Keep Your Arms Out While the Ride is in Motion

Using Making and Process to Unlock Learning

By Prof. Matt Greco

Intro

After several years of integrating making, design thinking, and the use of makerspaces into my courses in photography, sculpture, and ceramics, my primary piece of advice for instructors exploring new approaches to teaching is this: embrace the uncertainty that comes with experimentation. While maintaining a cautious mindset has its merits - much like keeping one's arms inside on a roller coaster - there is also value in taking creative risks within the classroom. These risks, though sometimes uncomfortable, often yield the most meaningful rewards. Through this process, I have learned that expanding my definition of what constitutes relevant course content has led to measurable growth in student pride, confidence, and performance. This development is consistently reflected in the quality of their work and in their ability to master complex course material. Integrating hands-on making and design thinking practices - particularly through the intentional use of makerspaces as extensions of the classroom - has profoundly reshaped both my teaching philosophy and the pedagogical value I assign to experiential learning. In this chapter, I will describe the two courses that I created that integrate making, design thinking, and makerspaces – where I succeeded, the challenges I faced, and some lessons learned.

As I listened to my students articulate their aspirations and the skills they believe will be essential to their future success, I began to recognize two key areas within higher education that hold significant potential for improvement. First, students expressed a clear desire to engage with emerging digital tools and technologies - particularly 3D printing and laser cutting or engraving - that are increasingly shaping creative and professional practices. Second, many students conveyed a sense of being carried passively through curricula that emphasize memorization and testing over genuine understanding, confidence, and a sense of belonging within their academic experience. Integrating making and design thinking into the curriculum has proven to address both of these concerns. These pedagogical approaches provide students with opportunities to actively engage in hands-on learning while cultivating critical thinking, creativity, and problem-solving skills. More importantly, they empower students to take ownership of their learning and to see themselves as capable participants in the creation of knowledge, rather than passive recipients of information.

These developments not only enhance the experiences of current students but also point toward what will be necessary for the future of higher education. As the academic landscape continues to evolve, universities will need to redefine their roles and methodologies to remain relevant in an increasingly complex and technologically driven world. Higher education, as it currently stands, often struggles to meet the demands of the 21st century, a tension reflected in many of the challenges faced by today's students. I believe that pedagogical models grounded in making and design thinking represent one of the most promising paths forward - offering a way to cultivate adaptability, creativity, and resilience in both students and institutions.

In exploring the evolving landscape of making, design thinking, and makerspaces within education, I have encountered a range of definitions and interpretations. These concepts often overlap in practice, and at times they even appear to be in tension with one another. To clarify how I define them within the context of my teaching, I find it useful to outline the specific ways I employ these terms. I define making as any opportunity for students to engage directly with materials – using both their hands and their minds – to investigate physical properties and processes through tactile experience. Making emphasizes the value of learning through doing, of cultivating understanding by manipulating and transforming materials in tangible ways. Design thinking refers to the process of giving students agency in how they navigate learning challenges. It is the pedagogical space that emerges when an instructor provides students with the starting and ending points of a problem – step one and step three, so to speak – but allows them to determine how to reach step two on their own. This structure encourages creativity, experimentation, and reflective problem-solving, key elements in the development of adaptable and critical thinkers. Finally, makerspaces are the physical environments that support these modes of learning. They are spaces equipped with tools, machinery, materials, and expertise that enable the creation of almost anything – from birdhouses to robots. The notion of "building," however, extends beyond the physical; it includes digital fabrication, computing, software development, and programming, all of which are integral components of most contemporary makerspaces.

Although I have been incorporating these teaching strategies into my courses for nearly a decade, my most intensive engagement with them – and the writing of this chapter – emerged as a result of a five-year, two-million-dollar National Science Foundation (NSF) grant awarded to Queens College, CUNY. The purpose of this grant was to investigate the effects of this pedagogy on both students and faculty. I served in dual roles on the project: as a Co-Principal Investigator and as a Faculty Fellow. My involvement stemmed from my position as a co-author of the original NSF proposal and from my prior experience implementing this pedagogical model in my own courses. While I was more deeply involved in designing and facilitating the professional development sequence than in receiving it, the experience nonetheless offered considerable opportunities for learning and reflection. Much of this came through collaboration - through sustained dialogue with colleagues at Queens College about their experiences, challenges, and solutions in integrating similar approaches into their teaching. Working alongside faculty and staff from beyond my department, and even outside my academic division, proved especially rewarding. One particularly meaningful collaboration was with the New York Hall of Science (NYSCI), our partnering institution on the NSF project. We selected NYSCI for its recognized expertise in informal STEM education, and the partnership provided invaluable insights into effective strategies for engaging learners through making. Their *"Design, Make, Play"* philosophy deeply informed my understanding of how creativity, exploration, and iterative problem-solving can be cultivated both inside and outside traditional academic environments.

I have come to believe that learning is less about subject matter and more about process. If students learn how to be curious, think critically, investigate deeply, and engage confidently in research and experimentation, they can master any content. Following that reasoning, I often conclude that my students do not need my specific knowledge as much as they need access to the reasoning and methodology that produced it. This challenges some long-held assumptions in higher education and may explain why institutional change is often slow.

[[GRECO IMAGE 2 HERE]] caption - "Students preparing their 3D models for 3D printing."

Description of the Classes:

The Course

3D Modeling, Printing, and Casting was the first course I designed – and continue to refine – that intentionally integrates making, design thinking, and the use of makerspaces. The course provides students with an opportunity to explore how digital technologies can intersect with traditional craft processes to produce meaningful, functional objects. This three-credit course meets once a week for four hours over fifteen weeks. While I consider it an intermediate-level course, there are no prerequisites; students acquire all necessary skills during the semester. Most students, however, tend to enroll after completing their intro courses. A version of this course was originally offered without any digital component. In its traditional form, students created original clay prototypes by hand for the purpose of mold making and ceramic slip casting, a historic process that employs plaster molds and liquid clay ("slip") to produce multiples of an object; itself an early form of mass production. The original course emphasized craft and repetition but lacked opportunities for digital exploration.

The Project

The redesigned version of the course introduces a comprehensive making project that integrates 3D modeling and 3D printing with traditional ceramic slip casting. The primary project challenges students to design and fabricate two functional objects – a ceramic cup and bowl – via our new digital workflow, that share a cohesive aesthetic and demonstrate thoughtful attention to form and function. This project was developed to introduce students to new tools and processes and to encourage students to think critically about how emerging technologies can coexist with traditional making practices. By replacing hand-built prototypes with 3D modeled and 3D printed prototypes, students experience a complete workflow that bridges digital design and physical production. The intent is to help students approach making as both an iterative and reflective process, one that values design thinking, problem-solving, and craftsmanship equally and, importantly, through which I can introduce some of the fundamental principles at work in the course.

[[GRECO IMAGE 1 HERE]] caption - "Finished 3D prints ready to be molded in plaster."

The Process

The first six to seven weeks of the semester focus on developing students' foundational skills in 3D modeling also known as computer-aided design/modeling (CAD/CAM). Using Autodesk Fusion, an accessible and educationally licensed software, students learn to construct and manipulate virtual objects in three dimensions. Through guided demonstrations, prerecorded videos, and exercises they explore essential modeling techniques such as revolving, lofting, and sketch patterning, beginning with basic geometric forms and progressing toward more refined designs. Once students are comfortable with the software, they begin developing their cup and bowl designs. I provide logistical parameters related to scale, orientation, and design to ensure that each model can be successfully printed, molded, and cast. These constraints establish practical boundaries while still allowing for creative interpretation and experimentation. In the 3D printing phase, I lecture on various 3D printing technologies, discuss the history and evolution of additive manufacturing, and demonstrate practical applications of the process. Students export their finalized designs as watertight STL files and prepare them for Fused Deposition Modeling (FDM) printing using PLA filament, a safe, affordable, and sustainable material. Printing can be completed in university makerspaces, through online service bureaus, or on personal printers. The second half of the semester transitions from digital design to physical production. Once 3D models are printed and approved, students proceed to the mold making and casting stages, where the process returns to one of the oldest ceramic traditions. They create plaster molds from their printed prototypes and cast each in a porcelain slip, producing multiple copies of their designs, which are then bisque fired, glazed, and glaze fired via the traditional ceramic process. By the end of the semester, each student presents for final critique eight glazed ceramic cups and eight glazed ceramic bowls. This sequence –

from virtual modeling to physical fabrication – allows students to engage with the full cycle of design and production, fostering a deeper understanding of both digital and traditional processes while emphasizing creativity, precision, and material awareness.

[[GRECO IMAGE 3 HERE]] caption - "Making clay castings from plaster molds."

The Course

Digital Pinhole Imaging is the second course I designed, and the first I created entirely from the ground up with making and design thinking at its core. The course serves as an example of how a curriculum can be fully restructured so that every stage of learning engages students in both conceptual and hands-on processes. This three-credit course meets once a week for four hours over fifteen weeks. It is considered an intermediate-level course, and *Digital Photography I* is a prerequisite. The course was previously offered in a more traditional format, focusing on basic pinhole photography. In earlier iterations, students would construct pinhole cameras from everyday materials such as oatmeal containers or shoeboxes, often replicating a standard instructor model. The results were typically low in quality and ephemeral – few of these cameras or images survived beyond the course itself. In contrast, the redesigned course integrates design thinking, digital fabrication, and precision, lasting craftsmanship. Students now design and construct reusable, light-tight pinhole cameras using a combination of hand-drawing, software-based modeling, and laser cutting/engraving technology. This process allows them to explore the historical and scientific principles of lensless imaging while employing contemporary design tools and makerspace resources.

The Project

The central project in *Digital Pinhole Imaging* asks students to design, fabricate, and use a functioning pinhole – or "lensless" – camera that is fully reusable and reloadable. The project was developed to engage students in the complete design and fabrication process, from concept sketches to final large-format printed images. Students employ critical thinking, problem-solving, and technical precision as they move through each phase of the project, learning how decisions directly impact outcomes. Unlike the traditional pinhole camera exercises, this project emphasizes iterative prototyping, digital translation, and material understanding. Students use Adobe Illustrator and a laser cutter/engraver to fabricate the components of their camera from wood or acrylic, replacing the imprecise and temporary nature of earlier handmade versions. The inclusion of these technologies not only elevates the technical quality of the final camera and resulting images but also reinforces essential design thinking principles – iteration, reflection, and materiality.

[[GRECO IMAGE 4 HERE]] caption - "Laser cut parts awaiting fabrication."

The Process

The semester begins with four weeks of lectures and demonstrations introducing the scientific and technological foundations of pinhole imaging. Students learn about the physics of light, camera obscura principles, and the unique properties of lensless photography. Early assignments ask them to sketch conceptual designs for a functional pinhole camera - an enclosed, reusable, and completely light-tight box capable of holding 5" × 7" darkroom paper as the photosensitive medium. These sketches, created outside of class, are the first step in developing their technical drawing, spatial reasoning, and analytical skills. Students refine their drawings through successive iterations, learning to calculate dimensions, consider material thickness, and plan for features such as hinges, closures, and pinhole placement. This phase emphasizes design thinking: students must make independent decisions and troubleshoot their own design challenges, with my guidance serving primarily as a facilitator rather than a prescriber. I introduce them to examples of joinery techniques – such as butt, finger, and miter joints – and demonstrate various adhesives, fasteners, and surface finishes appropriate for camera fabrication. Around the fifth week, students transition from design to prototyping. Using cardboard – chosen for its approximate ¼” thickness, which mirrors the final laser-cut material – they build physical prototypes of their cameras. These prototypes allow them to identify and correct measurement errors or design flaws before fabrication. Once the prototypes are approved, students translate their hand-drawn plans into digital files using Adobe Illustrator, which interfaces directly with most laser cutter/engraver systems. During this phase, I lecture on the history and operation of laser cutters, including calibration, safety procedures, and file preparation. Students learn to configure vector paths for cutting and engraving, manage fill and stroke settings, and safely operate the machines. They then cut their final camera components from either Alder wood or acrylic (Plexiglass), assemble them using glues and fasteners, and focus on achieving precision in craftsmanship – emphasizing clean, square, and well-fitted joints. Students receive lessons and demonstrations on fit and finish and have available to them all the tools and supplies necessary. This is where a makerspace can be of great assistance in having all the equipment, tools, supplies, safety equipment, and knowledge all in one place. Once assembled, each camera receives a professionally manufactured 0.35 mm laser-drilled pinhole, which produces higher-quality images than the traditional tinfoil-and-needle method. Students then test their cameras for light leaks and structural integrity before beginning to photograph. The final weeks of the semester are devoted to capturing images. Students produce approximately a dozen exposures on 5” × 7” darkroom paper, develop these prints, and scan them into Adobe Photoshop for image correction, digital inversion, and preparation for printing. The course concludes with each student printing two large-format (30” × 40”) final prints which they present, along with their pinhole camera, at the final critique.

This progression – from conceptual design to tangible artifact and final image – embodies the full cycle of making and design thinking. Students not only gain technical proficiency in software and fabrication but also develop patience, precision, and a reflective awareness of how design impacts creative expression all while reinforcing the basic principles of photography.

[[GRECO IMAGE 5 HERE]] caption - “Students applying the *fit and finish* to their pinhole cameras.”

Teaching Goals

I have found considerable success in identifying opportunities within my courses to incorporate object-making and the design thinking process as means to deepen students’ understanding of course principles. Students consistently demonstrate a stronger grasp of object design and manufacturing when engaged in 3D modeling and printing. Similarly, they better comprehend the scientific fundamentals of light and physics when constructing their own cameras, rather than merely observing demonstrations or lectures. Through these hands-on experiences, students also acquire valuable ancillary skills related to problem-solving, critical thinking, and material awareness.

In my commitment to introducing these pedagogical strategies, I have also expanded my own technical repertoire. This process of exploration and adaptation has opened new pathways through the material, allowing me to design coursework that engages a wider range of learners and fosters a spirit of inquiry and experimentation.

In *3D Modeling, Printing, and Casting*, my goal was for students to engage in the design thinking process using digital tools – specifically CAD/CAM software, which is often entirely new to them. This software not only introduces an unfamiliar design methodology but also equips students with a transferable technical skill set applicable across disciplines. Through this project, students learn how contemporary digital tools can coexist and collaborate with traditional making techniques, reinforcing the idea that innovation often emerges from reinterpreting and refining established practices. In doing so, they are also exposed to the mathematical, engineering, and computational principles that underpin 3D modeling and printing technologies.

Providing students with greater autonomy – particularly by encouraging them to work beyond the classroom, such as in a makerspace – has also proven to be an effective teaching strategy. Allowing this flexibility gives students a sense of ownership over their work, which builds confidence and self-direction. Some of the most rewarding moments have been observing students deeply engaged with their projects and collaborating organically with one another, even in my brief absence. These instances demonstrate that while guidance and structure are essential, meaningful learning often occurs when students take active control of their process and environment.

My personal curiosity about emerging technologies such as 3D printing was also a key motivation for integrating them into my teaching. Witnessing 3D printing firsthand – its (relative) immediacy, creativity, and transformative potential – made it clear that this technology would one day have a significant impact on design, manufacturing, and daily life. Including it in my curriculum therefore felt both relevant and forward-looking. Although some may view 3D printing as no longer novel within makerspace communities, it continues to captivate students and serves as an effective tool for engagement. Its visual appeal and seemingly “magical” process sustain students’ enthusiasm and curiosity, helping to maintain high levels of motivation and participation throughout the course

[[GRECO IMAGE 7 HERE]] caption - “Josee Leyllah Clervoyant”
[[GRECO IMAGE 8 HERE]]caption - “Eva Carolina Sanchez”

Learning Objectives

This is how I state the learning objectives in the two syllabi:

At the close of *3D Modeling, Printing and Casting* the successful student will have a comprehensive understanding of 3D modeling, preparing files for 3D printing, 3D printing, mold making, slip casting, and the fundamental ceramic process. Students will be able to design objects in Autodesk Fusion, prepare them for 3D printing, and export them as an STL file. They will have expanded their vocabulary to include the proper terminology for the major components of CAD/CAM modeling and Fused Deposition Modeling 3D printing. Students will become proficient in plaster mold making, the unique properties of ceramic casting slip, producing multiples via casting, and glazing and firing finished ceramics. Students will have a sound understanding of how new digital tools and technologies can advance traditional practices. They will demonstrate the ability to think creatively, form project ideas, and follow those ideas from conception to realization.

At the close of *Digital Pinhole Imaging* the successful student will have a comprehensive understanding of the operation of primitive lensless “pinhole” cameras and the history and origin of such cameras. They will become familiar with the software and equipment involved in creating files for and having materials processed on a laser cutter/engraver. They will master a fabrication workflow that includes making sketches of the basic design of a pinhole camera including solutions to their design problem, which is to make the cameras reloadable while making the camera sturdy and better able to capture high quality images. They will create cardboard prototypes to prove their designs. Students are taught the basics of Adobe Illustrator and will lay out simple, precise plans on a digital artboard. After translating their sketched designs to digital files students will run those files to a laser cutter/engraver and once cut, they will assemble their cameras. Students will learn basic safety for the laser cutter/engraver, how to prepare the laser cutter/engraver for operation, how to load material, and how to process their files. Students will expand their vocabulary to include the proper terminology for sketching, designing, and fabricating objects, laying out designs in Illustrator, and creating and processing files for laser cutting/engraving. They will demonstrate the ability to think creatively, form project ideas, and follow those ideas from conception to realization.

While these paragraphs highlight some of the primary learning objectives in both courses, they also reveal a wide range of complementary skills that students develop through the process. Each course begins with problem-solving and creative thinking, encouraging students to engage deeply with both conceptual and technical challenges. Students in *3D Modeling, Printing, and Casting* develop an understanding of geometric principles and learn to navigate and measure three-dimensional space in a virtual environment through their exploration of CAD/CAM software. Students in *Digital Pinhole Imaging* engage with the physical aspects of spatial reasoning as they analyze and design functional pinhole cameras. In both courses, students are required to understand entire workflows from conception to completion. This holistic approach teaches them to analyze complete systems – an essential skill for any designer or maker. Throughout the semester, they acquire practical proficiency with multiple software applications and gain insight into their broader design and production contexts.

Because of the technical and interdisciplinary nature of these courses, students also develop numerous STEM-related competencies. They investigate the behavior of light and its interaction with matter, discovering the intricate physical and chemical principles that make photographic imaging possible. Students further enhance their spatial awareness and critical thinking through geometric reasoning and problem-solving exercises that address real-world engineering concerns. They are challenged to ensure that their designs are both aesthetically refined and functionally sound. As students manipulate various materials, they gain foundational knowledge in material science – learning how the inherent properties of different substances influence both process and outcome. Through this process, they cultivate an appreciation for the intersections of art, science, and technology.

Collaboration with Makerspace

Through my faculty fellows I was introduced to teaching perspectives and strategies that I adopted and directly improved the quality of my teaching. I now talk explicitly about instructional design models like ADDIE – Analyze, Design, Develop, Implement, and Evaluate – when talking through assignments. I have collaborated with several faculty on small projects and have plans in the works for co-teaching several courses. It gave me confidence in my teaching, and it introduced me to faculty that think similarly which made me feel less like I was the only one making these changes in the classroom.

My courses illustrate how a well-integrated makerspace can effectively support curriculum. Many students enter these courses with limited or no prior experience using basic hand or power tools and may never have constructed a physical object before. Yet, these foundational skills are essential for successfully completing the assignments. Teaching such skills within class time can be valuable but is also time-consuming, often detracting from the primary learning objectives of the course. For this reason, it is crucial to have access to a makerspace that is intentionally aligned with course goals and provides direct instructional support. However, many makerspaces operate primarily on a do-it-yourself (DIY) model, which can significantly extend the learning curve for students unfamiliar with the equipment. Others are designed to serve specific disciplines, such as engineering or architecture, and may not accommodate students from diverse academic backgrounds. While these DIY or exploratory makerspaces offer important opportunities for experimentation and play, they are not always suited to complement or reinforce structured course curricula.

Both of the courses described in this chapter benefit greatly from the availability of a dedicated, curriculum-focused makerspace. That said, it is important to note that the pedagogical approach I describe does not *require* a makerspace to be effective. All of the principles and processes outlined here can be implemented within a traditional classroom environment, and any specialized fabrication or production steps can be affordably outsourced if necessary.

Student Projects

In *3D Modeling, Printing, and Casting* students made a 3D model of a cup and a bowl, a 3D print of a cup and a bowl, and eight finished glazed ceramic cups and eight bowls.

[[GRECO IMAGE 6 HERE]] caption - “MJ Caragan”

In *Digital Pinhole Imaging* students made drawings, prototypes, and a wooden or acrylic 5x7 pinhole camera.

[[GRECO IMAGE 11 HERE]] caption - “Mackenzie Taller”

Project Success

I consider success in two distinct ways: my evaluation of students’ success and their own self-evaluation – the latter being, in my view, the more significant. My assessment is grounded primarily in the quality of completed projects and the attainment of specific learning outcomes. Students’ perceptions of success, however, are more nuanced and not always directly aligned with grades. I observe evidence of this throughout the semester and make a deliberate effort to nurture it whenever possible.

In both courses, I incorporate final critiques or presentations in which students showcase their work and receive feedback from peers. These moments are invaluable for cultivating pride and confidence, and they often serve as the clearest demonstrations of student growth. Knowing that their work will be viewed and commented on by classmates typically motivates students to invest greater effort – a tendency that reflects human nature. While students may approach my evaluation pragmatically, aiming to earn the grade they calculate with the least necessary effort, their drive to impress peers appears boundless. I intentionally draw upon this dynamic in final critiques or presentations. Although I do not require extensive public speaking, each student presents their work, introduces themselves, and provides thoughtful commentary on the work of others. I track these contributions, which factor into the final grade.

Another indicator of success is how frequently students share their work beyond the classroom - with friends, family, or on social media. Inviting others to public exhibitions of student work or displaying it proudly in digital spaces suggests a strong sense of ownership. When students choose to showcase their projects on social media – a context they curate carefully – it is clear they are proud of their accomplishments. To support this, I routinely photograph students' projects professionally – typically after the final critique or presentation – and invite them to observe and take their own photographs during the session.

I am continually impressed by the diversity and originality of student work, even when all students are using the same software tools or studying identical examples. The designs they produce – whether cups, bowls, or pinhole cameras – consistently display remarkable creativity and problem-solving ability. These projects, being deeply personal and hands-on, allow students to take full ownership of their work. The resulting confidence and pride are both genuine and visible.

Challenges Encountered (and solutions)

Revising any well-established course inevitably brings challenges, and I encountered many during the first few years of offering these redesigned classes. Each obstacle had a solution, but most required some degree of compromise—often in the form of adjusting the curriculum. The first and most critical step was to reexamine my original learning objectives. This process was not easy; it required asking difficult questions about what knowledge, skills, and experiences were truly relevant for students. What will be expected of them upon graduation, and are we adequately preparing them for those expectations? From there, I analyzed which projects best aligned with these evolving goals and made deliberate decisions about which curricular components to add or remove. In truth, I have sacrificed portions of traditional coursework to make space for making and design-thinking projects. However, the skills and insights gained through this pedagogy far exceed the value of rote content that can be easily accessed elsewhere. Some of these decisions were logistical – limited time, budget, and course space simply make it impossible for every student to learn everything. These compromises are difficult but necessary to maintain focus and ensure success in a fifteen-week semester.

A clear example of these challenges can be found in *3D Modeling, Printing, and Casting*. The course's scope and resources do not allow each student to have access to an individual 3D printer or the time necessary to print their own models. 3D printing, while transformative, remains a relatively slow process – small prints can take six or seven hours to complete. Instead, I incorporate detailed lectures, demonstrations, and multimedia presentations to ensure students understand the technology's history, mechanics, and applications. While direct access to printers remains limited, advances in print speed and affordability are rapidly narrowing this gap. I anticipate a time in the near future when every student can print their own designs as part of the course workflow.

Another early obstacle was the need for students to have digital files to print in the first place. I knew few would have experience generating 3D models. While it is possible to use 3D scans or downloaded designs, I wanted students to create their own from scratch, as this aligns with the creative ethos of the course. To achieve this, I adopted Autodesk Fusion – free to educators and students – as the primary software platform. The program's intuitive interface and extensive online learning resources make it feasible for students to learn its core functions within four weeks. Supplemental tutorials from Autodesk, LinkedIn Learning, and custom videos I produce help students develop these skills outside of class, freeing in-class time for deeper project work.

In *Digital Pinhole Imaging*, another challenge emerged: the lack of fundamental hand skills among many students. The course begins with a deceptively simple task – sketching and designing a light-tight box with a single pinhole. For students unfamiliar with measuring, cutting, or accounting for material thickness, this can be a daunting assignment. Yet these challenges offer rich teaching opportunities. Within this single exercise, students encounter a range of learning objectives: spatial reasoning, measurement, visualization, precision, and basic tool use. Many students enter the course without experience using even simple hand or power tools safely, so I begin by teaching these foundational skills in context. I argue that these competencies – observation, analysis, and material awareness – are far more transferable and enduring than memorizing, for example, standard shutter speeds.

This is precisely where the right kind of makerspace can be invaluable. Makerspaces provide structured environments in which students can safely learn tool operation, material handling, and fabrication techniques under supervision. I am currently developing a proposal for a general education course focused on making and design thinking. Such a program would teach essential technical and conceptual skills applicable across disciplines, helping students build a foundation for creative and analytical work while saving instructors the need to teach these basics within individual courses.

Outcomes

One of the most significant outcomes of these redesigned courses has been a marked increase in student confidence, particularly evident in *Digital Pinhole Imaging*. The course begins with a project that most students have no prior experience with and initially doubt their ability to complete – yet they always do. This experience not only strengthens their technical abilities but also builds a sense of self-efficacy. In follow-up interviews with seven students from the course, each expressed confidence that, if faced with a similar challenge in the future, they could complete it successfully. Their responses were consistently enthusiastic, suggesting that the course fosters genuine belief in their capacity to learn and problem-solve independently.

Students also appear to grasp new concepts more efficiently. By embedding individual technical skills within larger, outcome-oriented projects, each task gains clearer purpose and relevance. This contextual learning helps students understand how discrete ideas interconnect and how they function in real-world applications. For example, in *3D Modeling, Printing, and Casting*, students develop a more intuitive understanding of capillary action when they observe plaster drawing water from ceramic slip as the slip dries almost instantly upon contact with the plaster. This tangible demonstration transforms an abstract principle into a directly observable phenomenon, deepening comprehension and retention.

A further noticeable impact has been an increase in students' sense of ownership and pride in their work. Their care and attention toward their creations – how they handle, pack, and present their objects – often reveal how they value their efforts. This behavioral cue offers rich insight into their engagement and self-perception as makers. The inclusion of final critiques or presentations reinforces this sense of ownership; knowing their work will be displayed to peers motivates students to invest more effort and care into their projects. The resulting pride is visible, both in how they speak about their work and in their eagerness to share it.

This sense of personal connection extends beyond the classroom. Students frequently request to take their projects home, treating them as objects of personal accomplishment. I often ask to retain exemplary pieces for display, and the enthusiasm – and persistence – with which students later request their return is a clear indicator of the value they place on their creations. This heightened investment reflects a deeper transformation: students move from completing assignments for grades to creating artifacts that hold personal and creative meaning.

Evaluation

These courses differ from traditional models in that they are designed to build skills exponentially and cumulatively, guiding students toward a single, comprehensive final outcome. Rather than dividing learning objectives into discrete, self-contained assignments, each course integrates multiple skills and concepts into a continuous project that develops in clearly defined phases. Each phase serves both as a formative learning stage and an assessment opportunity, culminating in a final presentation that demonstrates mastery of the full process.

Students are evaluated on both the completion and quality of each phase as well as on the coherence and functionality of the final project. Throughout the semester, they are required to document, archive, and submit their work at each stage – some materials are already in digital form, such as 3D models, while others, like pinhole camera prototypes, must be photographed. All documentation is organized in a shared cloud drive, submitted at scheduled intervals using standardized file-naming conventions. This process reinforces habits of professionalism, organization, and reflective practice – skills that are valuable beyond the classroom.

From the first day of class, I emphasize that my evaluation is based on effort rather than innate talent. Demonstrated engagement, perseverance, and thoughtful iteration are the most important indicators of student success. This approach allows room for different levels of prior experience while maintaining high expectations for growth. Admittedly, assessing effort can present challenges – particularly when distinguishing between students who meet expectations and those who demonstrate exceptional dedication or innovation in their designs. To address this, I adopt an assessment philosophy that is largely mastery-based: if students meet the learning objectives and can clearly articulate and demonstrate their process, they succeed.

A useful example comes from *Digital Pinhole Imaging*, where the first phase assessment involves the creation of design sketches for each student's pinhole camera. Evaluation focuses on clarity, precision, and problem-solving within the design process: Do the parts fit together logically? Have they accounted for material thickness? Are all necessary details included? How many iterations have they produced? I remind students frequently not to discard any of their work, no matter how imperfect, since every draft, experiment, or failed attempt constitutes evidence of learning and effort.

To make assessment transparent, I provide a straightforward grading rubric that allocates equal weight to each project phase, including the final presentation. Grades reflect both successful completion and the evident degree of engagement throughout the process. In addition to the project-based components, students are also assessed on participation in class discussions, attendance during field trips, and completion of short written assignments. This balance ensures that evaluation reflects both their creative output and their intellectual engagement with the course material.

[[GRECO IMAGE 9 HERE]] caption - "Ann Madera"
[[GRECO IMAGE 10 HERE]] caption - "Sean Lomba"

Lessons Learned

One of my earliest and most valuable lessons as an instructor was learning how to guide students' understanding and help them adjust their expectations from the very beginning of the semester. On the first day of class, I take time to clearly outline the goals and distinctive nature of the course. Because the course departs from traditional formats, students often recognize these differences immediately. Their initial reactions can be a mix of curiosity and uncertainty – there are often skeptical glances as they try to imagine what the next fifteen weeks will entail.

Over time, however, I have found that this initial uncertainty transforms into genuine engagement. By the end of the semester, most students have become enthusiastic participants who appreciate the unconventional approach. Capturing their attention early on is key; while their curiosity may begin as hesitation, it quickly becomes a productive openness to learning. Ultimately, students come to value that this is not a typical class experience, and that realization plays a crucial role in reshaping and raising their expectations of college courses.

I have found that students in my *Digital Pinhole Imaging* course are often initially unnerved by the fact that it takes nearly three months before we create our first image. Not many photography courses do that! However, this extended preparation period is intentional. During this time, we focus on mastering the fundamental learning objectives of the course – understanding camera design and exploring the principles of light and aperture that enable image formation within a pinhole camera. I make it a point to reassure students that this slower pace is deliberate. It encourages them to approach the process with greater mindfulness and presence, rather than rushing to produce quick results. While modern smartphones excel at enabling rapid and abundant image capture, they often foster habits that prioritize quantity over quality or meaning. By intentionally slowing the process down, students begin to unlearn these habits and cultivate a more thoughtful, deliberate approach to photography.

Conclusion

Things were a little nerve wracking for the first few years while I worked out kinks and proved the courses to be successful. This was simply part of the process. Now that I have had several years to develop these syllabi more fully, I am as confident in these courses as I was in the ones I taught before and equally confident in the continuing integration of making, design thinking, and makerspaces in my curriculum. This path forward is clear to me, and it starts with increasing student ownership, embrace, and investment in the material and in the classroom, not new ideas, but these teaching tools and techniques are and it is helping to sharpen that image. Perhaps my future as an amusement park safety officer is questionable but my advice here is not; let the train run off the rails, let the track disappear ahead of you, and let your arms out.

You are welcome to view the syllabi, course materials, and resources available on my teaching website https://www.professorgreco.com/. Feel free to use what course materials you find valuable. If you would like to use images of student work or course activity please contact me at matthew.greco@qc.cuny.edu.