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Utilizing art exhibits as a low-stakes activity to improve teamwork experiences

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Abstract

Engineering students may obtain the technical skills required of them upon graduation, but many students still need development in the interpersonal skills necessary for teamwork and team efficiency. This research proposes that the low-stakes activity of Visual Thinking Strategies (VTS) can be used as a tool to practice communication and active listening. VTS is a tool for observers to have guided interactions with artwork and has shown to promote observation and listening skills in participants in the medical field, though little research has been done on the impact in the engineering field. This research found that implementing VTS activities in a small pilot course was an effective way to increase students' preference towards teamwork, as measured by the Collective Orientation instrument. This shows 16 out of 22 participants increased their Collective Orientation score and positive interview data was collected from the diverse population that participated, which varied in year, major, race/ethnicity, and gender. This study shows VTS can be a powerful, free, low-stakes tool to help increase team cohesion and efficiency in any course.

Introduction

The ability to work in teams is a vital skill for engineers when designing for and responding to design challenges in their professional careers; however, developing this interpersonal skill is often insufficient across the curriculum as there is a lack of consensus among instructors on how to teach teamwork skills to undergraduate engineering students [1]. For example, it is common for engineering design classes to engage in group work that provides a valuable experience; however, receiving guidance and feedback on team interactions are uncommon even though they can significantly enhance team behaviors [2]. Additionally, design courses tend to focus on the technical skills needed for projects work, and rarely are students taught *how* to work in teams [3]. Designing teamwork exercises and dedicating class time for students to practice these skills, while important, often detracts from the content specific to their disciplines [4]. Hence, there is a need for educators to employ an easy method that allows students to practice the development of interpersonal or “soft” skills early on in their academic career to ensure that they are well-equipped by the time they enroll in design or capstone courses.

The goal of this study is to explore a promising technique for facilitating a collaborative team environment through Visual Thinking Strategies (VTS). VTS is an art observation technique developed by Philip Yenawine, the Director of Education at the Museum of Modern Art in New York City, and Abigail Housen, a cognitive psychologist at Harvard studying aesthetic development, where students have guided interactions with artwork. The VTS method has been used in the art field since the 1990s [5]. More recently, VTS has been implemented in the medical field through Harvard Medical School’s course *Training the Eye: Improving the Art of Physical Diagnosi*s and has subsequently been employed in more than thirty medical schools to increase observational skills and prevent misdiagnosis [6]. However, this method is novel in undergraduate engineering education research. Although engineers do not diagnose patients, they do require a similar skillet that is necessary for complex problem solving in groups, such as adequate observational, listening, and interpersonal skills required to discuss open-ended problems and scenarios. How this technique helps shape engineering students' interpersonal skills has not been previously studied. This study uses VTS as a guided practice activity to observe its effects on engineering students' preference towards teamwork, which is measured through the validated instrumentation of Collective Orientation [7]. This research aims to understand how VTS impacts undergraduate engineering students' Collective Orientation to determine if VTS could be used as a method to help students collaborate better in teams.

Background

Collective Orientation, or the preference for teamwork over the individual, is a metric that is linked to higher team productivity and performance [7]. This is an important metric because individuals that place a team over oneself have been shown to improve overall group performance by creating a collaborative environment and encouraging effort among their peers [8]. However, developing teamwork activities and allocating class time for students to exercise these skills often take time away from the discipline-specific content. This could be why Wilson and her collaborators found 93% of 200 undergraduate science-degree seeking students agreed or strongly agreed that teamwork was necessary for a career, though only 60% of these students agreed or strongly agreed that it is developed during their degree [9]. Hence, an efficient, brief, yet impactful activity like VTS holds potential to enhance a student's Collective Orientation and foster inclusivity within their undergraduate program.

The VTS methodology has been ubiquitously used for years in the art field by docents providing tours to art museum patrons [5]. This arts-based observation of inherently ambiguous non-science themed artwork is a process that involves a museum docent asking specific, research-driven questions to the patrons. This technique is explained in more detail under the *Methods and Design* section. In short, participants observe artwork in a small group and are asked what they see occurring in the piece, are asked to provide specific evidence for why they say that, and actively listen as other participants share their opinion. In recent years, guided facilitations of VTS have been implemented in the medical field. Research shows that after VTS experiences, medical and dental students' ability to accurately describe clinical findings increases [10], nursing students feel more empowered to speak up to their supervisors [11], positive attitude increases in pharmacy students [12], and one becomes more tolerance of ambiguity and objectivity [13].

Though the medical field has used VTS to enhance observational and communication skills for the past two decades, research is still in its infancy within the discipline of engineering education with only one research team studying VTS on engineering students. In 2017, Campbell and his collaborators introduced VTS to upper-level engineering students in hopes of creating more reflective engineers [14]. A comparison of essay responses before and after the VTS experience showed that students were indeed more reflective afterward, though the essay prompt was related to the art they previously viewed rather than engineering concepts [14]. They expanded upon their work with graduate engineering students using instrumentations for insight, contextual competence, reflective skepticism, and interdisciplinary skills [15] and using reflective prompts [16] [17] [18]. Significant increases in insight and contextual competence were seen through pre- and post-tests, indicating engineering graduate students may be more reflective after practicing in VTS. Graduate students may naturally be more reflective in nature since reflectiveness can develop as one progresses through a program [19]; therefore, there is still a substantial need to understand and perform this analysis on undergraduate students.

This proposed research builds on the existing literature in new ways by measuring its impact on how undergraduate engineering students view teamwork using the Collective Orientation instrumentation. There is the potential for VTS to establish a collaborative, open-minded environment, which may enable participants to hone their communication skills and subsequently enhance the effectiveness of their group work in the future. To understand how VTS impacts students' opinion of group work, interviews were conducted in addition to the quantitative Collective Orientation scale.

Abigail Housen's theory of aesthetic development [20] provides the theoretical framework for VTS to be used as a method to increase aesthetic cognition and creative thinking. VTS creates a shared experience and offers an ambiguous environment to engage in complex ideas and is grounded on Bruner's theory that learning is an active process where meaning is derived from one's experiences [21]. This research is based on Martson's Critical Realism [22] since transformation is happening within the internal relationship between the phenomenon (the VTS experience) and the experiencer. Additionally, this research focuses on understanding transformation from an experience through multiple types of collected data and utilizes a mixed-method design collecting and analyzing qualitative interviews and quantitative data from validated instrumentation [23] as the methodological framework for this research.

Methods and Design

Research Participants

Participants in this study were undergraduate students (n = 22) enrolled in *HON 2400 – Honors Discovery: Using Art Exhibits to Improve Communication in Engineers.* This course was specifically developed for this research study utilizing VTS. *HON 2400* qualifies as an elective for honors students and are typically courses that can integrate unique disciplines or topics. These seminar-based courses meet up to five times during the semester and do not have required learning outcomes for a specific curriculum. Instead, they focus on current events or activities that are not typically integrated into the students' programs.

Though any honors student at the university could enroll in this class, most participants were engineering students (Table 1). A class gender breakdown comprised of 12 females, 9 males, and 1 non-binary student. Most participants in this study were at the end of their undergraduate degree, with 23% of students in their 2nd year, 18% of students in their 3rd year, and 59% of students in their 4th year. Class demographics showed most students identified as White (59%), followed by Hispanic (18%), Black (9%), Middle Eastern/North African (9%), and Asian/Pacific Islander (5%).

Table 1. Breakdown of majors within the course

Major	Number of Students	Percentage
Civil Engineering	7	31.9%
Mechanical Engineering	6	27.3%
Computer Engineering	3	13.6%
Environmental Engineering	2	9.1%
Industrial and Systems Engineering	2	9.1%
Non-Engineering (Computer Science and Public Relations)	2	9.1%

Art Exhibition Activity

The participants visited the museum twice during class time, taking up two of the five meeting times. The students spent one hour at the museum during each trip. Once at the museum, students were split into self-selected groups of 5-8 students and were assigned a museum docent who was trained in VTS. The course instructor did not lead any groups at the museum. Each group was led through the museum by a trained facilitator to observe works of art. The facilitator, or docent, asks *only* the following three specific, open-ended questions about the artwork to the entire group:

1. *What is happening in this picture?*
2. *What do you see that makes you say that?*
3. *What else do you see?*

The facilitator repeats participants' ideas and compares them to comments from other group members. The VTS facilitator ensures that everyone has had a chance to share their opinion as to what story the artwork is telling and that all opinions are acknowledged in a non-judgmental way. The group listens as each member participates and is exposed to different points of view of the same work of art. This encourages students to observe, present their own ideas, actively listen to other ideas, think critically, and communicate with one another while the facilitator ensures an inclusive atmosphere [24]. The three questions are repeated until all participants have contributed to the discussion; in which case the group moves on to another work of art. This guided viewing of art lasts about 15 minutes per work of art and does not conclude with the 'correct' answer of the artist's purpose, but instead leaves it open to interpretation.

Data Collection and Analysis

Driskell, Salas, and Hughes' Collective Orientation scale was used to observe how a student's enthusiasm towards teamwork was affected by the VTS activity in the course [7]. This instrument includes 15 five-point Likert-type questions. The pre- and post-Collective Orientation tests were administered in class during the first and last week of classes, respectively.

Debriefing interviews were also conducted at the end of the course and students were interviewed within the same small group that they viewed the artwork with at the museum. These interviews were conducted by a separate researcher than the one teaching the course to allow students to be honest in their responses. All interviews were recorded and transcribed. To ensure that students did not feel like they were being judged or graded at the museum, no recordings occurred during the VTS activity.

Results and Discussion

Collective Orientation Data

Following the five-week course, a class exhibited an average increase of 6.7% in their Collective Orientation score. A t-test analysis comparing pre- and post-test sample means rejected the null hypothesis (that there were no significant differences between the pre- and post-test sample means), revealing a statistically significant difference with a p-value of 0.03.

These results show that after the VTS activities at the museum, the students were significantly more likely to have a higher Collective Orientation score and a higher satisfaction in teamwork. Sixteen out of the 22 participants (72.2%) had a higher Collective Orientation score after the VTS experience at the museum. Figure 1 shows the average scores for each of the museum groups, with Group 2 having the highest post-test Collective Orientation average and Group 3 with the largest overall increase. With a value of 1 equaling the lowest Collective Orientation score and 5 equaling the highest Collective Orientation score, the question on the instrumentation that had the largest increase between the pre- and post-test was "*I find working on team projects to be very satisfying,"* with an increase from 3.14 to 3.64. This indicates that the class's self-reported fulfillment in teamwork increased after the VTS activities.

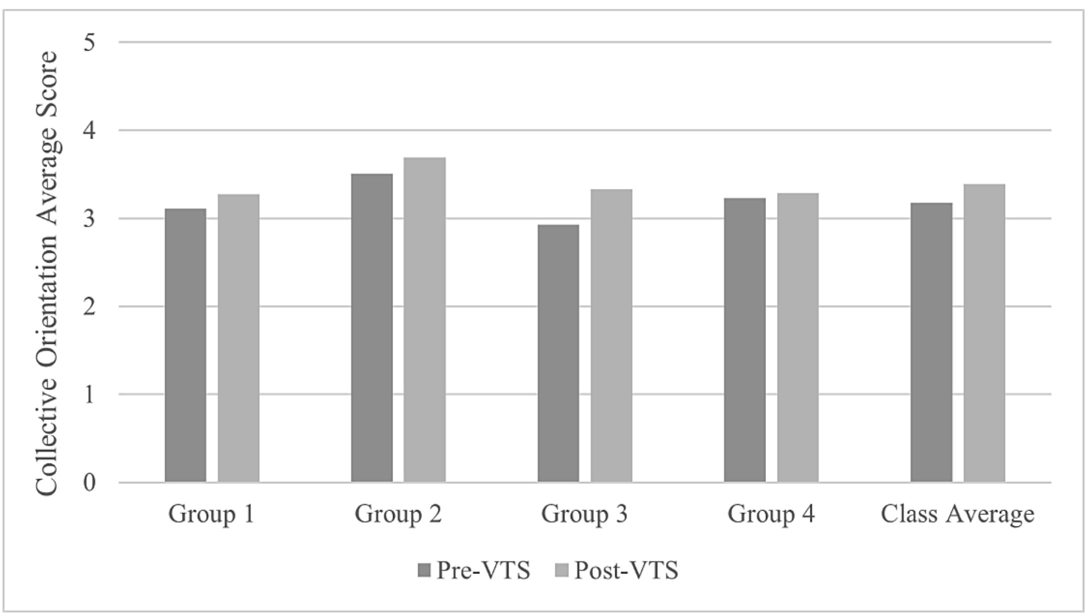

Figure 1. Comparison of Collective Orientation before and after the VTS experience

To understand how the students' year of study affects the impact of VTS on their Collective Orientation score, the pre-test values and percent change from pre- and post-test scores were analyzed by year with the percent change and standard deviation presented in Table 2. Students in their 3rd year of study experienced, on average, the highest increase in their Collective

Orientation, with 19% difference between the pre-test and the post-test. This is slightly unexpected since a survey of 6,435 engineering students found that a student's satisfaction with teams increases as the course level increases [25]. Therefore, other factors might have been at play, and it is important to also look at how the diversity of each group may have contributed to the change in Collective Orientation post-score.

Table 2. Percent change between pre- and post-tests based on students' year of study.

Year of Study	Average Collective Orientation Pre-Test Score (out of 5)	Percent Change in Post-Test Score	Standard Deviation of Percent Change
Year 2	3.11	+2.1%	11.97
Year 3	3.32	+19.0%	5.44
Year 4	3.16	+5.8%	13.57

Group 3 had the highest Collective Orientation increase at 10.28% and also had the most diverse group of students, ranging from 2nd to 4th year students from five different majors: mechanical, computer, industrial and systems, and civil engineering, and public relations. Comparatively, Group 4 had the smallest increase in Collective Orientation at only 1.67% and had the least diverse group consisting of only 4th year students from two different majors: civil and computer engineering. Therefore, the data underscores the correlation between diverse educational backgrounds within teams and the impact of the VTS experience, suggesting that varied academic perspectives fostered richer communication exchanges, potentially contributing to the substantial enhancement in Collective Orientation observed among Group 3 participants.

Another thing to consider is that Group 3 started with the lowest Collective Orientation average out of the four groups. To evaluate the type of change experienced with respect to the pre-test score, the pre-test scores were stratified into three equal groups: lower scores (values of 2.60 – 3.07) with 7 participants, moderate scores (values of 3.2 – 3.27) with 8 participants, and higher scores (values of 3.4 – 3.93) with 7 participants. It is evident from Table 3 that students with the lower scores benefitted the most from the VTS activity and had the highest increase in Collective Orientation, with a positive increase of 14.65%. Moderate pre-tests also experienced a large increase in Collective Orientation, experiencing an overall increase of 11.8%. Therefore, the VTS experience not only enhanced the positive inclination towards group work among participants but also had a significant impact on those who initially held contrary views beforehand. This suggests a broader potential for mitigating negative perceptions of teamwork, which, if left unaddressed, can foster intergroup hostilities and biases [21].

Table 3. Pre-test Collective Orientation change

Group by Pre-test	*n*	Pre-test		Post-test		Change (%)
		Mean	StDev	Mean	StDev	
Lower Pre-test	7	2.73	0.30	3.13	0.41	+14.65%
Moderate Pre-test	8	3.22	0.05	3.60	0.37	+11.80%
Higher Pre-test	7	3.57	0.20	3.40	0.51	-4.76%

It is also important to note that while lower and moderate pre-tests experienced a large increase in Collective Orientation, participants that started with a high Collective Orientation score experienced an overall decrease of -4.76%. This may be due to ten of the fifteen questions on the instrument focusing on the affiliation of the individual (the preference for teamwork over individual work), and the other five focusing on dominance (self-interest and control). It is important to note that a perfect Collective Orientation score of 5 out of 5 is not necessarily the most desirable value for this scale. High scores for the dominance items are inversely related to Collective Orientation. For example, selecting 'Strongly Disagree' for a dominance question, such as "*When I disagree with other team members, I tend to go with my own gut feelings*," might provide the highest Collective Orientation score, but might also be viewed by some as someone who doesn't stand for their own convictions. Indeed, when the data is disaggregated and the dominance questions are removed from the average, the students with a high initial Collective Orientation score saw a decrease of only -0.1% in the post-test, as opposed to -4.75% when all questions were considered.

Interview Data

Analysis of the interview transcripts centered on the participants' perception of groupwork. Students were asked about their initial opinion of teamwork, their VTS experience, and if VTS changed or impacted their perspective of teamwork or engineering. Participants in this study enrolled in this course for different reasons, ranging from an interest in developing communication skills, enhancing creativity in their engineering designs, and for the sole purpose of obtaining honors credit. While everyone had their own individual goals and perceptions of the VTS activity, the overall class consensus indicated a positive reception of the experience. As seen in the Collective Orientation scores, the VTS experience notably impacted the students' perspectives on collaboration. The lower pre-VTS Collective Orientation scores are consistent with what students shared in the interviews, as most are apprehensive of working in teams, highlighting concerns that were formed from past experiences, unknown work ethics of others, and varied abilities within a team. One student noted:

> *"I usually resent [groupwork] and I'm immediately like, 'Oh my God, no!' I don't really want to do group work as much. I didn't really have a bad group work experience except for like maybe one time, but it's just like kind of trying to form a group of people who maybe don't really know that much, and you don't know if they're going to help with the group at all."*

Students also expressed their hesitation with groupwork due to judgement from their peers:

> *"No one wants to be the guy who has an idea everyone hates, and no one wants to be the guy who, like, tries to take charge of everyone either, you know? Everyone either says they don't like this guy, or they secretly resent this guy without telling him, you know, and I'm scared of being either."*

An emerging way to alleviate these concerns is to incorporate a team forming tool such as Comprehensive Assessment of Team Member Effectiveness (CATME) to assign teams, potentially paring students that work well together and improving team effectiveness. Though once students enter the workforce, they will likely encounter challenging group dynamics that may pose difficulties in collaboration. Therefore, educating students on how to actively listen and collaborate in diverse groups is valuable. Since VTS has been used to enhance active listening in the medical field, it is possible this could be used in the engineering field as well to improve team effectiveness. Indeed, the interview data revealed two main reasons that students' Collective Orientation increased: (1) they felt comfortable within their group, and (2) they recognized the value of diverse perspectives in problem-solving.

Many participants mentioned during the interview that the time out of the classroom allowed them the opportunity to bond over a collective experience, much like many team building interventions do. For example, a student stated:

> *"Talking with each other for you know that hour in the museum. I think it kind of indirectly allowed us to build somewhat of a connection."*

However, VTS potentially expands beyond a simple teambuilding intervention due to its ability to help students recognize that there is not a singular correct solution within engineering design since at the museum they realize there is not just one correct interpretation of art. One student commented:

> *"[At the museum] it was just your opinion, or it was how you saw it - and that could also be in the field of engineering where there's not, like, one answer. You can do it in many different ways. You can have, like, a discussion about it. It's not really a wrong idea. There's just how people see it and how it can best be used if it has to fit an idea or a project."*

It may have been easier for students to listen to others' opinions because the VTS activity helped take their personal bias and opinions out of the situation through the help of the trained facilitator and they recognized the value of diverse perspectives in problem-solving. As a student stated:

> *"The VTS days kind of helped us be more open to hearing everyone else fully and trying to just objectively look at it and not take offense as to, like, 'It's not our own opinion, so it's wrong!' And, so, I think we were able to eventually gather in the best parts of each idea."*

The idea that everyone could see something different when interpreting artwork, yet none were considered wrong, resonated with their engineering field, highlighting that multiple solutions exist for a problem, and varying viewpoints contribute to comprehensive discussions and innovative solutions.

Additionally, the VTS activity was not a formally graded assignment in the class. This may have contributed to students sharing uncommon opinions and ideas more openly in a safe environment. Therefore, it might be beneficial to keep VTS activities as a low-stakes, ungraded or pass/fail assignment where one receives full credit for attending. Students did not mention whether it was preferred that their instructor was not leading the VTS facilitation, though that may have contributed to the low-pressure environment as well.

Conclusion

This study found that implementing VTS at non-science themed art exhibits in an undergraduate engineering class can be an effective way to increase students' Collective Orientation. Through data analysis, our findings revealed that there was a statistically significant increase in the overall class Collective Orientation after the VTS experience. Research shows that Collective Orientation correlates to team productivity; thus, this is a valuable method to foster an inclusive group environment with positive team dynamics and increase team effectiveness.

The authors acknowledge limitations in this study, notably the small sample size of 22 students. Increasing the sample size could enhance statistical robustness and potentially reveal additional themes. Although the small sample size raises the possibility of concurrent, external social interactions impacting Collective Orientation, the VTS experience at the museum appears influential, as evidenced by 16 out of 22 individuals in the class increasing their Collective Orientation. Positive reflections from the diverse participants (varying in year, major, race/ethnicity, and gender) further support the significant role VTS can play for all types of academic backgrounds, though more analysis is needed to observe if there are emerging themes in addition to participants teamwork commentary as studied here. Despite these limitations, the study offers novel insights into how VTS can benefit team dynamics, can aid in the formation of collaborative environments, and shows it has great potential to be further explored within engineering education.

One implication of this research is the potential for faculty to integrate VTS activities into their respective engineering courses. Since the artwork used in this research was not inherently science or engineering-themed, this activity can be incorporated into any course emphasizing critical thinking, communication, and group work. Additionally, a visit to an art museum is not a prerequisite, as instructors can present artwork in the classroom using an overhead projector and guide discussions using the three open-ended questions. This adaptation would only take a small portion of class time rather than the entire period.

Moreover, instructors can adapt this activity for specific engineering topics by selecting artwork or incorporating engineering-related visuals directly related to a class topic, such as schematics, photographs of structural failures, or technical diagrams [26]. By employing the three open-ended questions during discussions of the engineering figures presented, students not only enhance their communication skills but also practice applying their analytical abilities to engineering-specific topics.

This approach, as indicated by research, presents a low-stakes, cost-effective, and impactful method to foster team cohesion and efficiency, thereby enhancing students' preference towards teamwork. Ultimately, implementing VTS activities within engineering courses can contribute positively to students' interpersonal skill development, equipping them for success in their future engineering pursuits.

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