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Video Feedback: A Method for Effective, Inclusive Feedback on CAD Models

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Abstract

This paper explores the effectiveness of video feedback (VF) for solid models (CAD). Traditional feedback methods, primarily written, are often inadequate for non-written artifacts like presentations, videos, and CAD models due to their lack of precision and specificity. VF involves recording audio and video of an instructor giving feedback on student artifacts, including directly manipulating the artifact. The study compares traditional written feedback with VF across multiple sessions of a Solid Modeling class for biomedical engineering students. One session used traditional feedback (9 students), while three sessions used VF (35 students). Students completed seven assignments and received feedback on their submissions. The traditional group received written comments, while the VF group received videos of the instructor manipulating their files with commentary. The data suggest that VF is at least as effective as traditional feedback and may positively impact student skill acquisition. Utilization data shows that 83% of videos were viewed at least once. The mean video length per student per assignment was approximately 7.5 minutes, indicating that VF is reasonable for moderately sized classes. Student feedback was overwhelmingly positive, highlighting the personalized and accessible nature of VF and its role in improving motivation and identifying errors.

Introduction

Effective feedback is consistently recognized as essential to student learning [1][2][3]. The effectiveness of feedback is a function of manner and mode [4]. Though the manner -- content, tone, and approach – is critical to all feedback, here we focus on the mode of delivery. The majority feedback in engineering education is written[5]. Specifically, we define four types of written feedback:

1. Scored work: A numeric value is assigned to indicate the quality of work (e.g. “+ 2pts”)
2. Scored work with a rubric: A numeric value is assigned to indicate quantity, but is partnered with a general rubric to indicate what the value means (e.g. “+2pts for defining of assumptions”)
3. Commented: Student specific comments are added to a work to describe its quality (e.g. “good description of lab set-up”, “Does not state assumptions clearly”)
4. Holistic Narrative: A summary statement is written about the submitted work to describe its quality (e.g. “This is a good report. The introduction was clear and stated the problem well…”)

These modes can be used independently or combined – a lab report may include a scored rubric and a holistic narrative that summarize the feedback for instance. They are particularly well suited to written work where they can balance the effort and expertise required by the evaluator with the precision and specificity of the feedback. In general, scoring work requires low effort but some amount of expertise from the evaluator, while given moderately precise feedback (e.g. “this is where the error occurred”) with low specificity (e.g. “this is what the error is”). Adding a rubric can decrease the expertise required for evaluation while increasing specificity.

Commented and holistic narratives often require more effort and expertise but can offer increased precision and specificity. We summarize this in Table 1.

Table 1. Qualitative comparison of feedback modes for written artifacts.
Effort and expertise describe the work and domain knowledge required by the evaluator to provide feedback. Precision describes how feedback is related to a particular part of the work (e.g. where an error occurred) while specificity describes how the feedback relates to the particular students work (e.g. a general comment, vs a narrow one)

	Effort	**Expertise**	**Precision**	**Specificity**
Scored	Low	Moderate	Moderate to High	Very Low
Scored w/ Rubric	Low	Low	Moderate to High	Low to Moderate
Holistic Narrative	Moderate to High	High	Low to Moderate	Moderate to High
Commented	Moderate to High	Moderate to High	High	High

Alternatively, oral and visual feedback can be used. Direct oral or visual feedback, where an instructor describes the quality of a submission to the student is perhaps the oldest form of feedback [2]. Today, this type of feedback can be facilitated with recording technology, cloud storage and the ready access to the internet – items that most students are comfortable with and that institutions of higher education provide[6]. Both audio and video feedback have been explored as effective modes for giving feedback to students [7], [8], [9].

Along with the changes in feedback modes, there has been a change in the types of artifacts that are produced by students. Traditionally, the emphasis in engineering education has been on problem sets, exams, and reports (written artifacts). Non-written artifacts were limited to live presentations/demonstrations. With the ubiquity of video recording and editing technology, students are now producing more non-written work such as videos demonstrations, recorded presentations, podcasts, etc. In addition, students are producing digital artifacts that are inherently non-written like solid models, visual simulations, and animations.

In many cases, instructors apply the traditional modes of feedback to non-written work. The utility of this is unclear [10]. In particular, the precision and specificity of feedback is reduced since there is not a physical artifact to “place” the feedback on to. Additionally, this makes commenting on a video very difficult as comments are inherently connected to a particular area of an artifact. This is summarized in Table 2.

Table 2. Qualitative comparison of feedback modes for non-written artifacts.
Areas that differ from Table 1 are shaded.

	Effort	**Expertise**	**Precision**	**Specificity**
Scored	Low	Moderate	Very Low	Very Low
Scored w/ Rubric	Low	Low	Very Low to Low	Low to Moderate
Holistic Narrative	Moderate to High	High	Very Low to Low	Low to Moderate
Commented	N/A	N/A	N/A	N/A

Video feedback (VF) would appear to be a better fit for non-written artifacts. There has been significant work on its effectiveness for feedback on video presentations [9][10]. Here we explore the utility of video feedback for solid models (CAD) modes. We examine four hypotheses:

1. VF leads to more complex CAD models than traditional feedback methods.
2. VF leads to fewer errors in CAD models than traditional feedback methods.
3. VF increases independent skill acquisition compared to traditional feedback methods.
4. VF requires equivalent or less instructor effort than traditional feedback methods.

Video Feedback (VF) Overview

VF is the recording of audio and visual feedback directly over work submitted by students (see Figure 1). A non-written artifact is submitted to the instructor through electronic means such as a course management system. The instructor records a video of themselves as they interact with the submitted artifact. Once complete the instructor uploads the work to a cloud repository where the students can view the feedback when convenient. Depending on the system use, access can be limited to specific students, and the method of viewing can be controlled as well (via a browser, downloadable etc.) The number of views can often be tracked, if desired.

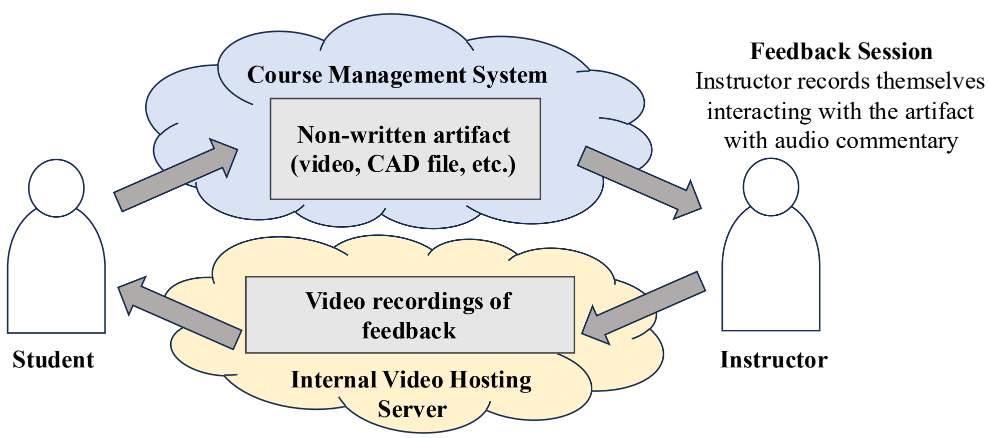

Figure 1. Video Feedback Overview: Student submits SolidWorks files to the course management system. The instructor records themselves manipulating the file. Video recording is posted to video hosting server where students can view it. Serve is secured and access to file is limited to selected students. Students can view files on any device that can view videos over the internet.

The type of feedback can vary depending on the artifact, but in most cases, it involves commenting on the quality of the submission and pointing out areas of improvement. It can also involve direct manipulation of the artifact to show how to correct errors and improve.

Study Details

This is a retrospective study using data from four instances of a one-unit Solid Modeling course for Biomedical Engineering students at the University of Miami. The University of Miami IRB has determined that this study is exempt from review. Each instance of the course had a similar structure: seven standard assignments were given to introduce and reinforce basic solid modeling tools. For each assignment, students created solid models based on a drawing or sketch. A list of assignments and their associate skills is shown in Table 3. An example of the drawing given in a drawing is show Figure 2. Between submission, each student was given feedback on their model and was required to revise it to fix any errors before moving on to the next assignment. The time between assignments was typically one week. Feedback was given within a few days of submission. At the end of the course, each student submitted a final project consisting of solid models of their own design. They were instructed to create a part or assembly of parts that shows their skill and creativity. They had up to two weeks to submit the project, though most work was completed over the course of a few sessions outside of class time. The final projects were used to assess skill acquisition.

Table 3. List of basic assignments and associated skills.

#		Skill/topic
1	Basic Sketch	Basic drawing tools, Basic dimensioning, Sketch planes
2	Lego Block Pt 1.	Boss -Extrusion/Cuts, Linear Patterns, Shell Tool, Chamfer/Fillet Tool
3	Lego Block Pt 2. and Hub	Ribs Tool, Mirroring, Circular pattern, Reference Geometry, Revolved - Extrusion/Cuts
4	Pipe and Tire Assembly	Sweeps, Simple Assemblies: Part Insertion, Mate Tool
5	Parametrized Block	Editing Feature Tree, Basic Parameterization: Configurations, Parameter Definition
6	Parametrized Block 2	Parameterization with Excel Tables
7	Lego Assembly	Copy with Mates, Exploded Views, Configurations in Assemblies

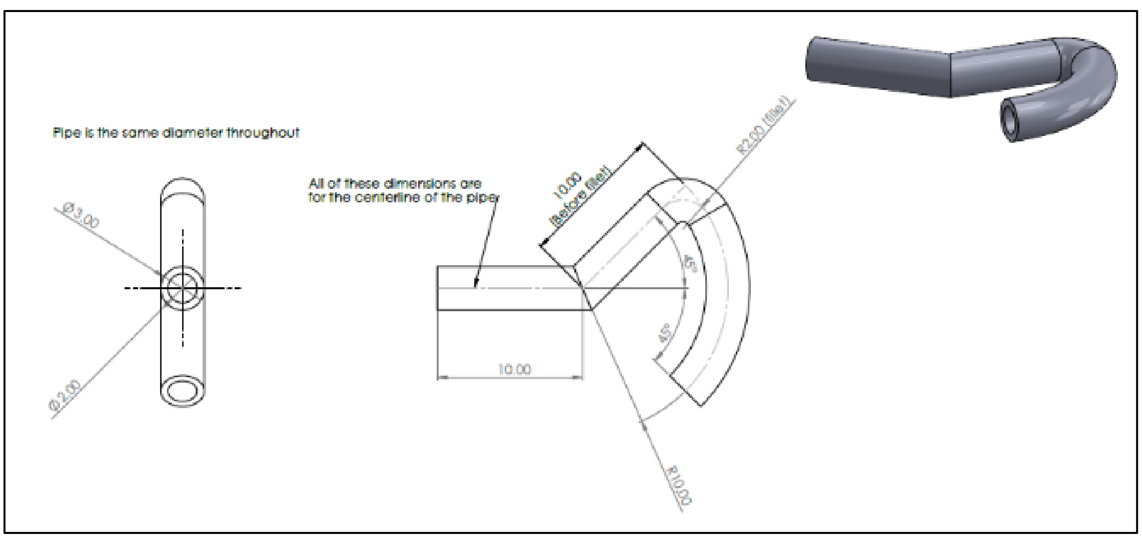

Figure 2. Example of drawing from assignment 4.

The first cohort had nine students and took place in Fall of 2019 (n=9). This cohort was given written (traditional) feedback on all of the assignments. The students submitted their SolidWorks files via a leaning management platform (Blackboard). The instructor reviewed each file, then wrote a holistic narrative describing any problems and/or revisions required to move on. The instructor also generated a score that represented full or no credit. These narratives were posted as comments on each submission along with a pass/no pass score for the assignment via blackboard. If a student received a no pass score, they were required to resubmit until they met the requirements.

The other cohorts (Fall 2021/Spring 2022/ Fall 2022: n=4/11/20 = 35 total) were given VF feedback. Specifically, students submitted files to Blackboard in the same manner as the traditional cohort. The instructor then opened the file and recorded their feedback as they manipulated and edited the solid model. Recording was done with Zoom. The feedback focused on identifying items that were done correctly, as well as pointing out errors and demonstrating how to fix issues (see Figure 3). Once done, the mp4 files of the recorded feedback were uploaded to a cloud repository (Microsoft Stream/SharePoint). The MS Stream/SharePoint repository automatically generated closed captioning of the audio. The permissions on each file were set so that only the student whose work was being analyzed could view the feedback. In addition, students were given view-only access (no editing or downloading of the file allowed) to reduce the likelihood of sharing. Links to these files were sent to each student via email, and a pass/no pass score was recorded on Blackboard. As with the traditional cohort, resubmission was required if submission did not meet the standards.

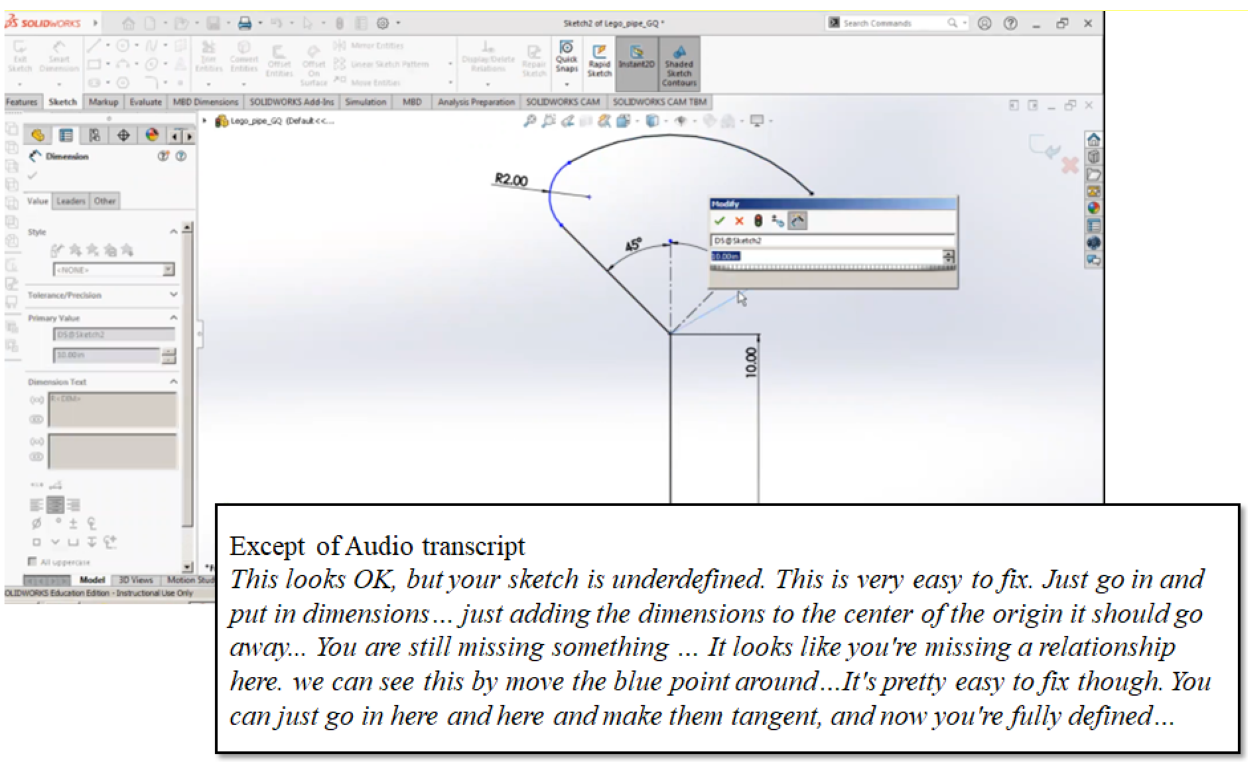

Figure 3. Example of Video Feedback with Excerpt of Audio. Video is captured using zoom. The instructor's face is not shown so that full screen is shown. Items on screen are indicated with curser. Excerpt was auto generated by Microsoft Stream/SharePoint and edited for clarity.

The year between the traditional and VF cohort is a result of the covid 19 epidemic. During this time the course was offered fully online, and feedback was delivered with a blend of traditional and VF methods. This confounds the data, making a clear comparison impossible, so it was excluded from the study.

Detailed demographic data was not collected for the students. In general, BME students have limited exposure to solid modeling, drafting and engineering drawings. This course is required for students in the mechanical engineering concentration of the BME program, but it can be taken by any student in the program as an elective. It is typically taken in the 3rd or 4th year of the program. Specific information on gender, academic rank and whether or not this was a required course is listed in Table 4.

Table 4. Basic Demographics of each cohort. There was a mix of male and female students across the cohorts. Most students took the class in their final year (4th) year as a non-required elective.

	Semester	Female/Male	3rd year/4th year	Required/Elective
Traditional	**Fall 2019**	**4/5**	**0/9**	**3/6**
Video Feedback (VF)	Fall 2021	4/0	1/3	3/1
	Spring 2022	6/5	6/5	4/7
	Fall 2022	12/8	2/18	5/15
	Total (VF)	**18/13**	**9/26**	**12/23**

Skill Acquisition Metrics

Assessment of student skill can be difficult to characterize analytically [12], [13]. Often a student is given a drawing and asked to replicate the part under a limited amount of time. The final product is then assessed to see if it matches the drawing. Any errors or incompleteness due to time limitations are used as measures of skill. This can be a valuable way to measure acquisition of specific skills ("Apply" level skills in Bloom's revised taxonomy), but it is limited in scope[14]. Measuring higher levels skills ("Create" level in the Bloom's taxonomy) like independent skill acquisition, and creativity is difficult using this method.

In this study we analyzed the final project submissions. Given that this was an open-ended project, there was an inherent variability in submissions. We use complexity and error rate as proxies for basic skill acquisition. Specifically, we count the number of features per submission (features) and sum of the unique parts, configurations, and subassemblies in each submission (items) as a measure of complexity. The higher the number of items, the higher the complexity of the submission. For error rate, we counted broken features, underdefined sketches, and features that appeared to be redundant or extraneous and then divided this total by the number of items in the submission. We assume that lower error rates correlate with higher skill acquisition.

We also look to measure independent skill acquisition. We do this by counting the number of tools that each student used in their final project that was not covered by the seven basic assignments as seen in Table 3. We call this total "new tools".

Utilization and Effort Metrics

Beyond skill acquisition, we are interested in determining if any changes are connected to utilization of the feedback. MS Stream/SharePoint allows us to measure the number of times videos were viewed, which we corelate with usage. The system also allows us to measure the length of each video. Though this does not capture the effort required to upload and send links to students, it does give a sense of the time required by the instructor, so we use it as a proxy for instructor effort.

Student Perspectives

Finally, we are interested in the perspectives of students on the VF. We analyzed end of semester student evaluations for specific comments about the video feedback.

Findings

Skill acquisition

Figure 4 shows the whisker box plots for number of features and items per submission. Both mean and median increased in all VF cohorts. The upper and lower quartiles are different and there is only partial overlap which suggest that this difference may be significant. However, there is a noticeable spread as indicated by the large range (whiskers) especially when the VF data is combined. There is no inherent reason the number of features and items per submission should follow a normal distribution, so this is not surprising. Indeed, it shows that some students in the VF cohort far exceeded the average level complexity for all students.

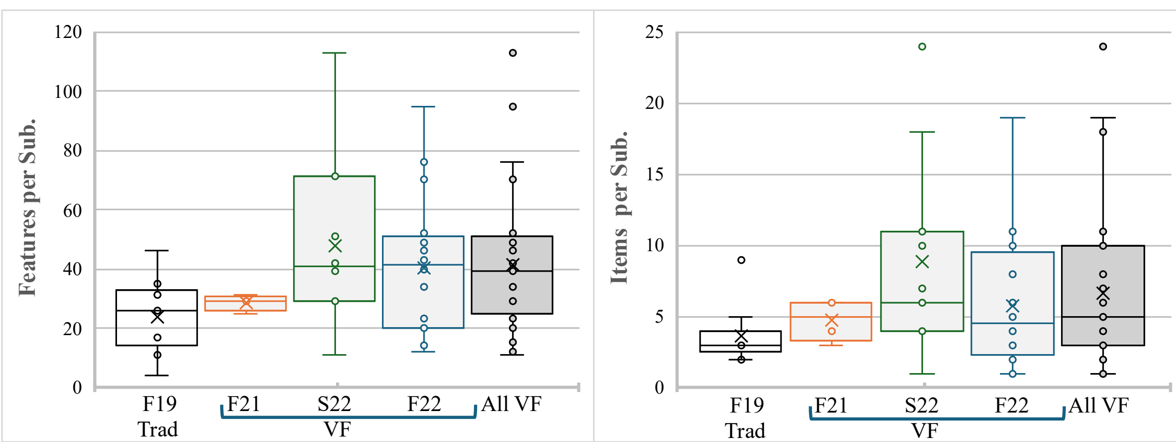

Figure 4. Measures of complexity in Traditional vs VF cohorts.
Both exclusive mean (middle bar) and median (X) for number of features and items per submission increase in the VF group compared to the traditional.

Figure 5 shows whisker box plots for error rate and number of new tools used. Though the change in means suggests improvement (lower error rate and higher new tool usage) the upper and lower quartile are almost identical. There are also once again many outliers in both error rate and new tool usage so no conclusion can be drawn.

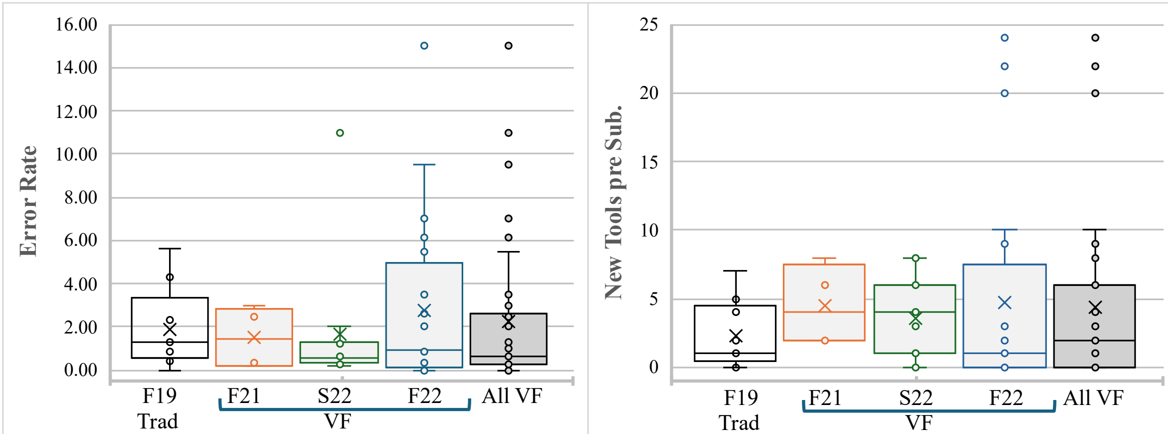

Figure 5. Error rate and number of independently acquired tools (New Tools)
There is no clear difference between cohorts.

Utilization

Figure 6 shows the percentage of videos that were viewed across the VF cohorts. Most videos were video at least once (83% across all cohorts) indicating that students used the videos. More interestingly, 37% were viewed more than once, suggesting that students used the videos as a reference rather than just to see what they did incorrectly.

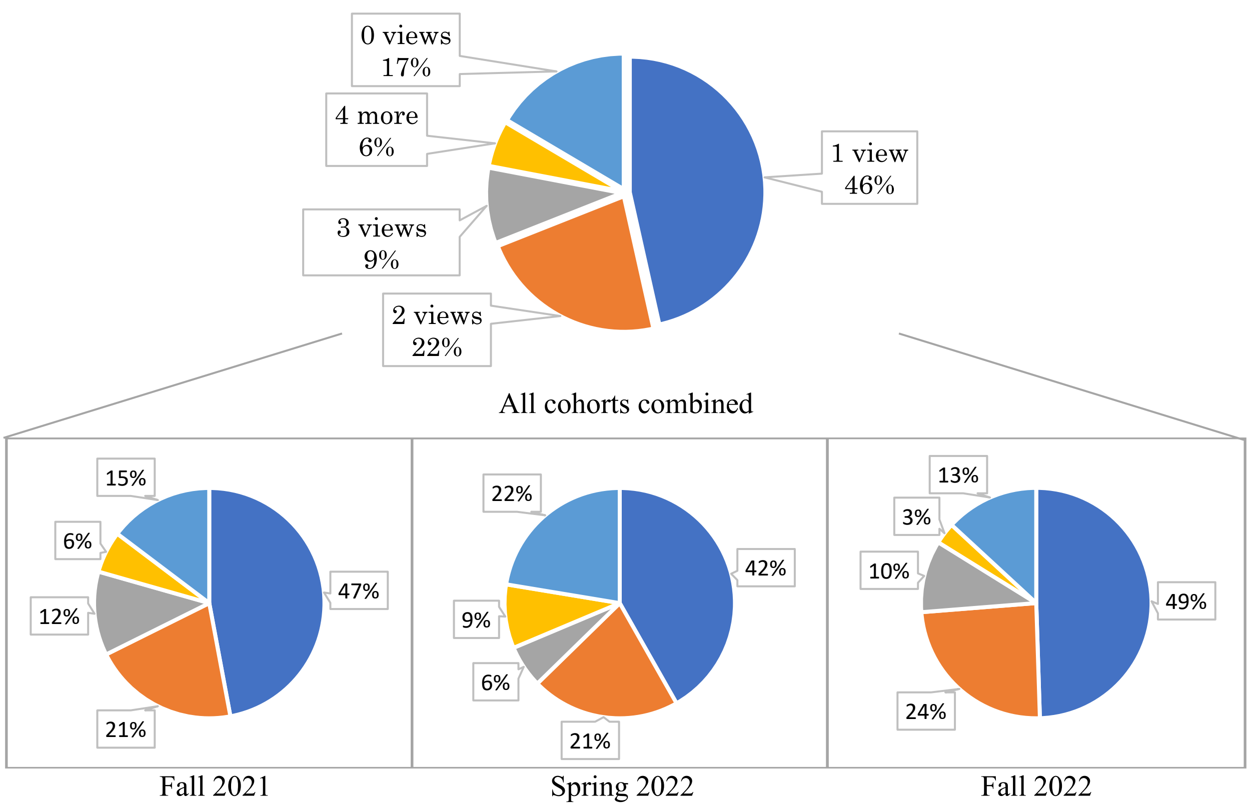

Figure 6. Video Utilization Date.
Each segment represents the percentage of times that each video was viewed. Most videos were viewed at least once across all cohorts.

Effort
To gauge effort, we first look at the histogram of video lengths across all cohorts (see Figure 7). Clearly the length of videos is not normally distributed. Given this, the median video length is a more reliable measure of typical effort. Table 5 shows the descriptive statistics of the video length data across the VF cohorts. Across the cohort the median video length is 7 minutes and 23 seconds. If we average the total video length per student per assignment, we see a similar length (7:24).

The other trend that appears is that all of the metrics decrease from cohort to cohort even though the cohort size increases. This could indicate that there is an increase in efficiency as cohorts get larger since some video content will be similar between students, and/or that the instructor skill at delivering is increase with more repetitions – from semester to semester as well as within each semester.

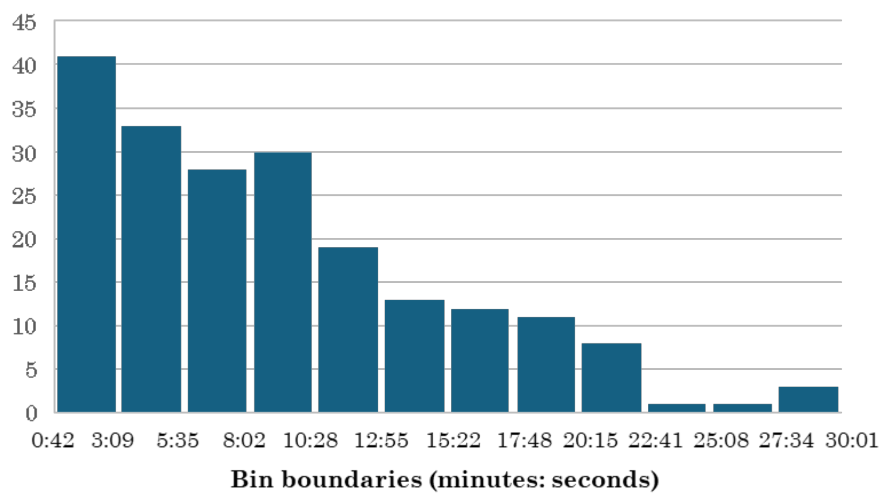

Figure 7. Histogram of Length of Videos across all VF cohorts

Table 5. Video Length statistics across all VF cohorts

	F21	S22	F22	All Cohorts
Cohort size (students)	4	11	20	35
Mean length (min:sec)	10:57	9:21	8:14	9:04
Median length (min:sec)	10:49	7:29	6:48	7.23
Mean total length per student (min:sec)	93:07	56:59	40:45	51:51
Mean length per assignment per student (min:sec)	13:18	8:08	5:49	7:24

Student Feelings

The students were not directly asked about how they felt about VF, however many commented on the videos. 17 students out of 35 submitted evaluations. Out of these, there were 10 comments that mentioned video feedback. These were wholly positive (no negative comments were recorded about the video feedback). Two examples of general comments:

I really appreciated the feedback videos, for they were extremely helpful in identifying errors.

The way the processor[sic] went about teaching the class and having instructional videos was amazing

Several indicated that the videos had additional benefits due to access and format. For example:

Videos were helpful since they are readily available any time.

The main educational formats were videos and 1-on-1 examples. I'm a visual learner so videos worked really good for me.

Lastly, there were comments that indicated that the personalization of videos helped with feelings of belonging and motivation:

The personalized videos were incredibly useful. This teacher clearly cares about students absorbing content as well as teaching them how to go about things the right way and develop healthy habits when practicing the course material.

Something that really surprised me about this class was the feedback that [the instructor] provided for us. After the first 2 assignments and [the instructor] gave us feedback, I thought the videos were all the same and contained general mistakes that we all made on the assignment. Little did I know, you actually made feedbacks that pertained to our specific file that we submitted. This really showed me how much [the instructor] care for us as students and how you want us to learn. Knowing this made me try a lot harder in the class and motivated me to learn the material the best as I can because I know how much effort you are putting in us. Please keep doing this(as I'm sure you were going to) for the future classes as it helped me immensely.

The comments are presented as an indication that students appreciate VF. However, a survey designed and coded to probe students' feelings about VF would be required to draw specific conclusions.

Conclusion

We tested four hypotheses about VF in this work. Given the small cohort size, and lack of randomness and normality in our sample we cannot draw statistically certain conclusions about any of these hypotheses, and more generally that that VF is better than traditional (written) feedback. However, our data does suggest that VF is at least as good and may have positive impacts on student skill acquisition. This is shown in the higher levels of complexity (median and mean) of student work in the VF cohort. There does not appear to be a change in the error rate or independent skill acquisition in the VF cohort. There are also indications that students like the personalized feeling of VF and that it helps with skill acquisition and motivation.

The main critique is that VF is time consuming. A median video length of approximately 7.5 minutes and a mean of 52 minutes of feedback per student over the semester is not prohibitive. The mean and total time per student also decreased from cohort to cohort even though the size of the cohorts was increasing. It is hard to determine why this is happening – increase in instructor skill, or economies of scale – but it does indicate that effort required for VF tends to decrease.

As with most retrospective studies, there is potential for confounding. Since the traditional cohort was also the first cohort chronologically, there is the possibility that the improvement in student skill was a result of the instructor's skill improving rather than VF. A different study would have to be conducted to illuminate this question. Regardless, VF has been shown to be a viable option for feedback on CAD models.

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