Pinnacle Educational Research & Development
ISSN: 2360-9494

http:/www.pjpub.org

Research Article Vol. 2 (6), 2014

College Students' Use of YouTube Videos In Learning Biology and Chemistry Concepts

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Accepted 27 October 2014

ABSTRACT

Over three hundred fifty students from two- and four-year colleges were asked to indicate their frequency of use, and to provide their perspectives, on the usefulness of YouTube videos in learning biology and chemistry concepts. This research paper describes the study, shares the results, and discusses the implications of the findings for students, instructors, curriculum, and academic leaders. A case is made for including YouTube videos in the teaching and learning of science concepts in the classroom. What is more, we discovered that a majority of the students surveyed have noted being left to their own devices in their attempts to peruse the many YouTube videos in search of those that are useful, relevant, and credible with the biology and chemistry concepts in question in a particular class. As the students expounded the great value of the videos, there was a keen desire for instructors to search for, and integrate, related videos on a weekly basis in their courses; students felt that in this shift to instructors assuming this responsibility for locating the videos, they would have more time to study and engage in the learning process. This, in their eyes, would increase their chances for success in the arenas of biology and chemistry. While we are sure that YouTube videos play a significant role in motivating and engaging students in the learning process--- especially with the low-performing students--- we must acknowledge that it is the faculty whom are required to spend time and energy on behalf of the students looking for and integrating them in the fabric and the pedagogy of a given course. They will be more effective if this task becomes part of what the faculty does in designing and preparing for their own courses and pedagogical strategies.

Keywords: Modern Learners, Learning Resources, Video-teaching Pedagogy, Academic Performance, Student Success.

Introduction

Most of the students we encounter in our classrooms and lecture halls today are the so-called Millennial's, or Generation Y, "a generation mostly of teens and 20-something's known for constantly holding up cameras or cell phones, taking pictures of themselves and their surroundings and posting them online in various forms including YouTube videos" (Stein 2013, p. 26).These students have cell phones and access to the Internet, are very savvy in technology and its uses, and expect to be in contact 24/7 through communication, suggestions, and feedback-positive and negative-traveling in both directions. Because of this, they have higher expectations for the effective use of technology in the teaching/learning environment than their instructors. They expect faculty to incorporate technology into their teaching, and be proficient

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in the use, at the very least, of Web-communication, online resources, interactive presentations, instant access to instructional and learning materials, discussion boards, and electronic classrooms with instant animations and short videos on every imaginable topic.

YouTube is a video-sharing Website created in 2005 by three former PayPal© employees, Chad Hurley, Steve Chen, and Jawed Karim. Depending on the type of user (registered or unregistered), YouTube allows users to upload, share, and view videos. The Website is only accessed through the Internet and has become one of the most highly used of social media (Erick, and King, 2012). Today's young college students are more tech savvy than ever before, and most have grown up using computers and the Internet since grade school.

> More than 90% use email to communicate with professors and 73% say they cannot study without technology. Seven in ten take notes on keyboards instead of paper, virtually all students who own an e-reader read textbooks on it and most use digital tools when preparing a presentation. All that tech [sector] has caused something of a dependency too - 38% of students can't go more than ten minutes without checking their smartphones or other devices…. [Furthermore,] "Twelve million students take at least one class online today. By 2014, analysts say, more than 3.5 million students will take all of their classes online," and in five years that number is projected to exceed 22 million. (Laird 2012, ¶.1,3).

The feasibility of using technology to transform teaching and learning has been on the upswing. Indeed, the National Education Technology Plan 2010, released by the U.S. Department of Education, notes that "technology-based learning and assessment systems will be pivotal in improving student learning and generating data that can be used to continuously improve the education system at all levels. The challenge for our education system is to leverage the learning [of] sciences and modern technology to create engaging, relevant, and personalized learning experiences for all learners that mirror students' daily lives and the reality of their futures" (U.S. Department of Education 2010, p. v-vi).

Administrators, academic leaders, and directors of educational programs, especially in the STEM fields of science, technology, engineering, and mathematics, have started to realize that tools, devices, and platforms such as social media, blogs, YouTube videos, etc., have a strong potential to support and advance their programs, especially when they can be successfully integrated into students' curricular activities. Moreover, many have started to convincingly argue that the time has come to overcome "textbook fatigue" in how we educate students by reaching within and beyond the textbook to access many kinds of 21st century tools (Lent, 2012). In the process, learning aids will likely become seen as part of a spectrum of resources, rather than sole sources. In this study, we investigate students' perspectives on the use of YouTube videos in learning biology and chemistry concepts.

Rationale

The rationale for conducting this study involves the high failure rates of long standing in introductory college biology and chemistry courses (e.g., Wagner, Sasser, and DiBiase 2000; Zeegers and Martin 2001; Rowe 1983). The rate is even higher in large lecture introductory courses in STEM fields (Popejoy and Asala 2013). Likely adding to the high failure rate is the challenge of grasping the link between chemistry and biology, a concept fundamental to understanding biology, and one that is integrated into most biology courses. In addition, class size comes into play, as large, lecture-based biology courses are a norm in many institutions.

The Study

In this study we asked 385 (144 + 241) students from two- and four-year colleges to provide their own perspectives on the use and usefulness of YouTube videos as tools in learning biology and chemistry. In this paper, we share the results and discuss the implications of the findings. We conclude that being aware of how students use and perceive the effectiveness of YouTube videos in learning the subject matter can help instructors decide how to integrate YouTube videos into their courses and curriculum. The goal for them is to find workable pedagogical options that can lead to an increased rate of student success measured in terms of higher satisfaction, better academic performance, and long-term retention of learned concepts.

Methodology

The research method used in this study consists of four integrated stages: (1) preparing the survey questions, (2) distributing and collecting the study survey questionnaires, (3) analyzing the data, and (4) interpreting the results.

A survey questionnaire consisting of 10 multiple-choice questions related directly to YouTube videos was distributed to 500 students from two- and four-year colleges located in large metropolitan areas of the Midwest in the United States. The questions covered a myriad of topics, as the study's holistic purpose was to gauge a reflective look at a new educational paradigm… *YouTube use as a learning, teaching, and possible assessment tool*. With this in mind, questions posed reflected ideas such as: 1) YouTube use, 2) effectiveness, 3) relevance, 4) accuracy, 5) helpfulness, 6) 7) professionalism, 8) student interaction, 9) searched topics for YouTube videos, 10) student-made videos, 11) type of learner, and 12) use of other Internet data sites. Additional personal questions relating to college level, academic major, gender, number of years in college, and how often they used the Internet were included as optional.

The target participants in the study were students in two course types: 1) those seeking credit for their science major, and 2) those non-science majors looking for applicable science credit. Participation was voluntary, and responses were kept anonymous. Out of the 500 surveys distributed, 385 (or 77%) were completed and returned. The return rate was significantly higher at 4-year colleges (96%), than at 2-year institutions (58%). As a strategy to gain even deeper

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insight for such a novel study, a follow-up oral discussion was also conducted with 37 volunteers out of the 385 survey respondents.

In analyzing the participants' responses, a full set of the completed surveys was distributed to each of three reviewers, who, working independently, sorted and categorized the students' answers to the non-objective questions. The reviewers then compared their data and findings. In instances where the analyses were not identical, the reviewers reread the students' answers to the divergent questions, and refined their categories until the data were consistently sorted.

Analyzing the Data

I. Participant Profiles

More 4-year college students (63%) than 2-year college students (37%) participated in the study, including the oral in-depth-discussion. There were also slightly more female (52%) than male (40%) participants in the study. Nearly an equal number of participants majoring in science (43%) and in non-science areas (42%) participated. However, while there were more non-science majors (37%) than science majors (16%) from 4-year colleges, there were more science majors (28%) than non-science majors (5%) from 2-year colleges. A majority of the participants in the oral in-depth-discussion were non-science majors.

In addition, while the majority of the participants (70%) had been in college for two to three years, 12% were in their first year, and 16% had been in college for four years. Finally, a total of 88% of the participants indicated that they used the Internet all the time (70%) or most of the time (18%) on a daily basis, while 7% indicated they used the Internet only some of the time, and 6% did not answer the question. None of the participants indicated that they never used, or didn't have access to, the Internet. However, among those who participated in the oral in-depth-discussions, 62% indicated that because they worked part- or full-time, they didn't have enough time to explore the Internet for educational purposes as they would have liked.

II. Survey Data Results

Question 1: How often do you purposely search for YouTube videos to help you learn a biology and/or chemistry concept?

As seen in Table 1 and Figure 1, only 25% of the students surveyed indicated that they never had, or provided no answers to, whether or not they purposely searched for YouTube videos to learn a biology and/or chemistry concept. A total of 181 (47%) students indicated that they purposely searched for YouTube videos to learn a biology and/or chemistry concept all or most of the time (15%), or some of the time (32%). In addition, 108 (28%) of the participants indicated they do, but rarely search for YouTube videos.

Figure 1: Question 1 (N=385)
Purposely Searching for YouTube Videos to Learn a Biology and/or Chemistry Concept

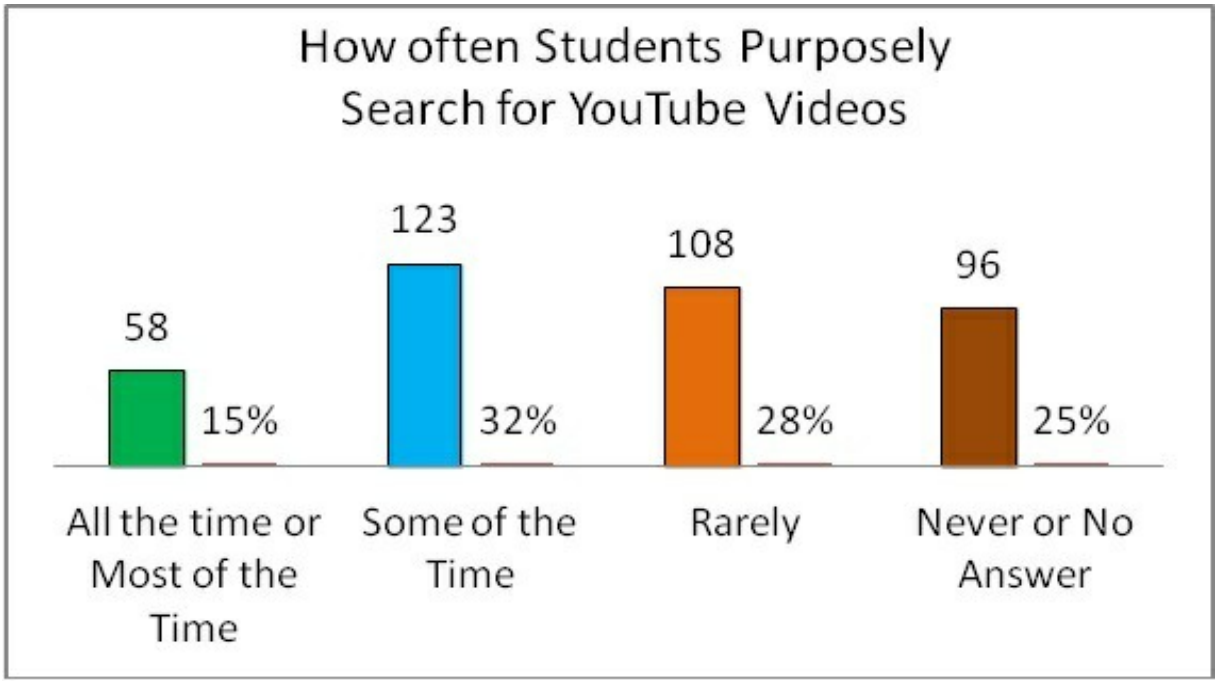

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Table 1: Question 1 (N=385)
Purposely Searching for YouTube Videos to Learn a Biology and/or Chemistry Concept

Purposely Searching for YouTube Videos to Learn a Biology and/or Chemistry Concept (n=385)				**Total**
All or Most of the Time	Some of the Time	Rarely	Never or No Answer	
58	123	108	96	385
15%	32%	28%	25%	100%

Question 2: How often do you find YouTube videos that are related to what you want to learn in biology and/or chemistry?

As shown in Figure 2 and Table 2, only 22% of the students surveyed indicated they either *never found relevant* YouTube videos or *provided no answer* to this question. On the other hand, a total of 216 (57%) students indicated they often find YouTube videos related to what they want to learn in biology and/or chemistry *all* or *most* of the time (30%) or *some* of the time (27%). In addition, 21% of the participants indicated they *rarely* found related YouTube videos.

Figure 2: Question 2 (N=385)
How Often Students Found Related and Relevant Biology and/or Chemistry YouTube Videos

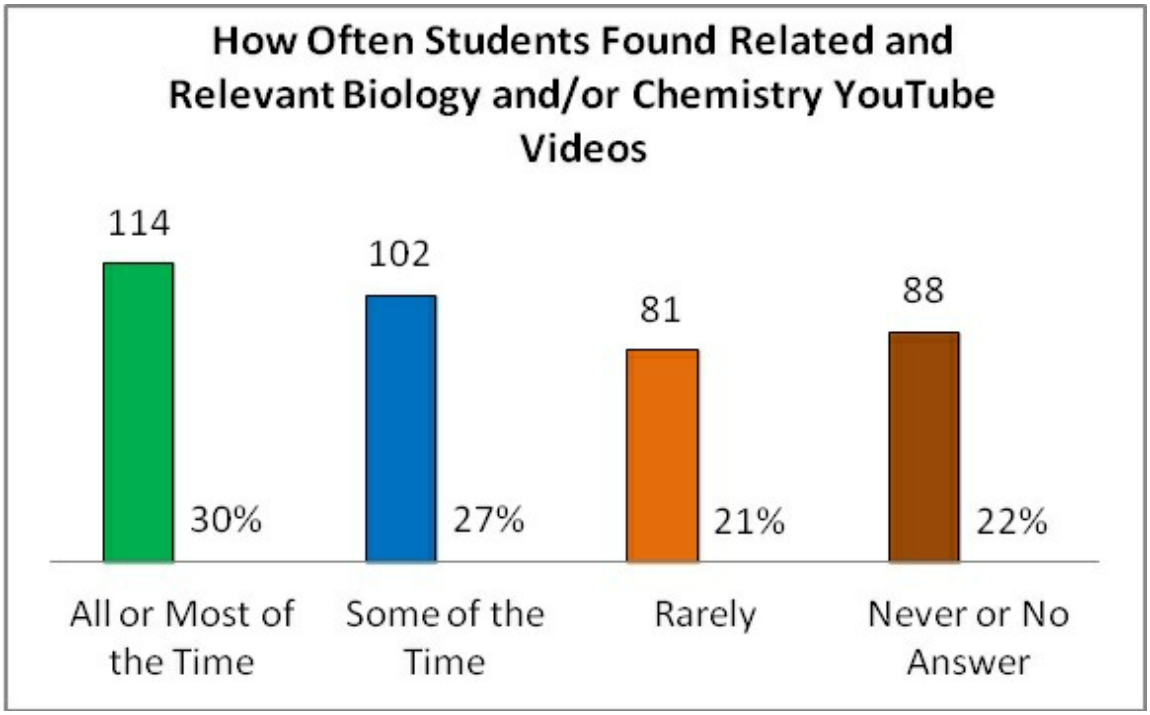

Table 2: Question 2 (N=385)
How Often Students Found Related and Relevant Biology and/or Chemistry YouTube Videos

How Often Students Found Related and Relevant Biology and/or Chemistry YouTube Videos (n=385)				**Total**
All or Most of the Time	Some of the Time	Rarely	Never or No Answer	
114	102	81	88	385
30%	27%	21%	22%	100%

Question 3: How often are the videos you find really useful in helping you understand the topic you are studying?

Figure 3 and Table 3 summarizes the participants' responses to the usefulness of YouTube videos in helping them educationally. Only 23% of the participants indicated that they *never* used these videos or no answers were provided to this question. On the other hand, a total of 242 (63%) of students surveyed indicated that *YouTube videos were useful* all or most of the time (33%) or *some of the time* (30%). In addition, 14% of the participants indicated that the *videos were rarely useful.*

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Figure 3: Question 3 (N=385)
How Often YouTube Videos Are Helpful to Students

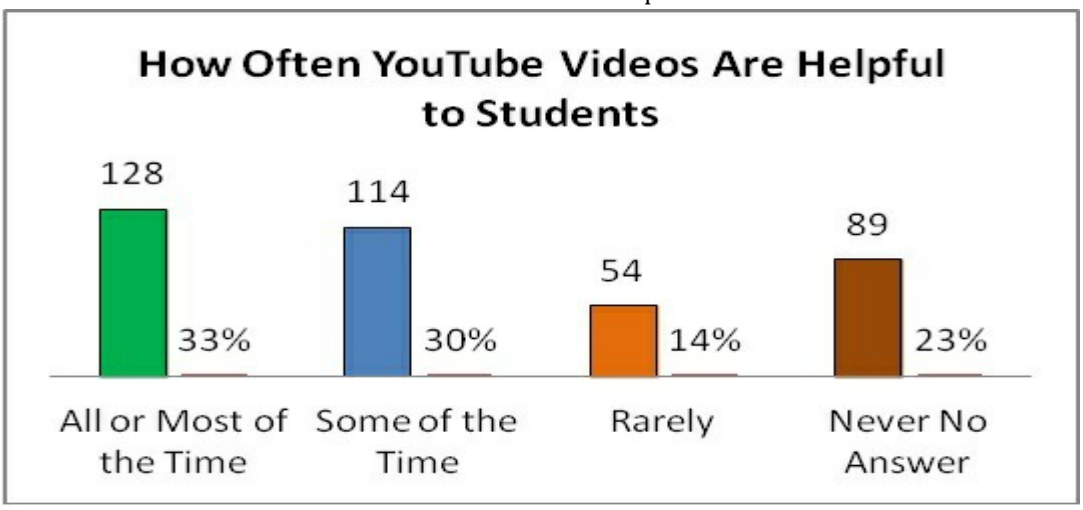

Table 3: Question 3 (N=385)
How Often YouTube Videos Are Helpful to Students

How Often YouTube Videos Are Helpful to Students				Total
All or Most of the Time	Some of the Time	Rarely	Never or No Answer	
128	114	54	89	385
33%	30%	14%	23%	100%

Question 4: How many of the YouTube videos were academically professional and accurate?

Figure 4 and Table 4 summarizes the participants' perspectives on the professionalism and accuracy of the YouTube videos they searched for and found. Only 11% of the participants suggested they either *didn't know* or provided *no answer* to the question. On the other hand, a total of 278 (72%) students indicated that the YouTube videos they found were *academically accurate*, regardless of whether or not they were made professionally (28%) or amateurishly (44%). However, 64 (17%) of the students surveyed indicated that the YouTube videos were *not accurate*, regardless of whether they were made professionally (5%) or amateurishly (11%). An interesting fact here is that even those 169 students (44%) who found the videos were amateurishly made, still found them academically accurate.

Almost all of those who participated in the oral in-depth-discussion indicated that they don't really care whether the YouTube videos were made professionally or amateurishly, as long as they were academically accurate, and educationally helpful.

Figure 4: Question 4 (N=385)
YouTube Videos That Were Academically Professional and/or Accurate

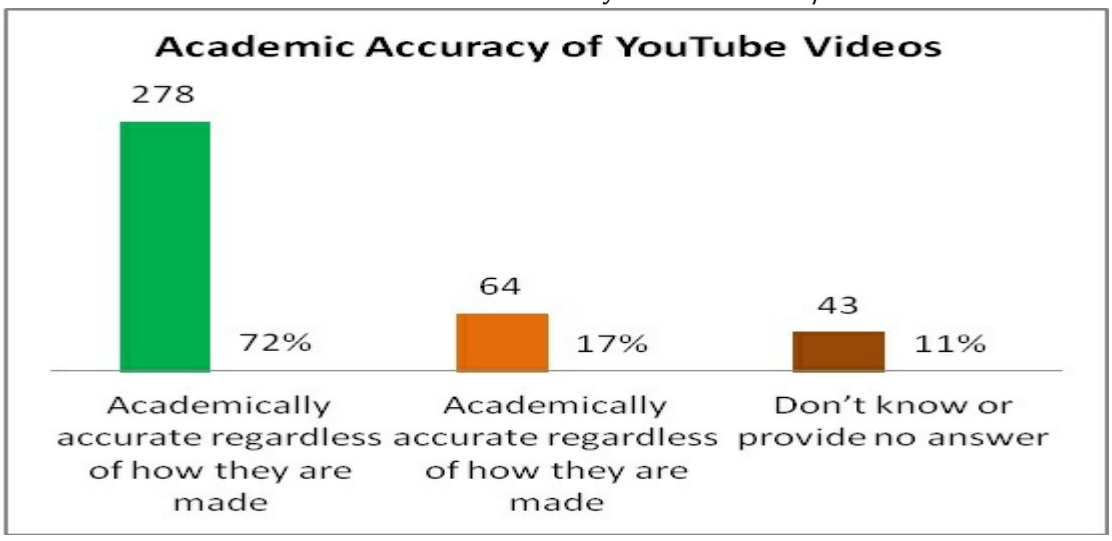

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Table 4: Question 4 (N=385)
Number of YouTube Videos That Were Academically Professional and/or Accurate

Number of YouTube Videos That Were Academically Professional and/or Accurate (n=385)					
Student Responses		#	%	#	%
A	Professional with academic accuracy	109	28%	278	72%
B	Amateurish, but with academic accuracy	169	44%		
C	Professional, but without academic accuracy	20	5%	64	17%
D	Amateurish without academic accuracy	44	11%		
E	Don't know	9	2%	43	11%
F	No answer	34	9%		
Total		385	100%	385	100%

Question 5: The YouTube videos helped me in …. (Check all that apply)

As shown in Figure 5 and Table 5, the academic usefulness of YouTube videos was found to be helpful 394 out of 492 times (or 80% of the time). Specifically, students mentioned the academic usefulness of YouTube videos 35 times (7%) in *developing critical thinking skills*, 129 times (26%) in *clarifying misconceptions and promoting understanding*, 127 times (26%) in *reinforcing their understanding of a given concept*, and 103 times (21%) in *seeing the relationship between concepts, principles, and applications in real life situations*. While *lack of academic usefulness* was mentioned only 55 times out of 492 (11%), there still were 43 students that provided *no answer* to this question at all.

Of those who participated in the oral in-depth-discussion, *only 5 students (14%) indicated that videos were not helpful*. However, *3 of these students explained that because they didn't have the time to search for good videos, they did not want to suggest that good ones were not out there*.

Figure 5: Question 5 (N=492)
The Academic Usefulness of YouTube Videos to Students

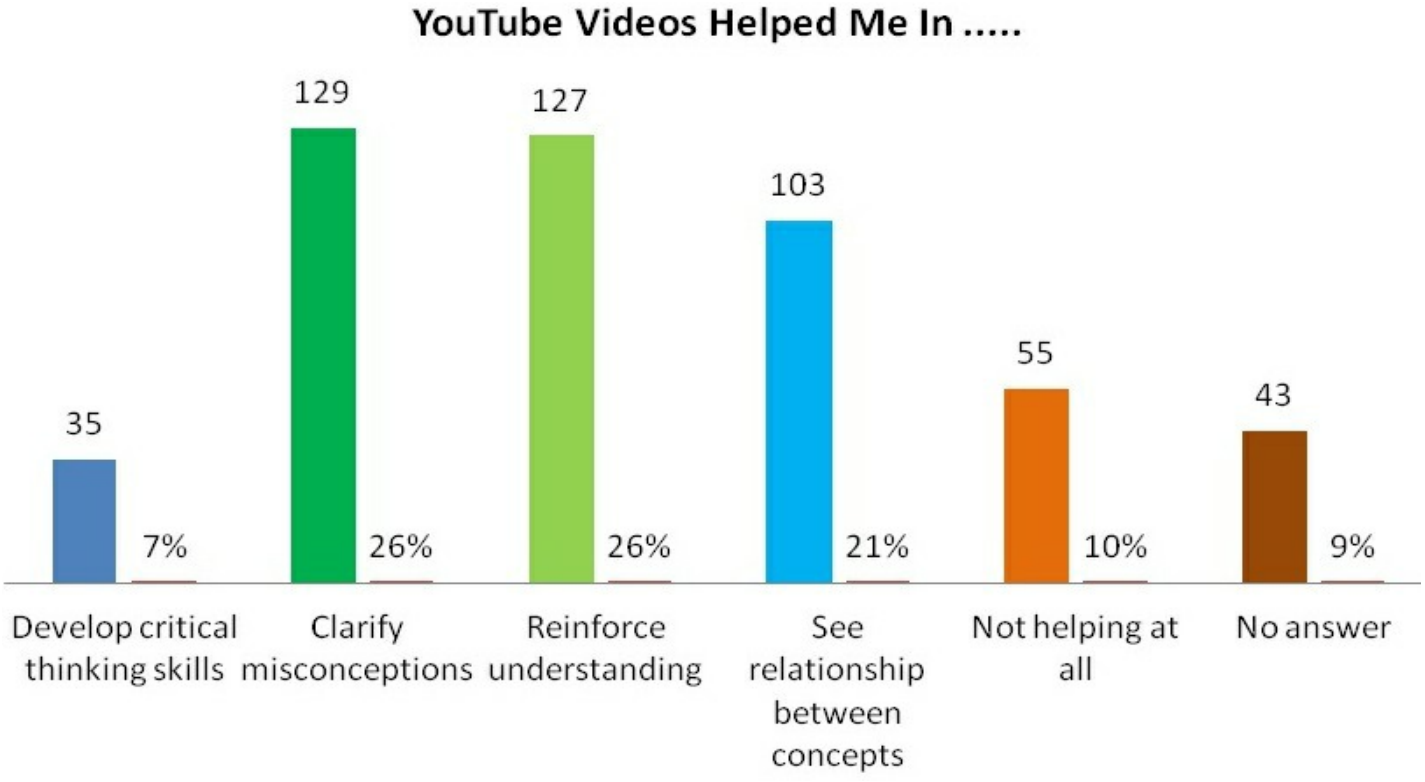

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Table 5: Question 5 (N=492)
The Academic Usefulness of YouTube Videos to Students

Academic Usefulness of YouTube Videos					
YouTube Videos Helped Me:		#	%	#	%
A	Develop critical thinking skills	35	7%	394	80%
B	Clarify misconceptions and strengthen understanding	129	26%		
C	Reinforce my understanding of a given concept	127	26%		
D	See the relationship between concepts, principles, and applications in real life situations.	103	21%		
E	Not helping at all.	55	11%	98	20%
F	No answer	43	9%		
Total		492	100%	492	100%

Question 6: Using a YouTube video helped me to: (Check all that apply)

Figure 6 and Table 6 summarizes additional purposes for using YouTube videos as seen by the participants. While only 2 % of surveyed students provided no answer to this question, 98% of the participants indicated that their use of YouTube videos was for *specific educational purposes* (a total of 535 out of 547 times mentioned). Specifically, students mentioned the videos helped them *establishing their baseline knowledge of the topic* 169 times (31%), *accurately assessed what they already knew or didn't know* 134 times (25%), *boosted their engagement in lectures and classroom learning* 99 times (18%), *illuminated their mastery of the content* 71 times (13%), and *simplified the concept to allow better understanding* 62 times (11%).

Almost all who participated in the oral in-depth discussion acknowledged that YouTube videos helped them academically, especially in *establishing their baseline knowledge of the topic*, and in *simplifying the concept to help understand it better*.

Figure 6: Question 6 (N=547)
How YouTube Videos Helped Students Academically

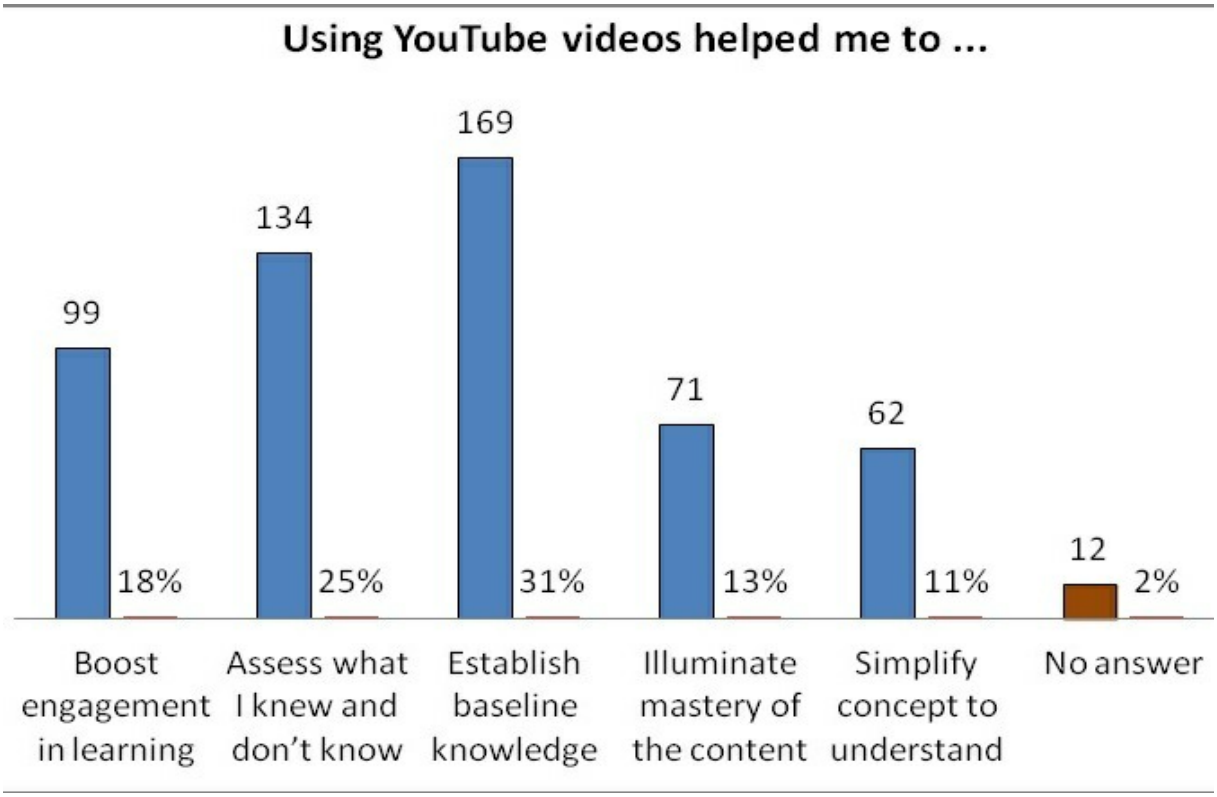

Table 6: Question 6 (N=547)
How YouTube Videos Helped Students Academically

Using YouTube videos helped me to:		#	%	#	%
A	Boost my engagement in lecture and classroom learning	99	18%	535	98%
B	Accurately assess what I already knew and didn't know	134	25%		
C	Establish my baseline knowledge in the topic	169	31%		
D	Illuminate my mastery of the content	71	13%		
E	Simplify the concept to understand it better	62	11%	12	2%
F	No answer	12	2%		
Total		547	100%	547	100%

Question 7: Have you ever created your own YouTube educational video? (N=385)

As shown in Table 7, while 32 participants (8%) *had created and posted* their own educational YouTube videos, the majority (338 or 88%) of the participants had *never* done so. Fifteen participants (4%) provided *no answer* to this question. Only two of the participants in the oral in-depth discussion acknowledged creating and loading videos on YouTube, but they were not in the sciences.

Table 7: Question 7(N=385)
Students Who Created Their Own YouTube Videos

Students Who Created Their Own YouTube Videos				
	Yes	No	*No Answer*	Total
#	32	338	15	385
%	8%	88%	4%	100%

Question 8: Have you ever encountered a YouTube educational video that you liked so much you shared it with your classmate(s)?

As shown in Table 8, while about 224 participants (58%) indicated that t*hey did share YouTube videos* with classmates, a significant number (161 or 42%) indicated that they had either never done so, or provided *no answer* to the question. Only 5 (14%) of the oral discussion participants acknowledged they had shared YouTube videos with classmates. Two of the 5 were the same who reported creating and loading videos on YouTube.

Table 8: (Question 8) (N=385)
Students Who Shared YouTube Educational Videos With Their Classmates

Students Who Shared YouTube Educational Videos With Their Classmates						Total
All the time	Many Times	Sometimes	A Few Times	Never	No Answer	
10	44	92	78	143	18	385
3%	11%	24%	20.0%	37%	5%	100%
	136 - 35%			161 - 42%		

Question 9: Do you consider yourself a visual, auditory, or tactile learner?

As shown in Table 9 and Figure 7, when participants were asked about their preferred learning style, 3% (12 students) provided no answers and 27% (103 students), indicated that they were learners who used all three types of cues-visual, tactile, and auditory. However, while 26% of the participants (or 93 students) claimed they were visual/tactile learners, 22% (or 83) of the students indicated they were purely visual learners and 13% (or 50) of them indicated they were tactile (kinesthetic) learners.

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Figure 7: Question 9 (N=385)
Preferred Learning Style of Surveyed Students (Visual, Auditory, and Tactile Learners)

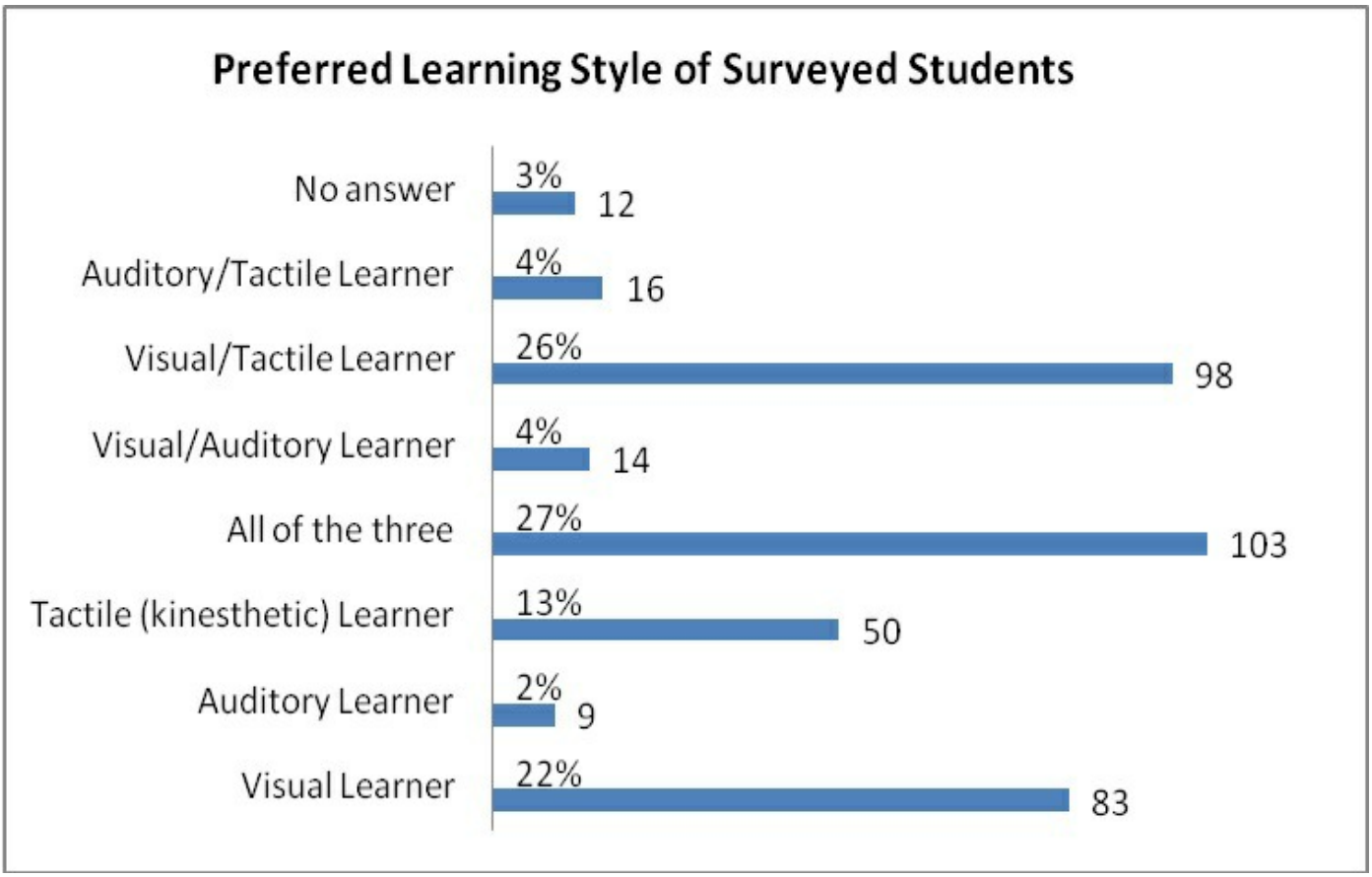

Table 9: Question 9 (N=385)
Preferred Learning Style of Surveyed Students (Visual, Auditory, and Tactile Learners - *Check all that apply*)

Preferred Learning Style of Surveyed Students (Visual, Auditory, and Tactile Learners)			
	Preferred Learning Style of Surveyed Students (Check all that apply)	#	%
	Visual Learner; learn best by seeing	83	22%
	Auditory Learner; learn best by hearing	9	2%
	Tactile (kinesthetic) Learner; learn best by doing	50	13%
	All of the above	103	27%
	Visual/Auditory Learner	14	4%
	Visual/Tactile Learner	98	26%
	Auditory/Tactile Learner	16	4.0%
	No answer	12	3%
	Total	385	100%

Question 10: Provide examples of those topics in chemistry, and/or biology, that you have often searched for YouTube Videos to help you learn.

As shown in Table 10, when students were asked to provided examples of those topics in which they often go on their own to search for YouTube Videos in the area of chemistry, students mentioned *redox reactions* and *chemical balance* 203 times, *atomic structure* 179 times, *orbital structure and bonding* 170 times, and *chemical bonds* 165 times. In the area of biology, students mentioned *replication - translation - transcription* 213 times, *meiosis (MI and MII)* 191 times, *molecular and microbial genetics* 182 times, *membrane potentials* 179 times, *enzymes and regulation* 170 times, and *metabolism*, especially *microbial metabolism*, 112 times, and *electron transport in cellular respiration* 98 times.

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Table 10: Question 10 (N=385)
Examples of topics in chemistry and/or biology surveyed students have often searched for on YouTube Videos

Examples of these topics in chemistry and or biology that surveyed students have often searched for on YouTube Videos			
Chemistry Topic	**Times mentioned**	**Biology Topic**	**Times mentioned**
Calculation based problem solving	51	Metabolism, especially microbial metabolism	102
Stoichiometry	57	Enzymes and regulation	160
Orbital structure and bonding	160	Biomass pyramids	27
Biochemistry basics	59	Global warming	16
Redox reactions and chemical balance	193	Difference between gas (natural) and gasoline (gas for the car!)	12
Organic chemistry in general	85	Fluid and Electrolyte Balance	76
Atomic structure	169	Statistics when working percentage growth rates	25
How to think step-by-step through chemical equation	38	Molecular and Microbial Genetics	172
Chemical bonds	165	Meiosis (MI and MII)	181
Nuclear Chemistry	25	Replication - translation - transcription	203
Chemistry involved with antioxidants	68	Membrane potentials - including channels cotransporters (symporters and antiporters), diffusion, facilitated transport, etc.	169
		Electron transport in cellular respiration	98

When the students were asked about devices and gateways they often use to access information for educational purposes, they mentioned Google©, Wikipedia©, Online Database©, Ask©, Internet search engines, Khan Academy©, Blogs, Science TV shows, Science Video games, Video Tutorials, History Channel©, Music Channel, Science Channel©, digital or Web magazines and journals, e-books, digital Encyclopedias, Tod.com/Ted.com©, Quiz list©, School Websites, Research Gate©, Academia.edu©, Crash Course© - YouTube,, and EDU©-YouTube. Khan Academy©, which was mentioned most often, is a website with a collection of thousands of videos explaining simple math, science, finance, and other areas that can be construed as difficult to comprehend. The tutorials were developed by an MIT-trained electrical engineering graduate and can be found at: http://www.khanacademy.org/. Those who participated in the oral in-depth discussion was almost equally divided on the use of Google© and Wikipedia© as resources for education, though acknowledging the use of YouTube videos in one way or another. In addition, 17 mentioned Khan Academy©, and ten of these 17 became aware of Khan Academy© and its academic usefulness when they were in high school through student advisors and school tutoring centers.

Interpreting the Results:

Since YouTube is a video-sharing Website that can only be accessed through the Internet, knowing how often the participants used the Internet was essential to any objective inferences from the results of this study. A total of 70% of participants used the Internet on a daily basis, and 24% used it most of the time or some of the time.

While 24 % either provided no answers or only rarely used it, an important point here is that *none of the participants reported that they* never used the Internet. This means that more than 90% of the participants had the opportunity, and the access to, a YouTube video for educational purposes, if they chose to, or were asked to do so by their instructors. In this same vein, one could suggest that this percentage of participants should be ignored in the data findings holistically (or more specifically, in Questions #2 thru #8), but this would be a limiting factor, that discounts something of importance. Crucial here, is that when one is looking at *validity* of the argument and/or question at hand, all data points need to be included, even when one is analyzing whether the results are measuring/suggesting what they ought to be looking for; for example, in numerous scientific realms, it is the outliers that 'say a lot,' sometimes as much as the expected general points of the curve. Who is to say, that the values here note a need to design a 'better' study to look at these particular findings more so in the future?

Furthermore, since 86% of the participants had been in college for two or more years, we can also infer that most had the academic experience to determine for themselves whether they needed extra help in understanding the concepts they were learning.

The study also indicated that YouTube videos that have educational value are available all around us in every subject we can think of, if students and faculty purposely search for them (see appendix 1). This was clear from the fact that 56% of the participants indicated they often found YouTube videos related to what they wanted to learn in biology and/or chemistry. We can also conclude that since over 75% of participants actively searched for YouTube videos, they recognized YouTube's educational value in helping them learn challenging and complex concepts in biology and chemistry.

From Questions 1 and 2, and Tables 1 and 2, we can conclude that the majority of participants used the Internet and most of this majority went to the Internet to purposely search for related YouTube videos to help them in their courses. In addition, over 60% of respondents found these videos helpful in learning challenging and complex - either all the time, most of the time, or some of the time (Question 3, Table 3).

The study also shows that regardless of whether the YouTube videos were made professionally or by amateurs, the videos were found to be academically accurate and helpful by 72% of respondents. This is another indication of why the majority of the participants continue to search the Internet for YouTube videos to help them in their studies (Question 4, Table 4).

When we asked for specific ways in which the videos helped students educationally, we received encouraging responses (Question 5, Table 5). Some form of specific usefulness was identified by 80% of the students. Clarifying misconceptions and misunderstandings was mentioned 129 times (26%), reinforcing the understanding of a given concept was acknowledged 127 times (26%), seeing the relationship between concepts, principles, and applications in real life situations was indicated 103 times (21%), and developing critical thinking skills was identified 35 times (7%). From these data, we can surmise that YouTube videos not only provide knowledge, but can also help develop important learning skills.

The surveyed participants also recognized other important advantages gained by using YouTube videos (table 6). For example, students said the videos helped establish their baseline knowledge of the topic (31% of responses), accurately assessed what they already knew or didn't know (25%), boosted their engagement in lectures and classroom learning (18%), illuminated their mastery of the content (13%), and simplified concepts to strengthen understanding (11%). Thus, by looking at students' responses to question number 5 (Table 5), and question number 6 (Table 6), we can conclude that students who participated in this study perceived YouTube videos as useful in specific ways, and particularly helpful for learning the subject matter, assessing what they know, gaining important learning skills, and enhancing their personal methods of learning. All these can be recognized as essential ingredient in student's academic performance and success.

While Internet access is essential for educational purposes, there are differences among the various online gateways and devices. (See list under Question 10 above.) Khan Academy©, which was mentioned most frequently, is a website with thousands of videos explaining simple math, science, finance, and other areas.

While most participants had used YouTube videos for educational purposes, only 8% had actually created and posted educational videos on the Internet (Question 7, Table 7), which means they were YouTube registered users (create, load, and view videos). The study also shows that more than half (59%) of the participants had shared their favorite videos with classmates (Question 8, Table 8). This could be another indication that many students trust the educational value of YouTube videos to the point that they share them with classmates.

Since sight and hearing are the two ways through which students can learn from the YouTube videos, how students learn was another topic of the study. The majority of respondents said they learn best if the activity involves seeing. That is, 26% indicated that they were both visual and tactile learners, and 27% indicated that they were visual, auditory, and tactile learners. This could help explain why the majority of students in this study purposely search for and use YouTube videos to help them understand the subject. For them, the videos provide an opportunity to learn by both seeing and hearing, more so than by doing.

Furthermore, the surveyed students knew which chemistry and biology concepts they would need help with, so as to learn and understand the concept at hand. Though many concepts were mentioned, a certain few kept being mentioned as possibly being problematic. For example, in the area of chemistry, redox reactions, chemical balancing, atomic structure, orbital structure and effects in bonding, replication - transcription - translation, and chemical bond types were mentioned the most. In the area of biology, Meiosis (MI and MII), molecular genetics, membrane potentials, enzymes and regulation, and metabolism, especially microbial metabolism, and electron transport in cellular respiration were mentioned the most.

Discussion and Conclusions

To further probe the results of the study, we held in-depth focused discussions with 37 students involved in the written survey. The majority of these students were from the four-year college level. The following is extracted from those interviews, as well as from what some of the participants wrote on the survey:

1. The participants appreciated the fact that they could look at an entire YouTube video repeatedly, and could also view parts they couldn't understand. In addition, they appreciated the fact that after watching the video, they were automatically referred to related videos that might be relevant to the subject. In this way, they might arrive at the particular video that was the most useful to their research.
2. Many of the participants wondered why instructors, curriculum designers, and other educators, had been slow in integrating YouTube videos as additional educational

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tools and resources for teaching and learning. Over 65% of those we talked to, thought it would helpful if instructors searched for videos that were relevant, and what is more, integrated them into the course. About 30% of the students thought it was their own responsibility if they felt the need for help in understanding the study topic.

3. The students that thought it pertinent for instructors to look for useful videos, also felt that teachers should use YouTube videos to motivate students about accountability and preparation; their thoughts are, that by viewing and reviewing videos before coming to classes, they would be more prepared to succeed in the classroom. This could be looked at as reading certain materials (such as a chapter in a book, or an article), before the day of class.
4. A few also suggested using YouTube videos as assessment tools. For example, after finishing a class lecture, show a video and then ask students to identify what they think was not covered or mentioned in that day's lecture and open the discussion by why this is important or not important in understanding the learned concepts. Finally, four students who are both full-time students and members of the workforce, told us that because they work they don't have the time to search the Internet for related videos. They preferred that the instructors provide these as either part of the course, or as supplementary instructional materials with specific instructions on accessing and in using them as part of the class instructional materials.
5. The discussions pointed to the fact that instructors and curriculum developers are not as aware as students of the relevancy and usefulness of these YouTube videos for achieving the learning objectives. If instructors expended the time and energy finding relevant and useful videos for their students, perhaps students would come to class more prepared for engaged learning.
6. While most of the students indicated that YouTube videos were relevant and available in their areas of study, many indicated that this also depended on:

    a. Whether the instructor had explained the topic in a way that all students understood, and thus had no need for seeking additional help for learning challenging and complex concepts.
    b. The discipline and the particular course. Students thought that science courses, by nature, have more challenging concepts with complex conceptual topics that need to be figured out and revealed before they can be understood. They thought that other subjects were less complex by nature, and thus could be understood by clear explanations without the use of animations, videos, and other visual/auditory educational means.
7. Students also explained they were attracted to YouTube Videos because:

    a. They engage the modes of visual and auditory learning which students are accustomed to and appreciate.
    b. They are short, often focused, precise, and thus can be viewed repeatedly.
    c. They meet all types of students' preferences, such as cartoon or realistic styles, three-dimensional styles, professional, amateurish, and so forth.
    d. They include all of the various learning styles of students, including visual, auditory, and tactile.
    e. They help them visualize what they read in their textbook. During exams, they often remember everything they saw in the videos, like watching a movie on the screen.
8. In complex and complicated concepts with multiple elements involved, such as meiosis, replication of DNA, Krebs cycle, electron transport in cellular respiration, etc., students suggested that they would like to see the overall picture first, with all the elements involved already connected. Then they would prefer to see each element explained separately, to see how each led to the next. This way, they could see the whole 'forest' first, and then understand how each element contributed to the creation and the sustainability of the whole. Approaches such as this can easily be done through animations in YouTube videos.

As Christy Price, a psychologist at Dalton State College states, today's students have a different mind-set about education and how can be achieved but that doesn't mean they are lazy, don't care, and or don't want to learn. Today's students just go about it differently (Price 2013). Today's students want us to communicate with them with languages they understand, tools they have been using, and technology with which they are familiar (Cherif, Movahedzadeh, Adams, and Dunning 2013). In other words, modern leaner's want us to create a dynamic learning environment driven primarily by the needs and the interests of the students via adopting a technology-driven education that focuses on quality and life-long learning.

This study indicates that the majority of surveyed students in two- and four-year colleges purposely searched the Web to find YouTube videos to help them in their biology and chemistry courses. This should not be surprising, as YouTube is one of the most used social media sites. But what is significant, is the finding that YouTube videos are useful educational tools for many students, especially as integrated into biology and chemistry courses. A notable source of this kind is the Khan Academy©. With a library of over 3000 videos covering everything from arithmetic to biology and from organic chemistry to computer science, Khan Academy© seeks to help students learn what they want, when they want, and at their own pace.

Today's students have grown up with computers since pre-school. Thus, utilizing teaching methods that leverage students' experiences will most likely generate enthusiasm for active involvement in the learning process (Cherif 2010). Furthermore, as educators we should all agree that capitalizing on students' existing knowledge base should make teaching more effective, and learning more meaningful. Integrating the use of YouTube videos in planning curriculum, in selecting and teaching the materials, and in assessing student learning, can help increase student satisfaction, performance, and persistence (Barseghian 2011).

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Therefore, we would like to offer a possible suggestion for educators. We believe that the use of YouTube videos can be an important part of effective curriculum development, teaching strategies, and learning materials and resources, and thus should be allowed in the curricular dialogue of today. Well planned integration of YouTube videos in our courses, can help free students' imaginations and get them engaged, inspired, and motivated to learn and to succeed. Furthermore, by providing videos and using video-teaching pedagogy as part of instruction, faculty will have more time to spend on creating a dynamic and engaging learning environment that help instructors to gradually transition from being the sage-on-the stage model delivery to learner-focused teaching pedagogy.

And again, knowing that YouTube is not a new, novel vehicle to deliver information, we nevertheless think it is an interesting 'tool' to capitalize upon, as it can be utilized in the teaching and learning dynamic. In addition, it is a unique component of the new 'Age of Media' that surfaced with the beginning of the Internet--- in our eyes, a seemingly untouched medium and resource, which specifically targets the multimodal, iconistic visual student learner.

As with any new, fresh approach in the educational arena, many possible critical, and not-so-critical, nuances need to be looked at and viewed. Without discounting any data provided here within the constraints and limitations of this particular study, we guarantee and offer opportunities for others in the educational realm to look further. Without this initial look, a possibility for greater clarity offered by further studies may be possibly overlooked. It is safe to say, that the research question must first be formed, even if it is not to the ideal standard of our educational times. But nevertheless, to look at changes in educational pedagogy, situated in possible paradigm shifts, one should not expect 'neat' or 'tidy,' results and analyses. This is the grand work of the field of education. The only constant is change.

Acknowledgements

We would like to thank the students who participated in this study and provided us with their own perspectives. We would also like to acknowledge the help of the reviewers for their valuable suggestions and recommendations that made this paper more effective. We would also like to thank and acknowledge all those colleagues at the high school and college levels who read the paper and provided us with valuable feedback. Lastly, we would like to acknowledge the help of Dr. Maris Roze. With his keen editing eye, he undoubtedly improved this paper more than we could have done without his support.

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Appendix 1

Examples of YouTube Video Resources

EduDemic: The 100 Best Video Sites For Educators http://www.edudemic.com/2012/08/best-video-sites-for-teachers/	
"Bringing multimedia into the classroom is a great way to engage students in learning. Supplementing lessons, opening up new interests, and offering inspiration, online videos make for an incredible teaching tool" (EduDemic 2013)	
• **Educational Video Collections** • **General Video Collections** • **Teacher Education** • **Lesson Planning** • **Science, Math, and Technology** • **History, Arts, and Social Sciences**	• **History, Arts, and Social Sciences** • **Video Tools** • **Network and Program Videos** • **Free Movies and Clips** • **How-Tos** • **Government and Organizations**

EduDemic: The 100 Best Video Sites For Educators http://www.edudemic.com/2012/08/best-video-sites-for-teachers/		
Under Science, Math, and Technology best video sites there are:		
• **Green Energy TV** • **BioInteractive** • **ARKive** • **MathTV** • **PopTech**	• **PsychCentral:** • **SciVee** • **ATETV:** • **The Vega Science Trust**	• **The Science Network** • **How Stuff WorksScience Stage** • **Exploratorium TV:** • **The Futures Channel** • **All Things Science:**

TeachThought 2012: 50 Awesome Chemistry Videos For The Busy Science Teacher http://www.teachthought.com/learning/50-awesome-chemistry-videos-for-blended-or-flipped-classrooms/		
"50 Awesome Chemistry Videos For The Busy Science Teacher; Some are funny, some impressive, but all will showcase the true awesomeness of chemistry."		
• **Amazing Reactions and Experiments** • **Lectures**	• **Courses** • **Miscellaneous**	• **Fun with Chemistry**

TeachThought 2012 : The Official Educator's Guide To YouTube http://www.teachthought.com/technology/youtube-guide/	
It is not only helpful but is also essential to achieving desirable outcomes	
• **Educational Principles for YouTube.** • **Producing Educational Videos.** • **Tent-pole Programming** • **Curricula on YouTube**	• **Video Optimization** • **Teaching Through Interaction** • **Further Reading and Resources**

TeachThought 2012 http://www.teachthought.com/technology/how-to-youtube-your-classroom/		
10 Characteristics of a "YouTube'd" Classroom With Specific Possibilities for Teachers:		
1. **Passive Consumption** 2. **Active Selection** 3. **Assisted Discovery** 4. **Interdependence**	5. **Diversity** 6. **Brevity** 7. **Selective Social Interaction**	8. **Non-traditional** 9. **Humor** 10. **Cultural Hyperbole**