right click to open a **new tab** for *certain words* in red to learn something new!

Digital Technology and Physics Education

Madison Colleen Burgess

Department of Physics and Astronomy

San Francisco State University

Thesis Advisor: Billy Caudy

Faculty Advisor: Joseph Barranco

Spring 2016

Abstract

The specialized development of physics education research started in the 1960s and erupted in the 1990s as a reaction to socio-political fronts in America and a boom in technology influenced by the *"Dot-Com bubble"*. As a result, the socio-political front of standardization, new content creation, and a push for the sciences highlighted what needed change in physics education and brought to mind by the Physics Education Research (PER) field. In addition, this change set up a standard by students as to what they expect *from* a physics education. As a result, there has been a shift towards fulfilling our students' expectation through technology. Student's expect education to be different as a result of the immersion of technology in their lives. This thesis is a discussion as to why there is a push for technology, what we currently have, and how technology can be incorporated into curriculum. This research on physics education has been done in part with help for open source technologies, a mass examination of resources, and an examination of pre-existing successful programs where the final product may be viewed here.

Methods

The original intent for this thesis was one of an analysis of undergraduate physics problems and eventually publishing this material for free use via Amazon Kindle Publishing and a free pdf download source, this part of the thesis was incorporated to some extent and the original version is seen in Appendix I. However, as a result of conducting research on the analysis of the problems that were to be in the book on the internet and then comparing them to various sources and textbooks; I quickly started to see patterns while I was researching the best approach to these problems. One pattern was the lack usability in physics media, the second was the lack of modernization, and the third was a lack of active learning while learning materials.

Stepping back to the first part, research on the analysis of basic undergraduate physics problems was conducted for about a month looking at various physics textbooks published anywhere from the 1930s up to around 2014. Looking at these textbooks I put myself in the place of someone having to learn this again for the first time, and found the textbooks to be overwhelming and riddled with useless information. Often, because I am well integrated with technology, I used the internet and often found better resources than the textbooks that I was looking at that had less “fluff”. This led to a critique, which will be discussed in the section of active versus passive learning specifically with a discussion of language or mathematics based learning, I started to move away from the use of these textbooks. This is because most of the textbooks that I had been using, I had found views online for them that were often negative. There was a trend between the type of publisher of the textbook, the qualities of the reviews and the accessibility of the textbook itself. Professors who had published their own textbook, or made it readily available online where often much better than those who have charged for these books.

Because of this, I started to look at the online publications of textbooks and resources. This is what began the digital part of this thesis investigation. This investigation included analysis of what was readily available for physics education online, availability of resources to students in physics departments, an analysis of PER, education in the United States, and then the technical aspect.

The technical aspect delve into more into more computer science and back-end development involved with applying dynamic learning through the use of html scripts and hosting. It also involves the interactions of existing technology and integration of this to education resources. While the full aspect of the dynamic resource tool that was developed as the main focus of this thesis will still be in development as a working resource, the sections that were developed during the initial investigation of this thesis was integrated in the first five chapters presented on the site made for this stage of research with the additional resources gathered as part of the second part of the investigation. The third part of this investigation will be highlighted in the development of this full thesis, in terms of the history of PER. The fourth part of this investigation will be developing the technical aspect of having a large resource, hosting online, and digital education integration from a developer's point of view.

There was also an extensive viewing of previously created education and human resources coursework and a prolonged discussion of online learning was also done in part with the help of Dawn DiMarzo, E.D.D, Professor of child development, human resources, and early childhood education, who creates and uses a series of online courses currently at Kaplan College's online portion. Dr. DiMarzo was also useful for a perspective on online learning in terms of learners whose english is a second language, where a number of her students in child development are english learners. As well as observations of her use of online learning platforms and content creation for her courses as a part of National University (majority online), Kaplan College (all online), and Miramar College (mostly in-person). As well as an extensive viewing of digital content that is currently presented for our undergraduate courses at SFSU which lead to the development of html specific scripts for the dynamic resource site that was made. Additionally, I investigated online learning as the part of the student through viewing a preparatory course given by Kaplan, which heavily influence the idea of dynamic and passive learning which will be developed in this thesis.

However, for reasons that will be fully explained, the full dynamical functioning hosted site presented as apart of this final thesis will be a prototype version of what is to be developed because hosting and gather a large database needs more efficient scripts than what I can put together manually. What is to be developed will have it's software be explained in full but not implemented until later in 2016.

Part I: Education Investigation

History of Education Reform in the United States

This thesis begins with a history of education reform in the United States due to a number of factors. The main reason being that students entering the university system in the United States would have been affected by education reform, and thus set up a certain perspective when it comes to education. In a discussion with child development professor Dr. Dawn DiMarzo, she elaborated that many students coming out of No Child Left Behind, as well as the new standard that has been adopted by states the Common Core, have a lot of pressure put on students. This type of curriculum has prepared students to enter college; however, it has put a lot of pressure on them to have a higher grade. The transfixiation on higher test scores is tied with higher success rates, thus putting more pressure on the grade often has lead to a decrease of students enjoyment of the class. This type of mindset, putting pressure on students to be better, comes in other forms as well. For example, in the past couple of years there has been a rise in transitional kindergartens. Often this means that with transitional kindergartens, actual kindergarten has become first grade; which causes a problem with development because students are not mentally developed. First grade, for example, is one of the most difficult grades with students learning how to read, and putting pressure on them to success when they have not met the development for their age causes problems. This is just one example of how this type of pressure occurs during early development. Take the example of a student who wants to get ahead and takes advanced courses, that student is pressured to succeed from multiple angles. These students, who have been pressured to succeed their whole lives now come into our university.

Eventually, when we tie this type of learning to the university system, students come in with an expectation, or pressure, to succeed. Often they leave with more enjoyment of the subject because universities alleviate this pressure and students often want to come back and continue school because of this. Stepping back, let us look at that history of education reform in America to see why the United States in particular is unique to this issue.

How one teaches and how one learns has been a focus in the U.S. physics academic community and as apart of physics education research (PER), has undergone many changes within the past 200 years. Recently, with falling test scores and increases standards, there has been a call for K-12 teachers and university faculty to transform their courses. If we want to look at the state of physics education in 2016 forward, then we must look back to the time where the majority of our students were first learning. The groups of students that will be entering or continuing university within the next two years were born between 1992- 2000 meaning that we have to see what influenced education during and after this period to understand what our students expectations are.

In terms of K-12 what students have had for their previous education was brought on upon by education reform in the 1990s during the Clinton administration. The late 90s and early 2000s were wrought with reports that students in America were consistently decline in test scores in mathematics and science. In fact in the 90s, the United States was ranked 28th in math and science test scores as part of an international study. In a new Pew Research Center report it states that in 2016 , only 29% of Americans rated their country's K-12 education in STEM as above average or the best in the world. Scientists were even more critical, a survey of members of the American Association for the Advancement of Science found that just 16% called U.S. K-12 STEM education the best or above average; 46%, in contrast, said K-12 STEM in the U.S. was below average.Standardized test results appear to largely bear out those perceptions. While U.S. students are scoring higher on national math assessments than they did two decades ago , they still rank around the middle of the pack in international comparisons, and behind many other advanced industrial nations, as we can see in Figure 1 below. However, it seems that our students also grow more slowly in mathematics proficiency were the major of our students' knowledge level was less than 60% on average not proficient and even less were advanced as seen in Figure 1 below. With United States score ranking in STEM near countries like Hungary and Spain, far below of of neighboring country Canada.

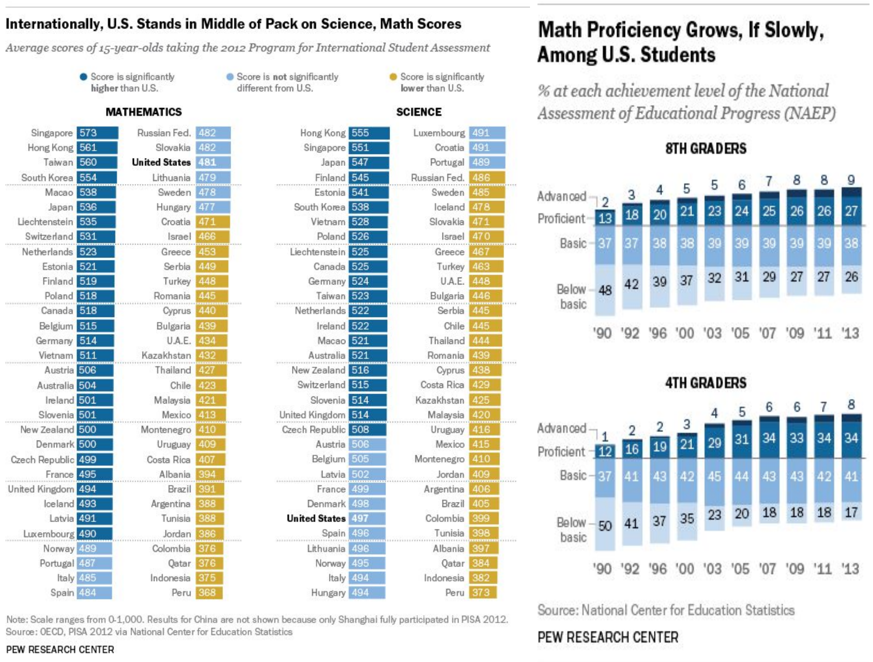


Figure 1.

The presidency of Bill Clinton tried to combat these statistics in the 1990s with his version of education reform. But the failure of education reform was at it's zenith as part of the Bush administration due to No Child Left Behind. This program was announced by former-President Bush three days after stepping into office and passed Congress with bipartisan support, because who *would* vote against education reform. The program was designed to be data driven and test children every single year as a way to "fix failing schools". President Bush at a press conference described this data driven system as an "the accountability system" where students are scored and it they don't meet a certain standard then this hurts the scores of the teacher and school, and visa versa. Bush describes this system saying that the, "accountability system must have a consequence, otherwise it is not much of an accountability system." This system, however, tripled the number of standardized tests from 6 to 17 on average. And often districts tied teacher pay to student performance using "value added analysis" which in theory was suppose to score students on a certain percentile and if students rating rose or dropped so did their teachers. However often enough the algorithms for the value added analysis data were impossible, often having unachievable scores. Why? Because the algorithm that was used was partially made from a model that modeled “the reproductive trends of livestock.” Having a national research system that forms the backbone of our educational system with faulty data has obviously lead to a nationwide epidemic of failing schools. In fact when teachers took these standardized tests for themselves, often enough when they looked at their test scores they ranked poorly as well. Students coming out of this system of No Child Left Behind have been berated with standards and expectations their whole academic career. This is why physics education research, or PER, has stepped aside from standardized testing and this type of data analysis because researchers have seen it fail on a nationwide scale. In addition there is a monopoly on testing, content, and curriculum from companies themselves. For example, a name that most educators are aware of is Pearson publishing. Pearsons has it’s hands in much of the curriculum and tests for mathematics and science education for K-12 and Universities. However, it is this type of mass produced content that is standardized that we want to keep away from when creating new physics content, because this is not what our students like nor want.

The field of PER has provided evidence supporting the use of various instructional strategies. However, as David ltzer, in his report of *A Brief History of Physics Education in the United States’* continues that,

> “*However, there has been little attention given to the history of physics education and to how the many reform efforts and often stormy debates of the past have played out. Few have asked, for example, how today’s pedagogical initiatives differ—or don’t differ—from those of the past, or what exactly has changed—or not changed—as a result of previous reform efforts. An obvious question to ask is “What must be done to avoid the shortcomings of previous efforts at reform?” Although we are not able to answer that question here, we provide a basis for initiating the discussion. A careful examination of the U.S. physics education literature dating back as early as the 1880s reveals that there are many similarities between the early writings about educational transformation and the discussions that are taking place today. In some cases, it is difficult to determine*

whether a quotation came from an article by a physics instructor published in 1912 or from a report by a national commission issued in 2012."

The main issue in physics is highlighted by David Itzer when he says that, "i*t is difficult to determine whether a quotation came from an article by a physics instructor published in 1912 or from a report by a national commission issued in 2012".* Because this is an issue that faces our modern content creation. We have been using sources that are outdated. These outdated references reflect physics teaching because the quality of the content is outdated and has not been modernized. *A modernization of our content is necessary, and this is what will be addressed in this thesis.*

The reason for modernization has been pushing on academia since the launch of Sputnik. Sputnik is the symbol of the scientific revolution, and a motivator for science in the United States. Two researchers at Kansas State University continue this idea stating that,

> "*Contemporary discipline-based physics education research can trace its roots to the post-Sputnik era beginning in the late 1950s."*

Karen Cummings, from Connecticut State University, in her critique of physics education research to a board in charge of PER concludes that,

> " *In addition, I believe that the launch of Sputnik left government official and educators alike with a new (perhaps nebulous) sense that the nation could no longer allow learning physics to be left to only the few who "have what it takes" to make it successfully through our physics courses. Physics was beginning a transition from Gatekeeper course to Gateway course. The same "Sputnik Era" outlook that had motivated the federal government to fund and scientists to focus on curriculum development for K-12 science instruction had also resulted in a significant boost in the production of physics PhDs. As a result, I think that there was a critical mass of fairly*

> *young, well trained physicists available and willing to investigate the novel but interesting opportunities the field of PER had to offer.The same "Sputnik Era" outlook that had motivated the federal government to fund and scientists to focus on curriculum development for K-12 science instruction had also resulted in a significant boost in the production of physics PhDs. As a result, I think that there was a critical mass of fairly young, well trained physicists available and willing to investigate the novel but interesting opportunities the field of PER had to offer."*

David Itzer in "A Brief History of Physics Education in the United States" builds on this further in this argument explaining that,

> " *A key outcome of this transformed social outlook was the creation of the National Science Foundation (NSF) in 1950, along with various science advisory committees that had access to and influence on the highest levels of government. Although a central federal funding mechanism for scientific research had been discussed and debated for at least 65 years, it wasn't until the Cold War that political resistance to this idea was finally overcome. However, in the short term, the single most transformative event of this period was the launch of the Sputnik satellite by the Soviet Union in 1957. The shock and concern that this launch generated among the U.S. public and policymakers was so enormous that federal funding for mathematics and science education increased by an order of magnitude in less than three years.The most direct outcomes of these events were (1) a very rapid expansion in the number of physics (and other science and math) teachers receiving in-service training in summer and academic-year "institutes" funded through NSF and private corporations, and (2) a vast proliferation of federally funded K-12 science curriculum development projects aimed at transforming classroom instruction on a national basis. The instructional materials and methods of many of the new."*

These trends in physics, that this is an increasing amount of students pursuing physics, increases every year and an increased amount of funding from the NSF, have greatly changed the field. The field is now more diverse than ever with a growing amount of women and minorities , as we can see from the APS studies that we can see in Figure 2. below the number of students entering this field has increased since the 1960s. In fact, this data goes back to the 1960s due the creation of the Physics Education Research field.

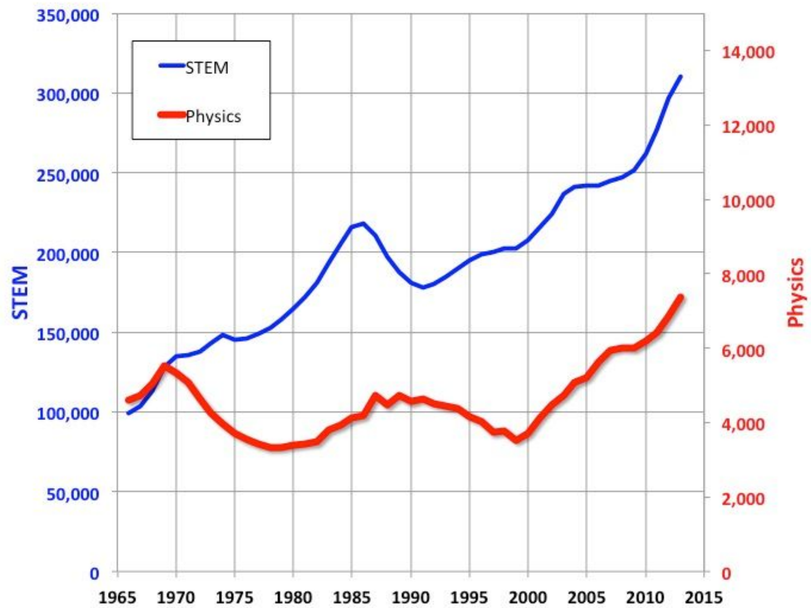


Figure 2.

A modernization of physics education occurred from 1992-2001, as a result of No Child Left Behind. However, due to PER reforms and a a way to encourage more students to go into STEM fields and physics in particular, physics courses in public high schools focused more on conceptual learning and laboratory methods. In fact, as a direct result of PER physics standardized testing in that specific field, in California for example, has high school juniors take an options standardized tests once during their academic career. Furthermore, in the United States *A Brief History of Physics Education in the United States* this is corroborated in that,

“ *This period saw the emergence and ascendance of two unprecedented and transformative phenomena in U.S. physics education: (i) significantly increased diversity* *in high school physics course offerings accompanied by dramatically rising physics enrollment; and (ii) the widening acceptance of contemporary physics education research in university physics departments. Diversity in the high schools included both new physics courses and the "rebranding" of older ones. The percentage of high school graduates who had taken a physics course was at or near all-time historical lows of 16–18% in the mid-1980s. It then began a steady rise, reaching 31% by 2001 in an upward trend that has continued to the present day.The largest single component of this rise was the rapid growth of the "conceptual" physics course, taught both in 9th grade and in higher grades, that emphasized qualitative descriptions and minimized use of mathematics.*

A widely cited landmark study by R. R. Hake showed that, among students in courses using research-based active-learning instructional methods that were often inquiry-based, learning gains in mechanics were far higher than in traditional lecture based courses.

Annual national meetings of physics education researchers were initiated and grew in popularity. Several of the university-based physics education research groups incorporated physics teacher education as a part of their mission. However, their various courses, programs, and workshops could reach only a tiny fraction of the approximately 1400 new physics teachers hired each year in U.S. high schools.69 Their impact on a national level, therefore, was very limited. An exception to this was the growing program in "Modeling Instruction" for in-service teachers founded by Hestenes at Arizona State University in 1990 and expanded nationwide beginning in 1995. Through an ongoing series of summer workshops that gradually spread throughout the nation, as former workshop participants became workshop leaders themselves, the cumulative number of participants grew into the thousands. By 2014 the total number of unique participants had exceeded 6500, with about 85% being high school teachers and the remainder middle school teachers.

This has led to deeper knowledge of the process of physics learning and has contributed to changes in college textbooks and other instructional materials, as well as to the development of instructional strategies informed and validated by educational research. The dynamics of education reform have shifted to include college physics instead of only (or primarily) high school physics, and indeed the focus of most recent reform efforts has been at the college level. At the same time, recent reforms in high school science have largely focused on increasing the availability of engineering and technological curricula, rather than on physics, chemistry, and biology courses, as was the case in the early to-mid 1900s.

Many things have simply not changed since the early 1900s. There continue to be severe practical and logistical challenges to implementing research-based hands-on, active learning, lab-based instruction on a broad scale, at every level—K-12 through college. As was the case in the early 1900s, there is substantial and widespread dissatisfaction with the way physics is currently taught (at least as expressed in the literature). Meanwhile, there continues to be the challenge of adequate teacher preparation, which is largely conducted or directed by science educators who tend to

The climate for physics education research is far different today than it was when the field began 50 years ago. Physics departments appear to be much more supportive of the field today than before. With greater awareness of the effectiveness of research-based instructional methods, a growing number of physics departments both at primarily undergraduate institutions as well as research universities are hiring faculty members who have Ph.D.s in physics with a specialization in physics education research. Human capacity development in the field is increasing with over a dozen physics departments granting physics Ph.D.s with a specialization in physics education research."

Points to Take Away*: From Education Reform*

As a result of knowing what type of education our students have had we must know what has to be done in order to avoid the shortcomings of the previous efforts of reform. Additionally, to avoid shortcomings and integrate more of what students would like, is a push towards digitizing our content and pushing for more technology to be incorporated. It is known that among students in courses using research based active learning instructional methods, students learning in mechanics, for example in a study provided by PER data, was far higher than traditional lecture courses. For this reason, an analysis of active versus passive (or traditional) learning styles must be first evaluated then reformed.

Active versus passive learning styles are noted for traditional lecture based courses versus smaller laboratory courses. It is *well* known that courses with a lower ratio of students to teachers is far more successful in terms of student's improvement throughout the semester, overall grade, and progress in later courses. Lecture courses often are a consequence of a large number of students having to take a course. An example being lower division versus upper division physics, there has to be more students taking lower division because it is required for more majors such as engineering, computer science, chemistry, meteorology, etc. Often these courses, if the department takes a laboratory based approach, have another element to the course which is a laboratory period where students learn about topics in their courses through hands on laboratory learning. However, many departments tends to take the theoretical approach to physics rather than an experimental one. This is unique to departments, and the ideology of the sequence of coursework is decided upon those who historically set it up.

As an example of the difficulties found when investigating digital resources in physics, which connects to the idea of a sequence of coursework presently previously, was investigated as well. The sequence of coursework from department to department and the ways that they are presented to students is of another matter, and was researched over the course of investigating this thesis. Many departments have sites online dedicated to providing students with recommended resources, but they were difficult to navigate or brought up links that were irrelevant. For example, just looking for recommended coursework or advisor emails to see how readily available they were to students often took 5-10 minutes to find, when it should only take up to a minute if these websites are suppose to be resources for students. Apart from poorly designed department websites, three honorable mentions are; the Montana State Physics Interdisciplinary Options coursework site which has hyperlinks above each course stating the name, credits, co/pre-requisites, and a description; the University of Florida coursework flowchart which is a colorful flow chart showing simultaneous coursework; and San Francisco State University's, half because of bias and half because it is a simple box. All of which can be seen in Appendix 2. In terms of PER, this shows one difficulty in students learning at all if they cannot readily access the resources to even take the coursework. This was one tipping point to moving towards a dynamic digital resource.

Apart from this aside, this point and the discussion of lecture versus laboratory based coursework will not be touched upon further, but is important to note as it is one connotation of active versus passive learning in a physical classroom before moving to a digital platform. Lecture based learning can be thought of as passive because the student is more of a sponge absorbing knowledge and passively learning and responding to what they are being educated about. In laboratory courses they often exemplify what is dynamic learning, meaning that students are hands on with their subjects.

Active vs. Passive Learning

The idea of active versus passive learning materials came about during the investigation of this thesis with the analysis of literature versus digital resources. The example of why this came about will come in the following scenario. Say I am confused about the subject in general and I want to try to look it up with a book. So go to the library, find the section where this type of book would be you take two elevators, past 20 shelves, find the right section, look through the books, find a few that might show what you are looking for, look up their index, and get the information. That's great if it's the 1980s. But often enough the books that are stored in our libraries, are outdated, that's why even libraries are converting their materials online. In fact, the largest endeavor to modernize this process of library studies is done through the Library of Congress, which will be discussed in the implementation of digital learning.

Now, if I simply search the internet for my question, I have the opportunity to search for the latest material and save time. This is the obvious example about why to go digital, to save time. The initial amount that one has to put in, which is converting what you want that is physical to what you want that digital is often the hardest part.

The second example, which is again obvious, about why to go digital is the following. Say I am confused about the wording of a question in my homework set, I remember reading the specific words but can't seem to find them in my book. If I can't find it them I can't solve the problem. One way is to scan over and over till you find it. The other option is to find a digital copy of the book and do a keyword search to find the instances that you are looking for. The first option takes a significant amount of time and the second option is nearly insignificant.

This searching in physical literature is a perfect example of the downfall of passive learning, because reading and doing is simply following a procedure to gain knowledge and doesn't really provoke dynamic thinking or problem solving, which are the skills that we want our students to take away.

The idea of searching in digital literature is an example of the most simplistic aspect of dynamic learning because it presents more options as compared to the time laboring aspects of searching literature or passively obtaining knowledge through lecturing. Searching is the simplest tool that makes dynamic learning possible because it speeds up the process of learning and allows the student to be more engaged because they can either 1) learn faster 2) learn something that they found 3) learning something that they found that is of better quality. The perfect example of this is a societal trend of falling into Wikipedia, where one looks up one thing say Isaac Newton and then begins a dynamic system of learning by clicking one link after another where 7 hours later the sun has set, you're now you know everything about quantum-tunneling, and began a rap about Aaron Burr's treason trial. Many teachers tend to discourage students from using Wikipedia as a source because it can be edited as part of an open community, however it is a wonderful learning project. Apart from Wikipedia as an open source technology, the other platforms that were investigated and highly integrated as a dynamic resource include CodeAcademy, KhanAcademy, GitHub, Cloud9, DropBox, Google Drive, Youtube,HyperPhysics, Wolfram Alpha online, Wolfram Alpha mathematics resource, the Physics Classroom.

However, these dynamic resources can be broken down into two types of educational materials that I tried to emulate as apart of creating physics content; chaotic learning materials and fluid learning materials. Chaotic learning materials take a more chaotic approach to learning calling upon many resources and the student chooses which resources they would like to investigate, this process of learning is what was created as a part of the dynamic digital resource material site for this thesis. Fluid learning materials, also called linearly progressing learning materials is what the prototype site, the chaotic site, will become when applied to a single lecture based course that wants to add a digital aspect to it. This type of learning, linearly progressing as a digital form allows for the chaotic materials to be used on a small scale and in directed ways, this is what is encouraged in most online courses, such as the ones investigated at Kaplan as noted previously.

However the content creation of this type of material must take into account the type of learning for the student. Typically this type of program, well instructed but encouraging outside chaotic learning on the part of the student, is the beneficial for a number of ways as compared to a traditional lecture course. For one if the student is not well versed in english, or wanted to learning in a native language, it is easier for them to access material in their own language if it is digital because an unencrypted text document can simply be translated. Secondly the material that is apart of the course can be saved or accessed by the student digitally, meaning they can go back to content and it will not be lost. Say a student moves, papers can be thrown away, forgotten, or if a student's laptop breaks. If the content is digitized and readily made online by a secure host, then that material will be available for as long as the host is up. And if the host is not up, then students can learn to download and access that material through virtual means that do not have to be tied to a physical hard drive through cloud computing or google drives. The technical aspect of how teachers and students can do this will be the next point and bulk of our discussion.

Apart from the technical aspect, the last educational content creation aspect when it comes to physics education if we want to put it digitally is the torn nature of mathematical or language focused content. As we known from the previous section, a history of education reform, there was a shift towards more conceptual based, or language based, learning in K-12 physics education that has spilled over into higher education with the focus on either theoretical or experimental based courses, as mentioned previously. The issue in this type of content creation is that going one way or the other is beneficial and harmful to some students. What was investigated as a part of content creation is the value of mathematics focused content versus language focused content. Typically for lower level or fundamental content, language based content was the best. For higher level content, mathematical based content was better because one could explain these concepts faster with the language of mathematics. If there is a math focus there there are minimalist words, numbers, diagrams, flow focused, logical. In terms of pros for students, this means faster study time, it is mathematics as a language orientated, quicker paces; but it leaves out abstract learners, can be hard to gasp, specified, not suited for language based learners. However it allows for abstract creation and dynamical connections in a mathematical way which is a highlight because it allows for dynamic but linear learning styles. If there it is language focused then it allows for a linearly progressing narrative, a more human connection through language and historical anecdotes, and allows for abstract content importance as a side effect. However, this sort of content creation is slow and meticulous but it is good for example based learning, historical learning, shows mistakes, and has a more human aspect.

Part II: Implementing Digital Learning

As a result of the previous sections and the investigation process of this thesis, a digital resource was created as the central focus with supplemental guides for content creation for educators who would like to implement this technology. The main focus of the digital resource site was for two investigative reasons that are the highlights of this thesis.

The first is implementing and investigating the idea of chaotic versus fluid learning and mathematical versus language based learning. This section includes three parts, the first is looking at what we have in terms of content based by physics and the second is integrating open source content through the dynamic learning site and the third is integrating this and implementing content creation.

The second is taking a computer science approach to learning, and seeing how a free open source programs can be easily integrated and developed. This aspect was the most time consuming, but was meant to be streamlined for those who come after it. A full implementation in terms of the dynamic virtual computer and hosting capabilities that will be discussed have be tested but not implemented as part of the site that has been planned but not created.

Difficulty in Implementing Online Learning

Before we investigate how easy it is to implement online learning let us go into the difficult parts that arise if we want to implement it on our own. One difficulty for educators is that if they want to create course content, often course content is not up to the teacher. In addition, if we want to host a site and we are given a domain by a university, the departments hosting capabilities is limited. For example, at SFSU teachers are given 1GB of hosting capabilities, which would not be suitable for hosting a large amount of resources. If we want to host a large amount of resources for a large number of files then doing this service will cost a nominal fee, if this resourced by a large number of people then it can be a bit costly. Additionally, in terms of content creation and conversion, it takes a long time to convert a number of files to a digital form if not accessible to proper resources. If the content is entirely created online, then over a course of time this isn't a problem, it is only presented with previously created content that wants to be used. Lastly, technology does fail. For example, the original design for the site has been hosted on Cloud9, which was working well as a free hosting service for a large number of files. However, I failed to realize that when I was not using Cloud9 , which is an online IDE that uses virtual Ubuntu computers, all of my files could not be accessed because the host died when I left it idle because the host was turned off my the c9 servers when not in use. Another example, when developing html code there are often failures that are simple mistakes that lead it to break, say I forget a comma or a bracket the whole page or site can break.

Simplisticy in Implementing Online Learning

The reasons for implementing digital learning as a supplement to education is essential to moving learning forward in a modern society that is depending on technology. The push to implement this type of learning to our current educational system is apparent. Many educational institutions have already implemented online learning into their courses where students can access recording of their lectures, lecture notes, quizzes, homework, and solutions entirely online. However, in terms of physics education this is used in only a fraction our our courses. In terms of a digital resource where one can access many resources in physics, this is not available, poorly done, or done by a publisher for a price. However, because there are free open source materials readily available on the internet, then creating a resource source is useful and easy to implement.

Digital Learning for the Student

Digital learning in terms of a student perspective take on the elements of active versus passive learning that plays into preferences when it comes to whether the student would rather be dependent or independent on structure, which ties into the idea of chaotic versus fluid learning materials. For example, Dr. DiMarzo commented on the nature of this type of behavior when it came to comparing the same courses, one lecture-based in person and one seminar based on an online platform. Typically students that want to take an in-person class need the structure of coming to class, where they can have person to person interactions, student-teacher interactions, and have more hands-on questions and answers. Whereas, students at Kaplan are more independent in their learning style, and the program is seminar based. Meaning that there are weekly instructions like with the professor with live question and answer, and the teacher has office hours online in a forum. The seminars are optional, and allow students to watch them at any time; however, the teacher keeps track of the student's progress through a system, where through Kaplan's course they designate it as course learning outcomes, which tells the teacher if a student has reached an objective or not. However with these online courses there are advantages and disadvantages, as explained by Dr. DiMarzo who has taught these courses for over a decade and by viewing them in action with her over the decade through various institutions including Miramar College, Kaplan College, and National University. The advantages of online curriculum means that content is often saved in archives, which is an advantage if some looses data a lot and for students who would like to review courses at a later time. For example, if multiple computers die with useful content that could not be recovered, having a digital area that that can be stored would be helpful to educators and students. Another advantage is that often if one has the digital content for a course, that course can be already be pre-built by the university operating it. For example, National University often had pre-built courses which means that teachers do not have to prepare months in advance generating new content. However, this has its disadvantage because pre-built courses allow for no academic freedom. Whereas for traditional courses many teachers can build a syllabus any way they want. In one way the highly structured digital content is better for students, and does allow for some content creation on the part of the student. But, it takes away part of the academic freedom of the teacher.

The great thing about digital implementation is a spectrum, and can be shifted upon the needs of the course, instructor, and student. Digital implementation had it's advantages when it comes to using free open-source materials, saving our content, and being able to learn more and at an independent pace. However, this implementation should be used more as a structure to enhance learning towards more technology driven students, and be worked into our traditional structure that encourages a student-teacher relationship, and students to succeed. We are giving the students the resources to succeed and get a leg up on competition by implementing new technology. In fact, the reason for taking a more computer science approach to this is because it is the next forefront in learning. In terms of physics education in particular we have seen the field shift more towards using computational physics for research and learning; often with computer science being heavily involved in physics core curriculum and course learning objectives. Physics education is evolving to a more computational aspect as our society modernizes and uses the tools at its disposal. The next section will be an overview of the open source materials investigated in this thesis.

Open Source Materials Investigated

The table below highlights the open source tools that were investigated. What is meant by open-source is computer software or material that is made available with a license in which the copyright holder provides the rights to study,change, and distribute the software to anyone for any purpose. This is the direct meaning on open-source, the connotation of open-source on the internet means more like free to use. Meaning that if I want to use cloud computing, for example, in a distributed network that provides users with content for a nominal fee, then I would not have to pay copyright to use a product that was intended to be free as long the source is acknowledged. The adoption of open source is beneficial to education because often it is very high quality and promotes; security, affordability, transparency, perpetuity, flexibility, and globalization.

Educational Tools	*Back-End Tools*	*Processes Uses*
Khan Academy *Code Academy* *Wikipedia* *HyperPhysics* *HyperPhysics Textbook* *MIT OpenCourse* *Project Gutenberg*	*GitHub* *d3* *w3schools/w3* *DropBox* *Google Drive* *Google Domains* *Cloud9* *VirtualUbuntu* *Wix* *Bootstrap* *OpenStack* *Amazon Cloud Storage* *RedHat* *SourceTree* *Qubes OS* *Amazon Web Services*	*Java Script* *HTML* *Json* *jQuery/noSQL* *SQL* *Linux commands* *Css* *Python*

Table 1.

Origin of Implementation of Open Source Software

The original intent for the implementation of the open source software to eventually make a digital resource was to be entirely on either Cloud9 or Google Drive. Hosting a number of files with content is easy in Google Drive because it is a free tool that can be used on all platforms, meaning, desktop computers, internet based machines, tablets, and mobile phones. Additionally it allows for 15GB of storage with upgrades to larger storage with minimal fees. Google Drive also allows for hosting these files under a domain; however, they are discontinuing this service August 31st, 2016 because of the variety of content hosting services available. In lue of this service discontinuing there were two options, having a similar hosting service like google's that used a cloud server and host ID (like googledrive.com/host/ID).

Figuring for a more permanent solution, I figured that hosting content on a pre-built website would work. There is a popular web-site template store and host called Wix which uses html website templates that one can alter through a simple graphical user interface that uses widgets. In act many cloud hosting sites embedded pre-built sites like Wix because it is very well done. However, wanting to build it from the ground up I went back to cloud computing and virtual domains that were hinted by the beta Google Domains, that sprung up from Google Drives discontinuing their web hosting services.

The first option, because I had been working in this system to test C++ code, was an online tool called Cloud 9. Cloud9 is actually a code editor that uses Ubuntu virtual machines and a designated hosting servers using cloud computing. Cloud9 is unique because it does not require one to install browsers and platforms in virtual machines for compatibility testing because the live preview allows one to interactively see what your web application will look like in any browser. Additionally, one can create a workplace (or language) specific areas to host content, or use a workspace to host content using many computational languages. For example if I have a html,css, js, and json file and they are not in the same directory, with the virtual machine they can connect to each other to host or run you content. This is unique, because typically online IDEs that use html,css, and js together are often specific to that IDE and do not run in other applications. Meaning that this is a usable and flexible working environment to test working on virtual machines. The one flaw with c9 is that while using the free version, say you want to host a website. Well that website will only be hosted for as long as your workspace is running. However, if your workspace is not running, because c9 automatically deactivates workspaces that are not active, then your site will not be able to view. Thus, because c9 has this function of detecting workspaces, then taking the idea of what c9 is, using virtual computers plus cloud computing, is the most stable platform to have a functioning digital resource tool. It should be noted that final prototype for the digital resource tool for this thesis will be presented on c9, the next step is using cloud computing when implementing the full use of this technology.

The full use of this technology first involves using a virtual computer. There are many advantages to using a virtual computer the number one being that it is virtual! Meaning that it is hosted on a server using the cloud that cannot be compromised. The second is that using a virtual host makes working faster due to no lags. For example, if I am working on my Acer Chromebook, Samsung Chromebook or MacBook and I have over 5 active tabs running, there is an obvious stunting of my computers use of resources to allocate processing time because they computer has become slower with use. This causes my computer to freeze or become non-functioning which hinders attempts at studying. Another example, I run a program using an IDE and the program uses 8 of my 16 processors to make a graph then freezes for 10 minutes. For one I am concerned that an IDE is using half of my computer's processing power, and second it renders my computer useless. For this reason a virtual computer is far superior because it allows, more or less, instant gratification through a direct connection that can allocate memory to different parts of a network of servers because it is apart of a cloud.

Another good use of a virtual computer is that it provides security. The best example of using a virtual computer for these purposes is with an operating system called Qubes. Qubes is a security-oriented operating system (OS). An operating system is the software which runs all the other programs on a computer, and thus having a secure operating system is optimal. Common operating system include Microsoft Windows, Mac OS , Android, and iOS. Qubes is free and open-source software, meaning that everyone is free to use, copy, and change the software in any way. It also means that the source code is openly available so others can contribute to and audit it . Most people use an operating system like Windows or OS X on their desktop and laptop computers, these are popular because they tend to be easy to use and come pre-installed on computers. However, they present problems when it comes to security. For example, you might open an email attachment or website, not realizing that you're actually allowing malware, to run on your computer. Depending on what kind of malware it is, it might do anything from showing you unwanted advertisements to taking over your entire computer. This could jeopardize all the information stored on or accessed by this computer. Malware can also interfere with the activities you perform with your computer.Qubes uses an approach called security by compartmentalization, which allows you to compartmentalize the various parts of a digital profile into securely isolated virtual machines.

A virtual machine (VM) is basically a simulated computer with its own OS which runs as software on your physical computer. You can think of a VM as a *computer within a computer*. Not all virtual machine software is equal when it comes to security, as Qubes source content explains. There is software known as "Type 2" or "hosted" hypervisor, which is software, firmware, or hardware that creates and runs virtual machines. These programs are popular because they're designed primarily to be easy to use and run under a the host OS on one's physical computer. However, the fact that Type 2 hypervisors run under the host OS means that they're really only as secure as the host OS itself. If the host OS is ever compromised, then any VMs it hosts are also. Instead of running inside an OS, Type 1 hypervisors run directly on the "bare metal" of the hardware. This means that an attacker must be capable of subverting the hypervisor itself in order to compromise the entire system, which is vastly more difficult. Qubes makes it so that multiple VMs running under a Type 1 hypervisor can be securely used as an integrated OS. For example, it puts all of your application windows on the same desktop with special colored borders indicating the trust levels of their respective VMs. It also allows for things like secure copy/paste operations between VMs, securely copying and transferring files between VMs, and secure networking between VMs and the Internet. Using a separate physical computer for sensitive activities can certainly be more secure than using one computer with a conventional OS for everything, but there are still risks to consider.

An advantage that one can use is that of physical separation which doesn't rely on a hypervisor. Physical separation can be a natural complement to physical security. It's disadvantages is that, physical separation can be expensive, since one needs to separate physical machine for each security level we need. There's generally no secure way to transfer data between physically separate computers running conventional OS's. Qubes has a secure inter-VM file transfer system to handle this. Physically separate computers running conventional OS's are still independently vulnerable to most conventional attacks due to their monolithic nature. Malware which can bridge air gaps has existed for several years now and is becoming increasingly common, which is why free software like Avast is popular.

On top of running a virtual machine, one needs a software to use on these virtual machines to create a public or private cloud. One service, that is highly integrates into existing cloud-based companies is a software called OpenStack. Which is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter, all managed through a dashboard that gives administrators control while allowing users to use provision resources through a web interface. OpenStack has to option to use it's services for computational services, object storage, or both. The software provides cores depending on what type of data will be hosted on it such as; object storage (Swift), identity (Keystone),computational (Nova). With additional resources such as adding additional software for networking (Neutron), block storage (Cinder), image services, dashboard (Horizon), database (Trove), shared filesystems (Manila), application catalog (Murano).

However, running a secure virtual machine with this secure cloud service is the second part of implementing a large data resource, this process is the entire backend development for a large scale digital resource. On a small scale, however, this was implemented easily through Cloud9 which have these services built in. The difficulty in implementing this large data-base using cloud computing and virtual machines is mostly formating and accessing the database. This has to be done through SQL, which are search queries.

Queries given a database, and well formatted json files which format the information in that database. This was done in a small scale test using open-source code from a source called

D3, which is used for data driven documents using json or similar files. D3.js (or just D3, Data-Driven Documents) is a actually a JavaScript (js) library for producing dynamic and interactive data visualizations in web browsers and is widely implemented in html5 and css standards. In contrast to many other libraries it allows great control over the final result because it makes it active, dynamics, and data driven. This type of library was the most influential on the digital data resource because d3 allows for a dynamic presentation of data in a well structured library. The second most influential part is the use of a json file. Json, or JavaScript Object Notation, is an open-standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. In computer science data structure since, a name–value pair, key–value or attribute–value pair is a fundamental data representation in computing systems and applications. Designers often desire an open-ended data structure that allows for future extension without modifying existing code or data. In such situations, all or part of the data model may be expressed as a collection of tuples <*attribute name*, *value*>; each element is an attribute–value pair. A combination of these means that we have a document that is readable and is easy for a database to read because it uses a simple data structure. Basically using this means that I can set a query in my cloud database to access a file that is key-pair, so it has a name and a value. Having it be as simple as this reduces the probability of error and eases development and computer processing time.

The third option is a mostly inclusive package that combines hosting, cloud computing, and virtual machines through Amazon Web Services which uses Amazon Cloud Computing and Amazon's access to server time in one package. There is a free tier that allows access to this service for free for one year ;however, it does have you entered a credit card and verify your information with a phone call that has the user enter a pin. The payment is for payments if the user exceeds the allocated storage of the free tier. All of the plans do have 24-7 access to customer service, support forums, white papers, and documentation. However with the tier plans, there is additional support and resources that come with a $50+ fee per month.

One advantage to using Amazon Web Service, other than it as a secure, trusted company that packages their services to in friendly user tool, is that it has access to scientific computing, education tools, and running databases. This service provides a number of tools for database management including managing relational databases, cloud databases, of NoSQL databases. Because NoSQL is a non-relational database it is not useful for our dynamic system tool in terms of a database for content, but it has been useful in testing data models for key-value attributes that is very fast. For example, when testing the usage of NoSQL versus other query services, I used SourceTree and Qubes to package a testing database that looked at the query of the most edited Wikipedia pages in a certain time period, and made a trend of the edits over a time period. As opposed to using regular SQL in testing receiving data from a CAS database, and then running that through a Schema Browser to view the output. Part of the documentation used was from SQL tutorials with the basic scripting process in Jozo Dujmovic's course reader for the 600 level Programming Languages course at SFSU. Another test was also made with MySQL using SourceTree and randomly generated .json file through an online tool called JSON Generator. A more specified file created in Mockaroo was also tested as well. MySQL was the most useful of the specified queries because it can help with a relational database. In fact as apart of AWS, there is Amazon RDS or relational database services (with minimal administration) that offers a managed database using MySQL, Oracle, and an SQL Server else Amazon also offers it's own database called Aurora which offers functions like scaled and computed storage. Meaning that queries will be as fast a the rising limits our, one statistics says that their query was 10 times as fast as previously. I found that generally my queries went from around 20 seconds using a terminal and a bad computer, to 5 seconds when using a gaming computer and less than a second using this service.

Apart from using AWS as a platform for a digital resource that will be acting as a database, if we want to implement this for education directly, then it provides an easily, flexible, but secure platform. Specifically for education there is a structured platform that allows developers to create web-sites, have big data, student analytics,desktop computing, and student security. With the platform, or website creator, the developer only has to pay the base fee and a minimal (less than a cent per hundreds of GBs or requests) fee for queries. Additionally, if there are student analytics involved with a platform, this platform meet FERPA's student security requirements and data privacy. Additionally, having students access the platform through a virtual computer such as the one discussed earlier with Qubes, will protect student privacy further by cloud hosting information.

Apart from the services mentioned. AWS allows for much more development for content once it is in motion, because it packages the following; building a web app, launching a virtual machine, backing up your files, building a backend for a mobile app, hosting a static website and performing analytics. Thus, the services that were analyzed to develop a system from scratch is community focused, secure, and well developed in one package. The original purpose for developing a system from scratch is to intend to build it with no operating costs. Using the free tiers for these softwares and trying to package them together into a working host has been riddled with problems, it is fantastic that Amazon Web Services is packaged in such a user-friendly way because learning the back-end to many different elements is time consuming and tiring. To ultimately have good content, you will have to pay.

Actual Implementation

The initial reason for implementing a digital physics resource, as stated in the methods, came out of the initial intention for this project which was creation of content. I often found that it was difficult to view good content because of the lack of usability for the sites. There were three main reasons for this; outdated content, outdated html, outdated javascript. The outdated content was a consistent trend of websites that source content was last updated generally around 2005. The only theories I had for a trend of 2005 is that most people forget that 2005 was actually a decade ago, the people who made the websites forgot about them, or they forgot about them because they are dead. The second is a lack of usability because the source code is using out of data html or simplistic html, this trend was seen in a majority of websites made by physics educators. The reason for the lack of usability was because they present it as pages with links that directly take the home page to the linked page without 1) having it open in another tab 2) having a menu 3) having a directory. This made viewing content very difficult because one often gets lost going from html page to html page with no directory. Additionally, many websites had non-functioning pages, applets, or did not work entirely because they had not updated their JavaScript from the old to the new package, which was made because Java applet's often were a security threat. They now cannot run on any popular browser, except for Internet Explorer on Linux machines. Which translates to non-functioning tools in a modern website.

For this reason I took my investigation of virtual machines, cloud computing, and scripting to create a dynamic resource that can host resources. The reason for hosting resources and showing others how to dynamically host resources is to have a secure digital materials for all. I wanted to host it virtually and through the cloud because I and many others have lost countless amounts of data and content by storing it on physical computers, because hard drives fail. I like to think of a hard drive as literally like a more sophisticated record in three-dimensional space ing lasers that uses binary (0s and 1s) to store data. If for any reason that hard drive is corrupted, or even a minimal amount of data is physically leaked, then it is gone forever. Cloud computing allows for secure data storage and access, which is why is is crucial to this investigation.

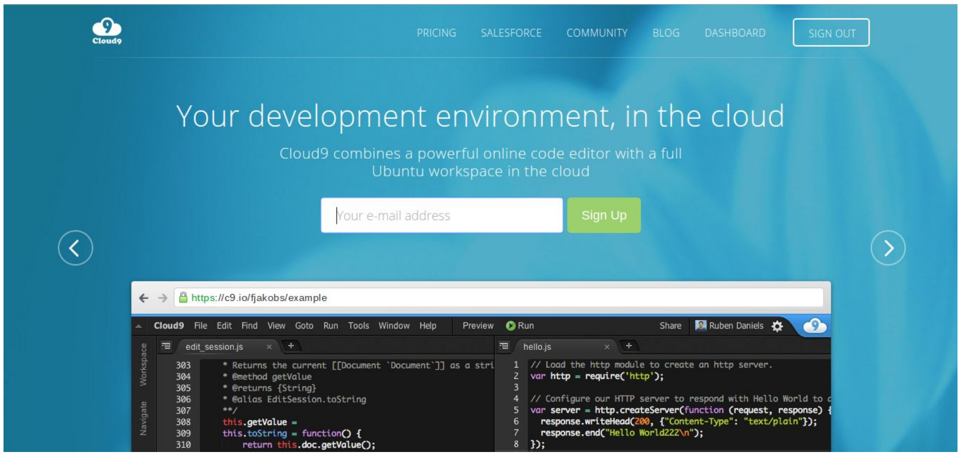
Dynamic Digital Resource

Raw Digital Resource

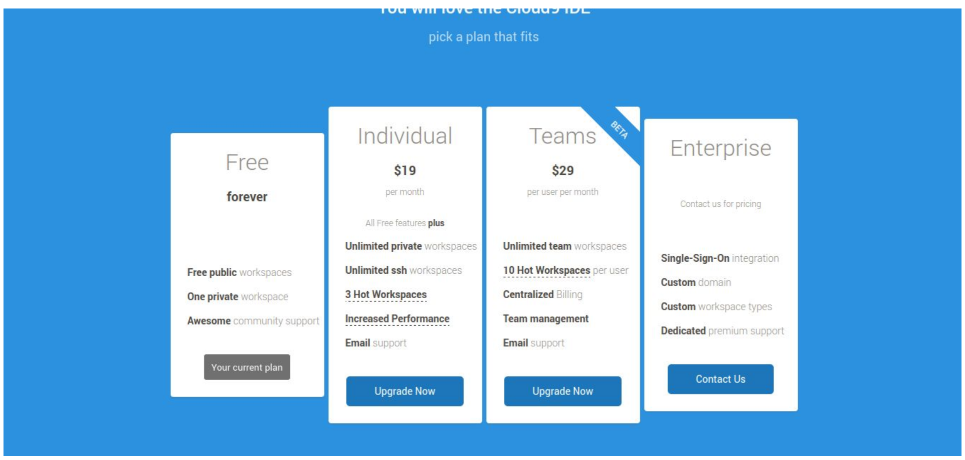
The raw way to do this is by <u>far not a recommended way to create a resource for students </u>but it is the *easiest way* to present content very fast and as dependable as possible . The first way is to learn the basics of html to put pages together with directories. The second way is to create a website for free and then host that on your server by obtaining the source code from that page. This walk-through of it's implementation is below. It is not refined, but it is the best working copy to work with when testing out this system and organizing it for further use.

Creating an HTML directory with dynamic links and references in c9

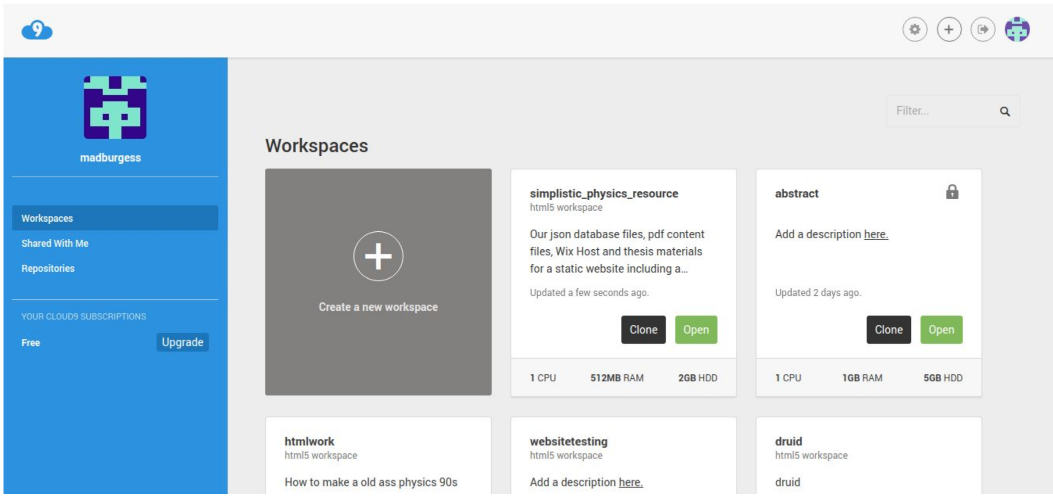
Using Cloud 9 (c9 io) as a development platform for testing virtual computing and cloud computing using host servers in a controlled and packaged way. However, it is for a working prototype and will be dumped in a bucket, that is technical term, when integrated into Amazon Web Services' hosting.



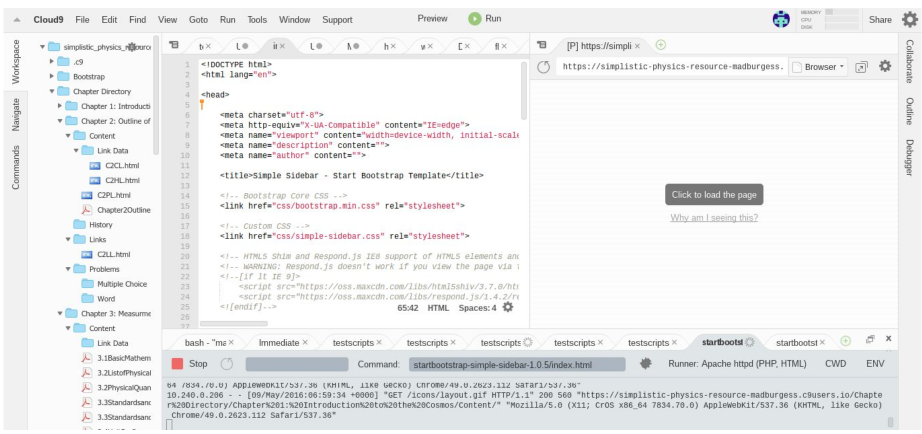
Opening page for Cloud9, which is primarily used as an online IDE, project workspace, and host



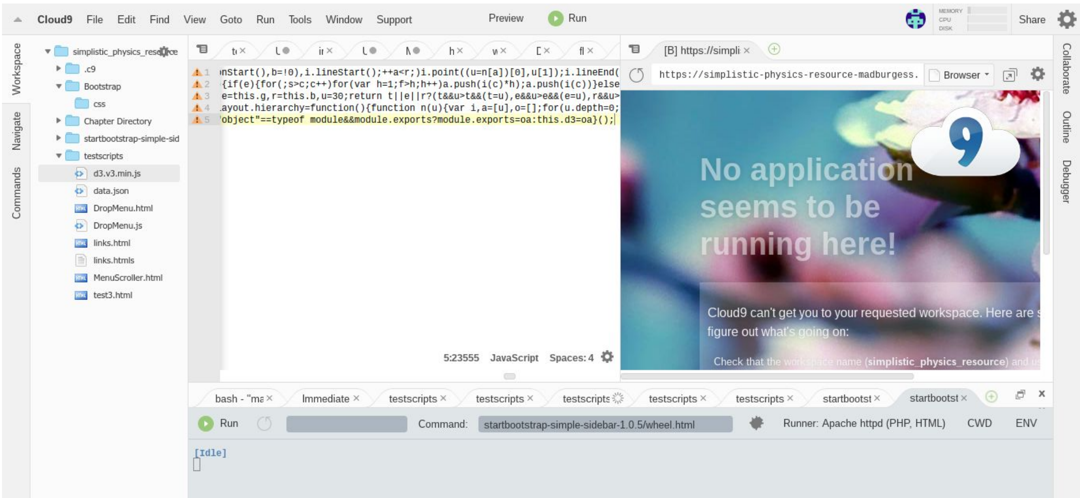
Packages avaliable for c9, offers free one private workspace and many public ones. Public means that it is an open domain, not that anyone *would* go looking for your host, but there is a chance.



Basic workspace and how they are organized, there is one private workspace with the locked icon

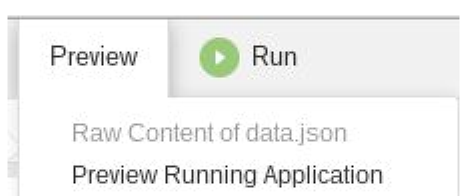


When you open the workspace it will be in the same dormant position as when you last shut it down, so it will begin to boot up or in an idle mode once you hit another page to open within a few seconds.

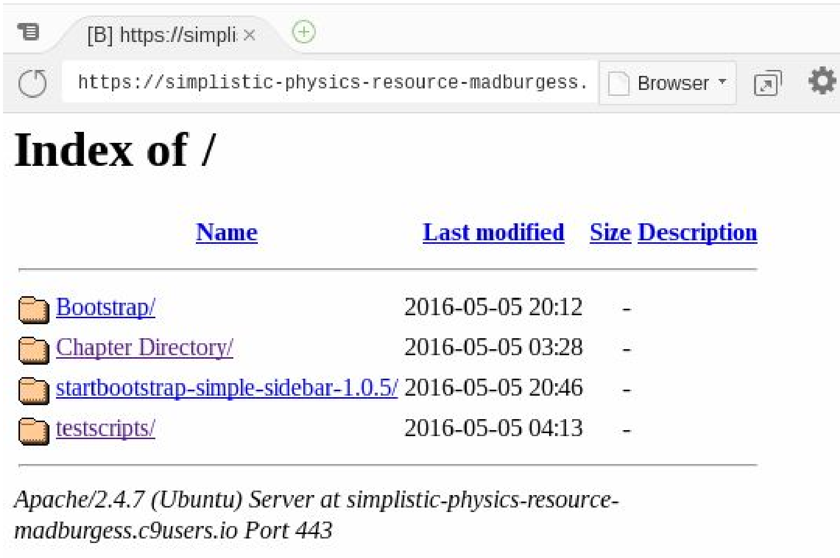


This is the idle mode, meaning the host is not connected to the server, if you don't do anything then it will not work because it is dormant. To wake it up again, you cannot just open a file or save a file or trying to refresh the page. In order for the virtual computer to be connected to the server, it must not be idel and must be connected to Apache.

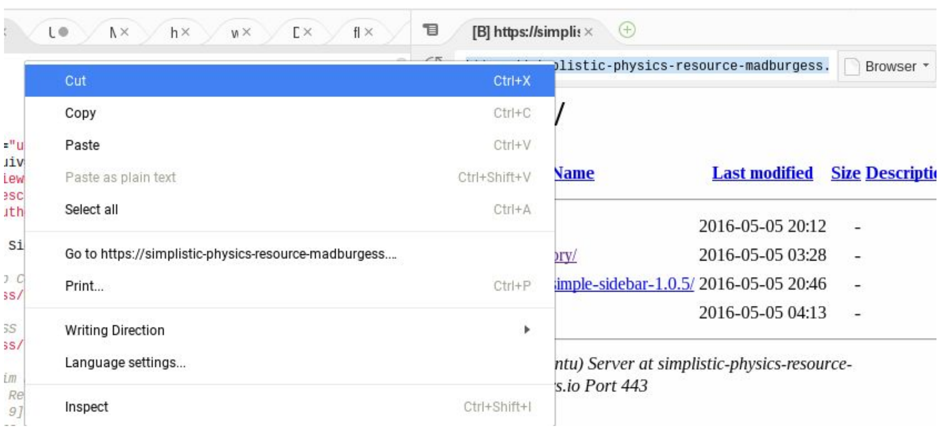
The Ubuntu virtual computer is in an idel mode, so no nodes going in or going out because that server space is being allocated to another workspace in c9. A new server is allocated to run the VM but Apache *has* to be running in order for the js (javascript), css (cascading style sheet, a form of a template) and html (hyper text markup language) scripts to run together to present a working application or object.



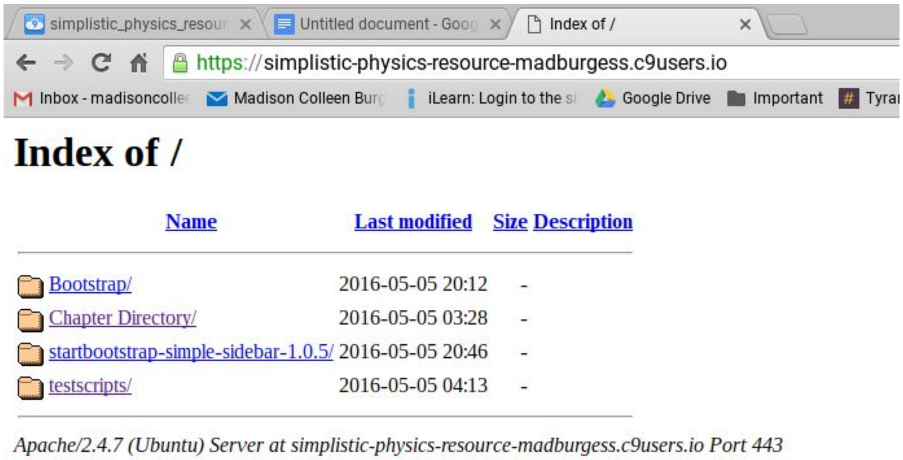
Once Apache is started up we can preview the running application



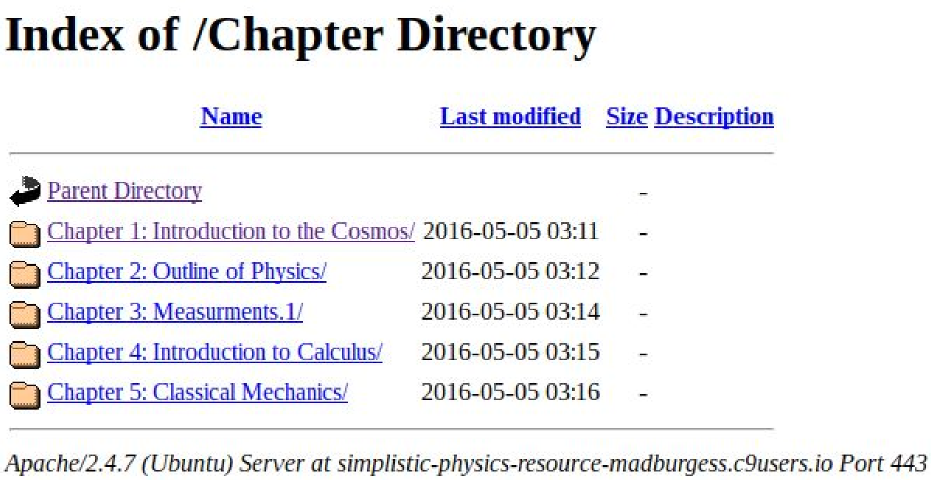
Here is a live preview of the simple html files being stored by folders and links via a port in our Ubuntu server, this preview is unique because it is running in c9.



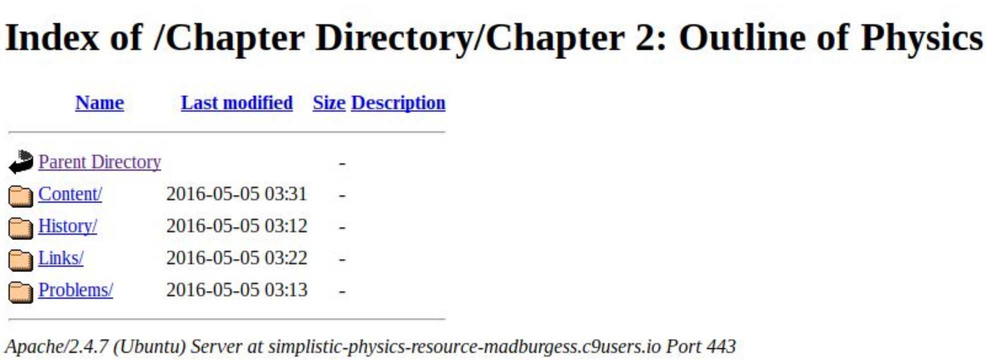
If we cut and copy the host site from the live preview in c9, we can see the functioning static host website in our browser



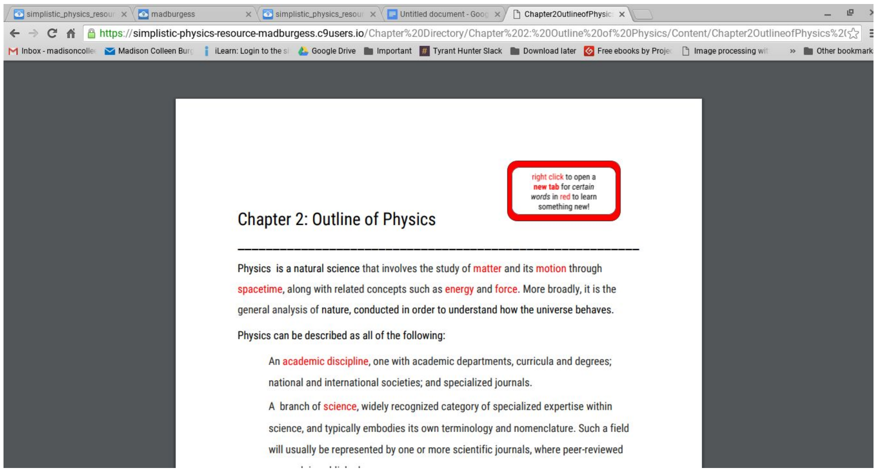
Main Directory in it's raw and simplistic form



We see that this is laid out as a series of directories with a parent directory

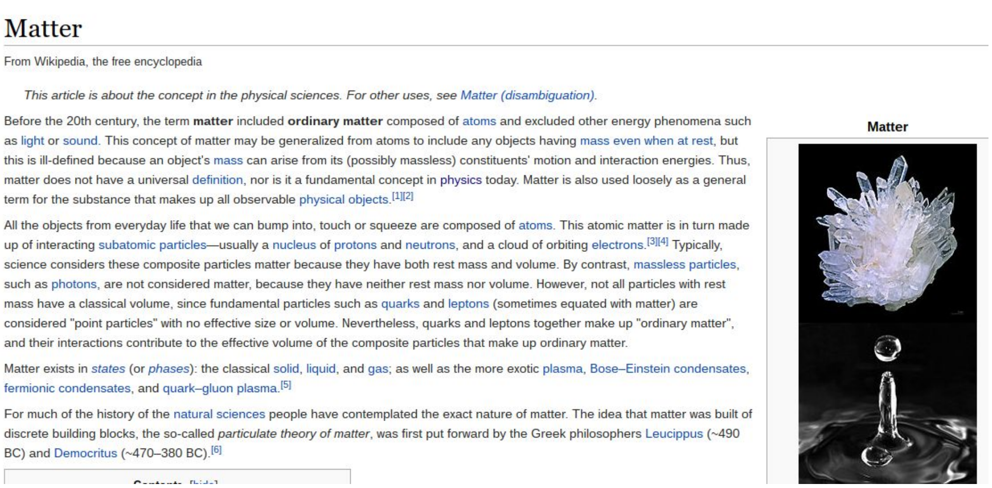


And these folders can have subfolders or subdirectories, which hold files



If we click on this link, and press new tab then it shows the pdf of the file in the directory

The file with our content also has embedded html links that show us even more information



Matter

From Wikipedia, the free encyclopedia

This article is about the concept in the physical sciences. For other uses, see Matter (disambiguation).

Before the 20th century, the term **matter** included **ordinary matter** composed of atoms and excluded other energy phenomena such as light or sound. This concept of matter may be generalized from atoms to include any objects having mass even when at rest, but this is ill-defined because an object's mass can arise from its (possibly massless) constituents' motion and interaction energies. Thus, matter does not have a universal definition, nor is it a fundamental concept in physics today. Matter is also used loosely as a general term for the substance that makes up all observable physical objects.[1][2]

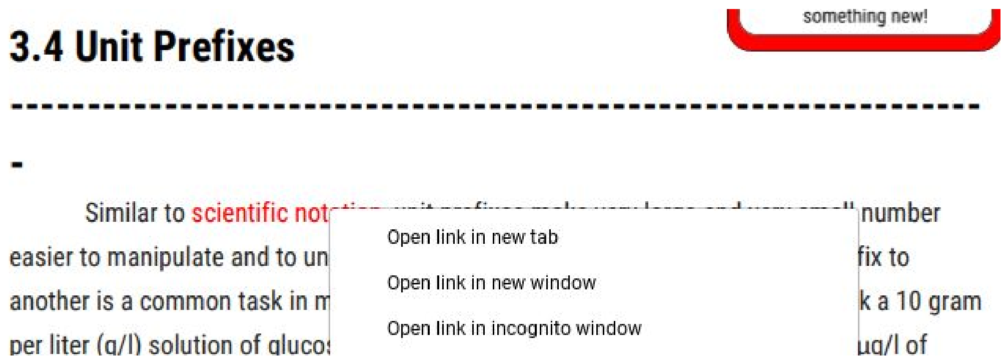
All the objects from everyday life that we can bump into, touch or squeeze are composed of atoms. This atomic matter is in turn made up of interacting subatomic particles—usually a nucleus of protons and neutrons, and a cloud of orbiting electrons.[3][4] Typically, science considers these composite particles matter because they have both rest mass and volume. By contrast, massless particles, such as photons, are not considered matter, because they have neither rest mass nor volume. However, not all particles with rest mass have a classical volume, since fundamental particles such as quarks and leptons (sometimes equated with matter) are considered "point particles" with no effective size or volume. Nevertheless, quarks and leptons together make up "ordinary matter", and their interactions contribute to the effective volume of the composite particles that make up ordinary matter.

Matter exists in *states* (or *phases*): the classical solid, liquid, and gas; as well as the more exotic plasma, Bose–Einstein condensates, fermionic condensates, and quark–gluon plasma.[5]

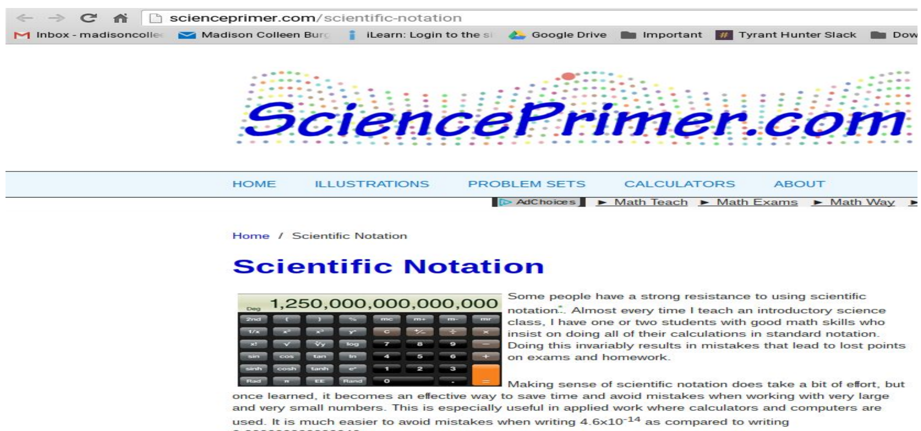
For much of the history of the natural sciences people have contemplated the exact nature of matter. The idea that matter was built of discrete building blocks, the so-called *particulate theory of matter*, was first put forward by the Greek philosophers Leucippus (~490 BC) and Democritus (~470–380 BC).[6]

Matter

Here the hyperlink of matter brought us to an open source material on its properties

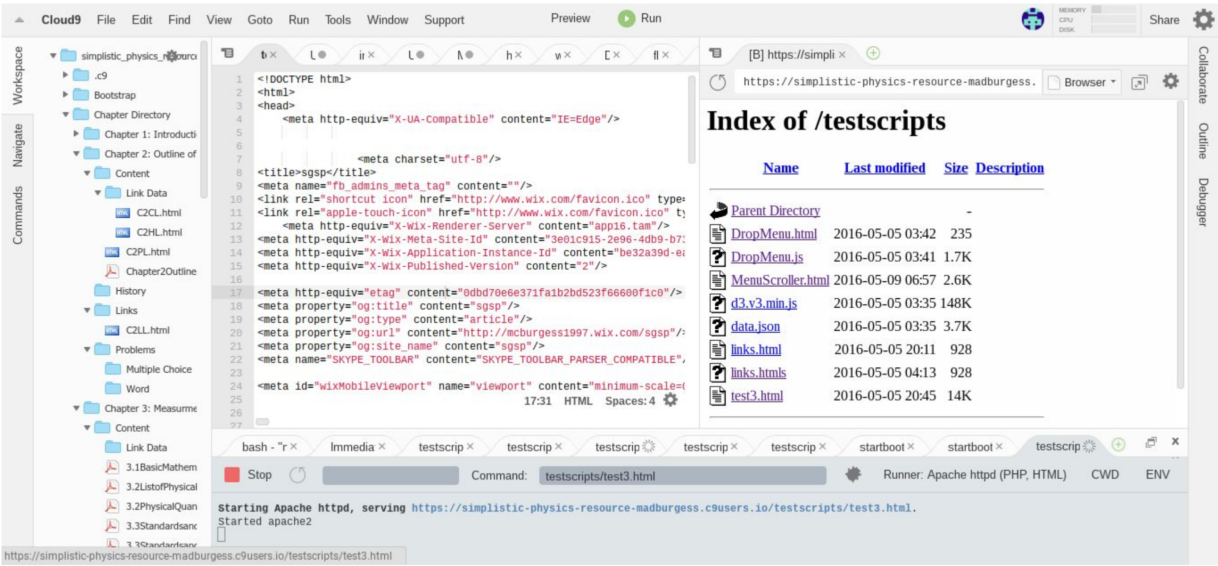


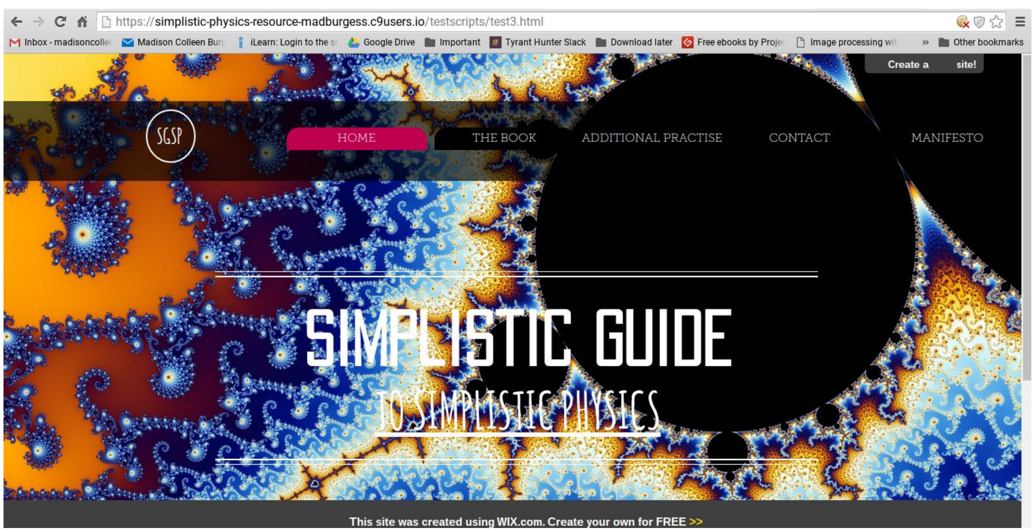
We can do this with a number of files in the directory



This one brings us to a website with a couple of examples.

Hosting pre-built site on c9 by using open source, source code from the original webpage

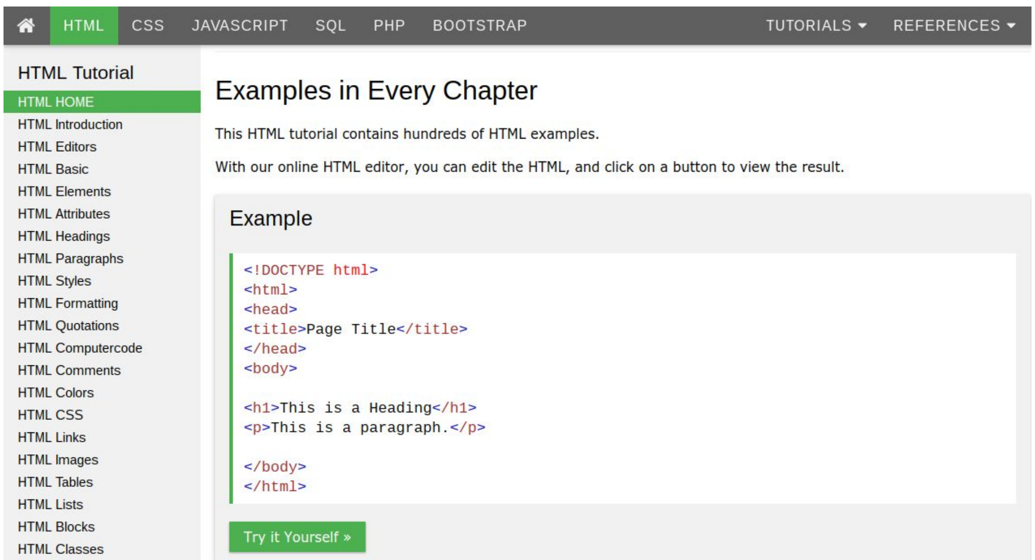




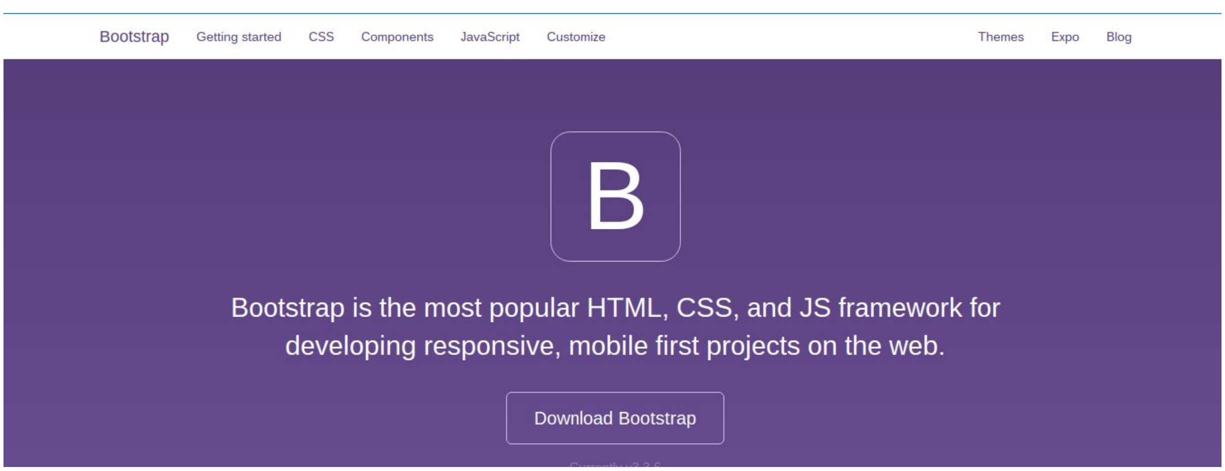
And we see the site that is hosted on c9 that is then connected to Wix templates because the html scripts in the source code link to the wix servers, connecting to a different site however shows why NOT to do this. The connection will not be able to preview in the virtual computer because it is calling on another server, which is not recommended for security settings, and there is a lag when connecting in general while using a different OS. It should be noted that this is quote “The worst website I’ve ever seen” and when asked why they stated “Because of the Mandelbrot's”. A simplistic site was then prompted from this critique, as it does take away from the content. Using bootstrap, which is pre-built html templates that are changed by the user through their our text editor rather than with GUI built into the software for a company that uses html templates like Wix, which is featured above.

Creating an HTML directory with dynamic links and references in c9

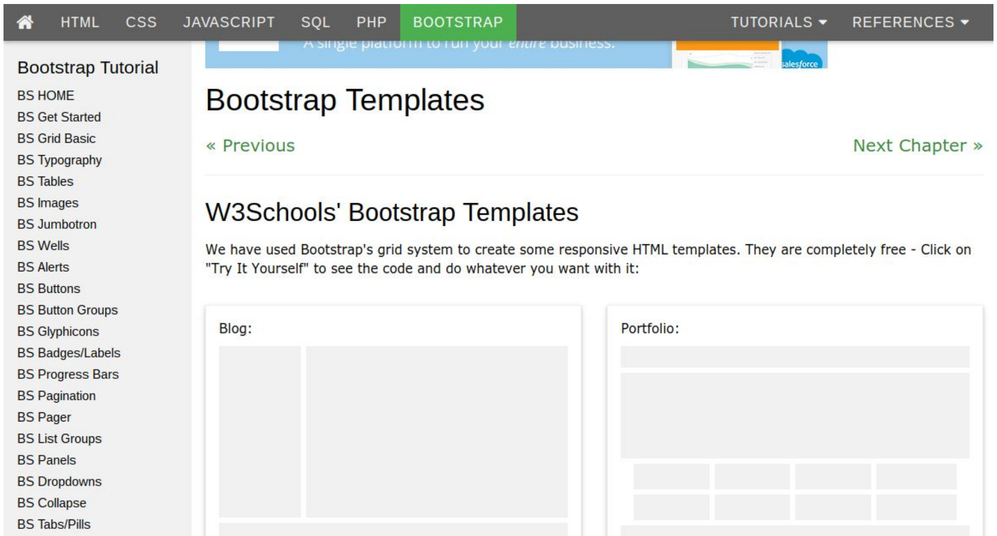
What we need is the skeleton of a build, using templates + tutorials to start building



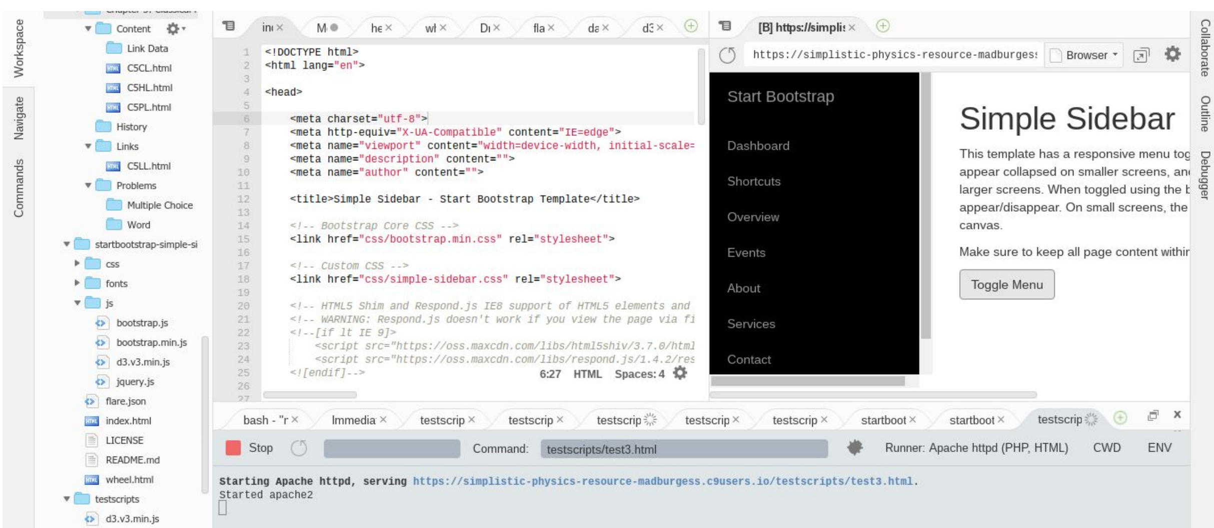
We need to know how to make a basic html page so that we can add content, and edit what we have. We need a simple reference to w3, which is the largest source for developers, which has examples and abstract/general scripts for any function that we can use in html. As well as HTML we need a basic knowledge of CSS and JavaScript as well; which also have tutorials on w3.



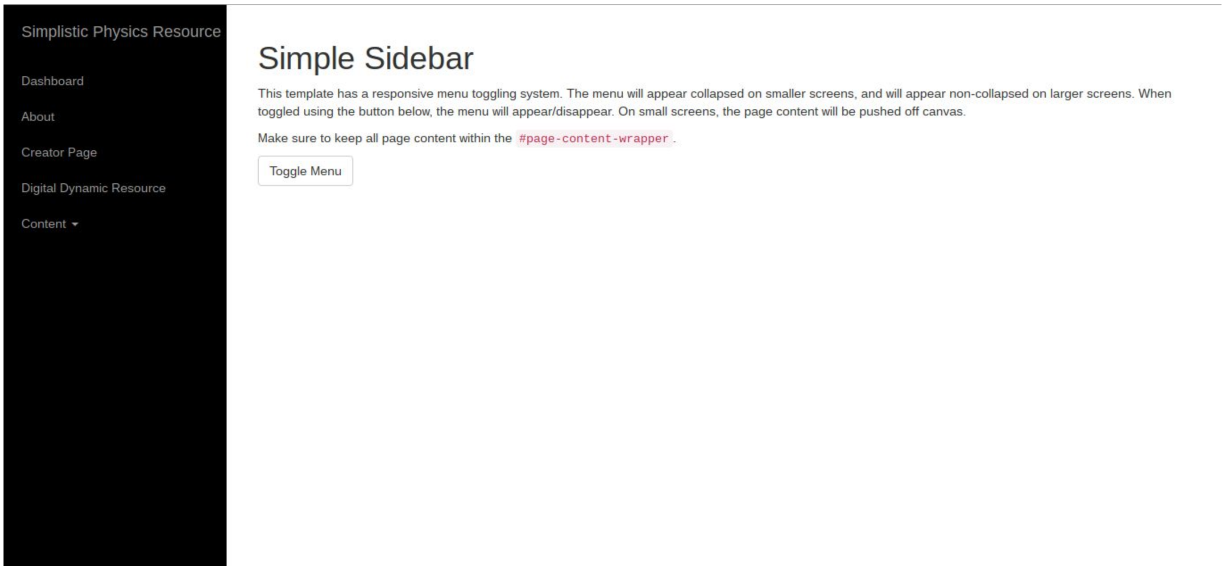
Utilizing Bootstrap as a template to incorporate html, css, and js we can use this to make a dynamic resource that runs on a static website through a host



There are prebuilt templates everywhere for bootstrap, as well as tutorials about how to change the different elements and set the core of it up. I did in the cloud9 host for testing purposes, might like in the previous section.



Once we put our scripts (html,css,js,json) together in the same folder this can be viewed view the virtual Ubuntu computer host as well. Here is the simple template for bootstrap that will then be changed to what we want.



Here is our clean website that has a toggle menu, is minimal, and is a short script the outsides the rest of our content to pre-existing html pages that are now hosted in cloud9, what we used at the backbone for our raw resource is used in the refined resource as the content database that will later be used for our queries when implementing this in AWS's tool for searching content in our database.

```
<!DOCTYPE html>
<html lang="en">

<head>

    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width,
initial-scale=1">
    <meta name="description" content="">
    <meta name="author" content="">

    <title>Simplistic Physics Resource </title>

    <!-- Bootstrap Core CSS -->
    <link href="css/bootstrap.min.css" rel="stylesheet">

    <!-- Custom CSS -->
    <link href="css/simple-sidebar.css" rel="stylesheet">

    <!-- HTML5 Shim and Respond.js IE8 support of HTML5
elements and media queries -->
    <!-- WARNING: Respond.js doesn't work if you view the page via
file:// -->
    <!--[if lt IE 9]>
        <script
src="https://oss.maxcdn.com/libs/html5shiv/3.7.0/html5shiv.js"></sc
ript>
        <script
src="https://oss.maxcdn.com/libs/respond.js/1.4.2/respond.min.js"><
```

```
                    <a href="#">Digital Dynamic Resource</a>
                </li>
                <li class="Content">
                <a href="#" class="dropdown-toggle"
data-toggle="dropdown" role="button" aria-haspopup="true"
aria-expanded="false">Content <span class="caret"></span></a>
                <ul class="dropdown-menu">
                  <li><a href="wheel.html">Chapter 1</a></li>
                  <li><a href="#">Chapter 2</a></li>
                  <li><a href="#">Chapter 3</a></li>
                  <li><a href="#">Chapter 4</a></li>
                  <li><a href="#">Chapter 5</a></li>
                </ul>
              </li>
            </ul>
        </div>
        <!-- /#sidebar-wrapper -->

        <!-- Page Content -->
        <div id="page-content-wrapper">
            <div class="container-fluid">
                <div class="row">
                    <div class="col-lg-12">
                        <h1>Simple Sidebar</h1>
                        <p>This template has a responsive menu toggling
system. The menu will appear collapsed on smaller screens, and will
appear non-collapsed on larger screens. When toggled using the
button below, the menu will appear/disappear. On small screens, the
page content will be pushed off canvas.</p>
                        <p>Make sure to keep all page content within the
```

```
/script>
    <![endif]-->

</head>

<body>

    <div id="wrapper">

        <!-- Sidebar -->
        <div id="sidebar-wrapper">
            <ul class="sidebar-nav">
                <li class="sidebar-brand">
                    <a href="#">
                        Simplistic Physics Resource
                    </a>
                </li>
                <li>
                    <a href="#">Dashboard</a>
                </li>
                <li>
                    <a href="#">About</a>
                </li>
                <li>
                    <a href="#">Creator Page</a>
                </li>
                <li>
```

```
<code>#page-content-wrapper</code>.</p>
                        <a href="#menu-toggle" class="btn btn-default"
id="menu-toggle">Toggle Menu</a>
                    </div>
                </div>
            </div>
        </div>
        <!-- /#page-content-wrapper -->

    </div>
    <!-- /#wrapper -->

    <!-- jQuery -->
    <script src="js/jquery.js"></script>

    <!-- Bootstrap Core JavaScript -->
    <script src="js/bootstrap.min.js"></script>

    <!-- Menu Toggle Script -->
    <script>
    $("#menu-toggle").click(function(e) {
        e.preventDefault();
        $("#wrapper").toggleClass("toggled");
    });
    </script>

</body>

</html>
```

This is the basic script in html to display what is on the screen, the back-end part is stored in the files in the client.

Part III: Conclusion

Sources Cited

"Bachelor's in Physics." American Physics Society, 2015. Web. 05 May 2016.

<https://www.aps.org/programs/education/statistics/bachelors.cfm>.

Cummings, Karen. "A Developmental History of Physics Education Research*." (2011): n. pag. Web.<http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072580.pdf>. Detailed critque of PER as apart of a board review for reform.

ltzer, David, and Valerie Otero. "A Brief History of Physics Education in the United States." (2014):
n. pag.
Web.<http://physicseducation.net/docs/pdf_archiveAJPIASvol_83iss_5447_1.pdf>.

Oliver, John. "Last Week Tonight with John Oliver: Standardized Testing (HBO)." *YouTube*. HBO,
03 May 2015. Web. 05 May 2016. <https://www.youtube.com/watch?v=J6lyURyVz7k>.

Rebello, N. . Sanjay. "Trends in Physics Education Research." (2005): n. pag. Web. <https://web.phys.ksu.edu/papers/2005/DZ_NSF_TrendsinPER.pdf>.Critique of physics education research published by two faculty at Kansas State University.

"U.S. Students Improving – Slowly – in Math and Science, but Still Lagging Internationally." *Pew*
Research Center RSS. N.p., 02 Feb. 2015. Web. 05 May 2016. <http://www.pewresearch.org/fact-tank/2015/02/02/u-s-students-improving-slowly-in-math-and-science-but-still-lagging-internationally/>.

Resources Used

Appendix