USING GOPRO HERO CAMERAS IN A LABORATORY SETTING

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Abstract

The design, implementation, and student perceptions of using cameras in a required engineering materials science laboratory are examined. GoPro Hero 2 cameras were used in a class laboratory setting to improve understanding of material failure mechanisms as well as increase student motivation in a materials science course. Students recorded video footage of destructive materials testing using GoPro cameras in order to evaluate material failure and develop a video presentation in lieu of a written laboratory report. Surveys given to the students after the semester was complete indicated a perceived an increase in their understanding of material failure concepts and the ability to share technical information with others. They rated the value and overall course higher when they used the cameras in the laboratory.

Introduction

In the past two decades, more and more attention has been devoted to the evaluation and appraisal of technology in the classroom. Studies have examined the methods of instruction as well as motivation and increased knowledge of students. In addition, studies also suggest that technology and hands-on experience in the classroom may improve learning and motivation. The innovation discussed in this paper is a modification to MENG 3319 Materials Science and Manufacturing, a required course in the mechanical engineering program at The University of Texas at Tyler. In the past few years, this course has received negative feedback from students complaining that the lab sessions were "boring" and "repetitive." The goal of this innovation was to make use of GoPro HD Hero2 action camera kits to stimulate student interest in the laboratory material, increase their understanding of material failures, and improve their technical communication skills.

Background

This study focused on the use of GoPro Hero cameras to impact student learning and motivation. GoPro Hero 2 cameras were purchased to enable 120 frame per second digital recording of destructive material tests such as impact tests, tensile tests, and student designed compression and bending tests. Students used the footage to further evaluate the damage mechanisms involved and provide them with visual data in addition to the numerical data they already collect.

An additional goal of this project was to prepare students to present scientific results in a format that goes beyond paper and to an audience that extends beyond their professors and classmates. To this end, students took the footage from the experiments and prepared video laboratory reports that implemented the footage they obtained. This videos were then uploaded to a dedicated YouTube channel and made available publicly. When grading these video laboratory reports, a rubric was developed in cooperation with the students.

To measure the effectiveness of the cameras in achieving the goals of this project, a short survey was sent out to the students after the class was over. These results indicated that overall the students did benefit from the experience, but areas for improvement were noted and are being addressed

This paper examines the implementation, issues encountered, and results of using GoPro Hero 2 cameras in a materials science laboratory setting. The impetus for this project came after two years of student comments complaining that many of the laboratory experiments seemed repetitive and boring in a required mechanical engineering course covering materials science and manufacturing.

Using New Technology in Teaching Materials Science

Goodhew and Bullough (2005) showed that in materials science laboratory sessions the goal should not be that the students have been able to correctly obtain a measurement for some property, but are encouraged to do something useful with their results [1]. New technology available to educators and students make it possible to find new ways of encouraging students to take a closer look at what they are studying, whether it be in the classroom or in the lab.

Davies *et. al.* developed a flexible learning studio with equipment not just for both studying and preparing presentations for materials science and engineering students, recognizing that modern engineering students need skills not just to obtain results but present them to others [2]. Pinder-Grover *et. al.* used screencasts to overcome the difference in academic backgrounds and interests of students coming into a large materials science course [3], while Tahar and O'Donoghue used a multimedia virtual learning environment to achieve similar goals [4]. Another web-based approach was taken by Kurt *et. al.* in a conceptual model of a virtual materials testing laboratory simulation for students [5].

The major goal of this paper was to more fully engage students during the laboratory sessions and increase their understanding of material failure mechanisms. GoPro Hero 2 cameras were purchased to enable 120 frame per second digital recording of destructive material tests such as impact tests, tensile tests, and student designed compression and bending tests. Students used the footage to further evaluate the damage mechanisms involved, and provide them with visual data in addition to the numerical data they already collect.

The applications of GoPro cameras in research have been numerous over the past few years. For example, it was used to record nest construction behavior of bees [6], echolocation patterns in dolphins [7], remote control monitoring of a robotic arm [8], and motion capture in microgravity [9]. The author also spotted a well-used GoPro Hero camera in its waterproof housing at a tour of NASA Johnson's thermal systems laboratory in 2013. Furthermore, GoPro cameras are finding applications in education. Kindt used a head-mounted GoPro camera to gain a better understanding of the students' point of view during a class lecture [10].

Description of Course

MENG 3319 Materials Science and Manufacturing is a required course in the mechanical engineering program at The University of Texas at Tyler. It consists of two hours of lecture and one hour of lab per week. The catalog course description is as follows: "Introduction to materials science including the structure of metals and polymers, the testing of mechanical properties of materials, the relationship between material properties, structure and processing techniques, and the capabilities and limitations of modern manufacturing methods."

The purpose of the lab portion of this course is to allow students the opportunity to gain hands-on experience with materials testing, focusing on tensile tests, impact tests, hardness tests, and bending tests. Inherent with this type of lab experience is learning to write professional quality reports on the experiments.

Three of 12 course learning objectives for Materials Science and Manufacturing affected by the innovation discussed in this paper are as follows:

1. Analyze the effect of heat treatment on metal alloys.
2. Perform standard hardness, tensile, and impact tests on metals and polymers.
3. Present experimental results in laboratory reports.

Up to this time, students performed numerous tests of material properties, using only visual aids for their own understanding. Lab reports included pictures they capture themselves at normal camera speeds using cell phone cameras. Any videos recorded were for their own use, primarily for the novelty of having a video of the test. Due to the destructive nature of some of the lab tests, this process could be risky for both the camera and, more importantly, the student.

GoPro Cameras

The innovation planned for this course was the use of a high definition GoPro HD Hero2 Camera kit to capture more than just numbers in the materials testing lab session, as shown in Figure 1.

Fig. 1. GoPro HD Hero2 Action Camera

According to CNET Editors, the GoPro HD Hero2 has glass lens, a mini-USB port for charging, a 2.5 mm microphone input, a full-size SD card slot, an HDMI video output, and a 1,100 mAh lithium ion battery [11]. In addition, it ships with a clear polycarbonate waterproof housing with spring-loaded waterproof buttons giving the user access to all buttons needed for recording and modifying settings [11]. The GoPro camera used for this innovation shipped not only with the waterproof housing, but a variety of other housings to facilitate its secure attachment to almost anything from someone's helmet to a piece of swinging lab equipment.

One of the innovative aspects of this approach was the use of a lower cost, more student friendly medium to capture relatively high-speed videos. While the video quality may not be as excellent as a 1000 fps, multi-thousand dollar camera, it was sufficient for students to perform experiments in material failure and capture exciting visual results.

The Educational Aspect

The action cameras captured 120 fps footage of material failure in impact tests, impact tensile tests, and tensile tests of metal and plastic specimens (including heat treated metal specimens). Cameras were setup to record the failure of the material for all three types of tests, as well as attached to the impact arm of the impact tester to obtain simultaneous footage from a totally different angle. The footage is available to the student teams to use in creation of video lab reports as supplements to the traditional lab reports.

It should be kept in mind, however, that not all lab reports in the industry are limited to paper. With the growing price economy of digital cameras and videos, as well as a variety of easy to use editing software, it has become far more feasible to present results in both paper and by video. An additional goal of this proposal was to prepare students to present scientific results in formats to audiences beyond the educational environment.

Students have complained about the monotony of performing repeated material tests; however, similar tests must be run on different types of materials to understand their behavior. This particular aspect of the course cannot be eliminated but should be addressed. The goal was for this innovation to include both new and informative concepts to the experiments. Furthermore, the project was to provide visual data to review and analyze in addition to the numerical data already collected, and therefore, students could post the video to share with others.

The Original Game Plan

Hardware is required to implement this innovation. However, rather than investing in several thousand dollars of high-speed digital videography equipment, the department opted for a more economic approximation that is easily operated by students. This includes (3) GoPro HD Hero2: Outdoor edition rugged cameras that support capturing 3D images and are ideal for an environment that involves destructive material testing.

Figure 2 shows the GoPro camera marked by a black circle in its protective casing setup to record a tensile test of a metal specimen. It is noteworthy that it has been placed in a position where it is easy to switch on and off during the test; yet, because of its small size, it is not in the way of safe operation of the equipment. A similar setup is used to record impact tests: one camera faces the specimen as it comes out of the impact tester, while another camera records the trajectory of the specimen as it leaves the impact tester.

Fig. 2. GoPro Camera Set-up to Record Tensile Test

To keep the lab sessions running smoothly as the teams take turns performing and recording their experiments, extra battery packs for power and additional flash drives to store video were needed. To achieve the simultaneous recording of the experiment from multiple angles, a WiFi BacPac + ComboKit would also allow the recordings to be started at the same time while keeping the students away from hazardous moving equipment (e.g., the impact tester pendulum arm) as recording begins.

Preparing the Students

In order to increase student interest in videos, the instructor and the lab assistant, created a dedicated YouTube channel [12] for their own lab videos and included videos of the impact test of a metal specimen from two different views, recorded at 120 fps (instead of the 30 fps that is typical of a standard digital video camera).

The first semester that the cameras were used, an in-class demonstration of how to edit the footage in Windows *MovieMaker* was provided [13]. This software was chosen since it may be downloaded for free from Microsoft, comes pre-installed on many of the newer Windows-based laptops, and is relatively easy to use. In addition, students were provided information on downloading free trial of *Camtasia Studio* from *TechSmith*, which supports integration of *PowerPoint* slides with video and imaging [14].

Providing the Videos to the Teams

To facilitate the creation of their videos, each laboratory team chose a team name and was assigned a Blackboard team page for sharing files and editing files. Their team names were used with the lab videos posted on YouTube to protect the privacy of the students.

After an experiment was performed, the laboratory assistant or instructor uploaded the video files to the team page on Blackboard; if issues arose with the file exchange on Blackboard, posted to another online file sharing system where a link to the file would be mailed to the team members. The student team completed their video lab editing and informed the instructor when it was ready for grading. The video would be downloaded from the team Blackboard page, graded, and posted on the laboratory YouTube channel.

Evaluation of the Videos

The first year the cameras were used, students were given the opportunity to assist in developing the rubric for grading the videos. During a morning lecture, about 5 to 10 minutes were taken to discuss what the main areas of focus should be in grading, and their overall percentage of the lab grade. The rubric is shown in Figure 3.

	Novice	Competent	Proficient
Content	0 (0%) - 10 (10.1%) Missing over 1/2 the required content	11 (11.11%) - 30 (30.3%) Includes at least half of the required content	30 (30.3%) - 45 (45.45%) Contains all the required content
Organization	0 (0%) - 1 (1.01%) Poorly organized	2 (2.02%) - 6 (6.06%) Organization present, but flow is not logical	6 (6.06%) - 10 (10.1%) Shows evidence of careful organization with logical flow
Format	0 (0%) - 2 (2.02%) Unprofessional formatting	3 (3.03%) - 7 (7.07%) Professional formatting, but minimal effort put into appearance	7 (7.07%) - 9 (9.09%) Professional formatting with considerable effort put into appearance
Clarity	0 (0%) - 5 (5.05%) Excessive use of technical jargon without explanation, or incorrect explanation	6 (6.06%) - 20 (20.2%) Use of technical terms fully explained with correct explanation, but requires a strong science background to understand	20 (20.2%) - 30 (30.3%) Technical terms fully explained with correct explanation, understandable to someone without a physics background
Creativity	0 (0%) - 1 (1.01%) Minimal creativity exhibited	2 (2.02%) - 4 (4.04%) Some level of creativity, but showing little evidence of thought or skill	5 (5.05%) - 5 (5.05%) High level of creativity, showing evidence of thought and skill

Fig. 3. Rubric for First Video Lab Report

Students agreed that the most important aspects as their associated weight for a grade were as follows: content (45%), organization (10%), format (9%), clarity (30%), and creativity (5%). All video grades were assigned on a team basis. The same rubric is in use during the second year of using the cameras.

Laboratory Assignments

The first video lab covered impact testing and required students to use the video footage to estimate the speed of the specimen as it flew out of the impact testing machine. This requirement helps the students to view video footage as part of the actual experimental data, rather than as a visual supplement to data.

The second video lab report was approached somewhat differently. Students were given the opportunity to record video footage for an experiment of their own choosing. They were given a list of possible types of experiments but had to work with the laboratory assistant and the machine shop manager to work out the details of their test and to prepare any additional specimens or equipment needed. Various tests were performed, including the following:

- Impact testing of a polymer specimen
- Tensile testing of a polymer specimen
- Tensile testing of an aircraft bolt
- Bending tests of steel
- Compression tests of tests of steel
- Bending test of heat treated Damascus steel

All videos submitted for the second video lab were shown in class. Students were given grading sheets were they could make comments on the videos produced by the other teams. These comments were shared with the teams via the Blackboard team page. Final grading was performed by the instructor.

Posting Videos on YouTube
When the submitted videos were posted on YouTube, the instructor was careful to use keywords that tie in directly with the experiments. Therefore, the videos are more useful to a wider variety of audiences. Keywords used included impact testing, material testing, bending testing, Hero GoPro, and others.

One of the goals for this project was the development of a Vimeo channel for the class that would show in excess of 100 hits per team video (as measured by Vimeo statistics), demonstrating an expanded audience for the material. Vimeo was not required for the videos developed for testing semester, and, therefore, all videos were posted on a dedicated YouTube channel shown in Figure 4. Not all teams completed their videos. However, 11 total videos were posted. It should be noted that two channels were inadvertently created by the instructor. However, all team videos (except for two, where the students uploaded to their own channel) were posted on the channel summarized in Figure 4. The views fell short of the goal of 100 views per video, but one video had 88 views since it was posted 10 months before this paper.

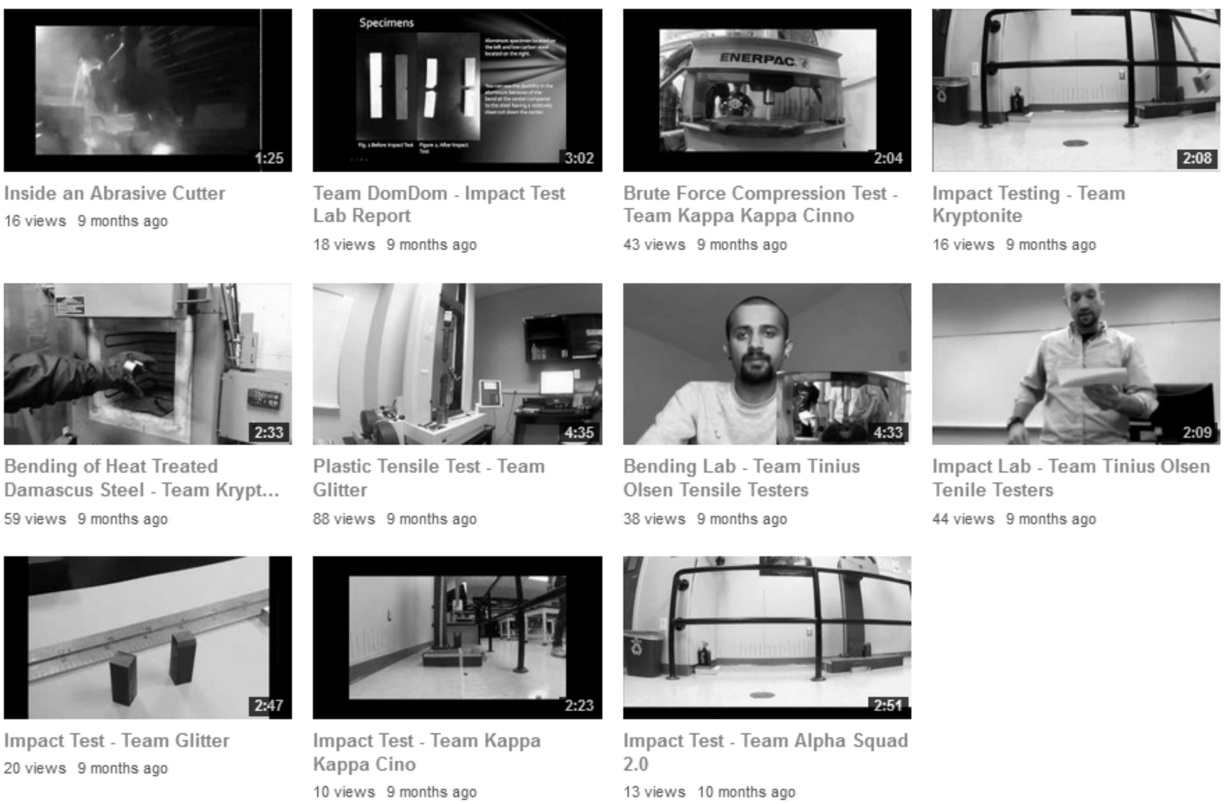

Figure 4. Thumbnails of Videos Uploaded to YouTube for the Materials Lab in 2013

Initial Assessment of the Project

Methods of Research

Students were asked to complete a survey regarding their experiences with the camera in the course Materials Science and Manufacturing. This short, anonymous questionnaire consisting of four questions was given on line after the end of the course. Three of the questions used a scale to collect the needed information. These questions consisted of student understanding, satisfaction, and improvement of technical communication skills. The final question was open ended asking for comments to improve the course using this camera.

For the pilot project, 11 completed surveys were analyzed. The response rate with the 11 of the 36 potential students responding was of 31%.

Results

A majority of the respondents (73%) indicated that they were satisfied with the variety of lab experiments performed, as illustrated in Fig. 5. On a scale of 1-7, the mean score was 4.9, with 7 being very satisfied and neutral being 4.

When asked the degree of satisfaction with the understanding of material failure based on what they learned from the lab experiments, 55% of the respondents perceived their understanding was adequate, while 45% indicated understanding was more than adequate. No respondents stated that their level of understanding was inadequate.

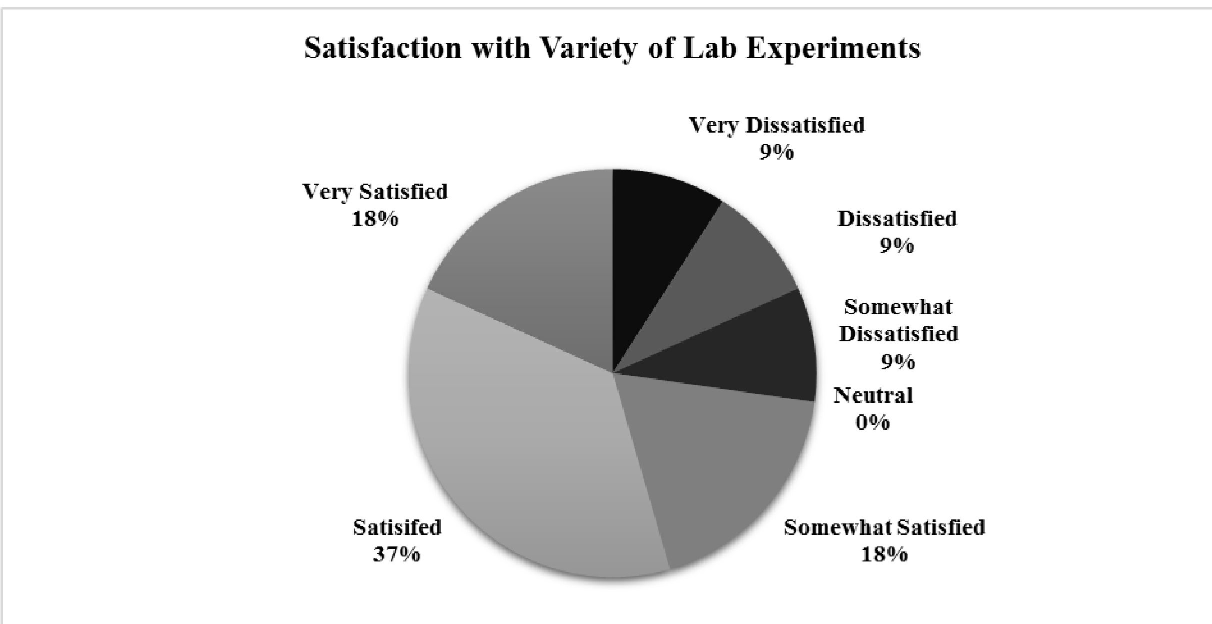

Fig. 5. Degree of Satisfaction with the Variety of Lab Experiments.

When asked if their technical communication skills improved as a result of the videos in lieu of written report, six students, or 55%, indicated a perceived improvement as shown in Fig. 6. However, fi students, or 45%, indicated no perceived improvement. However, a majority of the respondents (75%) indicated a perceived increase in their ability to share technical information through a medium other than written reports.

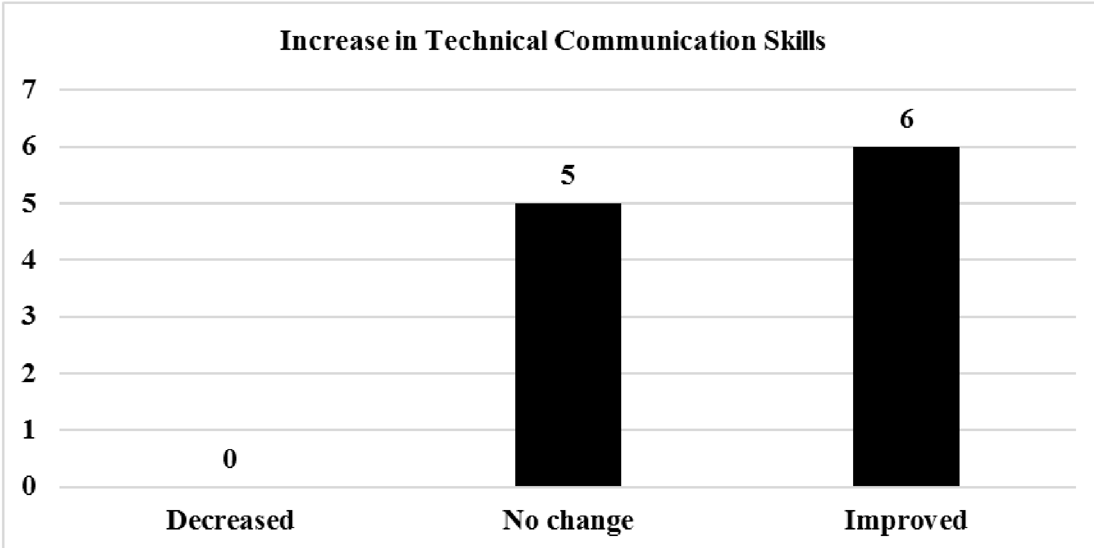

Fig. 6. Perceived Increase in Technical Communication Skills after Use of Camera in Lab

Students offered the following comments during the assessment process.

- The cameras showed great resolution and helped out with all of our projects
- When we had to turn in lab reports, I didn't prefer the videos. You won't necessarily do that in the future, whether it is in another class or in your job, and I would like to see the lab reports help prepare you for the future more or even better represent what you would be doing in future classes or your job. Other than that, I loved the lab!
- I loved them!
- They were great…more would I prove the lab.
- The video quality wasn't as great as I had hoped for but it got the job done.
- I enjoyed using them, however there is a need to learn some form of digital editing software beforehand. Until some familiarity with the software was gained, the video reports were somewhat more time consuming. Using the ` footage to analyze failure tests, however, was quite useful in watching for fine detail.
- I would enjoy some hands on experience with the GoPro cameras... I did enjoy the last couple experiments where we were able to choose our own material, test, and present it. I also wish the GoPros were capable of better high speed capture. The impact testing, in particular, was hard to document and analyze because of blurry shots.

Course Evaluation

Course evaluations were compared between 2013 and 2011 (2012 is not available at this time online). Table 1 shows no difference in the students perceived freedom to ask questions (4.3) and the instructor's overall rating (4.6). Results for questions that could be directly affected by the use of the video cameras in lab, the course rating and the course being of value, both increased.

Table 1. Course Evaluation (2011 and 2013)
(Scale of 1-5, with 5 being the highest)

	2011	*2013*
QUESTION	*N=22*	*N=11*
The instructor made me feel free to ask questions, disagree, and express my ideas:	4.6	4.6
At this point in time, I feel that this course will be (or has already been) of value to me:	4.2	4.5
Overall, this instructor was:	4.3	4.3
Overall, this course was:	4.0	4.3

The feedback for 2011 was based on the feedback of 22 students, while that for 2013 was based on the feedback of 11 students.

Grade Distribution

The grade distributions for the two separate video lab assignments given to the 2013 class is shown in Figure 7. The assignments were graded based on the rubric shown in Figure 3, which was developed in cooperation with the students.

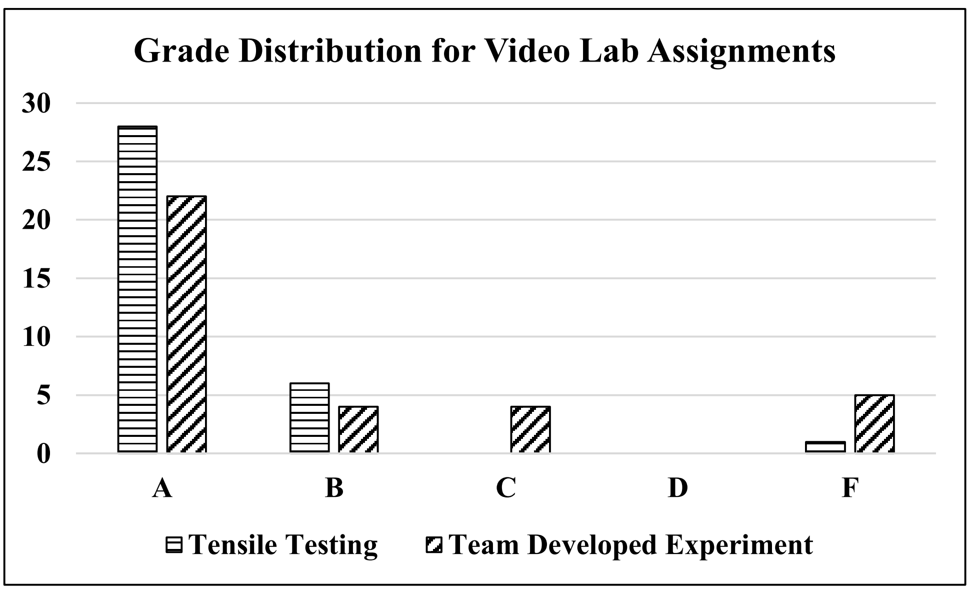

Fig. 7 Grade Distribution of Video Lab Assignments.

The students making Fs in the lab assignments did not submit their videos. After viewing the grade distribution, the instructor felt that the rubric needed to be enforced more aggressively to avoid grade inflation.

Unexpected Benefits

One student asked permission to use the cameras for an experiment in another class, where they needed to use the 120 fps video to determine how high an object bounced after being dropped from the walk through between buildings on campus. Also, a graduate student also used the cameras to record the deformation of an aluminum honeycomb nosecone material during a simulated impact. These cameras are ideal for other purposes, since they are both break-resistant, water-resistant, and student-resistant.

It should also be noted that video reports are becoming part of more of the undergraduate courses, including the capstone Senior Design class for mechanical and electrical engineering majors. Use of these cameras and associated video editing help to prepare these students for later coursework.

Changes based on Assessment Results

Based on the results of assessment for the first semester the cameras were implemented, the following changes are currently being implemented:

- <u>In response to student issues with using Windows MovieMaker</u>: Instead of an in-class demonstration of MovieMaker, students are provided with links to the download for the software, a YouTube link to an overall instruction video for its use, and another YouTube video explaining how to include slow motion in a video.
- <u>In response to students wanting more control over the cameras for recording their labs</u>: After the first lab using the cameras, training will be provided to the students so that they may have more freedom in the setup of the cameras and the direct retrieval of their own videos and images.
- <u>In response to the small number of views for the lab report videos</u>: A new laboratory YouTube channel will be advertised to other students in using an electronic bulletin board in the engineering building.
- <u>In response to an adequate but not high level of satisfaction with the variety of experiments</u>: An additional lab session using the 3D capabilities of the GoPro Hero cameras will be scheduled in connection with impact testing of metal specimens.

Conclusion

While these results did not reach the target of 75% indicating a high level of satisfaction, the instructor perceives that the usage of video did positively influence these results. However, the results for this question were very encouraging in learning effectiveness. Further, students felt the technical communication skills have increased. Also, technical communication skills have increased as a result of the experiment.

The use of the GoPro cameras in the materials science lab was a success, marred only by the instructor's inexperience in working with the cameras. Furthermore, the instructor perceived that students did have a better understanding of material failure by seeing it replayed in video. The video provided them an opportunity to see a specimen of metal undergo ductile or brittle failure over a span of seconds, as opposed to the blink of an eye. Students too nervous to stand close to the machines, even with appropriate safety glasses, were able to watch this failure without fear of loud noises or unexpected occurrences. In addition, part of this opinion is based on conversations, overheard comments, and question/answer sessions with students during the lab sessions.

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