Jim Doran
Summer 2014

Nuclear Power – The Core

Course Design Documentation

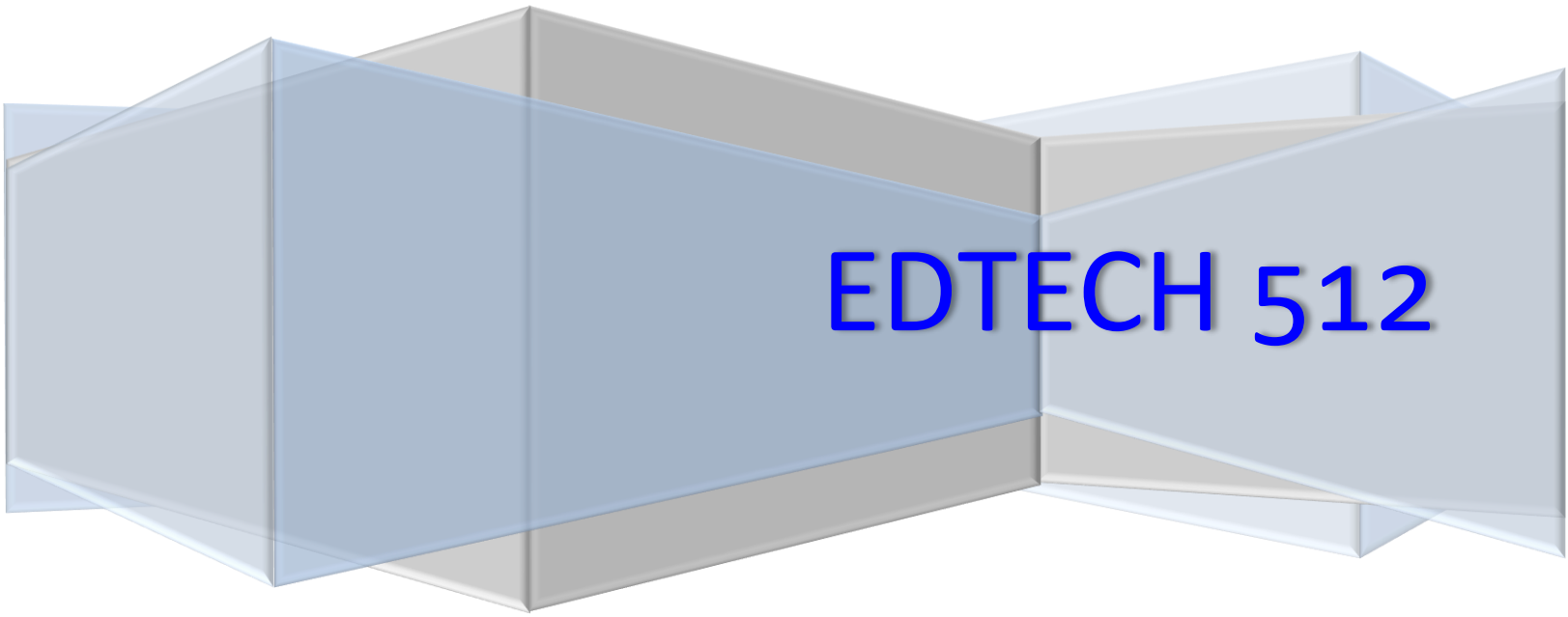


Table of Contents

Project Summary:

This course will familiarize the learner with the principals involved in the generation of nuclear power. The course will begin with a fundamental treatment of atoms as a whole and move on to address how Uranium atoms and nuclear fission are used to generate nuclear energy.

Front-end Analysis

Problem Analysis

What Problem Are You Trying to Address

There is a general lack of knowledge within the non-operations community as to the inner workings of the atom and how this relates to nuclear fission. In short, our personnel have less than a full understanding of the inner workings of the nuclear core, while at the same time their every action can affect those workings and thus the health and safety of the public.

Is Instruction An Appropriate Solution for the Problem

Instruction is the appropriate solution. The science of nuclear physics is complex and unique. There are terms which are new to the learner and require explanation and simplification. Far too often, the explanations presented in textbooks fail to simplify and thus are ineffective. By presenting the information as a series of lessons the learners will be guided through complicated concepts with a series of easy to understand examples. Additionally, the use of multimedia will present visual examples that cannot be duplicated by a textbook.

Is Web Base Instruction An Appropriate Solution for the Problem

Web Based Instruction is the only solution to this problem. The learners are all employed in other capacities within the plant. By presenting this topic on the web, the learners will be able to access the instruction when they have time and want to learn. As previously mentioned in the proposal section, this is not, at this time, a required course, which makes it an ideal candidate for Web Based Instruction.

What Is Your Instructional Goal

My goal is to give the learners a working knowledge of nuclear physics and nuclear reactor kinetics. While I don't expect them to apply to CERN following the course, I would expect them to have a basic understanding of the atomic structure and how nuclear fission produces heat within the nuclear core. The course will also touch on topics such as the neutron life cycle and neutron moderation. Lastly, my goal would be that they would be able to describe to their acquaintances outside the Millstone community how and why a nuclear power plant is different than a nuclear bomb.

Context Analysis

Description of Organization

Millstone Power Station currently employs approximately 1100 people. All employees have access to a company computer with access to the internet and all have access to personal computers and other web access devices.

Learner Analysis

General Demographics and Learner Characteristics

Employees at Millstone Station are between 18 and 65. All employees have received, at a minimum, a high school diploma. Additionally, prior to being hired, all employees are required to pass a competency exam in their chosen field. They are all taught to comply with station procedures and, for the most part, possess a high degree of technical competence. Over the next five years the age demographic will shift to a lower average age as the majority of the older workforce retires and is replaced by younger new hires. For example, System Engineering will be replacing 40% of its workforce over the next five years.

Motivations

All employees at Millstone Station are inculcated with the core values to keep the nuclear core covered, cool and contained, and while they can rattle off these three "C's," they really don't understand what is taking place within the core other than it is generating heat. Nuclear

fission is an amazing topic in that the reactions can't be seen, but we know how and why they are taking place. All nuclear workers are, by nature, genuinely inquisitive. They like to know how things work rather than just taking for granted that they do. As such, the ability to know how the core works at an atomic level will appeal to them just as much as knowing how a circuit breaker opens and closes.

Prior Knowledge

While prior physics knowledge will prove helpful, it will not be required. The learners will require high school level math skills which all already possess. Additionally, all nuclear workers have a rudimentary understanding of nuclear fission (the splitting of atoms) and different types of radiation.

Technical Skills

All employees are required to participate in computer based training for yearly qualifications. Thus, computer based learning is not a new concept. They will be required to navigate through multiple modules during this course, but this should not present a challenge.

Abilities and Disabilities

The learners will be required to have the ability to combine a series of simple concepts to understand more complicated principles.

Other Learner Characteristics

None

Relevant Standards

While INPO (Institute of Nuclear Power Operators) maintains standards for Operations, Maintenance and Engineering personnel, this course will be designed such that all workers have a fundamental understanding of the inner workings of the nuclear core. As such, at this time, no standards will be followed or applied.

Course Goal

Upon completion of this course the learner will understand the fundamental concepts behind nuclear fission and reactor kinetics and how those concepts work to produce thermal energy in a nuclear reactor.

Course Outcomes

1. Students will understand the Bohr model and standard notation of an atom and be able to determine the number of protons, neutrons and electrons from the Periodic Table of Elements and from the standard notation of the element's isotopes.
2. Students will understand the structure of the atom and the forces which are present within the nucleus of the atom. They will be able to explain how these forces react to produce energy within the nuclear core.
3. Students will know the four specific types of radiation produced in the core and how this radiation is produced. They will be able to explain the radioactive decay of elements and identify, using a Chart of Nuclides, how each element decays.
4. Students will be able to explain the life cycle of the neutron and the effects of a moderator on neutrons. Additionally, they will know the difference between fast and thermal neutrons and prompt and delayed neutrons.

Learning Objectives

Module #	Course Outcome	Learning Objective	Bloom's Level of Thinking for Objective	Assessment
1	Outcome Number 1	DETERMINE the number of protons, neutrons and electrons of a given atom, given a Periodic Table of Elements.	Knowledge	Short Answer
1	Outcome Number 1	LIST the properties of protons, neutrons and electrons including charge, location within the atom and relative mass.	Knowledge	Complete a Table / Fill In the Blanks
1	Outcome Number 1	DETERMINE the number of protons, neutrons and electrons of a given atom given an atom's standard notation.	Knowledge	Fill In the Blanks
1	Outcome Number 1	DEFINE the following terms: Atomic Mass Unit, Nucleon, and Isotope.	Knowledge	Short Answer

Module #	Course Outcome	Learning Objective	Bloom's Level of Thinking for Objective	Assessment
2	Outcome Number 2	STATE the forces present within the nucleus of an atom and arrange these forces in order of strength.	Knowledge	Short Answer
2	Outcome Number 2	DEFINE the term Mass Defect and CALCULATE the Mass Defect of an individual atom.	Knowledge / Analysis	Short Answer / Calculations
2	Outcome Number 2	CALCULATE the binding energy and the binding energy per nucleon of an individual atom.	Analysis	Word Problems
2	Outcome Number 2	CALCULATE the amount of energy released when a fission event occurs.	Analysis	Word Problems
3	Outcome Number 3	DESCRIBE the difference between an atom at ground state energy and excited state energy	Comprehension	Short Answer
3	Outcome Number 3	DESCRIBE how the stability of a nuclide is related to its neutron to proton (N/Z) ratio.	Comprehension	Short Answer

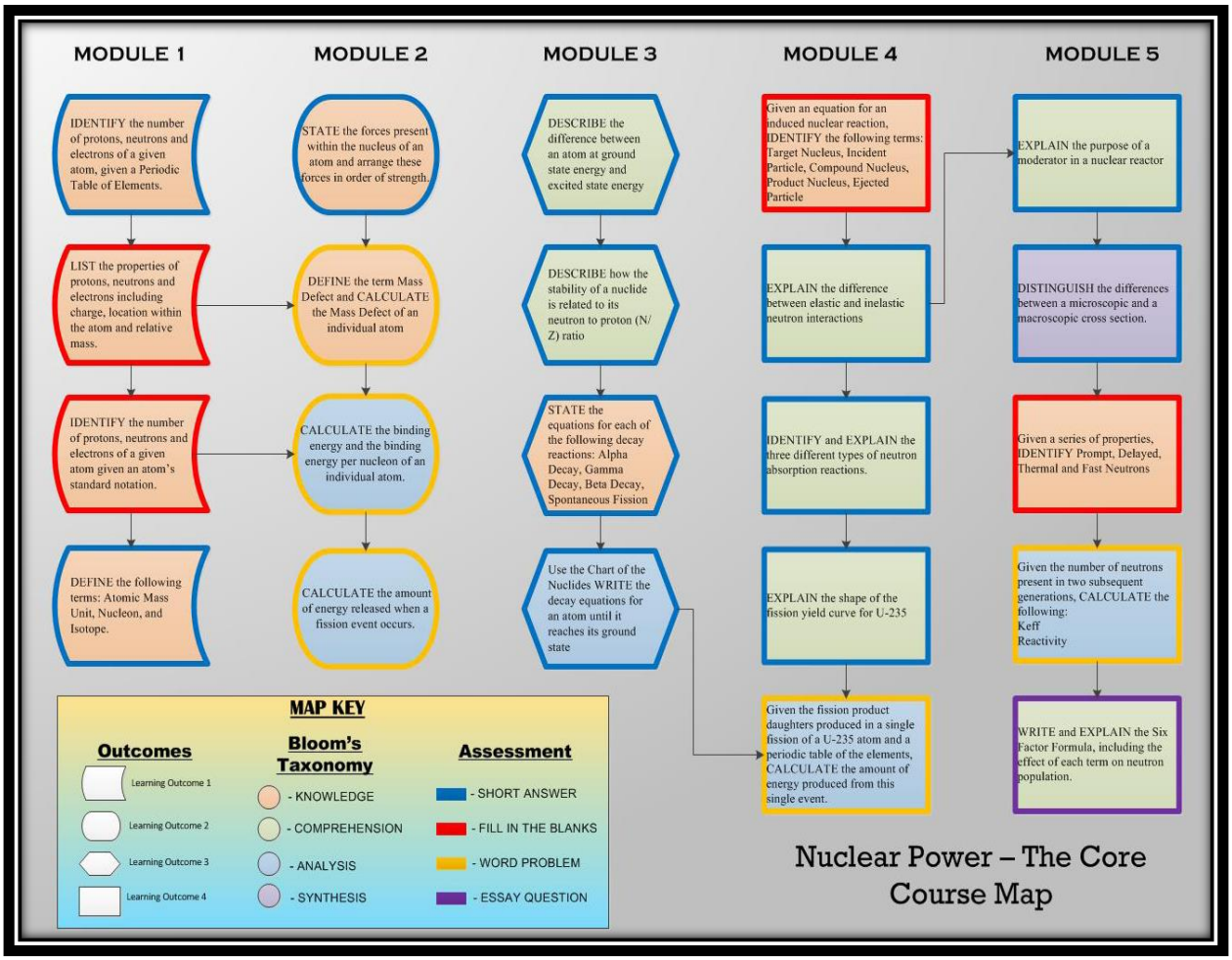
Module #	Course Outcome	Learning Objective	Bloom's Level of Thinking for Objective	Assessment
3	Outcome Number 3	STATE the equations for each of the following decay reactions: Alpha Decay, Gamma Decay, Beta Decay, Spontaneous Fission	Knowledge	Short Answer
3	Outcome Number 3	Use the Chart of the Nuclides WRITE the decay equations for an atom until it reaches its ground state	Analysis	Short Answer
4	Outcome Number 4	Given an equation for an induced nuclear reaction, IDENTIFY the following terms: Target Nucleus, Incident Particle, Compound Nucleus, Product Nucleus, Ejected Particle	Knowledge	Fill In the Blank
4	Outcome Number 4	EXPLAIN the difference between elastic and inelastic neutron interactions	Synthesis	Short Answer
4	Outcome Number 4	IDENTIFY and EXPLAIN the three different types of neutron absorption reactions.	Comprehension	Short Answer

Module #	Course Outcome	Learning Objective	Bloom's Level of Thinking for Objective	Assessment
4	Outcome Number 4	EXPLAIN the shape of the fission yield curve for U-235	Comprehension	Short Answer
4	Outcome Number 4	Given the fission product daughters produced in a single fission of a U-235 atom and a periodic table of the elements, CALCULATE the amount of energy produced from this single event.	Analysis	Word Problem
5	Outcome Number 4	EXPLAIN the purpose of a moderator in a nuclear reactor	Comprehension	Short Answer
5	Outcome Number 4	DISTINGUISH the differences between a microscopic and a macroscopic cross section.	Comprehension	Short Answer
5	Outcome Number 4	Given a series of properties, IDENTIFY Prompt, Delayed, Thermal and Fast Neutrons	Knowledge	Fill In the Blanks
5	Outcome Number 4	Given the number of neutrons present in two subsequent generations, CALCULATE the following: Keff, Reactivity	Analysis	Word Problem

Module #	Course Outcome	Learning Objective	Bloom's Level of Thinking for Objective	Assessment
5	Outcome Number 4	WRITE and EXPLAIN the Six Factor Formula, including the effect of each term on neutron population.	Comprehension	Essay Question

Design (Mapping the Course and Instructional Planning)

Course Map



Instructional Planning

Module #	Learning Objective	Possible Activity	Type of Interaction
1	All	Which Super Hero Are You Game	Student to Content
1	All	Class Intro / Game Results	Student to Student
1 & 2	All	A quiz submitted to the teacher via scan or electronic document. There will be math on the exam so sometimes students prefer doing math on paper	Student to Teacher
2	Not aligned with objective, but promotes knowledge beyond the course.	Which is the most important element in the generation of nuclear power forum?	Student to Student
3	All	Table of Nuclides Scavenger Hunt	Student to Content
3	Not aligned with objective, but promotes knowledge beyond the course.	In your opinion does nuclear power have a future in the United States? Why or Why not? Forum	Student to Student
3 & 4	All	A quiz submitted to the teacher via scan or electronic document. There will be math on the exam so sometimes students prefer doing math on paper	Student to Teacher
4	Not aligned with objective, but promotes knowledge beyond the course.	Choose a country and examine their energy policy. Explain the policy to the class. Are they on the right track, why or why not.	Student to Student
5	All	Create a map which represents the Six Factor Formula including on ramps and exits. Explain the map. Share with the class	Student to Content / Student to Student

Motivational Planning

Module	Plans to motivate your learners
Module 1	5 extra points for participating in an exercise to write an article about their favorite physicist. They then get to play the Which Super Hero Are You game. The game will have answers unique to the reading to encourage the learners to read the chapter as well as watch the video. I will bring this fact up during the introduction to the second video to ensure that the learners at least peruse the learning material
Module 2	The learners in Module 2 will be motivated because there will be a quiz which will count for 1/3 of their grade. Additionally, the concept of Mass Defect is a reward unto itself. The lead in to the module explains that something is missing from the atom. It starts like a good detective novel.
Module 3	Module 3 will include a table of nuclides scavenger hunt. When radioactive elements decay, they do so by a predetermined chain based on their energy. I will create a Chart of Nuclides that includes a code. The learner's job will be to follow the decay chain to the end and determine the appropriate letter to be used in the message. The learning will be taking place, that is to say that they will be learning to follow decay chains, but they won't realize it as they will be concentrating on deciphering the message.
Module 4	The fission process is the big reward. This is what, presumably, each student who has taken the course is eager for. This is the process by which we make money at a nuclear power plant. For my targeted learners, this is their core business.
Module 5	Again the lead in to the Module gets the student's attention. They now understand the effect of one butterfly flapping its wings and now they're going to learn how the fission process creates hundreds of thousands of butterflies.

Content Planning

Module #	Content
Generic Format	Course Videos – Create 15 – 20 minute videos to provide instruction. Course Lessons – Create written lesson broken up into sections for chunking. Course Text – Create PDF files for each course lesson and for entire course.
Module 1 Activity	Create – "Which Superhero Are You" web based activity.
Module 2 Activity	Create - 20 point quiz in PDF format for download.
Module 3 Activity	Create – "Chart of Nuclides Decode web based activity.
Module 4 Activity	Create - 20 point quiz in PDF format for download.
Module 5 Activity	Create – Template for Neutron Life Cycle activity. Create - 30 point final exam in PDF format for download.

Social Interaction Planning

Module #	Social Interaction
Module 1	Class Introduction including which Superhero the student is.
Module 2	In your opinion which is the most important element in the generation of nuclear power? forum
Module 3	In your opinion does nuclear power have a future in the United States? Why or Why not? Forum (Code Exercise Answer will be my favorite element.
Module 4	Choose a country and examine their energy policy. Explain the policy to the class. Are they on the right track, why or why not?
Module 5	Shared maps of the Six Factor Formula

Prototype

The course will use the Moodle Serenity template. I chose to use Moodle to present the course because of my desire to learn the software. The course could just as easily be presented via a web page and may yet be in the future, but one of the reasons for taking this course was to learn the Moodle software. I chose the Serenity template because of the clean lines and neutral colors. Both enhance the professional appearance of the course.

Typography

The module heading will be the default set by the template. Which is a Times New Roman 20pt black Font. The sub-heading will be a Times New Roman font 18 pt. with an RGB value of 38, 155, 172. The font used for the instructions of each module is a 12pt Times New Roman Font.

Heading 1: Times New Roman 20, bold, RGB: 0,0,0,

Heading 2: Times New Roman 20, bold, RGB: 38, 155,172

Body text: Times New Roman 12, black, RGB: 0,0,0

Color Scheme

Color	RGB	HEX#	Main Purpose
	193-188-187	C1BC9D	Page Background
	Pattern Fill	Pattern Fill	Title Banner Background
	110-104-85	6E6855	Moodle Nav Bar
	170-180-193	AAB4C1	Course Nav Bar
	255-255-255	FFFFFF	Moodle Nav Bar Text
	89-102-150	596699	Course Nav Bar Text
	134-127-106	867F6A	Menu Sub Nav Bar
	38-155-172	269BAC	Sub Heading Text

Design Prototype

Introduction Screen Shot

Week 1 Screen Shot

Design Justification

I chose this template because of the professionalism of the design. The tone of the course is light hearted, but I want the learners to understand that this is a serious learning experience presented in a fun way that is easy to understand. I also chose the template because of the left sided course navigation bar. Most internet users instinctively look left when attempting to navigate a series of pages. Thus, this design presents the lesson in a format that is intuitively obvious for the learner.

Formative Evaluation

Process

The evaluation was sent via email. The email contained both the course web address and the questions to be evaluated. That email was followed up with a phone call the next day explaining the need for the evaluation and an explanation that this material may be required to be completed by all Maintenance Department personnel at a later date. The evaluator responses were returned via email and follow up phone calls were made to clarify any outstanding issues.

Reviewers

Because this is training for the Maintenance Department, the following personnel were included:

- The Maintenance Department Manager – Tony Conant
- The Supervisor of Technical Training – Ellen MacLean
- A Senior Technical Instructor – Patrick Tolley
- A Junior Mechanic – Frank Fischer
- A Junior Instrumentation and Control Technician – Ryan Denny
- A Junior Electrician – Kyle Startz

Questions

1. How many years of experience have you had in nuclear power (include Navy experience)?
2. Have you had any prior training in nuclear physics?
3. Of the learning activities provided, which was your favorite and least favorite and why?
4. What difficulties did you have navigating the course?
5. What could be added/removed from the course to enhance your job performance?
6. Did you prefer the provided text in the two initial modules or the links to articles in the last three modules and why?

Additional Question for Nuclear Training Personnel:

1. What, if anything, must be added to the current design document to bring it in line with current Training procedures?

Formative Evaluation Results

Question 1: How many years of experience have you had in nuclear power (include Navy experience)?

Conant: 20 Years Navy Nuke Mechanic, 8 Years Savannah River, 2 Years Millstone

MacLean: 27 Years Millstone Training

Tolley: 5 Years Nuclear Electrician, 3 Years Nuclear Supervisor, 2 Years Trainer

Fischer: 2 Years Millstone Mechanical Maintenance

Denny: 2 Years Millstone Electrical Maintenance, 1 Year I & C Technician

Startz: 2 Years Millstone Electrical Maintenance

Question 2: Have you had any prior training in nuclear physics?

Conant: 6 Month Nuclear Power School
MacLean: None
Tolley: None
Fischer: None
Denny: None
Startz: None

Question 3: Of the learning activities provided, which was your favorite and least favorite and why?

Conant:

The Decoding Exercise was my favorite. There was a defined goal at the end of the exercise. The research and writing activities were the least favorite. They took too much time and were not specifically job related.

MacLean:

There were too many quizzes. You should consider adding another learning activity in place of one of the quizzes. Students enjoy learning in a fun environment and quizzes make things too formal.

Tolley:

Too much writing. Maintenance does not have the time to write book reports. The Superhero activity was the best one. Too many quizzes.

Fischer:

The Decoding webpage was my favorite. I did not do any of the research. I didn't have time. There should only be two quizzes.

Denny:

Rather than have us draw a neutron life cycle map. Provide an outline and have us fill it in. Internet activities were cool.

Startz:

Research and writing were my least favorite. Took way too much time. Too many tests. Stick with fun activities with one or two tests.

Revisions

Obviously, the writing activities should be removed. The issue I forgot as a designer is that the learners have a limited amount of time to access the lessons. I will leave the activities as is for the purpose of the online design course, but when this course is put out to Millstone workers, I will remove them. I am also considering removing all but the last quiz and substituting web activities in their place.

Question 4: What difficulties did you have navigating the course?

Conant:

No difficulties navigating. I liked that the videos were right there to watch. In line links are confusing.

MacLean:

Consider adding lists of activities to do after the videos. Start off with a brief intro describing the tasks and then create a to-do list to finish the module.

Tolley:

The words before and after the video are confusing. Start with a section of words describing the module then make a list of activities.

Fischer:

Videos easy to find. I had a hard time figuring out where things were.

Denny:

Make a list of stuff for us to do. Too many words in the wrong places.

Startz:

Format was confusing. I could find the videos but had to hunt for the rest.

Revisions

This message is quite clear. I will revise the course to have an introduction to each module followed by the activities listed in order after the video. The learners this course is designed for are serial people and as such, the format of the course should reflect that.

***Question 5*: What could be added/removed from the course to enhance your job performance?**

Conant:

More should be added to the course concerning core control with delayed neutrons. Rx kinetics should be discussed.

MacLean:

This is a good overview of nuclear power. There should be a discussion about control rods and what they do. You should be including OE in the material.

Tolley:

Material should be more specific to Millstone. How do we "Control" the core.

Fischer:

Nothing added or removed.

Denny:

Modules should be more directed at the job. What do we do that effects (sic) this?

Startz:

Nothing

Revisions

The course should be expanded to include reactor kinetics. Given the time limitations, this material will be added at a later date with OE (Operating Experience) which directly relates the material to each job description. The learners did not address this as they do not know all that is available to learn about the subject of controlling the core.

***Question 6*: Did you prefer the provided text in the two initial modules or the links to articles in the last three modules and why?**

Conant:

The text is good, but it takes too long to read and rehashes the video. The articles are better, quicker.

MacLean:

The text is too long. The video with short articles is a better format.

Tolley:

Get rid of the text. Zzzzzzzzzzz The articles are better.

Fischer:

The text is interesting, but took too much time to read.

Denny:

The articles are better. They didn't take up a lot of time.

Startz:

Articles because they're shorter.

Revisions

After initially choosing to go for all web based content, I've revised the decision and have decided to use the written chapters broken into chunked sections.

***Question 7*: What, if anything, must be added to the current design document to bring it in line with current Training procedures?**

Conant:

You need to include Industry Operating Experience and Human Performance tools within the modules.

MacLean:

There should be a Human Performance Section in each module. Also include OE where appropriate.

Tolley:

Need OE and HU tools.

Revisions

These comments are valid. I will include a Human Performance and OE Section in each module and eliminate the writing activities.

Survey Results Summary:

The results of the survey clearly point out that time pressure is a prime concern of those taking the class. This is not surprising given that work within the plant proceeds according to a set schedule. Even though the course time frame is laid out as self-paced, clearly the internal rhythm of the course will need to be quickened. Also, the formatting for the course will have to less focused on entertaining (except for the activities) and more focused on a to-do list format. Again this is not surprising given the personalities of the learners participating in the course. Nuclear Power workers are generally task driven individuals. Lastly, this course will need to be revised to include Operating Experience and Human Performance tools to comply with plant procedures and standards.

Based on this feedback, the following changes will be implemented in the listed timeframe.

Immediate Changes:

- Reformat the course to eliminate inline links and convert to a course where the introductory prose provides a lead in, followed by video lesson, followed by additional module activities.
- Eliminate the need for learners to graphically represent the neutron life cycle, instead create a fill in the blank graphic to be used for this activity.

Three Month Changes:

- Eliminate class participation writing exercises and replace with reviews of Operating Experience and Human Performance Standards with short answer quizzes to ensure this material is reviewed.
- Complete text material for weeks 3-7.

Six Month Changes:

- Add two additional modules: Module 6, Reactor Kinetics and Module 7, Reactor Control.
- Create online learning activities for Modules 2, 5 and 6.
- Eliminate Quiz from Module 2. Switch to a Midterm/Final format to be given up completion of Modules 4 and 7.

Summative Evaluation

Because the goal of this course is to promote understanding and appreciation of the nuclear core, the evaluation will be long term with both participant and management input. The outcomes cannot be measured in a discrete fashion, but rather by the day to day use of the information presented in pre-job briefs, two minute time outs, job site reviews, and post job critiques.

Evaluation Methods and Tools

Given the time constraints in the work day of the participants, post course and three month, evaluations will be performed electronically, providing an incentive in the form of a raffle for participation. Management observations will be evaluated using reviews of job observations and with a series of interviews conducted at three month and six month intervals.

Evaluation Questions

Immediate Post Course Questionnaire for Participants

Question	Excellent	Good	Fair	Poor
Please rate the quality of the online training materials,				
Please rate your comprehension of the material presented.				
What is the likelihood that you will use this material in the day to day performance of your job?				
Please rate the Instructor response time to any inquiries.				
Please rate your comfort level with participating in an online course.				
What is the likelihood of your participation in another, non-mandatory online course?				
Please rate your overall experience with this course.				
Please list three specific examples where you will use this course in the performance of your job.				

3 Month Post Course Questionnaire for Participants

Questions
Please list three specific examples where your knowledge of the core and reactivity in the performance of your job.
Please list three specific examples where your management has asked you about your knowledge of reactivity and the core.
Please list three specific examples where you have challenged your peers on their knowledge of reactivity and the core.

Question	Excellent	Good	Fair	Poor
Please rate your overall retained knowledge level associated with this course.				

3 Month Post Course Questions for Management

Have you noticed an increase in the number of references to core reactivity in pre-job briefs, 2 minute time outs and job site reviews?

What, if anything, have you done as management to challenge your workers about their knowledge of reactivity and the core?

Have you mentioned core reactivity in any of your morning meetings during the past three months?

Six Month Post Course Questionnaire for Management

Questions	Excellent	Good	Fair	Poor
Please rate the increase in your working group's knowledge of core reactivity in the last six months.				
Please rate the increase in your working group's references to core reactivity in the last six months.				
Have you mentioned core reactivity in any of your morning meetings during the past six months?				