Making It Happen: Findings From Processes Implemented to Continue Operating a University Makerspace During the COVID-19 Pandemic

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Justin Suriano is the manager of the New Jersey Institute of Technology’s academic Makerspace, which opened in 2018. Prior to managing the NJIT Makerspace, Mr. Suriano could be found on the sets of major motion pictures and television shows in Los Angeles, working as a set lighting technician. He returned to school in the summer of 2014 for a bachelor’s degree in Mechanical Engineering, completing this degree at NJIT in May of 2018. While managing NJIT’s Makerspace, Mr. Suriano is pursuing a master’s degree in Mechanical Engineering, with a thesis focused on metal additive manufacturing.

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Daniel Brateris is an electrical engineer and engineering educator currently serving as Director of Experiential Learning for the Newark College of Engineering and Program Coordinator for Electrical and Computer Engineering Technology at the New Jersey Institute of Technology (NJIT). Brateris’s areas of interest include embedded product design, design for manufacturing, engineering entrepreneurship, engineering education, and the impact of hands-on experience based learning.

Brateris was educated at Rowan University (B.S. 2009, Electrical and Computer Engineering; M.S. 2012, Electrical Engineering). Before NJIT he founded Atlanticus Innovations a consulting firm specializing in the design of LED lighting, wireless communication systems, mobile hardware, software applications, and design for manufacturing.
ABSTRACT

Manufacturing as a field is built on developing processes and protocols to overcome a myriad of problems. This foundation was put to the test in Manufacturing Education by the disruption brought from the COVID-19 pandemic. This work describes the approach taken to establish processes for the continued use of the New Jersey Institute of Technology (NJIT) Makerspace during the COVID-19 pandemic. The NJIT Makerspace is an Advanced Manufacturing facility consisting of additive, subtractive, and metrology equipment. The Makerspace serves multiple areas at NJIT, including the University’s Manufacturing Engineering Technology (MNET) program, freshman orientation/design courses, and open use by the student population for varied pursuits. A process was developed to allow continued operation of the NJIT Makerspace under state guidelines and was implemented in the beginning of the Fall 2020 semester. This process included new training measures towards access of the NJIT Makerspace’s general tools, polymer additive manufacturing units (3D printers), and laser cutters. In addition, processes were outlined for the Personal Protective Equipment (PPE) needed in the NJIT Makerspace, the donning and reapplication of PPE during Makerspace use, cleaning during Makerspace operation, and adhering to the social distance configuration in the Makerspace. The open question was whether these needed processes interfered with student’s achieving their personal objectives. This question was researched under three separate conditions. The first condition is in support of the MNET program, where the NJIT Makerspace houses a junior level manufacturing course utilizing manual machining (e.g. milling and turning). The second condition is an introductory freshman course that provides students with an overview of NJIT’s resources including the Makerspace. This course provides students with training to access NJIT Makerspace systems, which is reinforced with a NJIT Makerspace project that students currently have an option to pursue virtually or in person. The final condition is the general use of the NJIT Makerspace by students with varied interests. The presented findings from Fall 2020 will not only provide guidance for hands-on Manufacturing Education during the COVID-19 pandemic, but also potential options for safety processes that could be used in other applied academic activities.
INTRODUCTION

Background

The COVID-19 pandemic has presented a number of challenges throughout society and in several industries. The pandemic has; however, highlighted the importance of the manufacturing field as well as its ability to adapt to challenges and crises. This response could be seen from industrial manufacturing facilities that developed protocols and procedures to remain open throughout the pandemic to continue producing a number of essential items [1]. Manufacturing education faced a challenge as well namely, how to continue providing experiential learning to students under the restrictions created by the COVID-19 pandemic. At the New Jersey Institute of Technology (NJIT) this required addressing the operation of the NJIT Makerspace, which serves as a platform for manufacturing and experiential education.

The NJIT Makerspace is an advanced manufacturing and research and development facility [2]. This 10,000 square foot facility not only contains tools and equipment found in traditional makerspaces (e.g. 3D printers), but also advanced manufacturing, fabrication, and inspection equipment found in industry. This includes Computer Numerical Control (CNC) mills and lathes, multi-axis water jet, advanced additive manufacturing systems (e.g. metal and composite), and advanced metrology equipment (e.g. Coordinate Measuring Machine (CMM)). The NJIT Makerspace is a resource for students, faculty, and researchers for realizing their objectives. Student groups, including the Society of Automotive Engineers (SAE) Baja and SAE-Aerospace, have utilized the NJIT Makerspace to realize their designs that are being brought to competitions nationally. In addition, the faculty have integrated the NJIT Makerspace in several courses ranging from those interested in product design to those pursuing a manufacturing degree.

The NJIT Makerspace has not only been an open area for those in the NJIT community exploring personal product concepts and projects, but also a resource for local industry to realize components and pursue business ideas. The NJIT Makerspace has also contributed to the community at the state and national level. This could be seen during the response to the pandemic where the NJIT Makerspace designed, developed, and fabricated personal protective equipment (PPE) that were in short supply during the early stages of the pandemic. The face shields produced were distributed not only in our state but also to any facility nationwide where they were in short supply.

The NJIT Makerspace serves multiple groups and is a needed resource for realizing products, developing concepts, and serving as a platform for manufacturing education. Therefore, keeping the NJIT Makerspace operational under the pandemic conditions was critical. The requirements to continue operating the NJIT Makerspace required the integration of guidance from federal agencies (Centers for Disease Control (CDC)), state level agencies, and NJIT requirements. The integration of this guidance with the needs of a functioning advanced manufacturing facility required several decisions from the NJIT Makerspace leadership.

NJIT Makerspace COVID-19 Protocol

The NJIT Makerspace COVID safety protocol was developed to operate the Makerspace in compliance with state, federal, and NJIT regulations. The protocols put in place were directly
influenced by both the CDC guidelines [3-4] at the time of writing (August 2020), as well as NJIT’s COVID protocols for students, faculty, and staff in laboratory spaces [5]. In the creation of this protocol, the floor plan of the space and the user experience at each “station” was considered. General behavioral rules were put into place for all individuals in the space that were informed by both CDC COVID-19 guidelines and NJIT’s COVID-19 protocols. The entirety of the NJIT Makerspace COVID protocol was determined via a sequential, hierarchical process, where:

- The NJIT campus and laboratory-wide protocol and the CDC guidelines were reviewed and relevant measures proposed.
  - An example of a relevant measure involved placing wipeable covers over all the computer keyboards used in the Makerspace.
- When the existing NJIT COVID protocol did not cover a specific case presented in the NJIT Makerspace, a decision was made to align with safety practices for a manufacturing facility [6] and CDC guidelines.
  - An example of a procedure that was modified includes the use of gloves. Glove usage was modified for those operating rotary power tools and equipment to comply with manufacturing safety standards.
- A custom facility layout was also developed as part of the protocol in order to comply with social distancing requirements. This included the implementation of barriers, signage, and new routing and workflow for users of the facility (Figure 1).
- The proposed protocol was then reviewed by key members of the NJIT Makerspace team:
  - Makerspace full-time and part-time staff reviewed and provided input throughout the protocol. This group was critical in the development because not only do they provide perspective on implementation of the protocol at the various Makerspace stations, but also they needed to confirm that the protocol made them feel comfortable supervising and working in the facility.
  - The Makerspace Faculty Mentor with experience in standard hospital practices, medical devices, biomedical sciences, and clean room procedures reviewed and provided input.
- The faculty and staff then conducted a walk through with the protocol and iterated as needed to ensure that the protocol complied with CDC and NJIT COVID guidelines, but also allowed the NJIT Makerspace areas to function as intended.
- The completed NJIT Makerspace COVID protocol was then reviewed by NJIT leadership before final approval and posting on the NJIT Makerspace site [7].

The NJIT Makerspace was updated with stations to handle the donning of Personal Protective Equipment (PPE), routing indicators, signage for procedures, and cleaning methods and supplies. Figure 1 provides a diagram showing the configuration of the Makerspace prior to the pandemic and after the COVID protocol implementation.
Figure 1. Representative diagram of NJIT Makerspace floor layout (A) under pre-pandemic conditions and (B) with modifications to meet COVID-19 protocol requirements.

The main features of the NJIT Makerspace facility changes included:

- A Dirty (D) and Clean (C) workbench system was created for key areas including at the entrance for donning of PPE (Figure 2A) and at areas of tool procurement and return (Figure 2C).
- Barriers (e.g. stanchions) were used to guide and separate key areas (example shown in Figure 2B). Clear acrylic barriers were placed in key staff areas (e.g. front desk).
- Floor markings were used to drive traffic towards maintaining six feet of social distancing (Figure 2D). Markers were applied as well for appropriate areas to stand for social distancing (Figure 2C).
- Workbenches were separated to maintain the required six feet of social distancing (Figure 2E).
• **NJIT Makerspace** COVID protocols were made visible through the use of poster boards placed at key locations (e.g. front desk) in the **NJIT Makerspace**.

• Signage reminding users of protocol procedures were placed in acrylic holders throughout the facility at key locations.

**NJIT Makerspace** users followed the following procedure upon entering the facility:

• Members were required to have facemasks to enter the facility.
  - Face masks with “valves” were not accepted.
  - Students who required a mask were provided a disposable one.

• Upon entering the space, members were instructed to remove necessary *work items* from their person (e.g. backpack, purse) and place them onto the “dirty” workbench for cleaning.

• Personal items that would not be used during their visit were placed into a plastic bag and onto a shelf to be stored until they exited the facility.
  - Wallets, along with headphones, personal USB flash drives, smart watches and personal measuring instruments were prohibited to prevent contamination within the space.

• Members would then sanitize their hands with hand sanitizer and don nitrile gloves. Glove usage has many functions including:
  - Protecting member’s hands when they used cleaning reagents.

• Sanitizing wipes, disinfectant spray and paper towels were then used to clean their designated *work items*.
  - Once each item was cleaned, it was placed onto the “clean” work bench adjacent to the “dirty” work bench (**Figure 2A**).

• Members were then instructed to use hand sanitizer to clean their nitrile gloves prior to grabbing their supplied lanyard for their NJIT ID cards clipped on their outer clothing.
  - The NJIT ID is used extensively in the Makerspace for accessing locations and checking out tools.
  - The NJIT ID clipped to outer clothing with a lanyard made the ID accessible without reaching into pockets.

• Once this personal sanitization process was completed, members were instructed to follow pathing arrows along the floor of the space to enter the work bench area.

There were also changes to the general **NJIT Makerspace** facility protocol in response to the changing pandemic environment [7]. This included

• Changes in occupancy that complied with state and NJIT requirements. A sign was implemented at the front entry of the **NJIT Makerspace** to indicate vacancy and members were directed where to wait in a socially distant manner.

• Facility hours changed in order to accommodate a NJIT staff cleaning schedule implemented per the CDC cleaning and disinfection guidance [4]. This required typical **NJIT Makerspace** hours to be changed from 12 PM-9 PM (pre-pandemic) to 12 PM-7:30 PM to implement the **NJIT Makerspace** staff cleaning at 7:30 PM.
- All *NJIT Makerspace* trainings independent of a course were scheduled and conducted online through the NJIT Learning Management System. Course specific *NJIT Makerspace* trainings were handled on a case-by-case basis and were provided under the modality of the specific course.

![A](image1.png) ![B](image2.png)  
![C](image3.png) ![D](image4.png)  
![E](image5.png)  

**Figure 2.** Representative images of *NJIT Makerspace* facility changes: (A) entrance of the facility with D and C workbench system, (B) example of a barrier at entrance used for guidance, (C) tool procurement area with floor markings for social distancing, (D) example of floor markings driving traffic, (E) workbenches separated for social distancing.
Members were instructed to practice six feet of social distancing. Pathing around the facility prevented members from compromising social distancing guidelines at “choke-points” in the facility. Members were encouraged to avoid touching their faces or other exposed body parts once nitrile gloves were put on. Members utilizing the work benches were instructed to clean all work bench table tops after use. Signage was available throughout the facility referring to the protocol. Members were instructed to use hand sanitizer before and after utilizing each work area as a redundancy to promote cleanliness. All users of the space were encouraged to use sanitizer on their gloved hands if needed and appropriate, rather than re-gloving. Specific work areas in the *NJIT Makerspace* require eye protection. Under pre-pandemic conditions, eye protection would be available at key dispenser areas throughout the facility. Under the pandemic condition, new sealed safety goggles were provided to students at no charge. These safety goggles would then be kept by the student and become one of the *work items* requiring sterilization upon returning to the facility. A secondary eye protection option was also provided for student purchase. Designated work areas also had specific procedures.

Tools are accessible through the use of a Snap-On ATC tool chest work area *(Figure 2C)*. This system allows members to tap their IDs on a card reader to access a variety of hand tools from their designated drawer locations. In this area, the “dirty” and “clean” table concept was again employed specifically for tools: Members were encouraged to sanitize their gloved hands with provided hand sanitizer and nitrile gloves before accessing the tool chests. This area was sectioned off with stanchions and plastic chains, and signage was used to communicate only one member would be allowed in the area at a time. Before members would return tools to the chest, they would place all tools onto the “dirty” table and clean them with provided disinfectant before placing them onto the “clean” table, where they could then be moved back into the tool chest. Because steel tool surfaces are prone to rust, members were also asked to apply a thin coating of machine oil to exposed steel surfaces that were cleaned with disinfectant before returning said tools to the chest.

The *NJIT Makerspace*’s self-serve 3D printing area is another area with a specified procedure. This area was similarly sanctioned off with stanchions in order to promote pathing through the area, and an entrance and exit was clearly marked with signage. The two-table setup for this area naturally created three lanes; only one member was allowed per lane while interacting with the 3D printers. Floor markings were used to help users identify where to stand in the work area as well as a reminder that only one occupant was allowed in that zone. Again, members were instructed to sanitize equipment before and after usage, including all computers, *NJIT Makerspace* provided USB flash drives, writing utensils, 3D printers and their related tools. If *NJIT Makerspace* staff removed a completed 3D print from a printer, the produced part would be stored at the front desk awaiting pickup. This allowed the user to pickup their completed part directly from a staff member at the front desk without the need to follow the full COVID-19 entrance procedure.

**Study Question**

The COVID-19 protocol was needed to provide a *NJIT Makerspace* environment in compliance with the NJIT requirements as well as state and federal guidelines. All users of the *NJIT Makerspace* were required to comply with the protocol. The question that arose during the
development and implementation of the COVID-19 protocol was if it would affect the student’s use of the facility limiting their manufacturing and experiential learning education in a face-to-face environment. Studies in the literature have not yet addressed this question, but instead have detailed the transition from a traditional face-to-face learning to virtual options resulting from the COVID-19 pandemic [8]. This includes in the electrical [9], mechanical [10], and physics [11] fields. Moreover, the area of manufacturing education has been limited to studies on transition to virtual options applied to aligned areas of automation [12] and mechatronics [13]. The literature has studies describing the development of safety related laboratory protocols [14-15] but not directly their impact on education. Therefore, to begin understanding the impact of the NJIT Makerspace COVID-19 protocol on manufacturing education required us to pose the question to NJIT groups that had access to the NJIT Makerspace during the Fall 2020 semester. This focused scope did not include assessing the effectiveness of the NJIT Makerspace COVID-19 protocol on preventing the spread of COVID-19.

METHODS

This study was conducted through a survey that was distributed to three NJIT groups that have access to use the NJIT Makerspace for personal or academic purposes during the Fall 2020 academic semester. These are students that have gone through the needed NJIT Makerspace training courses including the COVID-19 protocol. These groups are the University Makers (Univ. Maker), third year manufacturing course (3rd Yr. MFG CRSE) students, and the introductory first year course (Intro. 1st Yr. CRSE) students. The Univ. Maker groups are students that are using the NJIT Makerspace for varied manufacturing interests. This includes for personal projects, academic requirements, and for activities related to student engineering teams (e.g. Society of Automotive Engineers (SAE) Baja). The Intro. 1st Yr. CRSE provides students with an introduction of the resources and organizations available at the NJIT. This valuable freshman course includes an introduction into the NJIT Makerspace including training. The students have a semester long group project where they would detail a design they would like to realize using the resources at the NJIT Makerspace. The use of the NJIT Makerspace was made optional for the Fall 2020 semester towards completion of this academic requirement. The 3rd Yr. MFG CRSE is a junior level manufacturing engineering technology course that directly provides students with an applied education on fabrication and inspection tools. This is conducted with manual mills, manual lathes, drill presses, and a several hand fabrication and inspection tools. The course has a lecture component and an applied lab where students utilize the equipment to not only complete weekly laboratory exercises but also a semester long project. The course required students to use the NJIT Makerspace to complete their academic requirements.

The survey was structured to determine if the COVID-19 Protocol had an impact on respondent experience with the NJIT Makerspace. Questions related to respondent academic background were also posed to provide insight on the current scope, or potential future areas of evaluation. A distinction is made between different majors, and common engineering/science groups for purposes of this study. The survey followed a qualitative and quantitative assessment structure that has been applied to evaluate makerspaces [16]. The survey was primarily structured with quantitative 5-point Likert-Scale questions. Table I describes the Likert scale language used for different types of questions and the point scale. Specific relevant survey
questions towards addressing the goal of the study are detailed in the results section. Figures presented in the result section only contain non-zero results. A Likert scale category not represented in a figure indicates no respondents selected that option. The Likert scale results for specified questions were further analyzed to produce a mode and median point for a pertinent group. Qualitative comments were also requested for informational use.

Table 1. Likert Scale language and point scale for respective survey question type.

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Likert Scale</th>
<th>Likert Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement</td>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>Importance</td>
<td>Extremely Important</td>
<td>Very Important</td>
</tr>
<tr>
<td>Frequency</td>
<td>Always</td>
<td>Often</td>
</tr>
<tr>
<td>Awareness</td>
<td>Extremely aware</td>
<td>Very aware</td>
</tr>
</tbody>
</table>

| Point Scale | (5) | (4) | (3) | (2) | (1) |

RESULTS & DISCUSSION

Fifty-four students responded to the survey. The distribution of the 54 students among those that have enrolled as Univ. Maker, 3rd Yr. MFG CRSE, and Intro. 1st Yr. CRSE is shown in Figure 3A and Table 2.

Table 2. Respondent University Groups and Makerspace Usage Fall 2020

<table>
<thead>
<tr>
<th>University Group</th>
<th>Number of Students</th>
<th>Used Makerspace Fall 2020</th>
<th>Did Not Use Makerspace Fall 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Univ. Maker</td>
<td>24</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>3rd Yr. MFG CRSE</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Intro. 1st Yr. CRSE</td>
<td>22</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Totals</td>
<td>54</td>
<td>28</td>
<td>26</td>
</tr>
</tbody>
</table>

The majority of respondents are in the Applied area where 39 out of the 54 respondents are in NJIT’s School of Applied Engineering and Technology. Further breakdown of areas that their majors fall is shown in Table 3.

Table 3. Number of respondents in engineering/science categories.

<table>
<thead>
<tr>
<th>Engineering/Science Group</th>
<th>Number of Respondents</th>
<th>Used Makerspace Fall 2020</th>
<th>Did Not Use Makerspace Fall 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Engineering</td>
<td>20</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>13</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Civil Engineering/Surveying/Construction</td>
<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Computer Science</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Biomedical, Chemical, &amp; General Engineering</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Biology &amp; Physics</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>54</td>
<td>28</td>
<td>26</td>
</tr>
</tbody>
</table>
The majority of respondents were aware of the resources at the NJIT Makerspace (Figure 3B) and agreed it was important for their professional growth and development (Figure 3C). This case saw a response of “strong disagreement” but no “disagreement”. Less agreed that the NJIT Makerspace was important for the completion of their academic course requirements (Figure 3D).

The entire group’s responses to these questions were further quantified into a mode and median summarized in Table 4.

Table 4. Mode and median results on specified questions from all respondents.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am _____ with the resources available at the University Makerspace.</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Use of the University Makerspace is important for my professional growth and development.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Use of the University Makerspace is important for completion of my academic course requirements.</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
This group was separated further into those that used the Makerspace in the Fall 2020 semester (28/54 respondents) and those that did not (26/54 respondents) (Tables 2-3). This was a fairly even separation. The NJIT groups in each category is described in Table 2, please note that all of the 3rd Yr. MFG CRSE students are required to use the NJIT Makerspace and therefore cannot appear in the group that would not use the NJIT Makerspace during the Fall 2020 semester. The responses of those that used the NJIT Makerspace in the Fall 2020 semester were then used to gauge the effect of the COVID-19 protocol on NJIT Makerspace usage.

COVID Protocol Results from Those that Used Makerspace in Fall 2020

The responses of the group that used the NJIT Makerspace in the Fall 2020 semester (Table 2) were evaluated. The majority of these individuals would use the NJIT Makerspace under pre-pandemic conditions (Figure 4A), where no respondents “disagreed” or “strongly disagreed”. In addition, the majority of respondents indicated they would use the NJIT Makerspace with “often” or “always” and no one indicated “never” (Figure 4B). The importance of the protocol in the decision to use the NJIT Makerspace and its resources was nearly split (Figure 4C) although the majority agreed on its importance (Figure 4D). This may have resulted because some of these respondents were students that had a course requiring the use of the NJIT Makerspace.

Figure 4. Response from those that used the NJIT Makerspace in Fall 2020 on whether (A) they would use the NJIT Makerspace and (B) how often under a typical (pre-pandemic) environment. (C) Influence of COVID-19 Protocol on their decision to use the NJIT Makerspace. (D) Importance of the COVID-19 protocol.
Regardless, the majority indicated that it makes them feel more comfortable to use the NJIT Makerspace resources (Figure 5A), where no one “disagreed” or “strongly disagreed”. This is in-line with the respondent attitude of the quality of the COVID-19 protocol (Figure 5B) where it was rated as “Excellent” by the majority of respondents and no one rated it “poor” or “very poor”. The effect of the protocol on the respondent’s use of the NJIT Makerspace is described in Figure 6. The majority of respondent’s did not believe the protocol’s requirements had a negative effect on use of the resources (Figure 6A). The majority of respondents also did not believe that the protocol’s PPE (Figure 6B), social distancing (Figure 6C), and cleaning requirements (Figure 6D) had a negative effect on their use of NJIT Makerspace resources.

![Figure 5](image.png)

**Figure 5.** Responses from those that used the NJIT Makerspace in Fall 2020. (A) Reaction to comfort level COVID-19 protocol provides towards NJIT Makerspace use. (B) Impression of quality of the COVID-19 protocol.

The responses to these questions, for all respondents who used the NJIT Makerspace in the Fall 2020 semester, were further quantified into a mode and median summarized in Table 5. Most respondents indicated that the protocol’s requirements did not have a negative effect on accomplishing academic requirements (Figure 7A), where the mode was 1 and the median 2. This group of users from the Fall 2020 included a segment that did not have a course requiring the use of the NJIT Makerspace (Figure 7A). In addition, this group of users could also include potential students where use of the NJIT Makerspace may have been optional in their program. To further evaluate this question the 3rd Yr. MFG CRSE respondents, who were all required to use the NJIT Makerspace during the Fall 2020 semester, were evaluated alone. There was no “strongly disagree” in the 3rd Yr. MFG CRSE response and an increase in the “Agree” response. The mode and median in this group alone were 2 and 3 respectively. These findings may indicate that the COVID-19 requirements do pose a concern for those trying to pursue academic requirements. This point would have to be further investigated with a follow up study. Representative comments from this group also reflect the results of the compiled surveys (Table 6). Comments reflect that respondents recognize the importance of the protocol for safety, but it does affect their NJIT Makerspace usage time. In addition, PPE such as the gloves presented a concern in practice. This would need to be further explored including providing further training on their use and additional
information on sizes available to members. The positive aspect of helping students become more organized was also of note.

Figure 6. Responses from those that used the NJIT Makerspace in Fall 2020. Reaction to whether (A) protocol requirements (B) PPE (C) social distancing (D) cleaning requirements had negative impact on NJIT Makerspace use.

Figure 7. Respondents that used the NJIT Makerspace in Fall 2020 impact of protocol requirements on use of NJIT Makerspace to meet academic requirements for the (A) entire group and (B) solely the 3rd Yr. MFG CRSE where all respondents were required to use the NJIT Makerspace.
Table 5. Mode and median results on specified questions from respondents who used the NJIT Makerspace Fall 2020.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have or would use the University Makerspace under a typical environment (pre-pandemic: no public health crisis).</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Under a typical environment (pre-pandemic: no public health crisis) I have or would use the Makerspace:</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>The University Makerspace COVID-19 Protocol was ____________ on my decision to use the University Makerspace and its resources.</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>I believe the University Makerspace COVID-19 Protocol is:</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>The University Makerspace COVID-19 Protocol makes me feel comfortable to physically use the University Makerspace and its resources.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>How would you rate the quality of the University Makerspace COVID-19 Protocol?</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>The requirements described in the University Makerspace COVID-19 Protocol had a negative effect on my ability to use the resources at the University Makerspace.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>The University Makerspace COVID-19 Protocol social distancing configuration had a negative effect on my use of the University Makerspace and its resources during the Fall 2020 semester.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>The University Makerspace COVID-19 Protocol cleaning requirements had a negative effect on my use of the University Makerspace and its resources during the Fall 2020 semester.</td>
<td>2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 6. Representative comments regarding physically using the NJIT Makerspace and adhering to the NJIT Makerspace COVID-19 Protocol.

<table>
<thead>
<tr>
<th>Number</th>
<th>Comment</th>
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<tbody>
<tr>
<td>1</td>
<td>The University’s COVID protocol gave me peace of mind when it came down to visiting the makerspace for my class this semester. We are dealing with some challenging times but I am glad that the University has taken the necessary steps to make everyone feel safe.</td>
</tr>
<tr>
<td>2</td>
<td>The gloves are really hard to work with and are always way too small for my hands.</td>
</tr>
<tr>
<td>3</td>
<td>When working with any abrasive material, the gloves break easily.</td>
</tr>
<tr>
<td>4</td>
<td>The protocol is understandable and I agree with it but it does make learning and physical use of makerspace difficult with less time.</td>
</tr>
<tr>
<td>5</td>
<td>Using the University Makerspace this past semester was great. Adhering to the protocol was no problem. In fact, it allowed me to be more organized. I only brought in components necessary for the project and worked on them.</td>
</tr>
<tr>
<td>6</td>
<td>Everything is understandable and the rules are only for the sake of safety.</td>
</tr>
</tbody>
</table>

Open Questions for Future Work
The open questions generated from this study are centered on the group of students that did not use the NJIT Makerspace during the Fall semester. There are members of this group that indicated that they would not use the NJIT Makerspace under non-pandemic conditions, and also
not as often (Figure 8). This finding is in contrast to what is seen with users of the NJIT Makerspace during Fall 2020 (Figure 4A-4B). Table 3 shows certain engineering/science groups have more individuals that did not use the NJIT Makerspace in the Fall 2020.

![Figure 8](image)

**Figure 8.** Responses from those that did not use the Makerspace during the Fall 2020 semester. Reaction to pre-pandemic Makerspace (A) usage (mode=5 & median=4) and (B) frequency (mode=4 & median=4).

This can be seen in the Electrical Engineering and Civil Engineering/Surveying/Construction areas. This suggests that there may be an influence by the area of study that affects NJIT Makerspace usage, which has been reported in other Makerspace studies [17]. An analysis on the importance of the NJIT Makerspace for professional growth and development also demonstrates that the group that did not use the NJIT Makerspace, does not feel as strongly on its value on professional development as the group that did in the Fall 2020 (Figure 9).

![Figure 9](image)

**Figure 9.** Difference in view on NJIT Makerspace contributing to professional development for those that (A) used the NJIT Makerspace (mode=5 & median=5) and (B) those that did not (mode=5 & median=4).

In addition, the open question on NJIT Makerspace usage also involved the general effect of the COVID-19 pandemic on student interest to come on campus. Based on the potential contribution of discipline this was observed looking at one discipline. Mechanical Engineering shows a close split between those that used the NJIT Makerspace and those that did not in Fall 2020 (Table 3).
This group also shows that those that did not use the *NJIT Makerspace* would under pre-pandemic circumstances (*Figure 10*). The COVID-19 protocol did not provide the same comfort between the groups that used and did not use the *NJIT Makerspace* in the Fall 2020 (*Figure 11*). Half of the respondents indicated they were “neutral” and a segment “disagreed”.

<table>
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*Figure 10*. Difference in view on *NJIT Makerspace* use for Mechanicals that (A) used the Makerspace in Fall 2020 (mode=5 & median=5) and (B) those that did not (mode=5 & median=5).

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<td><img src="image" alt="Figure 11" /></td>
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*Figure 11*. Difference on how the COVID-19 protocol made Mechanicals feel for those that (A) used the *NJIT Makerspace* in Fall 2020 (mode=4 & median=4) and (B) those that did not (mode=3 & median=3).

In addition, Mechanicals who did not use the *NJIT Makerspace* in the Fall 2020 also took more courses online (*Figure 12*), where all the respondents were registered for courses and no one indicated they were taking face to face courses alone. This may indicate a general effect of the COVID-19 pandemic on respondent interest to come on campus, which in turn affected their use of the *NJIT Makerspace*. These observations were not part of the scope of this research; however, provide future areas of potential study.
CONCLUSION

The development of the *NJIT Makerspace* COVID-19 protocol has allowed in person manufacturing and experiential learning to continue to take place at our university during the COVID-19 pandemic. The implementation of this protocol was not without its challenges and questions. This study begins to address some of the questions centered on whether the protocol’s requirements have a negative impact on students use of the *NJIT Makerspace* resources. Most respondents who used the *NJIT Makerspace* in the Fall 2020 did not believe the protocol’s requirements had a negative effect (Figure 6). However, one area requiring further investigation is if the protocol had a negative effect on the use of *NJIT Makerspace* towards achieving academic requirements (Figure 7). This would have to be further explored in a follow up study. The qualitative comments (Table 6) are in line with the quantitative findings. Respondents recognize the protocol’s quality and importance for safety; however, express concerns on the glove PPE and usage time. These points would need to be addressed with potentially further protocol development and training. Future work could also explore groups that did not use the *NJIT Makerspace* in the Fall 2020. This includes whether it is driven by overall COVID-19 pandemic concerns, or by academic and professional interests. This study has limitations that could affect the interpretation of results. This includes the data which was collected by the self-reporting of students. This limitation would have to be addressed through the development of assessment tools that are independent of self-reporting. In addition, student responses to some survey questions could have been influenced by minimal experience in using the *NJIT Makerspace* under non-pandemic conditions. In conclusion, this work provides preliminary guidance on protocols needed to facilitate in person manufacturing and experiential learning education during the COVID-19 pandemic. This guidance could have a broader impact and potentially be applied to other in person academic activities.
REFERENCES


