Strategies for Flipped Classroom Video Development: Educating Generation Z Engineering Students

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Abstract

The ever-growing presence of technology is changing not only the way we communicate, work, and entertain ourselves but also the attention span given to individual tasks. Due to the rapid integration of technology, even those who grew up without a cell phone now find themselves "multi-screening". This is particularly concerning for the digital-native students who are now in college and have different needs in the classroom than previous generations. Known as, Generation Z or Gen-Z, students born between 1996 and 2010 are the majority of engineering students today. As they disrupt traditional college lecturing practices, educators are researching new pedagogies to best fit these students. One of these methods is "flipped" classrooms. This instructional method moves learning to video lectures for at-home, self-paced learning, whereas class time is reserved for activities or practice of the material. The content of a software-based undergraduate simulation course was converted to a flipped classroom environment for half of the course material. The main objective of this research pilot project is to investigate the impact of video length and video activities on the retention and understanding of Gen-Z engineering students for a software-based simulation course. Results show that students are more likely to watch medium-length videos than short-length videos, but those who do watch short-length videos have better learning outcomes.

Keywords

Generation Z, flipped classroom, engineering education, video length

1. Introduction

The engineering students today are from Generation Z, the cohort of individuals born from 1996-2010 [1]. They are high-efficiency multi-taskers with 8-second attention spans, typically splitting their focus across 5 screens (e.g. phone, computer, tablet, etc.) at once [2], as opposed to millennials, the cohort of individuals born from 1981-1995. Millennials have 12-second attention spans and only utilize 3 screens simultaneously. Engineering educators are facing the continuous challenge of keeping these students' attention. Gen-Z is the first generation who are digital natives and are accustomed to having immediate access to information [3]. Since Gen-Z students have easier access to more information than generations in the past, they have learned to quickly filter out information that does not interest or bring value to them [4]. Gen-Z students are also using

technology in different ways than past generations. For example, they watch online videos on social media platforms (e.g., YouTube, Instagram) as a method of learning as well as using it to deal with everyday stressors [5]. In fact, the majority of Gen-Z consider YouTube videos as their #1 source for learning [6]. Because of these differences, traditional styles of teaching no longer providing enough engagement for Generation Z students [7] and many are continuing to convert to "flipped" classrooms [8], [9].

Unlike traditional classroom where students learn information in the classroom, flipped classrooms deliver information via pre-recorded lectures that students watch before coming to class. Pre-recorded lectures allow for a student to complete their learning at their own pace by pausing or rewinding at a part that may be confusing to them [10]. Gen-Z students are attracted to this idea of being in control of the timing, pace, and environment in which they learn [11]. In addition, instead of expecting the students to complete difficult homework outside of the classroom, flipped classrooms allow for active-learning activities (i.e. homework assignments or labs) to occur in the classroom [12]. Flipped classrooms also change the traditional transfer of knowledge from a teacher-student model to a hyper connected model where students learn from teachers in the digital world as well as other students in the classroom [12].

In this paper, we seek to understand how video length effects Gen-Z student engagement and performance in a flipped software-intensive industrial and systems engineering senior-level course. This 3-credit course intends to introduce some basic techniques for modeling and simulating industrial systems in the presence of uncertainty and it is required for students to have access to the defined simulation software in the class. Both semesters (Spring 2019 and Fall 2019) utilized a flipped classroom for the second half of the semester in Industrial Systems Simulation course. The Spring 2019 semester utilized medium-length videos to teach students. Some of these videos also included in-video quizzes to create a more interactive video. In Fall 2019, the videos were shortened but still included the same in-video quizzes. In this paper, we will compare student engagement for chapter 7 from the two semesters to determine if shorter videos motivate increased student engagement and lead to better learning outcomes.

2. Methodology

A flipped classroom teaching strategy was implemented for the second half of the semester during two consecutive semesters (Spring 2019 and Fall 2019). Students were given the same course outline in both semesters including assignments and quizzes with identical weightings for each activity. Topics covered during this period come from four chapters (Chapters 5, 6, 7, and 8) of the course textbook: i) advanced simulation modeling, ii) output analysis of terminating simulations, iii) output analysis of steady-state simulations, and iv) entity transfers. The course material is software-intensive and recent former students have not found the traditional lecture style to be supportive of their learning needs. This software-intensive course is a 3-credit senior-level course required for the Bachelor of Science program in an Industrial and Systems Engineering (ISE) Department. The makeup of all cohorts is majority Generation Z (over 90%), and the makeup of the ISE department is 54% Male and 46% Female [13].

The **Spring 2019** flipped classroom lectures were **medium-length (20-50 minutes)** and the **Fall 2019** videos were re-recorded or split to create **short-length videos (10-12 minutes)** to meet generational differences in the attention spans of Generation Z engineering students. For the specific chapter explored in this work, there were two medium-length videos and nine short-length

videos. We did not explore longer, workshop-style videos of 1.5-2 hours. For the rest of the paper, we will refer to the Spring 2019 semester as the ***medium group*** and the Fall 2019 semester as the ***short group***. The students were asked to watch the videos prior to an in-class lab, which had a follow-on homework assignment due one week later. The final exam was a few weeks after the in-class lab associated with the chapter reviewed here.

The videos required students to log in with a unique user ID, which enabled us to track when students watched the videos. Consequently, we classified students who watched the videos into three cohorts: 1) *Pre-activity* cohort are those students who watched the videos by the assigned due date before any corresponding in-class activities occurred; 2) *Post-activity* cohort are students who watched the videos by the due date of lab and/or homework assignments for the corresponding chapter; 3) *Pre-exam* cohort are students who watched the videos in preparation for the final exam. The software also tracked video coverage, which is the percent of total video length watched. Students had to have >60% video coverage to be classified into one of the three cohorts of students who watched the videos. Finally, we established the 4) *Never* cohort for students who never logged in to view a specific video or who had video coverage <60%.

Assessment measures were collected for the percentage of video coverage; number of students who watched the videos *Pre-activity*, *Post-activity*, and *Pre-exam*; and results from the in-video quizzes. This study will provide evidence on the impact that short-length videos have on learning outcomes based on whether students engage with the videos on-schedule or if they wait until reviewing for the final exam. **Table 1** shows the video lengths for all videos in the study. The instructors worked to make sure the sum of the short-length videos in a given section was similar to the video lengths of the medium-length videos from the semester before. A few time discrepancies exist due to variance in re-recording the lectures. Videos containing a quiz have a Q in the label (e.g. 7.2Q).

Table 1: Number of videos, video length, and defined label for each video chapter (Q next to the videos' label show the non-graded multiple-choice quiz).

Medium Group (53 Students)		**Short Group** (68 Students)	
Label	**Length (mins)**	**Label**	**Length (mins)**
7.1	43:37	7.1a	7:16
		7.1b	6:10
		7.1c	6:31
		7.1d	9:34
		7.1e	11:50
		Total	41:21
7.2Q	38:31	7.2a	5:05
		7.2b	11:56
		7.2c	10:30
		7.2dQ	10:45
		Total	38:16

3. Statistical Analysis

Now we will present statistical analysis to show the impact that short-length videos had on Gen-Z students for one chapter compared to the impact of the medium-length videos. A total of 68 students were enrolled for the short video series group compared to the 53 students in the medium group. We will look at their overall video engagement by comparing the percentage of the number of students who watched and the average video coverage in each group. We will also compare the short video series student quiz results and the number of students in each cohort who took the quiz with those in the medium group.

3.1 Video Engagement

The first part of analyzing video engagement is to determine what percent coverage qualifies students for one of the "watched" cohorts (*Pre-activity*, *Post-activity*, *Pre-exam)*. As seen in **Figure 1**, when students attempt to watch the videos, most of them watch more than 60% of the video. For example, in the 7.2a video, only one student (1.5%) attempted to watch less than 60%. This is a noticeable trend throughout all the videos. For this reason, we consider students who watched more than 60% of the videos the watched cohort (*Pre-activity*, *Post-activity*, *Pre-exam)*.

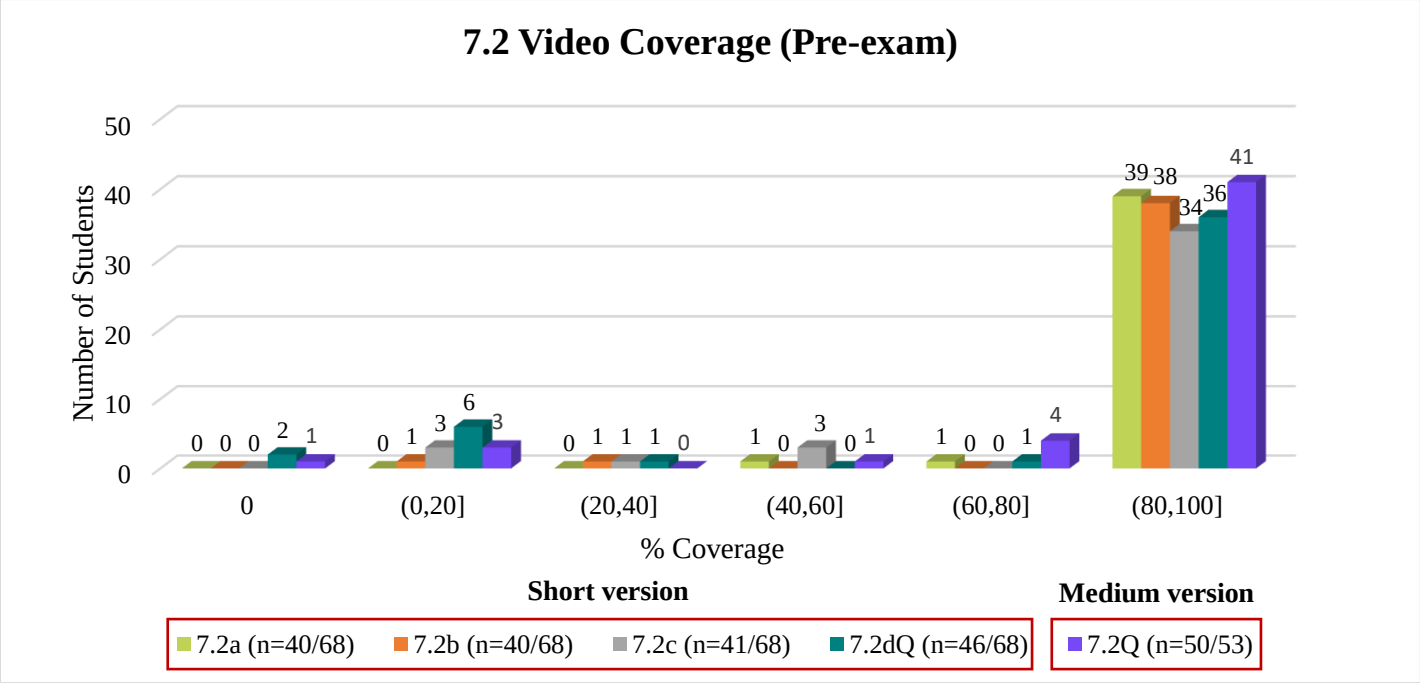

Figure 1: Video series 7.2 *Pre-exam* video coverage for medium and short groups

Before we begin the further analysis, we need to create a fair comparison between the medium- and short-length videos. To do so, we used a weighted average to combine the video coverage from the short-length videos (e.g. Videos 7.2a-7.2d) into a single metric for comparison with the corresponding medium-length video (e.g. 7.2Q). This weighted average is based on video length. Consider a video series $v \in V$ where, V, is the set of video series (e.g. $|V| = 2$ sections: 7.1 and 7.2) and we need to determine the video coverage for the medium group, denoted c_v^m, and the short

group, denoted c_v^s. If a video series v has a_v short-length videos of length $l_{i\in\{1,\dots,a_v\}}$ and there are $j \in \{1,\dots,J^s\}$ students in the short group, and we also know that student j watched video $i \in \{1,\dots,a_v\}$ for l_i^j minutes, then the video coverage (%) for each student $j \in \{1,\dots,J^s\}$ in the short group of video series v is computed by:

***EQ* 1.** $$c_{vj}^s = \frac{\sum_{i=1}^{m} l_i^j}{\sum_{i=1}^{m} l_i} * 100$$

Finally, the average video coverage (%) for the short-length and medium-length videos for video series $v \in V$ is calculated as:

***EQ* 2-3.** $c_v^s = \sum_{j=1}^{J^s} c_{vj}^s$ and $c_v^m = \sum_{j=1}^{J^m} c_{vj}^m$, respectively.

Now that video coverage can be computed, we can place students who watched >60% of the videos into the *Pre-activity*, *Post-activity*, and *Pre-exam* cohorts based on when they achieved this benchmark and classify any remaining students into the *Never* cohort.

Figure 2 compares the percentage of students who watched chapter 7 videos. Most surprising was that a smaller percentage of students watched the short-length videos compared to the medium-length videos. In video series 7.2, 49% of students never watched the short-length video compared to only 15% never watching the medium-length videos. Even among the cohorts of students who did watch the videos, an average of 23% fewer students watched the short-length videos than the 7.1 one-medium-length video. Similarly, there was an average of 22% fewer students who watched the short-length videos compared to the medium-length 7.2Q videos. This indicates that students are more likely to engage with the medium-length videos than they did with the short-length videos.

A few other trends are apparent in **Figure 2.** For example**,** an increasing number of students watch the videos as the semester progresses. In the short-length *Pre-activity* cohort for video 7.2Q, there were only 24% of students who watched the videos, but this increased to 31% for *Post-activity*, and 51% for *Pre-exam*. This trend is consistent, independent of the video length and video series. Finally, we also see that video series 7.1 had slightly high engagement levels (e.g. 89% and 60% for the *Pre-exam* cohort) than the 7.2Q video series (e.g. 85% and 51% for the *Pre-exam* cohort), but this could be based on the section topics.

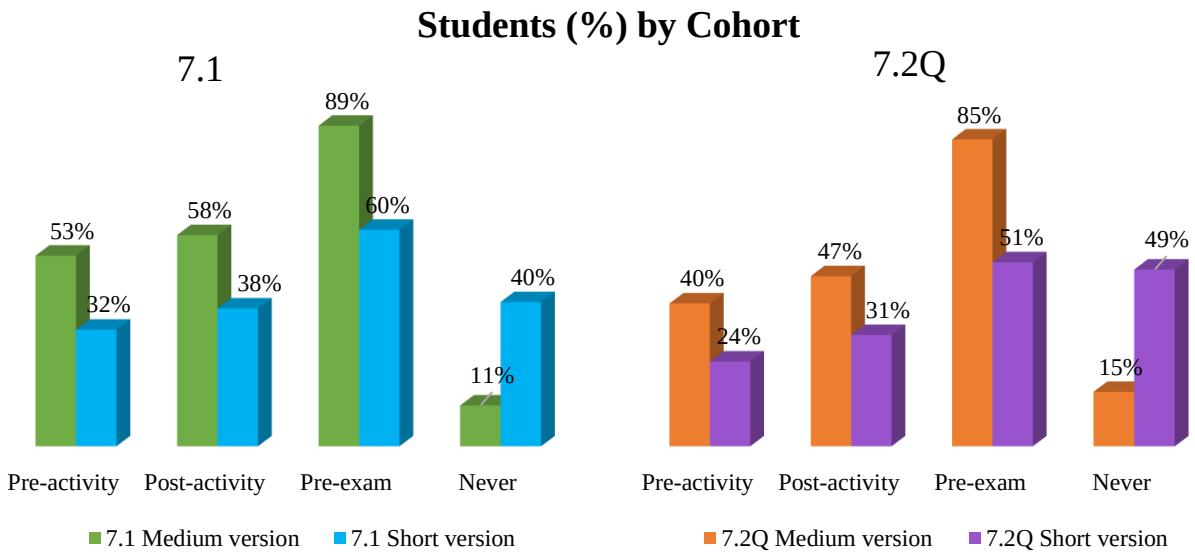

Figure 2: Percentage of students who watched videos by cohort (*Pre-activity*, *Post-activity*, *Pre-exam*, and *Never*)

We now analyze video coverage and see in **Figure 3** that the students who did watch the videos in the medium group had better video coverage than the students in the short group. For example, the *Post-activity* cohort of students had larger video coverage by 4% in video 7.1. This shows that more students engage with the medium-length videos, also they have higher levels of video engagement than the short group.

Figure 3 also shows that regardless of when the students in both groups watched the videos, they watched nearly the same percentage. For the medium-length videos, there was an average of 2.5% increase in video coverage from the *Pre-activity* cohort of students to the *Pre-exam* cohort of students. In comparison, in the short group, there was only a 1% increase in video coverage for the same two cohorts. Intuitively this means that fewer students are watching the shorter videos and engaging less in the semester.

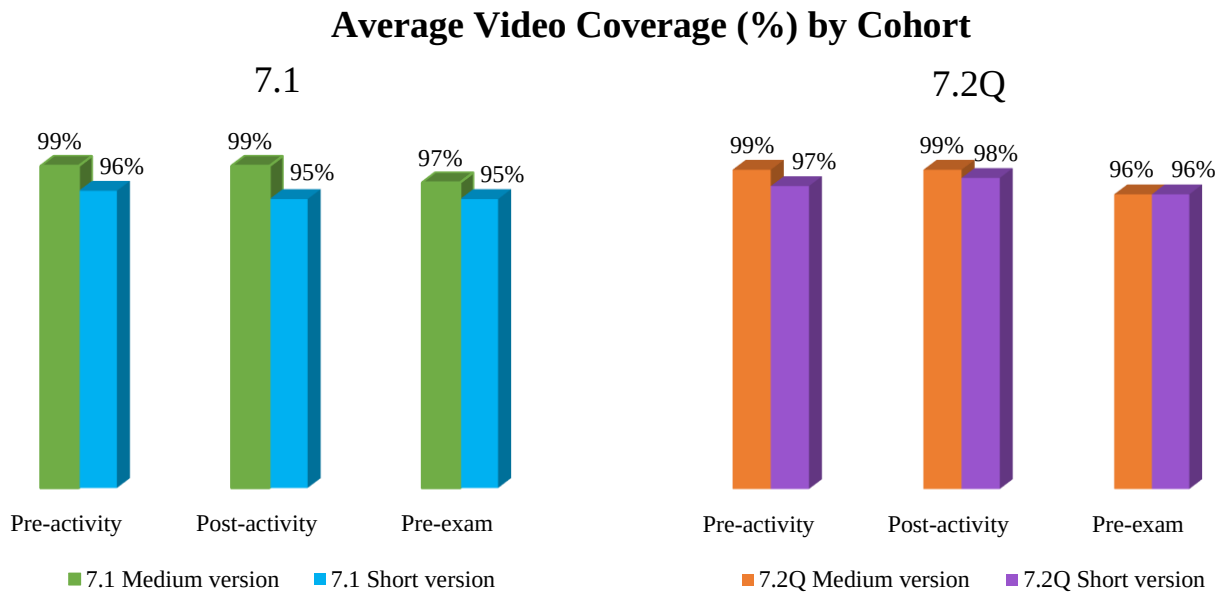

Figure 3: Percentage of the video coverage by cohort (*Pre-activity*, *Post-activity*, and *Pre-exam*)

3.2 Learning Outcome

To help determine whether long or short-length videos were more effective, we also measured students' performance on in-video quizzes throughout the semester. The same quiz was given to both groups. We continued using **EQ 1** to determine which cohort students qualified for, and the cohort sizes were adjusted to reflect the earliest time period in which students watched the videos. In other words, now students only appear in one cohort. **Figure 4** shows the percentage of students who took the video quiz in parenthesis for each cohort and the average percent scored for each cohort on the x-axis. For the short group, the video quiz was at the end of 7.2d, but it had information from all 7.2 videos. As seen in **Figure 4**, students had better learning outcomes with

shorter videos at the time of the activity (*Pre-activity*, *Post-activity* cohorts), but medium-length videos had better learning outcomes at the time of the final exam (*Pre-exam* cohort). The *Pre-activity* cohort for the short group had fewer people in it; however, they scored 8% higher than those students in the *Pre-activity* cohort in the medium group. The *Post-activity* cohort for both semesters had the same percentage of students in it, while students in the short group scored 35% higher than the medium group. There were more students in the *Never* cohort, yet they scored 26% percent higher on the in-video quiz.

Unlike the other three cohorts, the *Pre-exam* cohort from the short group scored, on average, 34% lower than those students in the medium group. Overall, the average for the medium group was 57% and the average for the short group was 66%. This shows us that typically, fewer students in the short group are watching the videos and taking the quizzes, regardless of what cohort they are in, however, when they are taking the quizzes, the short group performs better on the in-video quizzes.

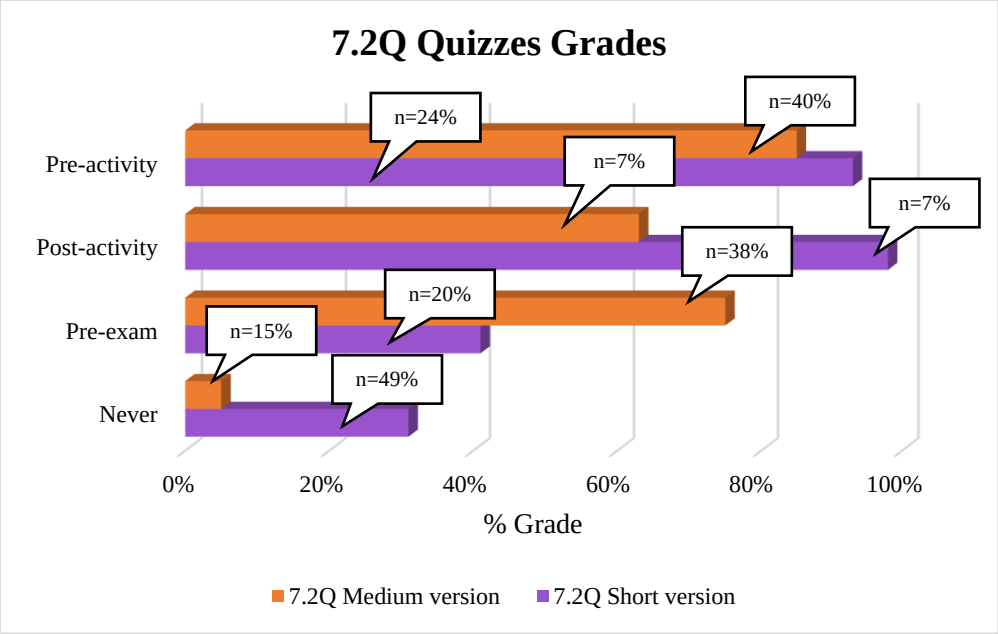

Figure 4: Percentage of average quiz grades from 7.2Q by cohort (*Pre-activity*, *Post-activity*, *Pre-exam*, and *Never*)
*n on the bars show the % of students in each cohort.

4. Conclusion

The medium-length videos (20-50 minutes) for the flipped classroom of an industrial engineering simulation course were converted to 4-5 short-length videos (10-12 minutes) in order to study the effects video length has on student video engagement and student performance. The goal of this research project was to investigate how Generation Z engineering students respond to shorter video lengths by looking at their overall video engagement and grades. The statistical analysis reveals that fewer students watch short-length videos than medium-length videos. On average, 31.5% more students never watched the shorter videos compared to the medium-length videos. Moreover, those that did watch the medium-length videos had high video coverage (2% higher on average).

In-video quizzes also reveal that fewer students took the quizzes in the short group compared to those in the medium group. However, when they did take the quizzes, they performed better than the medium group of students. Future work will expand this pilot study to multiple chapters to see if the same trends remain. Additionally, we will allow students to select which group they want to be in by running the analysis in the same semester. Finally, we want to explore more active-learning content to observe how it will affect overall performance and video engagement.

There are some limitations which the authors recognize to be present in this work. The most obvious is students sharing outside of the classroom. For example, if students chose to watch the videos together the video data would only register the student logged in as participating. There is also the possibility that groups of students took the in-video quizzes together. In future studies, the authors are using anonymous survey data to attempt to account for these limitations. As mentioned earlier the researchers are providing students with the option for which video platform, they choose to engage. Survey data from pre and post semester will be compared to the performance of the students for an indication of their preferences. The authors also recognize that when students are presented with the videos in a specific section, they are shown links with times and short descriptions of the videos. For the medium group, there was a maximum of four links shown, in comparison to the short group where there were sometimes 6 videos in one video series and up to 16 videos for one chapter. Seeing the initial number of videos to watch could have hindered students from attempting to watch at all viewing it as too much time to invest.

The most surprising data is that fewer students watched the shorter videos when research so clearly points to the preference of students for short videos. However, what these results indicate is that it may not be the video length itself that discourages students from participating but rather a combination of factors such as presentation of the video material, number of videos presented, and student preference. This research will continue to investigate each of these factors in further studies.

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