CritViz: Web-Based Software Supporting Peer Critique in Large Creative Classrooms

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Abstract— **CritViz is an online framework for supporting real-time critique, conversation, and peer ranking of creative work in the classroom. In creative classes where student work cannot be entirely graded on objective criteria, classes often arrange critique sessions to provide direction and feedback to students, raise their level of performance, and teach them to give and receive constructive criticism. Critiques usually work best in classes small enough to sustain a single discussion. CritViz was created to scale up critiques for large classes whose size normally prohibits this activity. Through CritViz's countdown timers, assignment uploading, and randomized peer feedback, we can now run effective critiques in much larger classes and have seen changes in overall classroom "motivational structure." Typically with classrooms "Smaller is Better" but our work implies possibilities for increasing class sizes with little negative impact, and even leading to "Bigger is Better" in the classroom.**

Index Terms—**Art, Collaborative Software, Computer Science Education, Educational Technology**

I. Introduction / Background

A. The Power of Critique

THE "crit", or critique session, in which students share work and engage in a structured critical discussion, is commonly used in art classes, but also in design, architecture, creative writing, and even engineering and science contexts. Because evaluating creative output in classroom settings can be complex and subjective, students benefit from hearing varied criticism from a diverse group, each with a unique perspective. Hearing feedback from multiple people allows the critique recipient to blend the feedback, discounting the outlying overly positive or negative comments, forming a better sense of the overall reception. Receiving feedback on creative work from a group of peers is not easy, and not always comfortable. Well run critique sessions are authentic, honest, and powerfully motivating. As teachers, finding ways to effectively leverage peer critique in the classroom can lead to more authentic student motivation, improved performance, and even improved attendance and participation. A critique-based environment fosters personally relevant learning because it focuses on improving skills and processes rather than on earning points towards the highest grade. Critiques also benefit instructors by providing valuable feedback on the reception of class content, allowing for rapid "reteaching" and retooling of instruction. Finally, through critiques, students hone communication skills, learning to give and receive constructive criticism, a broadly useful and valuable skill.

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B. The Traditional Classroom Model

In many creative classes today, the prevailing classroom model consists of many students receiving feedback and evaluation from the single (or few) expert instructors. This model can be ideal at a certain small scale, but as the classroom grows, the amount of attention the instructors can provide declines linearly with the numbers of students in the classroom. More students simply means less time to spend evaluating each individual. With larger classes more teachers or assistants can be added, but the problem of scale persists. Shifting larger classrooms to use peer critiques can alleviate this problem by increasing the amount of feedback each student receives. "Because teachers do not have time to provide extensive feedback, peer conferences are a way to engage students in meaningful formative assessment dialogues with each other" [1]. This shift however only changes the nature of the problem from that of "instructor overload" to "critique management." The bottleneck is no longer the instructor's time and attention, but how to effectively manage a large, cohesive critical discussion. These discussions can of course be distributed over multiple groups or multiple class sessions, but this fragments the class and/or leaves little time for anything but critique.

At Arizona State University, we recently opened a new undergraduate major called "Digital Culture," which aims to combine technical and creative skills into a flexible curriculum geared towards preparing students for a rapidly changing cultural landscape. Our students are a diverse group with interests ranging from music, art, film, and architecture, to interaction design, engineering, social networking, gaming, entrepreneurship and the sciences. Our physical classrooms are very large reconfigurable "maker labs" in which it is not uncommon to have classes with up to 150 students in the same room, learning hands-on to create digital work. Classes this large present a logistical and pedagogical problem. As instructors, we want students to acquire and hone both

technical and creative skills, and although students do receive traditional letter grades, individual assignments rarely have clearly "right" or "wrong" answers. We focus on experimentation, discussion, critical thinking, invention and creative risk-taking. In this setting, making mistakes is often the very best way to learn. Organizing our classes around peer critique is ideal for the kinds of material we teach, but the scale of our classes presents a logistical problem. Running fully-inclusive in-class critiques with 50 - 150 students is difficult in face-to-face settings. Using online tools to help facilitate large critiques is an obvious direction, so we sought a method for conducting peer critiques for our classes via the participatory web. We found existing technology for sharing and turning in students digital projects (e.g. uploading files to BlackBoard, blogs, message boards, email attachments) less than optimal for both instructor and peer evaluation. Often these tools caused more cognitive overhead, complexity, message overload, and confusion than they were worth. It quickly became clear that there are no existing online tools designed to facilitate a large classroom critique session. We decided to develop a system specifically intended for the purpose of facilitating large classroom critique sessions. CritViz was created out of a need to manage the process of providing students in large creative classrooms high quality real-time feedback on their work.

C. The Problem of Facilitating Critiques in Large Classrooms

Traditional critiques work best in smaller classrooms where everyone can take part in a single discussion. In developing CritViz, we first needed to identify what are the specific challenges to scaling up the critique session to large numbers of students. We identified several common problems in our larger classes which tended to thwart a sense of cohesion and community necessary for large scale peer feedback to be effective.

Anonymity

Smaller classes mean increased individual attention, a stronger sense of community, and tighter group cohesion. Likewise, large classes lead to less individual attention and more of a sense of anonymity. When students are aware that the instructor is the only person who will see their work (and that they will receive little feedback due to the high volume of work the instructor must evaluate), the all-too-logical strategy among many students is to try to earn the maximum grade for minimum time and effort. Students are essentially anonymous, and are fully aware that their work is practically invisible to their peers. The motivational structure of the classroom quickly becomes "grade maximization through mistake minimization." In creative classrooms it's often mistakes that offer the most valuable lessons, and not only to the one student, but when students see each others work, to all students. Accordingly, one of our goals in designing CritViz was to remove a sense of anonymity in large classrooms by having students critique each others work in a manner visible to everyone in the class.

Insecurity

Another concern with large classes is the feeling of insecurity that frequently comes with learning difficult new material, approaches and processes. When students do not see the output, struggles, and learning process of their peers when taking on challenging new material, it's not uncommon for many students to simultaneously assume they are the worst student in the class—that they must be the only ones struggling. Many students tend to think their skills and abilities are fixed rather than malleable [2], [3] and that if learning does not come easily, it must be that the student "just isn't cut out" for this kind of work. These self-imposed beliefs profoundly impact one's actions [4], [5], and negative self-views are an especially difficult cycle to break, as low confidence likely produces low-quality work, further reinforcing low confidence in future work, and so on. With this in mind, another objective for CritViz was to allow all students to see every other student's work, as well as all the critiques that the student receives, in real-time. When students can simply see what each other student is working on (and struggling with), in addition to the critical feedback they are receiving from their peers, this misplaced insecurity might be alleviated.

Late Work

Another serious consideration in managing large-class peer critique is keeping the entire group on schedule with deadlines, doing the same work at the same time. Critiques need to start and stop on time, as they are group activities, and a lack of synchrony erodes community. If a large number of students come to a critique session without completed work, not only will they have no work to contribute to the conversation, they also have suboptimal perspectives to offer peers because they have not seen the process through to the end of the assignment. Furthermore, in disciplines where learning builds on learning (like computer programming), late work is like sand in the gears. A student is not in a position to move on to a subsequent project if he/she has not mastered prior foundational work. Accordingly, a third aim for CritViz is to foster social accountability for turning in assignments and offering peer feedback.

D. Social Media in the Classroom

In considering how we might engage such a large group of students in ongoing conversations about their work, we were naturally drawn to the features of social media. Students are already accustomed to communicating through web-based media and do so daily [6]. Furthermore, in contrast to a traditional classroom environment where the only evaluator is a teacher, today's "digital natives" have become accustomed to sharing their thoughts and ideas with a "real" audience of peers who offer feedback through comments, likes, etc. [7–10]. In fact, social media research has even demonstrated that peer feedback received via social media can impact one's self-esteem [11–13].

Findings such as these have spawned major interest among educators in how to learn from, integrate, and leverage social

media to create a better classroom. This fascination with all types of social networking tools may stem from one central property common to social networks, and alien to the classroom: with social network tools, bigger means better. More users of social media platforms such as Facebook, Twitter, and Google+ mean more options, more connections, more data, and more richness for that network's users. However, social media's appeal to educators does not stem from the excitement of using any specific platform in the classroom-they simply want to repurpose the engagement that social media brings for educational purposes.

In opposition to the "bigger is better" of social networks, in the classroom, larger class sizes generally lead to less attention and bandwidth from instructors, more anonymity, and less peer interaction. Essentially, in classrooms, "bigger is worse." Yet, if there is a way to flip this equation and make classes improve as the number of students increase, there is potential to improve the quality of teaching and learning for large numbers of people.

E. Computational Peer Feedback Systems

We are not alone in attempting to facilitate peer feedback using the participatory web. Educators have attempted to use discussion boards, blogs, and wikis ever since Web 2.0's explosive popularity. However, in attempting to use these existing platforms for peer feedback, we found them difficult to manage in the classroom. Social media systems are noisy; the instructor has little control over which pages students visit and which peers they choose to comment on. As a result, student attention is not focused, and some students (often the most popular) receive more feedback than others. Accordingly, an additional consideration for CritViz was to ensure that all students received a sufficient amount of feedback.

An additional challenge is teaching students to give valid, informed feedback to their peers. "[W]hile peers can provide helpful feedback, they need training in strategies and group processes" [1]. Students will obviously be less adept at evaluating their peers' work than their instructors, so an obstacle to quality peer feedback is training students to recognize the differences between poor, average, and exemplary work. One system in particular that explicitly addresses this issue is Calibrated Peer Review (http://cpr.molsci.ucla.edu/), which trains students by having them practice evaluating exemplars of strong, moderate and weak writing before allowing them to evaluate actual peer writing [14], [15]. However, this calibration process is time consuming and asks students to adhere to a rubric or metric. We felt that within the scope of our classes, the time required for such a calibration would be especially amplified. It is a difficult undertaking to define a metric for evaluating subjective artwork, and because our assignments vary widely throughout the course, students would essentially need to "calibrate" for every assignment. Thus, in creating CritViz, we sought procedures for allowing the critiques to happen quickly and ways for the evaluations to be intuitive, rather than being contingent on an existing rubric.

II. CritViz, the System

Critviz was designed and implemented by two instructors whose initial motivation for creating it was the need to immediately use it in the classroom. For this reason the system was intentionally kept as brutally simple as possible, and the primary intention for the software was (and still is), to do one thing well--support peer critique in a large creative classroom. In the following section, we will outline how a typical assignment works within the CritViz framework, from its initial creation by an instructor to the final peer critiques whole-class rankings.

A. Courses, Users and Profiles

Critviz has a basic username/password system, where students and instructors are given accounts to access the system. After an administrator creates a "class" in the system and assigns an instructor to that class, the instructor adds all the students to the class by entering a list of email addresses. After this set-up, the students can log in and create a basic profile which shows their name, basic contact information and a profile photo. They can modify their profile information and photo at any time. In addition, the instructor can write a profile for the course itself, which may include a text description and links to important documents such as syllabi and a course schedule.

B. Step 1 - Assignment Creation

With the course's instructor, student accounts, and student profiles in place, the next step is for the instructor to create the first assignment. Critviz revolves around the students' completion of assignments. First, the instructor navigates to an assignment creation form which includes text fields for the assignment's title and a space for a brief text summary of the assignment's intent. Text fields support the lightweight markup language Markdown.

C. Step 2 - Assignment Questions

After summarizing the assignment, the instructor adds "questions" to the assignment. These questions are elements of the assignment which the students must answer in order for the assignment to be considered "complete." The concept of completeness is important in that only students who fully complete the assignment can be included in the critique. For each question, the instructor must add text describing the question for the students. We have implemented several types of questions available to the instructor, the first type of question being a simple text entry field. This allows students to respond to the question posed by the instructor with plain unformatted text of any length, and is often used for short or long essay answers. Another type of question allows students to upload a file. This allows students to upload a single file from their computer to the CritViz server. If the instructor needs students to upload more than one file, an additional question can be added to the assignment, or the students can be asked to compress multiple files into a single .zip file for uploading. The third type of question is a YouTube URL, with which CritViz can embed the YouTube video directly in the

upload page. And the last type of question is for embedding "sketches" created using the Processing programming language, a variant of Java, used widely by artists, designers, and students.

D. Step 3 - Assignment Options

Once the questions are formulated by the instructor, there are optional settings for the assignment such as whether the assignment is a group assignment or not, and whether or not to use a critique. In addition, if there is to be a critique, we have several possible critique assignment algorithms and the instructor must select which kind to use.

E. Step 4 - Due Dates/time

Here the instructor indicates exactly what day/time the assignment is due. This due date is presented to the student both as a date/time, but more importantly as a prominent countdown timer visible at the top of the assignment page when students log in. The countdown time serves to remind students how many days/hours/seconds remain before the assignment closes. When the countdown reaches zero, the assignment closes and it is no longer possible for students to answer questions. At this point the entire cohort of students who have successfully completed the assignment moves on to the critique phase.

F. Step 5 - Critique assignments

After the countdown timer reaches zero on the assignment deadline, the pool of students who have successfully completed all assignment questions move forward into the critique phase. Students who did not fully complete the assignment (all questions answered) do not move forward to the critique phase. We created this constraint for several reasons, but the primary justification is that it's not quite fair for any student who did complete the assignment to receive critical feedback from other students who did not complete the assignment. This constraint is understandable by students and serves as a powerful motivator. The implicit message to the class that we are a self critiquing group, and in order to be a part of the group, the whole group needs to observe the deadlines and treat them not as arbitrary time limits set by the instructor, but collective constraints and time boundaries used to structure the class and keep the critiques fair.

When the assignment deadline has passed and the instructor is ready to move into the critique phase, the instructor presses a button that assigns critiques to each student. Every student who completed the assignment is randomly assigned five other students to critique. These are not reciprocal assignments, or pairwise matches, rather they are one way random linkings of one student to five others. After the critique assignments are created, every student is presented with a critique page, listing the five works they are to critique, and shown another countdown timer, showing how much time they have remaining to complete their critiques. This is the first type of critique we designed, and still the one most commonly used, although it's not required than an assignment use the critique stage at all. After using the system, we realized that there are other useful kinds of critique assignment we needed to occasionally employ. Sometimes we do in fact want all students (regardless of whether they completed the assignments) to take part in the critique. Other times we want every student to critique every other student in the class. The three types of critique currently used by CritViz are the following:

1) "Contributors only, Randomized 5" - Students that complete the assignment are assigned to critique five random classmates.
2) "All Students, Randomized 5" - Every student (regardless of whether they completed the assignment) is assigned to critique five random classmates.
3) "All Students, All Projects" - All students critique all classmates' work.

G. Step 6 - Critique Format

Once the critique assignments are in place, and students begin looking at the 5 randomly selected pieces of work assigned to them, an important design consideration is the kinds of feedback are they asked to give? It's important to simply have a way for a student to write down feedback for each of the 5 works. Critviz allows the instructor to design a "critique question" where for each assignment the instructor can provide some written instructions for the student-critics on how to approach their written critique commentary. Often students are unskilled at giving criticism resorting instead to throw-away comments like "good job" and "I love this project". These comments are nice to hear but unhelpful as critique, and the critics need help with how to think through their own critiques.

We also wanted a quantitative aspect to the critique, such that each student receives a "score" of some kind from the overall response of their five reviewers. We debated and tried a number of different formats including a numerical score 1-10, or a five star system such as is used in iTunes music ranking, or restaurant reviews, or even simply allowing students to assign letter grades as part of their critical feedback. All of these systems suffer from the simple problem of calibration. How do you make it clear to each student what a 3 versus a 6 mean, or 2 stars -vs.- 5? This would require a very detailed rubric and would have to be modified for every type of assignment used. Other systems [14–16] use this approach and overcome the problem of calibration by first asking students to grade a single "fake" assignment. They use this response to calibrate each student's future responses to their peers work. This calibration step must be taken for each new type of assignment, and for each new student.

However, beyond the question of how to make numerical critique function properly, we are also mindful that the reason we want quantitative feedback in the first place is not because we want to reinvent grading. The real reason is simply that we want the class to be able to reliably and quickly self organize so that the students know where to look next for good examples of peer work. In a large class where all the work is visible and open to all students, a problem of "overload" quickly arises. With 75 students all wanting to see the best works in the class, without any self organization, each student

might have to look at every piece in order to see the best examples. With our basic ranking system, the class can efficiently approximate a global rank, enough to point students in the generally right direction to find strong work.

Rather than use a calibration step, or a detailed rubric, we simply ask each student, in addition to providing written feedback to their five randomly assigned peers, to place these five works in rank order from strongest to weakest (1 is best, 5 is worst). This means that every student will receive 5 scores from their peers, with a perfect score being (1, 1, 1, 1, 1) which would indicate that in all five groups of five, this student's work was ranked first place. This form of ranking can be considered a form of "autocalibrated peer review" and has similarities to how search engines index and rank web pages, in relation and connection to other pages. Whether this method is good as a grading mechanism remains to be studied, but its utility as a simple way for the class to "upvote" good work is clear.

H. Step 7 - Class Rank Calculation

Once the critique deadline passes, the critique is closed and the assignment finished. At this point the instructor can tell the system to calculate the overall class rankings for this assignment, at which point each student is given a rank score consisting of the average of their five individual numerical rankings. Averaging is a crude way of calculating overall class rankings and has the negative effect of removing information about the distribution of scores a student received (some works can be polarizing), but it has an important positive effect of being very transparent and easy to understand by students. More complex methods were tried but it was found that when students can't easily understand how their scores are calculated, overall trust in the system erodes. We have had to continually keep in mind that this quantitative ranking system we have is not designed as a grading mechanism, but rather for self organization and reflection as a class.

At this point, the overall full class rank has been calculated and students can see a ordered list of everyone in the class for this assignment. The student at the very top of the list typically has received all first place scores, resulting in a perfect score of 1, while the student at the bottom of the list typically receives the lowest score possible of 5. While this ranked list of all students is ordered by the average scores, we also include the full breakdown of the individual five scores received.

I. Anonymity and Visibility

A key design and pedagogical consideration was whether or not to show the identities of the authors of the five pieces of work each student is asked to critique. In the end we decided that during the critique phase we would hide the names of the students whose work is being critiqued, but after the critiques are over, the names of all authors, as well as names of the critics are visible. After a critique is over and the class can see the full ranking, everything is visible. Each student can see every other student's work, as well as the critiques they received, and the names of those critics. They can even click on the names of the critics and be linked directly to the actual work created by that critic, and the critiques they received.

III. FINDINGS

To date, CritViz has had 412 total users, and has been utilized in 15 Arizona State University courses by 9 instructors and 5 teaching assistants, resulting in 119 assignments, 4195 student responses to assignments, and 7116 critiques. During this initial trial, we have not only found CritViz to be an extremely effective tool in orchestrating large-class critiques, but also that its use changes the "motivational structure" of large classes.

Students who have used the system report that having an audience of peers for their work is more "authentic." In reflecting on using CritViz, one student reported:

> *I think having a system like Critviz elevates the work in the class. When your work can be seen by everyone in class and not just the instructors you're going to turn in work you're proud of, not just something to get a grade. I think Critviz also held everyone accountable. It was very clear when things were due because you could always check the countdown timer.*

Another agreed:

> *I became much more serious with my projects and aimed to make it good in the 1st attempt. You take the work into account much more when you're aware that your peers will be reviewing it.*

Additionally, because all students in a class were able to view each other's assignments, CritViz has also become a valuable resource for students looking for examples and ideas when beginning new assignments:

> *I loved looking at what other people did with their assignments. Looking at other peoples' work gave me ideas for my work. It was also nice to reference other patches if there was something I didn't know how to do and someone else did.*

A second student shared:

> *I looked at others' work as much as possible. I found myself doing it a lot in the beginning to see how people were doing certain things and also towards the end with the larger projects. I really like to know what other people are working on…Looking at the work of my peers is a great way to get ideas or think about things differently. Sometimes you can be stuck on a certain problem because you're just not thinking about it the right way and seeing a fresh perspective can help a lot.*

Finally, CritViz has greatly enhanced the feeling of community in our classrooms. Despite their large class sizes,

our students truly feel connected, and even feel they are part of a team. One student said:

> *It's amazing looking at all the different projects from the many creative minds in this class. I think this class taught us to take into account feedback and using that feedback to improve our projects. If I could describe this class as one word I think I would choose, "Teamwork." Every helps each other and we all share our results with one another.*

Another opined:

> *One thing I can guarantee is that you're onto something. This class had a sense of community which I think many college courses lack. When someone feels more comfortable in the class, they will do better in that class. They feel more of a need to impress those around them, as well as themselves.*

Essentially, we have found that CritViz's peer ranking and classroom self-curation allows students to not only share their creations and code, but also their ideas, best practices, frustrations, excitement, and even humor. As a result of their interactions on CritViz, our classes of 75 students naturally become a tight-knit community of learners who are deeply interested in helping each other improve their work.

IV. Future Work

CritViz is currently only used within Arizona State University. However, its staggeringly positive reception from students and instructors alike has encouraged us to broaden its scope. Several other institutions and K-12 schools have indicated interest in using CritViz, and so we are currently refining the system for piloting in a wide range of educational settings. In particular, we are preparing CritViz for use in writing classrooms at an interested Arizona high school. We are also developing several additional features allowing instructors to use CritViz as a class management tool, including grade-book-like views of class scores. Work is also being done on incorporating multiple grading options for the instructor, including the ability to add existing metrics and rubrics to the critiquing process, allowing students to reference them while critiquing and offer feedback based on the metric's explicitly-defined objectives.

V. Conclusion

We believe the future of grading is collaborative, social, transparent, statistical and real-time. While opaque grading systems lead to students logically trying to get the best grade for the least effort, transparency through feedback from the instructor and peers leaves no room to "disagree" with grades, "game" the grading system, or cheat. In fact, in creative classrooms, such transparency can entice hard work, time, risk taking, and creative thinking. Using CritViz in our own classrooms we have found a dynamic highly motivational experience for students. Knowing they have an authentic audience interested in helping them improve their work makes the educational experience less about grades and more about honing skills that students find valuable. By regularly sharing their assignments through CritViz and receiving a steady stream of quality feedback, students in large classes become part of a learning community who share their struggles and triumphs in ways similar to a smaller, more traditional critique-based environment. Although tradition suggests that "Smaller is Better" when it comes to classrooms, our work with CritViz points towards the possibility of erasing some of the negative effects of having a very large classroom and allowing professors to increase the sizes of their classes with little negative impact, leading to "Bigger is Better" in the classroom.

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