-called by the instructor. Orally answering questions could be by an individual or by a team. This self-reporting mechanism was both a formative assessment and mechanism for self-regulation.

Q&A Discussion on a Discussion Board

The instructor set up an online discussion board through the campus LMS. It allowed the students to post messages open to the class or groups and to receive feedback to their open message. (The instructor had designated the online discussion board as a place for Q&A.) In this activity, the students or instructor were able to ask others in the class various questions. The questions could be about content, procedures, or class logistics. Students were not allowed to send a question through email to the instructor unless it was about a personal matter or an emergency. This allowed for quick consistent responses that were provided by other students or instructor and were available to all in the class. The discussion board was a significant time saver for the instructor and provided consistent timely answers. In addition to increasing the speed of answers, it provided an opportunity for students to learn how to answer the questions of others as well has to see how others communicated when asking or answering questions. This helped to engage students, as they were no longer just a passive audience taking answers mainly from the instructor. Through this component, they became (to some degree) the instructor and began to actively do the work of finding answers. As a means of answer quality assurance and to make sure all questions were being answered, the instructor reviewed discussion board postings within 12 hours and provided

Table 4. Components for the computer architecture course and their primary purposes

Component	Primary Purpose*		
	Component Type	UDL Principle	Key Teaching and Learning Elements
Readings	Activity; Materials	Representation	Knowledge Connection
PowerPoint Slides	Activity; Materials	Representation and Engagement	Activating Previous Learning
External Links	Activity; Materials	Representation	Activating Previous Learning
Other Supplementary Related Materials	Activity; Materials	Representation	Activating Previous Learning
Learner Self-Reporting of Completed Activities	Activity; Formative Assessment	Engagement	Learning Responsibility and Mastery
Q&A Discussion on a Discussion Board	Activity; Formative Assessment	Expression and Engagement	Learn-by-Doing, Learning Responsibility
Team Scaffolding Projects	Activity; Formative Assessment	Expression and Engagement	Mastery
Team Capstone Project with Definition and Rubric	Activity; Summative Assessment	Expression and Engagement	Learn-by-Doing
Team Presentation	Activity; Summative Assessment	Expression and Engagement	Activating Previous Learning,
Peer Evaluations of Team Projects	Activity	Expression and Engagement	Learning Responsibility
Laboratory Exercises	Activity	Expression and Engagement	Learn-by-Doing
Laboratory Project	Activity	Expression and Engagement	Mastery
Laboratory Simulators	Activity	Representation, Expression, and Engagement	Learn-by-Doing
Laboratory Discussion	Activity	Expression and Engagement	Positive Motivation; Assessment and Feedback
Draft Contracts	Materials	Representation	Learning Responsibility
Contracts	Activity	Engagement	Learning Responsibility
Instructor Support	Formative Assessment	Representation, Expression, and/or Engagement	Positive Motivation; Assessment and Feedback
Q&A during Class Meetings	Activity	Engagement and Representation	Course Environment and Holistic Learning
Cold-Calling during Class Meeting	Activity	Expression and Engagement	Mastery; Learning Responsibility
Team Activities during Class Meetings	Activity	Expression and Engagement	Course Environment and Holistic Learning
Instructor Lecture of Difficult Material during Class Meetings	Activity	Representation	Course Environment and Holistic Learning
Weekly Quiz (Open Book and Open Notes)	Activity; Formative and Summative Assessment	Expression and Engagement	Mastery; Assessment and Feedback
Midterm Exam (Open Book and Open Notes)	Summative Assessment	Expression	Mastery; Learning Responsibility
Final Exam (Open Book and Open Notes)	Summative Assessment	Expression	Mastery; Learning Responsibility
Assessment Keys	Materials	Representation	Activating Previous Learning
Test Review/Help Sessions	Activity	Representation	Activating Previous Learning
Official or By-Appointment Office Hours	Activity	Representation, Expression, and/or Engagement	Course Environment and Holistic Learning; Positive Motivation; Assessment and Feedback
Email	Activity	Representation, Expression, and/or Engagement	Course Environment and Holistic Learning; Positive Motivation; Assessment and Feedback
Hallway Discussions	Activity	Representation, Expression, and/or Engagement	Course Environment and Holistic Learning; Positive Motivation; Assessment and Feedback

*The component primary functions are not limited to those in this table. Course design and learner interaction with multiple components can synergistically increase the function of the components

information when appropriate. This component was meant to increase the means of expression and engagement as well as instill a sense of learning responsibility and learn-by-doing.

Team Scaffolding, Capstone Project, Presentation, and Peer Evaluation

At the beginning of the term, the instructor grouped the students into *balanced* teams made up of four or five students. The teams were balanced in terms of major, prior courses taken, interests, leadership ability and interest, ability to perform certain tasks, and other information that students provided on a survey. These teams stayed together for the duration of the term and completed activities together. Creating class-meeting time for students allowed the instructor to assist them in developing good team dynamics (Michaelsen, Bauman-Knight, & Fink, 2003). The teams were given time during the class meeting to work on their projects.

Two of the first activities were team-scaffolding assignments. These activities/assignments allowed the teams to begin to work on skills that would prepare them for the capstone project. The term-long capstone project required students to build an instructional module (complete with learning outcomes) that extended the computer architecture content in the course. The students were provided example draft team contracts. They were able to modify these example drafts so that the final drafts they signed and submitted were aligned with their project goals. The creation and signing of a contract was aimed at giving students a sense of responsibility for their work.

Students were provided a written definition and rubric for the project that they delivered incrementally in five stages. The teams presented their learning module to the rest of the class. Each team evaluated the five deliverables and presentation of other teams and also peer-evaluated their own team members using provided rubrics. These components were meant as a way of promoting multiple means of expression and engagement as well as mastery, learn-by-doing, activation of prior knowledge, and learning responsibility.

Laboratory Exercises, Projects, Simulators, and Discussion

The laboratory period included exercises, projects, simulators, and discussion. Students were assigned to work in pairs during laboratory exercises that usually were completed during a one-hour period. Laboratory projects were much more extensive. Students were provided with written definitions of laboratory exercises and laboratory projects that were discussed. Two simulators were used in the laboratory with documentation (explanation and tutorial). These simulators were computer programs that simulated how the inner architecture of a computer worked and students were able to manipulate this visual representation so they could understand how the computer worked in spatial logic. Students received assistance from the instructor as needed. All of these laboratory components were meant as a way of promoting multiple forms of representation, expression, and engagement as well as learn-by-doing, mastery, positive motivation, and assessment and feedback.

Meetings

Meetings replaced the traditional "Lecture." Instead of a traditional lecture in which only the instructor speaks, the meetings were student-centered with the primary activities of a question-and-answer, answering questions voluntarily, or as cold-called formative assessment activity during which the professor asked students to answer reading and slide questions, or had rare instructor presentations/lectures of difficult topics, and or allowed team activities. This *flipped* classroom was meant to increase means of representation, expression, and engagement, as well as promote the course environment and holistic learning, improve student mastery, and learning responsibility.

Assessments: Laboratory Work, Weekly Quiz, Midterm, and Final

Every week students took an open book/open notes online quiz that was intended to be both a formative and summative assessment with key provided after the quiz was closed. All quiz questions were short-answer questions that allowed flexibility in the answers. All of these assessments (quizzes, the midterm, and the final) were open-book/open-notes. In addition to extra time during assessments, students with learning disabilities were provided special opportunities to demonstrate their knowledge when needed. In addition to laboratory exercises, lab projects, the capstone project, and the team presentation, these assessments provided multiple means for students to express what they had learned. The quizzes were also an avenue for engagement as students were able to attempt to apply their learning each week. These assessments also promoted mastery, assessment and feedback, and learning responsibility.

Assessment Keys and Test Review / Help Sessions

The students were given an answer key for all evaluations including the team evaluations and were also provided a time for discussion. Prior to each test, a help session was presented during which students were allowed to ask questions. The assessment keys and the test review/help sessions were meant as ways to promote the activation of previous learning and strengthen student achievement of course learning outcomes.

Instructor/Student Interaction

Student interaction with the instructor occurred: a) during the lecture and laboratory periods; b) through the discussion board; c) by appointment; d) through email if there were personal questions that needed to be answered; e) random discussions in the hallways; f) and during office hours held in a laboratory. Because interactions were variable depending on the needs and communications of a particular encounter, interaction could have promoted any one of the UDL principles. However, interaction was most likely to have promoted certain key teaching and learning elements, such as positive course environment and holistic learning, positive motivation, and good assessment and feedback.

Through implementation and dynamic interaction, the components of Table 4 could be mapped onto other functions. For example, within UDL principle classification as students become more engaged with the course material, they may find the readings, external links, and supplementary materials more motivating. Further, as students post materials on the discussion board, the discussion board becomes a form of representation of the course materials. Finally, all the materials can begin to contribute to multiple key teaching and learning elements. While some of the components (*student self-reporting of completed activities* and *cold-calling during class*) focus on promoting learning mastery by encouraging students to learn the material before moving on, other components (*readings and supplementary materials*) contribute to the mastery by supporting learning. The primary purposes of the components can vary depending on the instructor but the components will often have cross-functions based on the dynamics of instruction and student interaction.

This course is just an example of how UDL and the Key Teaching and Learning Elements can be implemented. It represents only some of the possibilities for creating a course design that is focused on access to successful learning. Other possible additions to a classroom include more representation materials, expression activities, or engagement activities. Other materials include activities or items such as online lecture or lab videos that students can watch as homework or models those students can view in-person. Other expression activities include working on a wiki with other students or creating a portfolio throughout

the course. Student engagement through activities could be achieved by helping students take responsibility for their learning, helping them to see the significance of the work in their own life, and by making the learning experiences relevant and efficient. The ways to implement these means of representation, expression, and engagement will vary according to the specific course, specific content, specific learning objectives, and *special circumstances*. Therefore, there is no one-size-fits-all approach to making learning achievement more accessible to all students.

Future Research Directions

Although there is a vast amount of research evidence that supports UDL (NCUDL, 2013), there is very little research conducted on courses in specific content areas or on courses with a high level of UDL implementation. This gap points to the need for research on courses in a variety of content areas and courses with varying levels of UDL implementation. Varying the content disciplines and varying the organizations being researched should help with the generalizing evidence. Further, using a randomized experimental design to place learners into courses with low and high levels of UDL should help with the validity of the data. Research can also be conducted on the instructor implementation of UDL. Further, what it means to be an *EOILS* needs to be explored. This is an excellent area of opportunity to perform successful research and provide supportive educational methodologies for those who want to improve their course in the future. It is often possible to publish these results if a good research question is defined and appropriate evaluations are obtained prior and post implementation of UDL.

CONCLUSION

The research that has been accomplished has shown that a *one-size-fits-all* approach does not work well for designing and implementing a curriculum for learners with various backgrounds and learning preferences. The main goal of using UDL in a curriculum is to have an environment that will allow learners with varying background knowledge and learning preferences to be involved in the same course and have an equal opportunity to learn. UDL can facilitate an environment where diverse sets of learners can begin to have an enduring passion for the course content and subject matter. Equal Opportunity Instructors for Learning Success will serve social justice when every attempt is made to meet the learning needs of all learners. Because using UDL has an implicit goal of achievement for all learners through a more accessible curriculum, UDL should be seen as a innovative means of achieving social justice. As more learners find educational environments that meet their learning needs, there is greater opportunity for success.The following are quotes that may be inspiring as UDL principles are implemented.

It is the supreme art of the teacher to awaken joy in creative expression and knowledge. – Albert Einstein

There are two kinds of teachers: the kind that fill you with so much quail shot that you can't move, and the kind that just gives you a little prod behind and you jump to the skies. – Robert Frost

REFERENCES

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Bloom, B. S. (1956). *Taxonomy of educational objectives, handbook I: The cognitive domain*. New York: David McKay Co Inc.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). How people learn: Brain, mind, experience, and school (Expanded ed.). Washington, DC: National Academy Press.

Bruner, J. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.

Center for Applied Special Technology (CAST). (2013). *About UDL*. Retrieved May 1, 2013 from http://www.cast.org/udl/index.html

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58. doi:10.1177/1529100612453266

Gagné, R. M. (1985). *The conditions of learning and theory of instruction* (4th ed.). New York: Holt, Rinehart, and Winston.

Grimes, J., & Desrochers, C. (2009). *Making your 1st class session really first class*. Retrieved May 1, 2013 from http://elixr.merlot.org/case-stories/course-preparation--design/first-day-of-class/goals-for-first-day-of-class7

Grimes, J., Victorino, C., Stuart, K., et al. (2010). *After the 1st day: Maintaining the momentum*. Retrieved May 1, 2013 from http://elixr.merlot.org/case-stories/teaching-strategies/after-the-1st-day-of-class/after-the-1st-day-of-class---constructivist-teaching-methods2

Mayer, R. (Ed.). (2005). *The Cambridge handbook on multimedia learning*. New York: Cambridge University Press. doi:10.1017/CBO9780511816819

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press. doi:10.1017/CBO9780511811678

Michaelsen, L., Bauman-Knight, A., & Fink, D. (2003). *Team-based learning: A transformative use of small groups in college teaching*. Sterling, VA: Stylus Publishing.

Mulcahy-Ernt, P. I., & Caverly, D. C. (2009). Strategic study-reading. In R. F. Flippo, & D. C. Caverly (Eds.), *Handbook of college reading and study strategy research* (2nd ed., pp. 177–198). Mahwah, NJ: Erlbaum.

National Center on Universal Design for Learning (NCUDL). (2013). *UDL guidelines – Version 2: Research evidence.* Retrieved September 13, 2013 from http://www.udlcenter.org/research/researchevidence

Weinstein, C., & Mayer, R. E. (1985). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 1–53). New York: Macmillan.

KEY TERMS AND DEFINITIONS

Assessment of Learning: A means of calculating how much has been learned by a learner or attempting to understand a learner's thought process.

Elements of Learning: Issues related to learning and instruction that help shape the process of implementing the Facilitation of Learning.

Equal Opportunity Instructor for Learning Success (EOILS): Instructor who tries to improve the potential for learning success of all of her/his learners'.

Facilitation of Learning: The process of helping to make learning possible. This can include identifying and making the most of special circumstances, learning outcomes, assessment methods, and potential interactions with learners.

Process for Including UDL in a Course: Steps taken when an instructor plans, implements, and evaluates the implementation of UDL in a course.

Scaffolding of Learning: A means of providing assistance and support for learners through

additional materials, peers, helpers, or tutors, or through direct guidance by the instructor.

Social Justice in Education: Opportunity in which every instructor can participate by focusing on how she/he can create an environment that maximizes the number of learners in her/his classroom who are targeted for learning success.

Special Circumstances: the environmental and learner variables that are somewhat unstable, unpredictable, and uncontrollable and make an iteration of instruction potentially different from former or latter iterations.

Three Guiding Principles of UDL: Provide multiple means of representation, provide multiple means of action and expression, and provide multiple means of engagement.

Universal Design for Learning (UDL): Educational structure that is based on research that provides principles for developing and implementing instructional goals, methods, materials, and assessments that maximize learning paths for learners in class.

ENDNOTES

[1] The term student is used when the person is in a classroom and the term learner includes the potential of being a student or a person who is studying beyond the classroom.