Teaching Quantum Computing with Videos

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Teaching Quantum Computing with Videos

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Abstract—Quantum computing will likely change our world as we know it today. In bringing together fields such as quantum mechanics, mathematics, and computer science in their construction and application, quantum computers hold a promise of tremendous increase in processing power when compared to present day technology. For an educator, teaching this topic requires that consideration be given to the fact that quantum computing is not only based on hard-to-teach aspects of physics, math, and computing, but that quantum computing itself is still in the early stages of its development. What is certain is that concepts such as Shor’s and Grover’s algorithms have already been developed specifically for use with quantum computing. Both algorithms are the beneficiaries of quantum properties such as superposition and entanglement which are at the core of the new technology. This paper is presented in a bottom up structure starting with the explanation of the basic component, the qubit, before moving to superposition and entanglement and ending with a lucid explanation of both of the algorithms. Due to the complex nature of the topic, teaching this subject requires that certain measures be taken to teach all students at all levels and have them feel comfortable within themselves about the topic. The course is meant for anyone who wants to learn quantum computing. It is furthermore recommended that those attending have a blank slate so we start with new students. We would like to see a variety of students taking and passing the course, with that in mind, the explanations of the topics are done without employing an excessive amount of math common to other courses in quantum computing. The recommended approach for teaching is through the use of videos and a curriculum which is broken down so topics are made more general and the discussion of that effort is the main focus.

Index Terms—Qubit, Entanglement, Superposition, Grover’s Algorithm, Shor’s Algorithm, Teaching, Quantum,

I. INTRODUCTION

The prospect of quantum computing is already making its mark on computer science. This technology has the potential to provide much faster calculations, and the ability to deliver better results and outcomes than the traditional binary computer. The fundamental underpinnings of quantum computing are in quantum mechanics; however, through abstraction, it is not necessary to master quantum mechanics or physics to become a programmer on a quantum computer. What is crucial to a quantum computer programmer is to keep in mind that the behavior of atoms or subatomic particles used in quantum computing do not follow the physics and mechanical rules as more significant, life-sized systems do. Understanding a few characteristics and practices of the sub-atomic and atomic world is sufficient to program a quantum computer.

Quantum computing, through quantum physics, provides us with two realities: before measurement and after measurement. The “before measurement” stage, the state of the quantum bit (which is composed of either an atomic or subatomic particle trapped in the quantum computer by design) is dynamic and moving. In the “after measurement” reality, the quantum bit (called a qubit) collapses and delivers its result, which is between a 0 or a 1. That 0 or 1 is used in classical binary computers as well.

A. Qubit

At the core of Quantum Computing is the qubit, or “quantum bit”. Its unique property is that unlike the typical bit, which is limited to values of 0 or 1, a qubit, in addition to those two states, can have many states in between. When referring to those states, the bit is noted as $|0\rangle$ or $|1\rangle$. Conceptualizing this ability presents a major challenge in teaching this topic particularly to those with limited prior exposure to physics or experienced with current computing technology. Figure 1 helps in illustrating the differences:

To further complicate matters, quantum computers rely on probability to present the output and may require multiple calculations before a result is accepted (considering that even with multiple calculations would still be faster using a quantum computer, this may be acceptable). This is due to a unique property of a quantum particle that ithat equation represents all those vectors being possibilities, and the set of all those possibilities if it is measured, which would be necessary to obtain a result, it collapses into one of the basic states of 0 or 1. It ceases being a qubit and presents the basic value [10].

B. Superposition

The name of the ability of a qubit to be in multiple states is Superposition. In Figure 1, $|0\rangle$ and $|1\rangle$ are not representing superposition, they are representing the basis states, and they are prominent on the diagram, so it is easy to get muddled. It is the equation on the upper right which shows the Hadamard gate, where all the vectors from the equator and going up to $|0\rangle$, (and for the negative, going down to $|1\rangle$), abilities, all those directions that a vector could be pointing, that set is the set of superpositions, and is expressed in this equation of $|0\rangle$ plus $|1\rangle$ divided by the square root of 2. This is called the Hadamard, or H gate. Quantum superposition is a fundamental principle of quantum mechanics. It states that much like waves in classical physics, any two (or more) quantum states can be added together (“superposed”) and the result is another valid
Figure 1. The unlimited amount of states that a qubit can be in at any given time is traditionally represented in a sphere where North = 0 and South = 1.

quantum state; and conversely, that every quantum state can be represented as a sum of two or more other distinct states. This is usually taught by using vector (linear algebra) arithmetic.

In explaining this phenomenon, Erwin Schrödinger used his famous cat illustration to demonstrate this ability where the cat can be thought of as both dead and alive, until a measurement of a qubit is taken, or in this case the box was opened.

C. Entanglement

Quantum entanglement is a physical phenomenon which occurs when pairs of particles are generated, interact, or share spatial proximity in ways such that the quantum state of each particle cannot be described independently of the state of the others, even when the particles are separated by a large distance [1]. Measurements of physical properties such as position, momentum, spin, and polarization, performed on entangled particles are found to be correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a specific axis, the spin of the other particle, measured on the same axis, will be seen to be counterclockwise, as is to be expected due to their entanglement. However, this behavior gives rise to seemingly paradoxical effects: any measurement of a property of a particle performs an irreversible collapse on that particle and will change the original quantum state. In the case of entangled particles, such a measurement will be on the entangled system as a whole.

As we dug deeper into our research and had the opportunity to use IBM’s quantum system known as the Q Experience [7], and we are finding that two quantum particles can, in fact, be generated to interact in both near and distant locations as done with entanglement. Two particles can be any distance away from each other and provide correct information on the quantum state they are in. Thus, allowing quantum computing to calculate the bit position on their respective axis and if they are at the binary relevant of a 1 or 0.

Figure 2. Entanglement

A more natural way to understand this idea is that entanglement arises in situations where we have partial knowledge of the state of two systems. We say that the qubits are “independent” if knowledge of the state of one of them does not give useful information about the state of the other. On the other hand, we say that qubit entanglement occurs when information about one describes the state of the other.

D. Grover’s Algorithm

Grover’s quantum algorithm searches for a subset of items in an unstructured set of (N) items. The algorithm incorporates the search criteria in the form of a black box predicate that can be evaluated on any items in the set. The complexity of this evaluation (query) varies depending on the search criteria.

With conventional algorithms, searching an unstructured collection of (N) items requires (N) queries in the worst case scenario. In the quantum domain, however, Grover’s algorithm can perform easy searches by making queries to any particular database, which created a quadratic speedup over classical bit computing. This improvement is contingent on the assumption that the search predicate can be evaluated on a superposition of all database items.
Additionally, converting standard search criteria to quantum circuits often entails a moderate overhead, and the quantum predicate's complexity can offset the reduction in the number of queries.

Unstructured search is often alternatively formulated as a database search problem in which we are given a database and we want to find an item that meets some specification. For example, given a database of \((N)\) names, we might want to find where your name is located in the database. The search is called "unstructured" because we are given no guarantees as to how the database is ordered. If we were given a sorted database, for instance, then we could perform binary search to find an element in logarithmic time. Instead, we have no prior knowledge about the contents of the database. With classical circuits, we cannot do better than performing a linear number of queries to find the target element.

The unstructured search problem can be solved using quantum computation. In fact, this is within a constant factor of the best we can do for this problem under the quantum computation model. In particular, since we cannot solve the unstructured search problem in logarithmic time, this problem cannot be used as a way to solve NP problems in polynomial time; if we did have a logarithmic time algorithm, we could, given variables arranged in clauses, solve the SAT problem by searching all possible queries after a few manipulations.

Nonetheless, solving the search problem in queries is still significantly better than what we can do in the classical case. In addition, Grover’s algorithm uses gates. If we think of the number of gates as being roughly running time, then we have running time almost proportional to the query number of queries after a few manipulations. Therefore, this caveat does not provide an unfair advantage to the quantum algorithm.

We can then make the probability of correctness an arbitrarily large constant. We do this by running the algorithm multiple times to get many different outputs. Then we can run each of our results through to see if any match the criterion desired. This strategy only fails if all outputs fail, and since these are all independent outputs, our probability of failure is great. Note that even with classical algorithms that only need to output the correct answer with two-thirds probability, we still need a linear number of queries. Therefore, this caveat does not provide an unfair advantage to the quantum algorithm.

### E. Shor’s Algorithm

Shor’s algorithm was a theory proposed in the 1990’s by Prof. Shor to use Quantum Computers to find vulnerabilities in the RSA encryption. In its most basic form, it is used to find prime factors of some number \((N)\). It works by using quantum mechanics to quickly factor large prime numbers, where a is a randomly chosen small number with no factors in common with \((N);\) from this period, number-theoretic techniques can be used to factor \((N)\) with high probability.

When used with the necessary equipment, such as sufficiently powerful quantum computers, Shor’s algorithm has the capability to destroy ciphers that are used by banks and other institutions and is also a key component in vast majority of online transactions conducted. This has the financial industry and the governments around the world concerned though there are many ways of encrypting data, using mathematical functions that do not involve factoring. The US Government NIST’s efforts \([3]\) are currently to try to come up with a plan of cryptography that is immune to Shor’s Algorithm. Shor’s algorithm would crack cryptographic keys that rely on the factoring of large numbers.

There are other mathematical functions, where quantum computers would not work much better than ordinary computers at trying to break passwords. Despite their name, many post-quantum algorithms are based on classical mathematics techniques that predate quantum information. There is fear of quantum computers being able to break the toughest passwords, which originates with Shor’s Algorithm-based cyber-attacks that are imminent with continued improvements in quantum computing capability.

## II. Literature Review

Quantum Computing is a relatively new field when compared to the current computing technology. Although theories concerning Quantum Mechanics have been around for over a century, attempts at building a computer based on those principles are fairly recent. A summary of the technology, where we currently are, challenges facing the engineers developing the machines, and various approaches to better quantum systems are being taken with very careful steps to not create a new system that can hurt others. takongyosi, et al. \([6]\]. The authors go through the detailed description of what is involved in quantum computations and how it differs from the computers in use today. Then they move on to describe memory which will have to be developed to work with qubits. Equally as important, a totally new approach will need to be developed for dealing with CPU’s and how they communicate with other components. Last, looking more into the future, consideration is given to distributed topologies as a way to utilize machines distributed at various locations. The description of the workings of a quantum computer is further provided by Bonsor/Strickland \([2]\) where it is compared to a modern Turing computer. They introduce the concept of a qubit and what devices are used to control them.

Studying the related literature of quantum computing, Shor and Grover demonstrate that a quantum computer can outperform any classical or binary based computer. The subject of quantum computing brings together ideas from classical information theory, computer science, and quantum physics. \([12]\) It is well noted that many different algorithms exist such as the traveling salesman and the Vehicle Routing Problem, but these remain insufficient to train students about quantum computing and the underpinnings of how it all connects. As of this writing, there are four types of quantum computers. The first is the quantum annealer which is known as the least powerful and most restrictive of Quantum Computers. In addition the annealer can only preform one specific function.
Most feel that the quantum annealer has the same comparison to a regular binary computer.

Second is the analog quantum computer which is able to simulate complex quantum interactions that are intractable for any known conventional model run on it. The analog quantum computer can handle between 50 to 100 qubits at any single time.

The third type is the universal quantum computer which is the most powerful, but hardest to build and work with. Although, this system will be able to work with 100,000 qubits which is substantial. [4]

Fourth, is the circuit-model quantum computer which operate on qubits with quantum gates, which perform transformations on a small number of qubits which are defined by unitary matrices [8]. These quantum gates are analogous to logic gates in traditional electronic circuits. Circuit-model quantum computers have been proven to be universal and have logical proofs of ‘quantum speedup’ for certain applications. Current commercial computers have many qubits. Applications of circuit-model quantum computers include integer factorization (Shor’s Algorithm) [11], search algorithm (Grover’s Algorithm) [5], simulation of quantum systems, and finding approximate results of optimization problems. Adding to the complexity of learning about this material, additional models for quantum computation are also being researched.

It should be noted that due to the ever changing technology in the field of quantum computing, with new discoveries and ever increasing capabilities being announced constantly, the authors chose to use publications more general in nature with their context unlikely to change in the near future. This ensures that the material mentioned here is going to stay relevant for a long time and not be subjected to the ongoing technological changes in the field.

III. Project Requirements

Lewis Westfall [13] explained all the necessary mathematics to understand Quantum Computing in his paper “Teaching Quantum Computing”. This work contributed greatly to the team’s understanding of the subject area. Lewis would be an accredited resource with extensive knowledge of the field. Having him and Prof. Leider as advisers, ensured that there would be no contextual errors in this paper and videos produced for the course would be accurate as well. We felt that this inclusion was necessary considering an abundance of materials from people who have questionable credentials at best and their conclusion would have to be accepted with a certain amount of skepticism when viewed on variety of websites.

The first, and most important step, was a determination as to the target audience. This choice would affect the design of the course material and would impact our expectations as to the number of students who would take it. An easier approach, light on math and physics, might attract a broader audience whereas an approach targeting more advanced students, heavy in math and physics, might be a deterrent.

In the end, the team decided on the easier approach in hopes of attracting a larger number of students with more text oriented material using few if any formulae. Once that was decided, the authors proceed with building a unit plan and break down lessons to help students understand what was set in the learning outcomes. Students were introduced to qubits, Superposition, Entanglement, Shor’s Algorithm, Grover’s Algorithm and how they all work together using quantum computing.

To achieve this goal, the team was in need of a professional platform to build the modules needed for the five learning outcomes. In addition, we would use this platform to teach, test, and get an assessments to gauge the students understanding. Lastly, it is needed for continuous use to train the students.

The team used programs like Camtasia and SnagIt to help with screen castings, videos of our five topics, and to add a clean look to the project. It is hoped that a more professional appearance continue to attract students especially when compared to other offerings on Udemy and other platforms. Having decide on the platform, we discussed our options as to the length of the recordings. Other competing products, which commanded a fee, ran anywhere in the range of 3 hours all the way to 14. During that time, they covered anything from Newtonian physics, to vacuum tube computers, into finally introducing transistor based technology. In our opinion, this was very inefficient since on the one hand it forced students to watch unnecessary material and possibly forcing them to lose interest, on the other, it did not inform them as to whether any of it could be skipped. Our approach would be to dive into the presentation with minimal background as to the history of the development with barely mentioning dates around Grover’s and Shor’s algorithms. This way, this intro level course could be kept to about an hour while providing, and expanding, on all the information included in the “Introduction” section of this paper. Once a recording was made, several platforms were considered for deploying it. Those under consideration were either generally available sites, such as YouTube, to more restrictive which require a user account and potentially a fee to join. In the end, Udemy would be a great place to meet the needs of this effort since it tends to attract a broader education-oriented audience than other sources at the same time avoiding sites such as YouTube which may attract registrations not necessarily from people interested in the topic. It was determined that since Udemy does not offer a way to immediately test the students, we were in need of a platform which would allow us to ascertain whether our methods worked. Due to its superior reporting capabilities, Udemy became the platform of choice. At the end of each course, each student would be presented with a link to our testing area where they are able to take a brief test composed of 10 questions and no time limit. Because this is a research effort, it is not necessary to time the test, and users can take as much time as needed.

Because of the constant changes occurring in the field of quantum computing, anyone teaching this material must constantly keep abreast of any new finding and updates what
they are teaching. The ongoing development in the field makes for an amazing feature or improvement one day, and an interesting historical footnote tomorrow.

This IBM quantum computer from 2018 is a good example (Fig 4):

![Image of IBM Q Series 2018 quantum computer](image)

**Figure 3. IBM Q Series [9]**

While top of the line at the time, would be compared in years to come as a vacuum tube computer of the 1950’s was viewed by those in the early 2000’s. It runs by a direct manipulation of its components and programmers working with it have no choice but to become familiar with some aspects of quantum physics. The architecture of that machine does not account for a quantum CPU, quantum RAM, or any sort of quantum storage surely needed to fully work with quantum data. To become even more familiar to programmers of today, quantum computers require some sort of an operating system and a programming language. This way, using the technology requires a programmer to learn familiar concepts and a programming language instead of delving into unfamiliar territory of Quantum Mechanics. For quantum computing to become main stream, it needs to account for those developments and anyone teaching about this topic needs to stay up to date.

**IV. METHODOLOGY**

We are presenting two sets of videos to two Cohorts A and B which will each be exposed to our videos that have complex topics broken down into a series of information that is much easier to understand for the students exposed to the videos. We will supply students two different platforms each having videos built into them. In addition we are asking the two Cohorts to take a test at the end. All videos for one Cohort were built by our team and were recorded by the authors, broken down and restructured to make understanding the materials easier. For the Cohorts we selected similar platforms, and similar ways. The goal is for the students to watch the two sets of videos on Udemy and see which Cohort has better outcomes on the final exam.

This study was structured in such a way as to produce two sets of results to determine which learning method and tool is better. We believed that students would score much higher on the final exam and learn quantum computing with our videos rather than those found elsewhere.

If Cohort A shows improvement on the final exam rather than Cohort B, we will know that you can have little knowledge about the subject and not include the heavy mathematics, nor the heavy subject of quantum mechanics; whereby proving our point that quantum computing can actually be taught in a manner that cuts out all of the complexities from the topic.

**V. RESEARCH DESIGN**

For this paper we have taken a qualitative approach to the outcomes of our methodology. We had a sample of n=1210 participants. No particular academic or specialized students were selected to see both sets of videos. We exposed the Cohorts of student group A 1-5 to the set of videos we created an group B 6-10 to another set of videos. We measured their performance based on a standardized test which we have created. This standardized test had 10 questions for the students to answer.

The idea behind this paper was to take a multi-pronged approach to teaching Quantum computing. The field is still young, dynamic, and as such, is undergoing constant changes. The obvious difficulty in teaching about an ever changing discipline is that it requires a contribution from different sources such as previously written documents, current research, and any new developments. The approach taken here incorporates written documentation which can be augmented by any new developments and video recording which should help to visualize more challenging concepts. Most recent data for this paper was obtained through Gyongyosi [6], who offers most complete summary of current development in the field, challenges facing both the developers and manufacturers, and potential pitfalls with future development.

In selecting materials for this research and teaching videos, priority was given to concepts which are unlikely to change such as the definition of the qubit, Superposition, and Entanglement or the discussion of Shor’s and Grover’s algorithms in written forms. On paper, these theories are sound though ultimately to need to wait to be proven when technology exists to verify their suppositions. Discussion of current technology was less of a priority since ongoing developments ensure that information, for example, on the number of qubits in the most advanced machine today most assuredly will be small when compared to the number in years to come. In this way, the authors aimed to keep this paper data agnostic and keep it relevant for years to come. The structure of the paper follows a bottom up approach to ensure that the student understands the basic fundamentals of the quantum world before moving to more challenging concepts. In this way, an instructor can ensure that all students have similar level of understanding when it comes to the material at the end of the Introduction.

1[https://goo.gl/forms/3WjoW5TyLBSh9fxe2](https://goo.gl/forms/3WjoW5TyLBSh9fxe2)
The results we expect will be obtained by studying our two groups A and B. The selection of each student will be double blind and selected by a number generator. If a student is in Cohort A, they will be asked to watch a number of videos that are much less math difficult so they will understand the subject material as it is quite complex. At the end the student will have to take a simple ten question test at the end. Our expected findings for Cohort A are as follows. A sample of \( n=1200 \) (this is an estimate) students to be tested and the mean score for this group is an anticipated 7.554, with less than 5 being a failing grade. We expect that the majority of students who take the test will be well over this. We will compute from our data of test results the standard deviation and the confidence level.

We project that Cohort B will also be a double blind sample in which the students end up here by way of selection by using a random number. Cohort B will be exposed to our quantum computing course with the same subject material, but with the mathematics and quantum mechanics far deeper than anybody would need to understand the subject. Our findings for Cohort B are expected to be as follows. A anticipated number of \( n=1200 \) (estimate) students will be tested for the second Cohort. The mean score for this group was 4 out of 10 questions and all students failed, as the passing rate was 5 correct questions (this is a projection). We will calculate the standard deviation and the confidence level.

This data will prove our hypothesis true, that student test scores are higher for the sample that watched the videos that we created with little mathematics and quantum mechanics, than the ones with more mathematics.

In addition, the students who take our test will give us valuable feedback, as they explain our course and quantum computing and they hopefully will develop a sense of willingness to seek out more information about the topic because it starts to interest them. We have found that approaches to teaching about quantum computing vary, and our research may help find the best path to fast comprehension.

VI. RESULTS

The videos were made more visible thanks to the fact that Udemy automatically enrolled users who expressed interest in quantum computing. In only 10 days since the course was opened, over 1,300 students from 95 countries signed up for it. The top 5 countries with registrations according to popularity were India, United States, Taiwan, United Kingdom and Poland. In some ways this could be expected since most of the current research is occurring in the United States but the inclusion of countries such as Taiwan and Poland was a surprise. It goes to show that the interest in this topic is gaining worldwide attention and illustrates the need for relevant teaching material. We also cannot lose the sight of the fact that over 130 people per day registered for these courses through various means. Of all those students, 37 have started the program and progressed to various stages of watching the videos as indicated in Figure 4.

![Figure 4](image-url)

**Figure 4.** At the ten day mark three percent of students had engaged with the course.

The breakdown of the stages watched by each student is shown in Figure 5. With limited comments, it is difficult to ascertain as to why they progressed to the varying stages though it is hoped that those watching are waiting until completion to provide an evaluation.

![Figure 5](image-url)

**Figure 5.** Breakdown of how far viewers progressed in the course. The total number of students who started the course was \( n=37 \). The y axis represents the number of students who completed the videos. The x axis represents the percentage completed.

Because the field of quantum computing is still largely under development, with new concepts and approaches being tested, it increases the difficulty in gathering pertinent information about this topic. Subsequently, testing needs to be constantly adjusted if new developments are to be examined. Speculation is rife as to what is being developed and a lot of “sources” are suspect at best with their information hard to verify. Efforts were made to check the information included for accuracy by verifying sources or by obtaining information from reputable organizations.
We have found nine similar video-based courses, listed on Table I four of which are also on Udemy, that introduce quantum computing. We reviewed them using the qualitative criteria such as how engaging the course was, if they used animations to illustrate their ideas, and other characteristics as listed in Table II. We are still reviewing these other videos, our competitor videos, and studying the good in them and also the bad. Our initial reviews indicate that these other videos are not satisfying to the students wanting to learn about quantum computing. It explains why so many signed up for our course right away.

Our course is a first effort, and not spectacular, yet more than one thousand students enrolled and paid about $10 each to take it. Our course must fill a need. These are the criteria we plan to use to review the other courses in detail to get ideas on how to improve our course.

The great interest in our course, in the presence of so many similar courses on the same topic, reveals that the students are not satisfied with the current offerings. Additionally, Udemy offers a star system, and our course, although primitive, received an average of 2 stars, while some other Udemy courses on Quantum Computing, some charging fees in order to view them, have received no stars at all. Our future work will be to take the other courses offered by the competition, and then take the best ideas that we find in those courses and include them in our course. We will also seek out ways to make 3D and 4D examples of the quantum computing concepts. Having worked through this complex material, and having found that visual aids would go a long way to help in explaining them, the team will evaluate the possibility of producing and including them in any future recordings. Static, and two dimensional, presentations currently available, do a poor job of representing the material whose very nature requires it to be in more than two dimensions. Showing a 3D representation of a qubit, how it stores data, and how that is done using superposition would be a huge improvement on the mere one way monologue supported by 2D pictures available today. Although more challenging, animating the behavior of entanglement as it relates to everything else discussed previously, would allow the students to get a complete picture of how a quantum computer will work. The animations would be complete when the moment of measurement, when the qubit collapses, and its value retrieved, would complete the representation. Instead of dry presentation, we would be presenting those watching, with a vibrant and gripping visualization lacking today. The Udemy platform allows us to continuously improve our course, uploading more and better videos, indefinitely. A separate decision would need to be made as to whether the videos will be added, or will replace, the current offerings risking being not watched due to the current low ratings, or an entirely new presentation created with improved graphics.

VIII. CONCLUSION

Our team experienced several difficulties in pulling the necessary resources together for this study. To start with, we did know whether we were onto something significant or if our vision for this project was fulfilled through existing means. This came form the adage that students are easy to teach it is just a matter of how you teach them. We also had to address a relative unfamiliarity of the team with the current developments on what is a very difficult topic. Other choices involved the level at which we wanted to pass this knowledge, whether we wanted to include everyone or have more target audience. Finally, the choice of the recording platform and an approach to those recordings had to be developed in order to attract as many people possible when competing with more established offerings. In the end, this relatively short effort, as far as its time frame is concerned, surpassed our expectations, when we attracted over a thousand pupils for a course which was hoped to attract a handful. If our hypothesis is in fact true, as our observations indicate, and if one were to stop and think can we motivate our students by giving them a understanding of a topic and if they like it they will research it further. In addition, are we giving them fundamentals and confidence to dig deeper into a complex topic by starting off slower? One would have to say yes. It was quite compelling as we planned the best approach for this paper and have been setting up how we will doing the experiments of the test results. Cohort B will
be allowed to see Cohort A’s videos after they take the test and we anticipate that many things they had heard in the videos they watched make sense. These researchers find it great to anticipate the results as we watch students learn the material which we created.

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