State of the Shop 2015:
Focusing Today's Arts Resources to Anticipate Tomorrow's Emerging Technologies

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I. Introduction

Academic theater's unique structure, both fiscal and production oriented, compels technical directors and shop foremen to engage with technical colleagues at peer institutions to plan expansion and modernization efforts in their own shops. By assessing the tools, equipment, and safety practices of shops in similar settings, technical directors are able to compare budget practices and spending percentages for sustainability, acquire new technologies with confidence in their applicable use, and create safety procedures and protocols on par or above the industry standard.

Technical directors and scene shop foremen, in this document referred to as TDs and Foremen respectively, often find themselves utilizing the advances and inventions of both similar and seemingly unrelated industries. These industries, steeped in a far more scientific and structured heritage than our own, develop highly specialized equipment with precise functions as solutions to their industry challenges. In that spirit, the "re-inventors" of technical theater identify, acquire, and repurpose these technologies in order to improve our productions. Lacking the profit-driven funding of the corporate private sector, technical theater artists adapt readily available equipment to achieve the often impractical, always imaginative, feats scenic designers and directors conjure.

Collaboration between designers, directors, and TDs, is the driving force behind stage production. Technical theater artists find their roots deep in an open-source community of trade secrets and experiences. A successful adaptation of emerging technology in one production inspires the creative process of another production; likewise, the organization and inventory of a single shop will influence industry standards

as colleagues move from scene shop to scene shop, attend professional workshops and conventions, visit old friends and institutions, or subscribe to relevant publications.

The ever-present fiscal reality of non-profit theater permeates every aspect of the shop. From production specific designs to company infrastructure and staffing, producers, boards, and artistic directors keep the dollar in most every conversation. Many of the impressive and exciting emerging technologies require substantial purchasing power that drain annual discretionary spending accounts and shop maintenance funds. One-time grants and private gifts are often sought to "green-light" modernization and development initiatives requiring TDs and Foremen to be savvy in more than just tools and construction. With the zeal of computer guided and automated equipment on our desktops, TDs must justify the cost of these large price tag technologies with their benefit to departmental productions and, more importantly, to the students in their higher education program.

The research collated in this document provides an introduction to popularly sought after tools and equipment with current appeal to shop leadership in the higher education community. The research aims to highlight common currents in theatrical funding at academic institutions. Examining factors such as annual production budgets, number of shows produced, and shop budgets as a percentage of the overall production budget, the research provides a context for discussions regarding new equipment acquisition and how they can improve the shop or productions.

This project is also the product of an extensive transnational survey of academic shop management. The cross-spectrum glimpse into diverse shop resources and technologies informed the data organization and structure of this comprehensive

snapshot. To that end, I distributed a survey to over 200 university scene shops in the fall of 2014 garnering 35 complete responses. This survey, which can be found in Appendix A at the end of this report, solicited information focused on six attributes of a scene shop: institution and facilities basics, scene shop basics, labor pool demographics, productions, grants and other funding, and a specific category looking at Virginia institutions access to and use of Equipment Trust Funds. Participants in the survey ranged from small liberal arts schools to nationally renowned programs. A complete listing of survey participants can be found in Appendix B. In order to organize these responses, a school's Annual Production Count, APC, was calculated and used for categorizing to provide a common context for each group. Placing programs and shops with similar volumes of work together allows the data to reveal how individual shops are accomplishing similar goals to its peers within the same APC range.

I would be remiss if the survey failed to address safety equipment, practices, and infrastructure in the academic shop setting. Initially concerned with Personal Protective Equipment, herein referred to as PPE, the survey investigated PPE provided in each of the respondent shops. With regard to safety, this study also addresses various shop practices regarding long-term exposure and environmental impact. Safety is paramount in our industry and as the survey revealed, the solicited shops are committed to providing a safe and conscientious workspace.

By looking, without bias, at the current trends in our fiscal realities and analyzing the cost and benefits of modernization, this project hopes to keep focus aimed on the progression of our craft at a sustainable pace by identifying and adapting the funding and acquisition patterns that fuel the vitality of our programs.

II. Context and Research

i. Primary Research, "The Survey"

Of the 200 four-year Universities and Colleges solicited, 47 institutions participated in the survey resulting in 35 responses with complete data sets. With the information gathered, three categories, A, B, and C, were developed as a means for comparative statistics grouping peer institutions by key data. To ensure the veracity of the statistics and data, the researcher confirmed responses that stood out or appeared significantly outside the data sets. Factual errors and anomalies unable to be reconciled were excluded from the research; thus, due to skipped inquiries or missing information, 35 respondent institutions were categorized based on their completed surveys.

The survey was structured such that respondents answered questions in the following areas with the following themes:

- Institution and Facilities Basics
  - Professor Count, Enrollment, Number of Theaters, Technological Infrastructure of Theaters
- Scene Shop Basics
  - Stationary Tools, Metal Working Tools, Safety Equipment and Procedures, Facilities
- Labor Pool
  - Number and Type of Employees/Volunteers, Degrees Held
- Production Basics
  - Annual Production Count, Budgets, Show Specific Technologies (Rigging, Automation, Flying, Rentals, etc…)

- Grants, Gifts, and Other Monies
    - Federal, State, Local, and Non-Profit Grants, Monetary Donations, Donations of Time, Materials, and Tools, Budget Surplus, Ticket Sales, Student Activity Fees, and Other Incomes
- Virginia Equipment Trust Fund
    - Years Applied, Frequency of Application, Asking Amounts, Amounts Received, How Was Money Used

With this format, the survey enabled comparison of seemingly dissimilar programs by aspects in which they are, at times, identical. The responses and resulting data sets allow an objective look at academically oriented scene shops based on the preceding six attributes and characteristics.

iii. Institution and Facilities Basics

. Survey wide, the average number of undergraduates participating in departmental work is 72 students and the average undergraduate student to faculty/staff ratio is 1:2.9. Furthermore, it was determined that 49% of categorized respondents provide graduate programs at their institution and averaged a 2.8:1 ratio of undergraduates to graduate students within the department[1]. The programs providing graduate studies sustained typically larger undergraduate programs with higher Annual Production Count, APC. If we compare the average enrollment of each category with their APC, listed in Figure 1 below, we can see, quite clearly, the percentage of a typical

[1] *Student Ratios were determined by respondent answers in The Survey and were calculated by the researcher.*

season each student is expected to support: Category A, 12.5%; Category B, 8.1%; Category C, 5.8%; All Participants Average, 7%.[2]

Survey Category	APC	Enrollment
Category A	11.7	93.9
Category B	6.1	75.6
Category C	4	69.1

Figure 1 - All Survey, APC v. Enrollment

iv. Scene Shop Basics

Some categories depend heavily on the individuals, as evidenced above, while others share the load, theoretically, more equitably across their larger enrollment, but all categories are susceptible to crippling infrastructure and equipment deficiency. TD's create shops that fulfill their expectations for production; they acquire the tools and technologies to anticipate the challenges individual productions bring. More so than non-industry tool catalogs geared towards home, road, and infrastructure construction, looking at institutions in each category, listed in Appendix B, gives an industry based answer to a question old as time: "Which is the right tool for the job?"

Prior to modernizing and updating tools, it is imperative to create a plan and identify which technologies are most critical to the day-in, day-out functions of one's shop while simultaneously identifying which tools are the most antiquated or obsolete. By cross-referencing the critical tools list with equipment in need of upgrade, a TD can use the combined list to make an educated plan for purchasing and integrating new equipment.

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[2] *The percentage of the season a student supports determined by dividing APC count by enrollment.*

This survey provides critical statistics for a list of basic shop tools, based off ownership rates at institutions in each category. Nowhere more apparent than with stationary power tools, the statistics created a short list of industry agreed upon tools by looking at the Percent Owned Rating, expressed %, of each tool. Asked to identify if their shop owned certain tools, respondent answers were used to create Figure 1 below, where the more frequent answers are in larger, bolder text showcasing responses occurrences.

Using the Percent Owned Rating of each tool, all 45 schools agreed upon the following five tools based on current inventory: Table Saw, Compound Miter Saw, Drill Press, Band saw, and Bench Sander. The first three tools warranted a 100% with Band Saw at 97% and the Bench Sander at 91%.

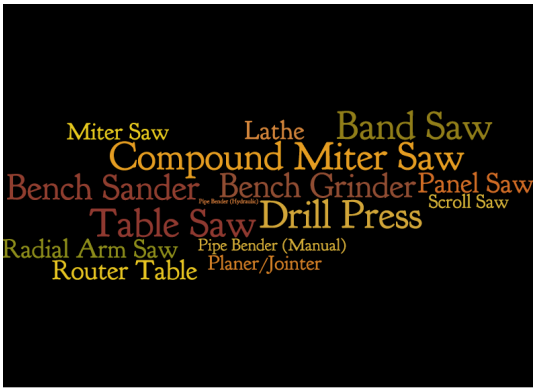

Figure 2 – Percent Ownership Stationary Tools

Tool	% Owned
Compound Miter Saw	100
Table Saw	100
Drill Press	100
Band Saw	97
Bench Sander	91
Bench Grinders	86
Panel Saw	71
Router Table	69
Radial Arm Saw	67
Wood Lathe	67
Miter Saw	60

Figure 3 – All Survey, Stationary Tools

Understanding these statistics provides a de facto, industry approved list of basic stationary power tools across the board, found in Figure 3 on the next page. Later, the report will look specifically at the unique tool combinations in each category; however, it is safe to say that all shops, regardless of category, should possess the top five tools and consider the remaining top ten tools prior to acquiring other equipment.

While the aforementioned tools primarily or solely benefit carpentry and wood working enterprises, the survey also assessed the shops based on their metalworking capabilities and equipment, directly asking about seven tools, listed in Figure 4. One of the seven, an Arbor Press[3], is not present in any of the shops within the purview of the survey; however, the ranking of the remaining six tools is quite enlightening. On the list of metal tools, three welders were present: Flux[4], MIG[5], and TIG[6]. Of these three tools, MIG welders are most popular in academic shops; a statistic most likely attributable to MIG weldings' shallow learning curve and reliability. Figure 4 shows the MIG welding process and equipment as preferential in collegiate production compared to TIG or Flux.

Tool	% Owned
MIG Welder	97
Abrasion Saw	93
Portable Band Saw	75
Plasma Cutter	60
TIG Welder	38
Flux Welder (Stick)	32
Arbor Press	0

Figure 4 - All Survey, Metal Tools

Some tools are created for precision, others power, and still some for the unconventional cuts. Based on the data collected, a metal shop, at minimum, should be equipped with a MIG welder, Abrasion Saw, and Portable Band Saw in order to meet the production challenges of higher education shops. Plasma Cutters and TIG welders may benefit the shop as it develops, but are perhaps best left for later acquisition.

Other factors should be considered when considering the Scene Shop. While the tools eventually dictate workflow and productivity, the physical limitations of the shop and secondary tools, i.e., personnel lifts, wenches, etc, plays a significant and long-term

[3] *An Arbor Press is a tool used for riveting and other tasks such as inserting bearings.*
[4] *Flux refers to a type of welder that uses Flux Core sticks in lieu of wire and gas. Commonly called "Stick"*
[5] *MIG refers to a type of welder that uses spool-fed wire and inert gas, typically carbon dioxide and argon.*
[6] *TIG refers to a type of welder that uses a non-consumable tungsten electrode, gas, and filler metal.*

role in shop atmosphere. Our shops must reflect the realities of our theaters architecture. For instance, a shop's ceiling height affects more than just the airiness and comfort of a shop. The shop should theoretically be taller than the Proscenium height of its stages to allow for mock load-ins of the set. From all the responses gathered, the average ceiling height is 21 feet tall.

Likewise, the shop floor is a critical design element of the shop. A concrete slab brings durability, longevity, fire resistance, and low maintenance; however, it is uncomfortable over long periods of time and can cause discomfort for those working on projects at the floor level for extended periods of time. Many carpenters develop chronic knee pains, shin splints, and lumbar/lower back pain when working 40+ hours a week on concrete slabs. A second option common in shops for flooring is wooden floor construction. Wooden floors allow for versatility of use, i.e., jigs and floor level construction, but require maintenance and repair far more often due to material degradation while its flammability remains a concern for any welding areas and shop safety. 74% of shops were built with primarily concrete floors, seemingly an indisputable industry preference, however the survey did not identify the extent at which a department had buy-in on the building design. 40% of the shops have combination floors, partially or completely wooden floors, specifying that their metal areas were concrete addressing the combustible dangers of welding. 14% of shops reported an "other" flooring solution, with 1/3 of these shops specifying a Masonite deck without specifying the sub flooring. Masonite is a brand name term for hardboard made of wood fibers pressed together under heat and pressure (Turner). In Figure 5, the volume of responses shows the overlap of combination shops.

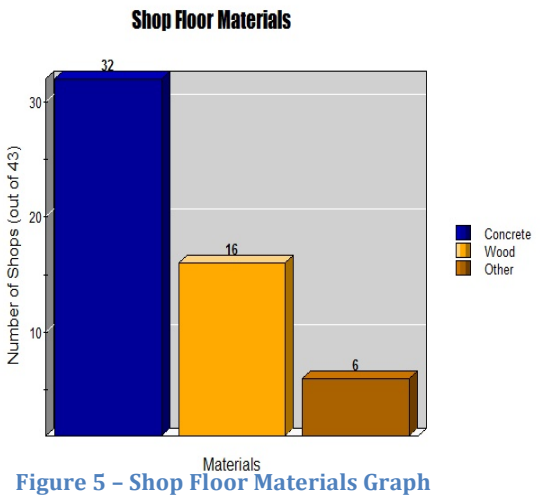

Figure 5 – Shop Floor Materials Graph

While it's commonly understood that no shop is big enough, shop layout can maximize the efficiency of use. To be sufficient, the square footage of your shop must provide ample area for stationary tools and their use, lumber and sheet good storage, and project work areas.

If it is deficient in any of these three areas, one can expect delays in production as time is spent moving projects, tools, materials, or people out of one's way in order to finish a project. While architectural factors like electrical outlet placement and pneumatic breakout points largely affect shop layout, one can maximize productivity by considering workflow and how their shop uses each tool. Perhaps the band saw is mounted on a mobile base, a vise can be unbolted from the concrete slab, and worktables are modular, allowing for flexibility of the space in light of one's structural limitations.

The respondent schools displayed a wide gamut of total square footage in their shops. As we will see in the categorical breakdowns, these ranges are full of common groupings. For example, many shops surveyed, are in the 1,200 sq. ft. range. For this reason, the report's typical trend of averages does not seem to fit for an all participants statistic. Instead, the data clearly showed that shops tend to fall in the following ranges: Large, >5,000 sq.ft. ; Medium, approximately 3,000-4,000 sq.ft.; Small, up to 2,000 sq.ft. Converse to logic, as we'll see when we break down the individual categories, not all high production shops are large square footage and vise-versa suggesting that proper use of any shop size will yield a high volume of production.

The last Scene Shop Basics question of the survey looked into tools that aid in installation, but not necessarily construction. The focus question for these tools asked participant institutions to identify if they owned a personnel lift for their facilities, for example a Genie®[7]. With resounding unanimity, 89% of institutions own a powered personnel lift with only five institutions reporting no lifts. While speculation of cost and maintenance coupled with the resilience of man-power might dissuade an institution from investing in a personnel lift, it seems apparent that the industry and our peers condone and encourage the acquisition of these tools.

v. Labor Pool

As an almost entirely hands-on industry, the work force in college scene shops dictates not only the pace, but also the quality of our work. In order to advance our human resources even keel to technology, we must see our employees, students, and volunteers as an evolving and moldable. We must focus on training and educating team members throughout their time with our companies. This facet of our labor pool comes naturally to the collegiate shop as the culture of mentorship and progression are intrinsic to our community, especially regarding students, but shops must consistently make room for technical training and educational opportunities.

Reporting shops show an even distribution of novice, mid-career, and master craftsmen in our shops. M.A.'s and M.F.A.'s[8] own a 25% share of the typical college labor pool, excluding students, while Bachelors degrees and High school diplomas share 27% and 28% of the work force respectively. From an education stand point, our shops

[7] *Genie is a brand name referring to powered personnel lifts that allow individuals to work at various heights from a secure basket like structure.*

[8] *Master of Arts and Master of Fine Arts are American post-Bachelor's degrees.*

are both diverse and well educated. However, we must look past the classroom and traditional educational opportunities, looking towards professional certifications, internships, and career building programs to provide a well-rounded education for our students, while stimulating professional advancement and accolades for our colleagues.

Our industry and peer industries are teeming with professional certifications and associations, yet a surprisingly small amount of the respondent shops are staffed with certificate holding individuals. The survey found 5% of shops responding are staffed with an Associate Welding Inspector[9] and only 2% of shops have advanced welding inspectors. Similarly low, surveyed shops reported small amounts of ETCP certified riggers and electricians[10] with only 21% employing ETCP riggers and 8% of shops supported by ETCP electricians. As educators, we must epitomize the ideal of life-long education by pursuing further credentials. On the healthy side, our institutions are empowered by professional organization affiliation and participation. Of the surveyed schools, 81% are affiliated with USITT and 40% employ members of IATSE. These connections are gateways to new ideas and professional opportunities to both students and staff alike, while our certifications continue to enhance our programs prowess both on paper and in practicum.

vi. Production Basics

In order to truly understand the how's and why's of a shop's structure, from the labor pool to the equipment, one must understand the scope of their work, or in the

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[9] *Associate Welding Inspector and other welding certifications are earned by fulfilling certain requirements through the American Welding Society.*

[10] *The Entertainment Technician Certification Program is the industry standard certification for Riggers and Electricians. The program runs through PLASA in conjunction with several national entertainment professional organizations and associations.*

theater world, the scale of our productions. A strong shop must be cohesive in all aspects of its production, directing the relevant resources to the correct project at the proper time. Budgeting and expense predictions are an every day occurrence in the TD's responsibilities. Eliciting the most efficient use of each dollar requires proper foresight, an intrinsic ability to cultivate symbiotic borrow/loan programs with peers, and foster beneficial relations with vendors. As the survey revealed, most of our programs operate on narrow margins and utilize our funds to their full extent.

Most college theater sets are produced on budgets less than five thousand dollars. The average scenic budget for a non-musical, department-sponsored production across all of the participating shops was $4,341. Scenic budgets in this category vary drastically. Many institutions specified ranges of their own citing different variables. For instance, one institution reported they have "main stage $4500, small stage $1000, [and] minimally produced $500" standard budgets. While the survey range was much larger, $250 to $30,000, this example seems much closer to the majority of shop's budgets. The most common range, as evident from the responses, is $2500 to $4000 for non-musical production. These productions make up the bulk of our collective seasons in conjunction with larger musical productions with approximately 5 productions annually in each of our departments.

In their responses, 77% of shops reported at least one musical production averaging a $6,770 scenic budget. If this statistic seems higher than you might imagine, you are correct, as several institutions reported scenic musical budgets in excess of $15,000, as high as $40,000. It may be helpful for comparative reasons to look at the

most common range of scenic musical budgets: $4,000 to $7,000. Typically, departments produced a single musical during their season.

Using the reported budget averages, the collective buying power of our scenic departments has a value of $173,650 for a single non-musical production annually.[11] For musical productions, just the participant schools scenic budgets total $236,950. Using the average number of productions from our 34 categorized[12] participant schools, factoring one musical per season, this leaves six non-musical productions per season. Statistically, this means that survey participant institutions have an annual buying power of $1.3 million. Extrapolate this to the 2,870 four-year colleges and universities in America[13], understanding that not all institutions will offer theater programs or produce seven shows annually, but quickly it emerges that our industry has significant purchasing power in our communities with consolidated expenditures in the tens of millions[14].

Regardless of our show specific spending, TD's and Foremen can attest the cost of a season doesn't stop at the lumberyard. Shop budgets are a typical form of support separate from production funds that aim to cover tool maintenance, replacement, and new acquisition as well as any infrastructure costs, such as new work tables, wood racks, material storage, etc… While the survey was inconclusive regarding shop budgets not earmarked for productions, from personal experience these budgets tend to come in around $5,000 per season depending on the size of your shop.

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11 *Statistic calculated using average scenic budget for non-musical multiplied by total number of institutions.*

12 *This statistic uses categorized schools only as they had complete Annual Production Counts reported.*

13 *According to the NCES and U.S. Department of Education, there were 2,870 four-year institutions for 2010-2011 academic year.*

14 *Conjecture based off annual spending totals of $300k for 34 schools then multiplied by 84 to account for the remaining 2,836 institutions. The conservative expenditure, 25% of actual statistics gathered, prevents bloating of statistic and understands the majority of remaining institutions would not produce 7 shows a season.*

vii. Grants, Gifts, and Monies

With most of the funding that passes through the shop tied up in directly related production costs, TD's must look outside the department in order to find capital to augment their shop budgets. As our shops all reside or operate in the context of an academic community, Grants and Gifts play a huge role in the search for additional monies. Federal, state, local, non-profit, and even corporate sponsorship and grant opportunities are all viable options. The logical first choice is additional funding through your home institution. Many schools offer additional funds and grants with qualifiers such as student experience impact or interdisciplinary themes. The University of Virginia for example offers grant opportunities, with varying requirements, to students, for staff ventures, and for community enrichment ranging from a couple hundred dollars to thousands of dollars.[15]

The survey asked institutions to identify where their grant monies originated and the results were much as one would expect. 37% of shops received supplementary grant funds from their home institutions while only 29% of shops received additional funding directly from the State. Similarly, 24% of participating institutions received funding from a Third-Party, Non-Profit organization with only 5% of shops citing Third-Party, Corporate sponsorship. Meanwhile, 10% of shops reported some form of support from Local, City, or County funding. Contrary to this project's conjecture, 0% of shops reported any direct Federal aid in grants or supplementary funds.

[15] *Information is publicly available through www.virginia.edu.*

While it would appear that most shops do not apply for or receive additional funding outside of their annual and production budgets, those that do, have found significant success. Of the shops that reported grant monies for discretionary use, the average three-year amount is $12,071 with a combined three-year total of $84,500. This means that the average annual grant award per shop over the last three years has been approximately $4,000; as stated earlier, the most common budget range for a non-musical production is $2,500-$4,000. It is imperative that scene shops are proactive in their search for additional funding in order to anticipate the eventual degradation of current equipment and the acquisition of new technologies.

There are other sources scene shops rely on for additional capital. 60% of surveyed shops reported getting some share of box office receipts. Additionally, 56% of the same shops garnered funding from the college or universities Student Activity Fees.[16] Even though the survey did not determine dollar amounts for either of these funding sources, it is apparent that over half of our shops consider these sources when determining total annual budget; however, like most academic based departments and organizations, the home institution typically reclaims any surplus at fiscal year close, as is the case with 92% of respondent shops. Excepting the 3 shops who retain monies year to year, this puts even more pressure on the TD grant search to procure new monies, as traditional savings based solutions do not apply since the home institutions receive budget surpluses.

[16] *Student Activity Fees are a standard part of an institution's Tuition & Fees and are used to fund organizational activities intended for student enrichment or experience.*

viii. Virginia Equipment Trust Fund (ETF)

In Virginia, the General Assembly[17] of 1986 created a higher education initiative that directly impacted the academic theater community. The Higher Education Equipment Trust Fund, or ETF, established a financial well to assist institutions retrofitting and modernizing their facilities (United States, Virginia 1). ETFs are available to countless departments throughout the academic community, but the survey found ETF has played an integral role in the advancement of theater departments throughout the commonwealth regardless of institution's general endowment. For example, ETFs have enabled survey participants to purchase panel saws, table saws, personnel lifts, MIG welders, pneumatic tanks, and lighting and sound equipment. Other significant facilities improvements at survey participant institutions that were funded by Virginia's ETF include J.R. Clancy equipment[18], Creative Connors equipment[19], wireless microphone systems, theatrical curtains, and LED[20] lighting solutions for the theater.

Five of the participant schools reported use of the Virginia ETF program: , Christopher Newport University, College of William and Mary, Radford University, University of Mary Washington, and University of Virginia. Respondents report successful grant applications as high as $100,000. Virginia academic theaters reporting have enjoyed relatively consistent success in applying and receiving monies from the ETF. Ranging from 33%-77% of applied funds granted, the average grant request

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17 *The General Assembly is the Virginia Commonwealth legislative body.*

18 *J.R. Clancy is a rigging and fly system company that provides installation and automation services designed for the theater.*

19 *Creative Connors specializes in stage automation and provides several models of automation equipment ranging from stage revolvers to overhead winches.*

20 *LED lights are a specific conductor that operates on low voltage to produce high output for energy efficiency.*

received 60% of the requested funding.[21] While only 20% of Virginia institutions surveyed apply for ETFs on an annual basis, the schools applying annually consistently receive $10,000 or more with the ceiling up to $100,000.

Virginia ETF Participants and Statistics		
School	Frequency Awarded	% Awarded
Radford University	1	77
University of Mary Washington	1	50
Christopher Newport University	1	N/A
University of Virginia	3	33
College of William and Mary	4	50

Figure 6 - Virginia ETF Statistics

Leading the list is Radford University with annual ETF applications and the highest reported disbursements. Radford both applies for the highest ETF price tag and sports the highest success rate at 77% of funds awarded. Following Radford, the University of Mary Washington applies annually receiving half of the funds applied for. Christopher Newport University receives money annually, but did not report any values, applied or received, so success rate is incalculable. University of Virginia applies for an ETF grant approximately every three years with awards equaling 33% of the requested funding. Following the University of Virginia, the College of William and Mary applies annually; however, they reported disbursements approximately every four years with 50% of funds granted.

ix. Categories

While NCAA Division status is a means for grouping the various sports teams in collegiate athletics, it is interesting to examine each category derived from this survey in terms of Division status as well. NCAA Divisions are accompanied with a preconceived

[21] *Calculations based off correlating respondent answers to questions 35 and 36 of The Survey.*

notion of size, endowment, and enrollment. As this report explores categories A, B, and C, in depth, it is apparent that D-1 schools produce, at least, at a higher volume.

a. Category A

Institutions in this category are the most populated of the surveyed schools. On average, 75.7 undergraduate students inhabit the shops and theaters of these colleges and universities. Totaling 833 undergraduates, Category A has the second highest volume of undergraduates, behind Category B. 63% of Category A institutions train the most graduate students of the categories with 200 students continuing their education at the eleven institutions for an average of 18.2 graduate students across the category. Category A accounts for 352 faculty and staff positions in higher education with an average 32 professionals at each school. The total student enrollment to faculty/staff ratio in Category A is 2.9 to 1, the lowest of the categories. There 1,385 sets of hands and brains at Category A's disposal, faculty, staff, and students, working to produce their seasons.

Category A's high production output is quite impressive; eleven schools producing a total of 129 shows in a typical season.[22] While this category may imply a high level of sophistication, overflowing budgets, and unrestricted access to resources, the composition of Category A is quite diverse. In fact, Connecticut College, an NCAA Division 3 institution, joins the likes of the University of Nebraska and Northwestern University, two NCAA FBS Division 1 schools, in Category A (Schools). Even with unique programs of distinctly different scale and home institutions, each of the Category A schools sponsor a minimum of ten productions each season. Assuming one musical

[22] *See Appendix B for individual institution's production count.*

production and nine typical stage productions, Category A averages $81,034 per school each season based on a $6,861budget for non-musicals and a $19,285 musical budget.[23]

To produce these seasons, Category A schools use both standard and cutting edge technologies, relied on significantly larger facilities, and use all of the Top 5 Stationary tools. More notable, is the percent ownership of the remaining Top 10 stationary tools.

90.9% of Category A shops have a Bench Grinder compared to 86% of all surveyed schools. Similarly, and more impressively, 81.8% of scene shops own a Panel Saw in Category A.

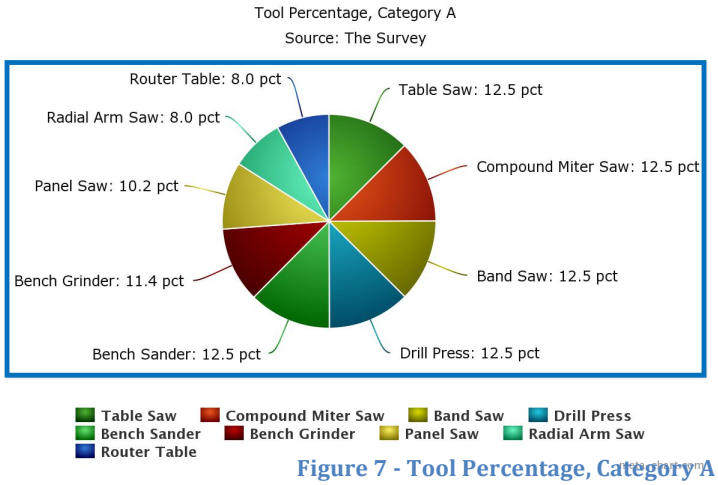

Figure 7 - Tool Percentage, Category A

All institutions accounted for, only 71% of schools had Panel Saws. As the Panel saw is used for cross-cutting sheet goods, the saw alleviates the need for sawhorses, handheld circular saws, and saw guides to cut stock goods down resulting in safer and more efficient build processes. Conversely to the first seven tools, the Radial Arm Saw and Router Table are found in less Category A shops than the all survey results would imply, with each tool owned by 63.6% compared to their respective 69% and 67% ownership survey wide. The data found in the survey results and subsequent categorization of institutions, helps us identify what stationary tools are intrinsic to a shop's success allowing us to focus our resources as necessary. From the data above, the

[23] *Averages determined by averaging the estimated budgets for individual productions from each university then multiplied by 129 for Category A's total production output.*

preference for a Table Saw over a Panel Saw is resounding even though the two tools are similar both in function and construction.

Meanwhile, the Averages for metalworking tools in Category A stayed fairly consistent with the all survey averages. 100% of scene shops in this category own a MIG welder, 3% higher than average, while about 12% more of Category A uses TIG welders than average: 36.4%.[24]

Citing technologies such as the Cold-Cut Saw[25], only 90.9% of A shops own Metal Cut-Off Abrasion Saws compared to 93% of surveyed shops as a whole.

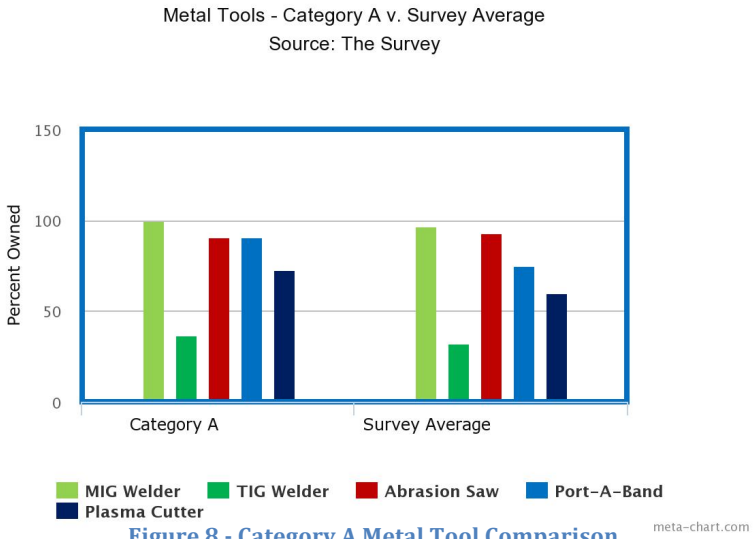

Figure 8 - Category A Metal Tool Comparison

Conversely, Category A shops are a significant group in the survey average, 60% of shops owning a Plasma Cutter, as 72.7% of shops in this category own one. Similarly, the Port-A-Band can be found in 75% of all shops, but in Category A welder has a 90.9% chance of using one.

To house all of this equipment, Category A shops rely on large shops. The average shop in this category is 3,243.2 sq.ft. which is almost 20% larger than the survey average 2,739.2 sq.ft. Surprisingly, the average ceiling height in Category A shops is only 19' 1 ¼", the lowest of all three categories and over three feet shorter than the survey average of 22' 4". While floor space is a premium, overhead space is useful for building

[24] *Percentage differences were determined by dividing the difference between the category and survey average percentages by the survey average percentage.*

[25] *A Cold-Cut Saw is a toothed-blade saw that uses a liquid medium to mitigate heat associated with cutting metal in lieu of a consumable abrasion blade.*

and moving large scenery, either from sheer space or, if the superstructure allows, rigging to the ceiling for a variety of applications. To alleviate workflow in the scene shop, 63.6% of Category A institutions also provide a specific Properties Shops.[26] Seven of the eleven Category A shops, 63.6%, also have designated Metal Shops equipped with higher amperage wall outlets, vent hoods, and other welding centric utilities. With these expanded facilities, counter intuitively, only 18.2% of scene shops in this category have separate shop facilities for scenic painting.

Category A institutions not only relied on larger shops and more tools to execute the higher volume of productions, but utilized more stages. 72.7% of Category A theaters reported 3 or more spaces in their complex. Most of the theaters are traditional Proscenium-style stages or Black-Box theaters as 90.9% of schools have at least one of each. 36.4% of schools in Category A own Thrust style performance spaces and none of the surveyed schools in Category A have a dedicated Arena space.

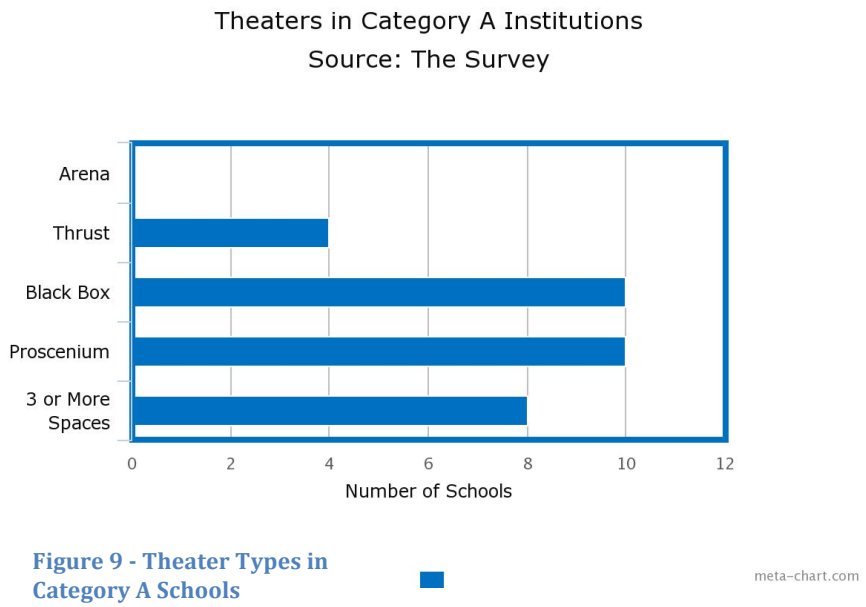

Figure 9 - Theater Types in Category A Schools

The quantity of facilities is a critical factor in APC as the percentage of schools with three or more spaces in Category B and C drop significantly, as do their average APC.

[26] *Properties refers to a department in theater whose work is similar to the scenic shop, carpentry, welding, painting, etc…and sometimes is combined with the scene shop facilities.*

Category A departments are steeped in a tradition of high volume seasons. Not only are they leading the surveyed universities in department productions, but also 36.7% of these schools host conventions, tours, and other productions in their spaces outside the direct purview of the departmental production teams. Admittedly, Category B plays host to outside productions more equitably, 43.8%, but also endeavor to present only 52% of the season Category A produces on average.

The seasons run a categorical collective of $891,374 in production costs based on a season average of $81,034, calculated at the beginning of this section from survey data. One school in Category A has an APC of 18; figuring the average scenic budget for non-musicals in this category is $2,766 and if the school produces only one musical at the categorical average of $6,242 for scenery, the institution spends an average of $53,264 on scenic elements alone. The budget averages used to determine the categorical PBP and MBP averages are in Appendix D, both all department and scene shop specific data, calculated in total dollars resulting in a PBP of 40.3% and an MBP of 32.4%.

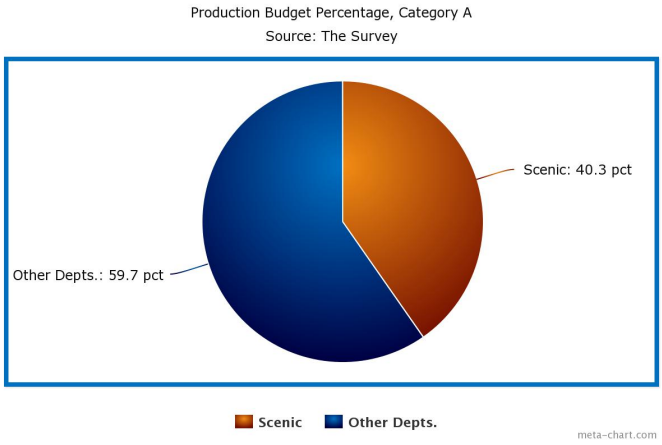

Figure 10 - Scenic Non-Musical Budget Share, Category A

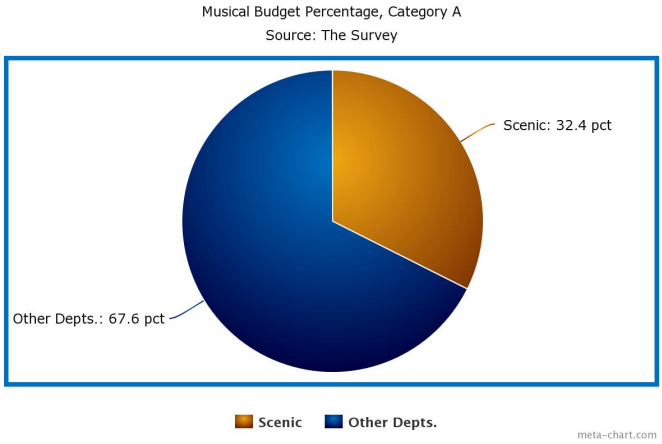

Figure 11 - Scenic Non-Musical Budget Share, Category A

Category A schools have produced advanced shows that incorporated many of today's appealing technologies. 63.6% of schools in Category A have contracted rigging professionals and equipment in order to fly performers in their venues. With only 21% of all shops employing ETCP certified riggers, this trend suggests that the in-house deficiency in credentials is covered through contracted services that bring liability insurance and experience to the table. Of the eleven schools in this category, just under half, 45.3%, create Automated scenery for their scenic designs. No doubt the 27.3% of institutions owning both drum winches and Creative Conners' Equipment, a company specializing in winches and automation motors, use these tools to execute their automated scene designs[27]. Expanding their stages to unprecedented levels, 90.9% of Category A schools use digital media solutions, such as image mapping and video, to enhance their storytelling. 36.4% of these schools are so committed to the consistent use of digital media that they have dedicated, permanently mounted projectors in their spaces. These technologies pose new opportunities for the stage that were seemingly unfathomable a few decades ago.

b. Category B

Compared to Category A, Category B produces less shows, but the group contains more schools. The aggregate totals from these two categories were very similar, often with Category B exceeding A's totals. In terms of student counts, Category B is comprised of over 200 more students. The 1,060 undergraduates in these theaters work with 150 Graduate Students; 50 less Graduates than Category A schools. The average enrollment for undergraduates and Graduates show a stark distinction from Category A

[27] *It should be noted that 0% of Category A schools reported renting Automation Equipment.*

however; average undergraduate totals are 75.7 and 66.3 per Category A and B school, respectively, but the Graduate enrollment averages are 18.2 for Category A and nearly half that for Category B institutions: 9.3.

With most participant schools in Category B having few to no Graduate students, 50% offer no graduate programs, the type of institutions forming Category B are more diverse in their program offerings, NCAA Division status, endowment, and other key characteristics of their universities at large. These universities represent a wide gamut of size, both in terms of enrollment and endowment; Category B is comprised of sixteen higher education institutions including the University of Virginia, Christopher Newport University, the University of Michigan, and the College of William Mary.

This diversity carries through to the individual departments. Fewer schools were produce at the higher ranges of Category A. The sixteen Category B schools produce 6 shows per season at each university, compared to 11 in Category A.

Eight of the sixteen B school facilities contain three or more theaters. Proscenium theaters, as one may suspect, were on all but one campus, with fourteen having full fly-lofts; thirteen schools have a Black Box theater. Half of these theaters are equipped with pit lifts/elevators and trap rooms.

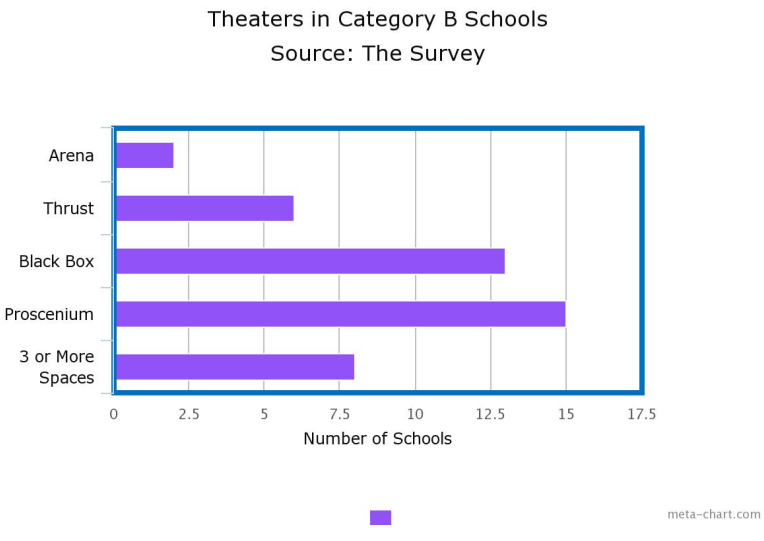

Figure 12 - Theater Types in Category B Schools

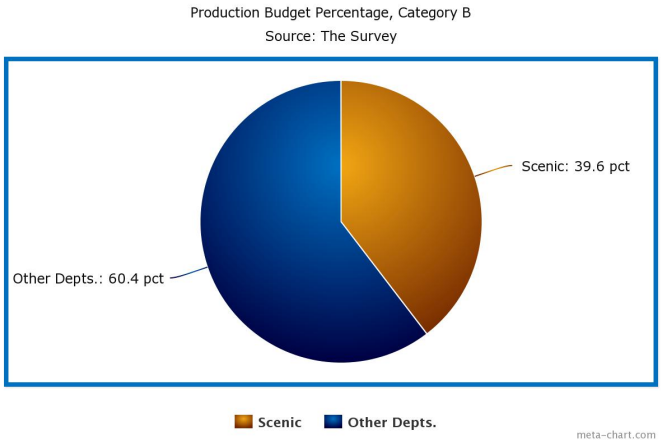

Figure 13 - Category B Budget Shares, Non-Musicals

In these spaces, Category B produce five non-musical productions with an average all department budget of $7,655. Scenic budgets for these productions averaged at $3,033. Gross budget for Category B non-musical productions per season have a major economic impact of $612,400.[28]

The Musical Budgets for Category B schools were substantially larger. Schools spent on average, $11,696 on all departments and $5,482 for scenic on their musical productions.

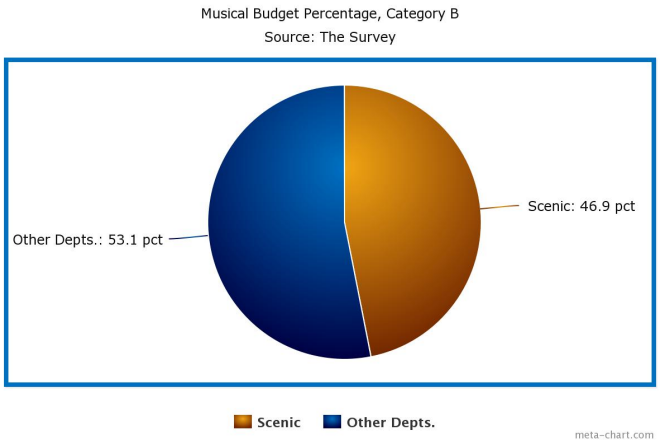

Figure 14 - Category B Budget Shares, Musicals

In Figure 9 and 10 of the preceding text, Category B's PBP and MBP are noted graphically.[29] The averages are relatively similar, about 7 points apart just under 50%, but the ranges are quite wide. Some Category B schools had PBP's as high as 80% and as

[28] *Gross economic impact of Category B non-musical productions calculated using the following formula: average number of non-musical productions per school (5) x average non-musical budget for all departments ($7,655) x number of schools (16).*

[29] *PBP is Production Budget Percentage and MBP is Musical Budget Percentage. These are budget comparisons of the scenic department's share of the overall production budget for each type of production.*

low as 19%. The MBP range is quite similar with 80% at the high end and 16% on the low. Assuming one musical and five non-musicals are produced in a season at each of the sixteen universities, the Category B schools represent an annual production cost of $799,536 and scenic specific expenditures of $336,112.

Many of these institutions spent portions of their budget on high-end equipment and services. Five schools reported contracting rigging professionals and equipment for performer flying in their productions, ensuring the production was safe and removing departmental liability. Only one school reported renting stage automation equipment, however nine of the school, 56.2%, own drum winches[30] and 43.8% own Creative Conners' equipment.[31] Most surprisingly, fourteen schools use digital media in their productions, implying access to high-end equipment including cameras, green screens, lighting kits, image and video editing software, projection screens, and projection systems. The tools and equipment used for these ventures, automation to digital media, directly translate to professional theaters and jobs.

Category B also utilized the standard and common tools our industry relies and thrives on. The stationary tools discussed in Category A exhibit very different ownership trends than in Category B. These tools included the Table saw, Compound Miter saw, Radial Arm saw, Drill Press, and so on. In the table below, Category B's tool shares in each shop for nine of the most owned stationary tools. Comparison to Categories A and C can be found in Appendix E, where Figures 3, 11, and 13 are listed.

[30] *Drum winches are commonly used machinery for stage automation.*
[31] *Creative Conners is an industry-wide producer of automation equipment and software.*

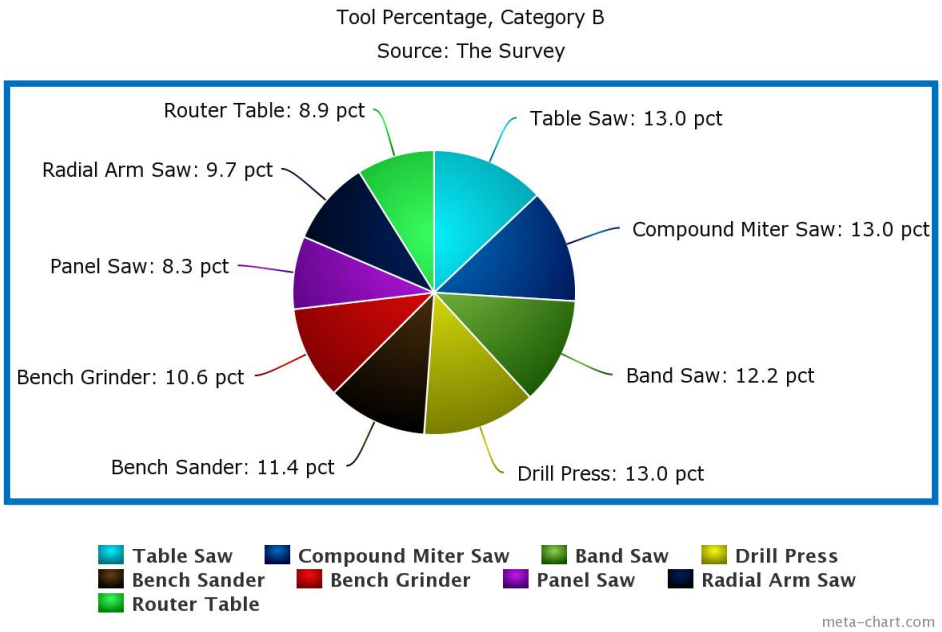

Figure 15 - Tool Share Percentages, Category B

Unlike in Category A, the Top 5 tools are not present in all shops. In every Category A and B shop you will find the Table saw, Compound Miter saw, and Drill press; however, in Category B shops, you may not find a Band Saw or Bench Sander as they are found in 93% and 87% of B shops respectively. Bench Grinders are the next most common stationary tool for Category B with thirteen of the sixteen institutions owning one. Meanwhile, only 75% have a Radial Arm saw in their shop and only eleven schools own a Router Table. Ten schools own a Panel saw, the 9th most commonly found stationary tool in Category B shops. The trends here vary from Category A. The panel saw dropped to the bottom of the list in Category B suggesting shops may not consider a crosscutting specific tool a lesser priority for their work.[32] Low-cost solutions to crosscutting include more affordable equipment such as sawhorses and a portable circular saw.

Category B shops relied on metal-specific tools for their productions as well.

[32] *A Panel saw is used to cut across the grain of sheet goods primarily, as opposed to a table saw, which is primarily used for cutting with grain primarily.*

Much as we saw in Category A, MIG welders remain the most commonly owned metalworking equipment. Fifteen schools, 93.8%, own MIG welders, while TIG welders were only found in 43.8% of shops. Interestingly, in Category B MIG welders came up short of the survey average by 3% and TIG welders gained 12% on the survey average.

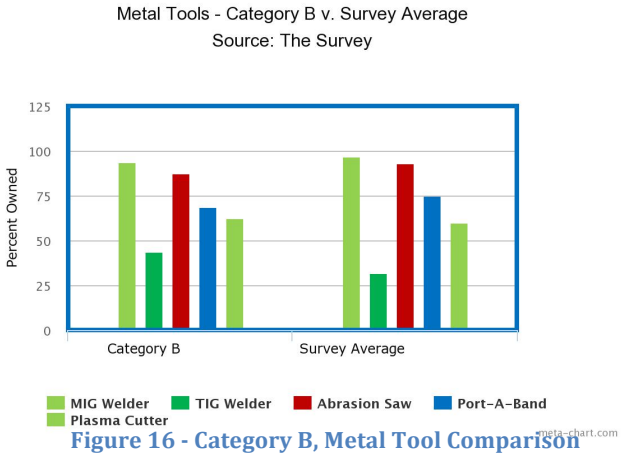

Figure 16 - Category B, Metal Tool Comparison

In Category B shops, the crew most commonly uses Abrasion saws in fourteen shops. Eleven shops own Port-a-bands and only ten shops own Plasma Cutters. As in the Figure 12 above, that is 87.5%, 68.8%, and 62.5% respectively for the three metal cutting tools.

Category B shops are also larger than the survey average at 2,831 sq. ft. compared to 2,739 sq. ft. As in square footage, the shops are taller as well beating the survey average of 22'4" at 23' 8 ¼" tall. With the higher ceilings, it comes as no surprise that nearly all of Category B owns a personnel lift, a safer alternative than extension ladders. Fifteen schools, 93.8% of Category B, have invested in personnel lifts. Combine these larger shops with their sophisticated tool inventory, Category B schools produce 98 shows a season for their academic and local communities.

c. Category C

While the survey enjoyed healthy participation from NCAA Division 1 schools, 77% of respondents are Division 1 status, Category C has the largest contingency of Division 2, Division 3, and unaffiliated schools. Four of eight schools, 50%, are either Division 2 or 3 programs. Category C schools reflect the smaller size, both enrollment and infrastructure, of Division 2 and 3 schools compared to Division 1 institutions. As one would expect, this is similar of how Category C compares to Categories A and B; Category A has only one Division 3 school, 91% Division 1, Category B has four non-Division 1 schools making it 82% Division 1.

The universities and colleges in Category C currently enroll 523 young theater artists pursuing Bachelor's degrees with an average undergraduate enrollment of 65.4 students. Simultaneously, these institutions are training 30 Graduate students, averaging 3.8 Graduates per school. Both of these statistics fall below the survey averages. Across the survey, per institution there are 69 undergraduates and 10.8 graduates.

Category C employs 107 theater related Faculty and Staff members, averaging 13.4 per institution and a Student to Faculty/Staff ratio of 5.2:1. Surprisingly, as many assume smaller institutions intrinsically provide a closer 1:1 Student to Faculty/Staff ratio, this does not hold true for the survey respondents. Category C is not only higher than the survey average, but is the highest ratio reported. Category A and B are 2.9:1 and 3.3:1 respectively. In Category C, Faculty and Staff carry a larger student load and the extra work and duties accompanying while producing 32 shows collectively each year. The official categorization range is 1-4 productions annually, however 100% of Category C schools currently produce four shows a season.

Many of the tools appreciate the same ownership in Category C shops. As before, the Table saw, Compound Miter saw, and Drill Press are found in each shop as is the Band Saw. 87.5% of shops own a Bench Sanders. The statistic stays with Bench Grinders and Panel saws.

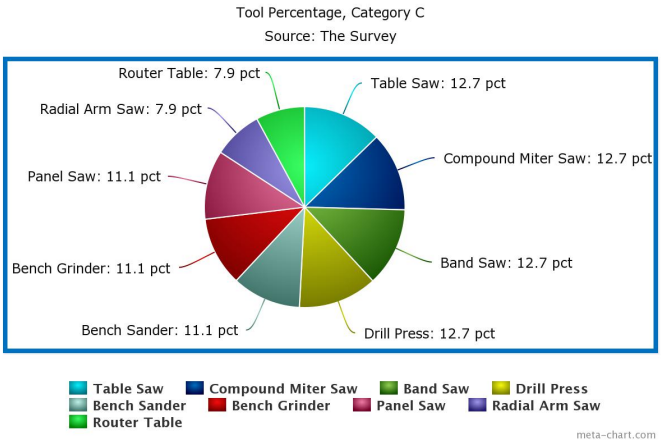

Figure 17 - Tool Percentage, Category C

Meanwhile, Radial Arm saws and Router Tables can be found in 62.5% of the shops. Throughout the survey, these nine tools are found in at least 62.5% or more of all shops in each of the three categories. The popularity of these tools suggests that a successful and dynamic shop should posses each of them to effectively answer the demands of a shop's workflow.

In concert with their stationary tools mentioned above, Category C schools make use of some of the metalworking tools. Like the rest of the survey, MIG welding remains the predominant choice of shops. 87.5% of Category C shops use MIG welding while only one shop owns a TIG welder, 12.5%. Three-quarters of the shops own Abrasion saws while 62.5% own Port-A-Bands. The least common metal-cutting tool for Category C is the plasma cutter at 50%.

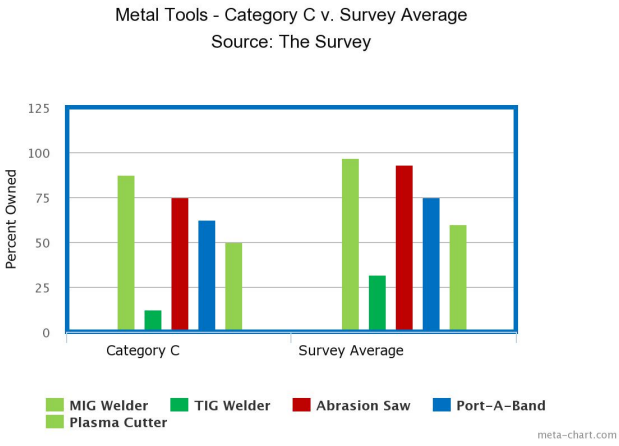

Figure 18 - Category C Metal Tool Comparison

The shops in Category C, like the statistics in metal working tools, come in below many of the survey averages. The major exception to this trend is in shop ceiling heights. Category C shops have the highest average of 24' 4 ½". On the contrary, their total shop size is the smallest of the categories at 1,862.5 sq. ft. Only one shop has a designated metal shop/work area which means that most of the metal work that happens in Category C shops requires additional set-up and safety protocols that many of Category A and B shops do not require. Similarly, 87.5% of shops in Category C do not have a separate Props shop. No schools in this category have a separate or designated Paint shop either, yet 50% of schools have Paint Frames. With the demand for tools, time, and workspace in a shop bartered between Carpentry, Welding, Props, and Paints, the annual production count accommodates the multi-use nature of these shops.

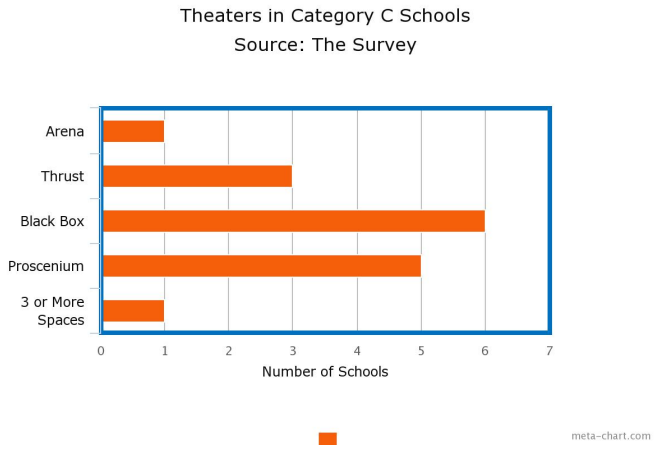

Figure 19 - Theater Types in Category C Schools

Most Category C shops are building for Black Box theater designs. 75% of institutions have Black Box theaters, while 62.5% of schools have a Proscenium theater. In Category C five of the eight schools have at least two theaters.

Interestingly, one school has an Arena theater on campus and three have Thrust spaces. The majority of the schools, 75%, have facilities with trap rooms. Half of the schools facilities are full fly-lofts and only one school uses Automated Fly Systems.

Again, reflecting the smaller pool of schools and NCAA Division status, the institutions in Category C have lighter budgets than Category A and B schools. Collectively, Category C produces a 32 show, $126,633 season at eight host institutions. The average non-Musical Budget for all departments is $5,043 while the corresponding scenic budget is $2,600. The PBP for Category 3 schools is the highest of all Categories at 51.5% of production budgets going to the Scenic department.

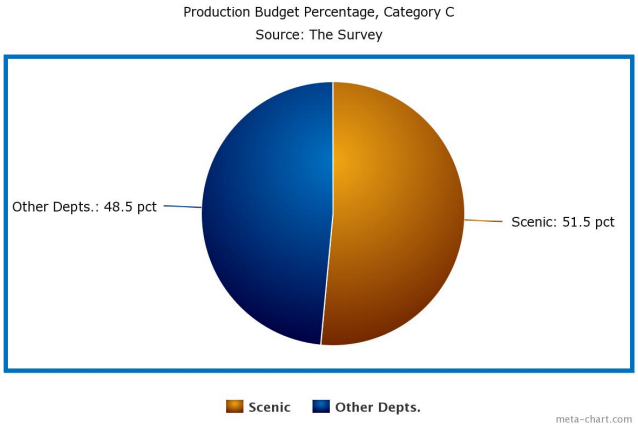

Figure 19 - Category C Budget Shares, Non-Musicals

Assuming one musical per institution each season, approximately one-third of the $126,633 season budget for all Category C schools is for musical productions, $28,125. This is drastically dissimilar to Category A schools where reported musical budgets ranged as high as $40,000.

The average musical budget at Category C schools for all departments is $5,625. The MBP is thus, higher than average as well, since the average scenic budget for a musical is $3,416. Category C's MBP is 60.7%.

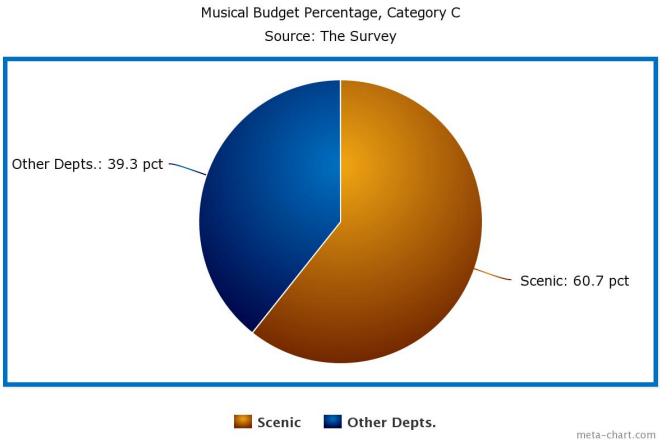

Figure 21 -Category C Budget Shares, Musicals

Where the conservative budgets are most clearly seen in Category C is in the technologies past typical scenic construction. No Category C school reported owning creating automated scenery, Creative Conners' equipment, or renting automation equipment; however, 37.5% of Category C respondents own drum winches, a tool that can be used to execute stage automation. Two schools indicated that they contract professional performer flying in their productions. 37.5% of Category C schools utilize Digital Media to expand the realms of their productions. Challenging smaller budgets, fewer students, faculty, and staff, and generally smaller spaces, Category C schools require workspace efficiency and prudent expense tracking in order to produce a successful season.

III. Emerging Technologies

i. Overview

Having identified the common categories and characteristics of higher education shops, one can develop a vision and plan for where their shop should be and what tools they will need to get there. As craftsmen we should be reluctant to place too much importance on the tool, for as the old adage goes, "a bad carpenter blames his tools". Yet, in pursuit of advancement and in creative spirit, the craftsman also seeks out new techniques, tools, and methods in order to grow his craft and improve his product. In the following pages we will explore some of the emerging technologies catching the eye of academic scenic shops and professional shops a like and currently in some of the surveyed shops. For purposes of organization, the technologies discussed will come in two waves. First, the technologies used in the production process, i.e., cutting, shaping, molding, etc… Second, stage automation technologies will be presented and examined.

Production technologies have consistently pursued computer-aid in their development. Many of these tools offer levels of precision afforded by the machinery that is either often not found in a carpenter's work. The basis of these tools is a concept known as CNC, Computer Numeric Control, which is "…a type of programmable automation, directed by mathematical data, which uses microcomputers to carry out various machining operations" ("CNC Training History…"). These tools aim to increase production through improved precision, decreased waste, and less time loss due to errors.

Meanwhile, many new technologies aim to make our production process safer. Quickly finding its way in to shops around the nation, SawStop technologies utilize the electric signals to alert the saw to human contact with the blade. Through safety, production can move confidently and expediently forward.

Other technologies focus on what is colloquially known as stage automation. These technologies are the product of many decades experiencing mechanical advances. In years past, to revolve a stage meant manual labor, either tediously preparing a drum winch with the precise amount of travel wire, inconspicuously pushing wagons by hand, or, as in Baroque periods, manually powering massive, demanding winches. With the advances in automation technology, there is now equipment that allows one to control a drive wheel from their chair, enabling the operator to execute an indefinite amount of rotations in either direction with the ease and precision of computer controlled systems at the touch of a button. These technologies advance the notions of stage mechanics and movements propelling the craft further into the pursuit for creating limitless worlds inside a box.

After describing the technology, personal experiences using equipment, general benefits and drawbacks to the technology, and median pricing, the technologies and their gross cost will be compared to the individual budget of a collegiate non-musical production as a means of quantifying their relative cost to a departments budget.

ii. Production Technologies

a. CNC Equipment

As noted previously, CNC equipment is a computer-controlled system. These systems are effective, yet expensive. CNC equipment should always be considered a system as they are comprised of many, varied elements. Part of the cost of these systems is the inevitable accumulation of cost with the assembled piece units. For instance, the basic units of a CNC system are the control computer, the software and programs that enable design of products and communication with CNC controls, the stepper motors that control machine functions, and the machine tool itself (Mauch 1). "The machines that can be constructed or retrofitted to machines is unlimited" and currently include routers, plasma cutters, lathes, sewing machines, and more (Mauch 1). These systems are the foundation of many of the production technologies, as Dan Mauch stated above, since the machine tool is virtually limitless in application making the breakthrough technology the movement of the machine in relation the cutting deck.

The CNC process can get bogged down quickly on the preparation end of production. Prior to using a CNC tool to execute the design one must produce a Computer Aided Drafting, CAD, file that is in turn converted to a Computer Aided Manufacturing file producing G-Code. The G-Code is the language by which the

computer calculates the machines movements, controlling the stepper motors that articulate the machine tool and its functions. (Mauch 1). Each of these steps requires different software and expertise and it all takes place prior to and in anticipation of production.

Once the requisite computer work is completed, the tool and deck will need prep as well. These tasks vary widely, dependent on the model and tool, but generally include homing the device, setting physical parameters of the cutting deck, calibrating cutting tools, and prepping the materials to be cut.[33] As the user will find, projects can vary drastically in speed. On a CNC router with ¾" CDX plywood, a theatrical standard for sheet goods, a simple line cut may require 3 passes of the blade. Called "geometry" in CNC terms, each movement of the blade stacks in a cue log. These logs can involve thousands of lines of geometry for complex applications, resulting in production times hours long.

To showcase the diversity of CNC tools, the router for example, C.R. Onsrud offers 4 basic models: Three-axis Gantry or Fixed Bridge, and Five-axis Gantry or Fixed Bridge.[34] The Gantry models ride along rails to facilitate X-Y coordinate plane movement.

Picture 1 - (ONSRUD)

[33] *Homing refers to a process by which the user instructs a computer-guided machine to find its origin point and set movement parameters.*

[34] *Gantry is defined by Merriam-Webster as "frame structure raised on side supports so as to span over or around something" (Gantry).*

The router unit travels across the Gantry X-axis and vertically to the tabletop. The Fixed Bridge models have a larger footprint and the tabletop, the cutting deck, moves in X-Y directions while the router unit functions as in the Gantry model. The number of axis describes lines of motion capable based on the center point of the router bit. Three-axis units will only have programmable functions in the X,Y, and Z axis; that is to say there is not ability to tilt the router bit on three-axis models.

CNC technology runs a wide gamut of cost, as can be found by a relatively simple Google search and a few minutes of sifting through results. Most CNC router tables with cutting decks accommodating 4'x 8' sheet goods or larger begin around ten to twelve thousand dollars and climb quickly from there. Secondary equipment needed will include calibrating equipment that measure to the hundredths of inches for router bit setup, maintenance costs must be factored, and training costs as well. This type of equipment represents a large investment for a department; aside from the aforementioned financial costs, one must also consider the area in your facilities these large tools will occupy. An ONSRUD three-axis, fixed bridge router feels confined in a 300 sq. ft. work area, from personal experience.

In light of these costs, one cannot dismiss the exceptional benefits of the technology. Precision to the hundredths of inches, ease and consistency of repetition, removal of dangerous, temporary work tables using sawhorses for intricate cuts, and the inherent development of your crew and productions in comparison. As crewmembers are trained in the CNC equipment, they receive highly specialized skills to take with them into the greater work force. As their carpentry and welding sit on display next to CNC created pieces, crewmembers will be compelled to increase their own attention to detail.

The tangible and intangible benefits are deep and the drawbacks revolve primarily around time and training: two things technology fixes with new iterations.

If we look at three tools that higher education shops currently use based on CNC technology, Category A schools dominate the statistics. Only sixteen schools, 39%, have access to or own a CNC router throughout the respondent schools. Almost half of these schools, seven, find themselves in Category A, which boasts an ownership rating of 63.6%. According to the survey, six Category B schools, use CNC routers landing near the survey average at 37.5%. No Category C schools reported owning or using CNC routers.[35]

Similarly, only 4.88% of survey respondents have access to or use CNC Plasma Cutter and neither school is in Category C. Category A and B each have one institution with a CNC Plasma Cutter; 9.1% and 6.3% respectively. Finally, Laser Cutters that utilize similar programs and controls to other CNC tools, are found in six shops throughout the survey respondents: 14.63%. Category B uses this technology most frequently as 25% of the sixteen shops own or has access to Laser Cutters. Meanwhile, Category A and C each have one school with Laser Cutting capabilities: 9.1% and 12.5% of schools respectively. It is interesting to note that of these CNC based technologies, only Laser Cutters are found in each Category.

With a ticket price of at least 5 non-musical productions scenic budgets, assuming the survey average and a minimum ticket price of $12,000, the low-end CNC routers alone have an actual cost just under a Category B season's scenic budget. With so many facets, a purchase of this caliber, whether it is a router, lathe, sewing machine,

[35] *The three remaining schools were omitted from Category statistics as they submitted incomplete data and were not categorized.*

plasma cutter, milling machine, or the next tool modified for CNC use, these purchases demand the utmost consideration when made once one realizes their cost in number of productions as the unit.

b. Abrasive Water Jet Cutting Systems

Of all the Production Technologies discussed in this report, Water Jets are arguably the least accessible to college scene shops. Many larger programs at the home institution, engineering, architecture, etc…, may have the requisite funding to purchase a Water Jet and allow sister programs, such as theater departments, access to and use of the equipment. The Water Jet, aside from cost, is the least practical, of the presented technologies, for theatrical use. The technology was initially developed for logging, however the last fifty years have seen its application and use in almost every industry and manufacturing process, from the manufacture of disposable diapers to the rescue of "Baby Jessica"[36] in the late 1980's ("Our History" 1).

As our industry continues to work towards fully automated staging and in doing so encourages a higher demand for precision and accuracy. Water Jet technology offers the same precision as its sister technologies, Lasers and EDM.[37] Each of these technologies can guarantee precision cuts to the thousandth of an inch, .001". If considering a Water Jet, understand the technology represents a capital investment of at least $60,000 with the price range surpassing $300,000 on the high end. In comparison, Lasers and EDM technology cost significantly more with market floors and ceilings of $200,000-$1M and $100,000-$400,000 respectively ("Comparative Cutting" Table 1).

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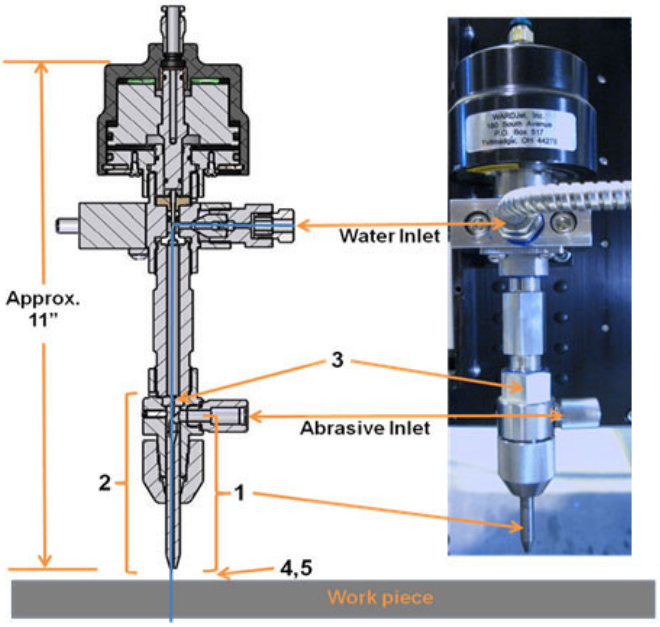
[36] *Baby Jessica was a National Media emergency from the 1980's where an infant was trapped in a well.*
[37] *EDM cutting is most commonly referred to as "spark" cutting where an electrode cuts the conductive materials.*

Water Jet technologies are effective in cutting any material up to 24" in thickness ("Comparative Cutting" Table 1). The cutting blade is a mixture of water and garnet, the green, recyclable material used in sandpaper ("Comparative Cutting" 1). In the Water Jet cutting process, "the abrasive does the cutting, not the water." (Olsen 1) The water's function is to collate all of the tiny abrasive particles into a single, pressurized stream (Olsen 1).

The water has a beneficial by product of minimizing heat making Water Jets a Cold-Cut technology. Tangible benefits of heat reduction include cleaner cuts, less deformation caused by heat, and little to no work needed in removing slag or other debris from the cut.[38]



Picture 2 - (Water)

Since Water Jets use similar CNC technology and cutting decks as discussed with the Router, many of the drawbacks translate to the Water Jet Cutting Systems. For instance, these large machines require a proportionally large space in one's shop to house and efficiently use the equipment. As found previously, there remains a steep learning curve for beginner users. The advantages are comparable as well, but most impressively,

[38] *EDM, Laser, Plasma, and non-water Abrasion cutting systems leave slag and deformed edges that require "cleaning up" prior to moving forward in the fabrication process.*

the Water Jet systems work on any material and with extreme depth allowances. Differing models can be limited by their design, i.e., three-axis or five-axis as in other CNC based technologies.

The critical question facing shop administration regarding Abrasive Water Jet Cutting Systems is the same as CNC technology: Is this high capital cost worth the investment when defined in terms of production count? That is to say, which is more important to a program, a number of productions or the ability to fabricate specialty pieces with extreme precision. In this case, the low-end technologies have a practical production cost of about thirty non-musical scenic budgets. More dramatically, these bargain priced tools cost more than the total season budget of a Category B school: $49,971 all departments. As we look to advance our craft, technical directors and department heads must maintain a pragmatic concept of costs associated with these technologies in order to negative financial blowback.

c. SawStop

SawStop technologies are manufacturer specific; SawStop is a company and trademarked technology currently used in table saws built by the SawStop Company and

Picture 3 - SawStop at the University of Virginia

available in 6 countries through over 350 dealers ("We Make North America's Best Safety Saw" 1). SawStop is more than a high-end table saw and far from an over glorified, expensive sticker in your shop. The technology available in the SawStop series centers on safety. The blade's ability to detect human contact virtually eliminates the risk of traumatic injury and accident-related time loss. The technology allows novice and beginner artisans to approach tasks using the table saw with confidence, setting the user up for more accurate and safety conscious work.

Picture 4 - SawStop at the University of Virginia

The technology allows novice and beginner artisans to approach tasks using the table saw with confidence, setting the user up for more accurate and safety conscious work.

SawStop technology works in three phases: Monitor & Detect, Brake Activation, and Reset. In the Monitor & Detect phase, the blade carries a small electrical charge that changes if the human body comes in to contact with the blade.[39]

This change is noted by the SawStop computer, which subsequently initiates the Brake Activation phase. During this phase, a spring-loaded aluminum block engages the blade, stopping its rotation, and the motor disengages. The time span from detection to full stop is five milliseconds resulting in a minor cut, most often requiring only a Band-Aid®, not an emergency room trip. The final phase, Reset, simply requires dismantling

[39] *It should be noted that any conductive material will initiate the Brake Activation phase including screws and staples embedded in the materials as well as the metallic backing to some commonly used beaded insulation foams.*

the blade from the arbor and replacing the brake cartridge and blade ("How Does SawStop Work?" 1).

It should be noted that the SawStop table saw does not require an OEM blade, though it will need replacing should SawStop engage, but the SawStop brake cartridge is only available through the OEM at an approximate cost of $80.[40]

Picture 5 - SawStop Brake Assembly

If you figure the cost of a new generic table saw blade, $40, and the new brake cartridge, $80, then a potential workman's compensation case and it's accompanying legal, financial, and time loss consequences were avoided for the low price of $120. It would be remiss to ignore the total equipment cost in this figure, but for argument's sake, this figure is eye opening. Compared to our budgets and the CNC and Water Jet systems, SawStop table saws are an affordable capital investment. Starting at $1,300 for the Job Site model, the saws fit most any budget. The high-end Industrial models cost around $5600 with all the bells and whistles, including dust collection arm, dado brake cartridge, and dado blade insert.

[40] *OEM refers to Original Equipment Manufacturer. Often times specialized equipment require parts distributed by the equipments Original Manufacturer.*

Regardless of Category, the benefits associated with the SawStop technology coupled with the affordable price range make this technology a must for any collegiate or professional shop. In personal experiences I have seen the aftermath of table saw injuries with and without SawStop technology. The statistics for table saw incidents are staggering; they occur every nine minutes resulting in ten amputations daily and accumulating billions of dollars of expenses ("We Make North America's Best Safety Saw" 1).

Our art should be risky and cutting edge. The tools and equipment we use should only be cutting edge. An academic shop already presents a high-risk environment as it seeks to train beginner and novice craftsmen. Even experienced carpenters benefit from the investment as accidents often occur when individuals are comfortable with equipment, exhausted, or stressed: three things most shop carpenters can identify with. The trend in collegiate theater shops is resounding; 24 shops, 53.33%, own a SawStop.

As a technical director looking to improve their shop, safety must be at the forefront of each decision. Undoubtedly a foreman would identify a piece of equipment in operable condition that is missing key safety features, such as blade guards or exposed wiring, as unfit for use and in need of repair or replacement; Table saws lacking SawStop technology, or similar products, should be seen as such. With the information provided above, from accident statistics to affordability, the next iteration of any higher education scene shop should require SawStop technology.

d. Cold Cut Saw

Picture 6 - Cold Cut Saw at the University of Virginia

The cold cut saw shares benefits with the Water Jet and derives from similar manufacturing parameters and demands. As opposed to the abrasion saw, port-a-band, or plasma cutters, the cold-cut saw incorporate a lubricant into the cutting process in order to reduce friction and heat prolonging blade life and minimizing sparks from the saw (Carlson 1). Most similar to the abrasion saw, both tools rely on vices to hold the material and a vertical, y-axis movement of the blade through the material.

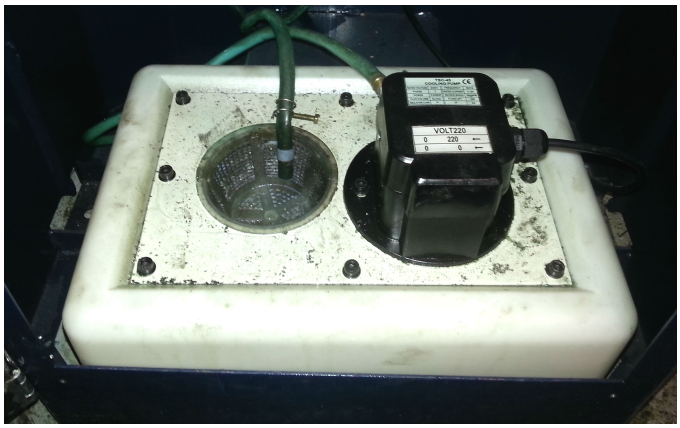
A cold cut saw is a circular saw meant for cutting metals at slow speeds to provide burr, spark, and heat free cuts in stick metals ("Cold Saws" 1).

Cold cut saws are unparalleled in precision compared to other metal cutting tools like band saws. Metal shops have begun to rely on cold cut saws "because of tighter tolerances on cut accuracies" (Carlson 1). Other benefits of the cold cut saw include the long life of its components. Properly using the tool and lubricating can make the blade's teeth "last longer between sharpening…[and] you sharpen a blade 30 to 40 times" (Carlson 1). Other options such as the band saw require expendable blades that are

disposed of once dull. Cold cut saws are manufactured both ferrous and non-ferrous applications ("Cold Saws" 1).[41]

There is a small learning curve to cold cut saws and technology. The material dictates the type of blade the user should install on the arbor. Thin walled box tube will require finer teeth to control the volume of metal chips during cutting. Coarser denser materials, such as stock material, will require larger teeth.

The entire cutting process is closer to milling than true cutting in that you are working the material with higher torque and slower speed in order to roll off chips of metal as opposed to cutting the material as we do with lumber (Carlson 1).



Picture 7 - Cold Cut Saw Pump and Filter

These chips are collected in the lubricating fluid and collect in a filter prior to the lubricant return and reservoir; unfortunately, at times the return lines and filter clog from the volume of chips, but both are easily cleaned and only require a few minutes to do so.

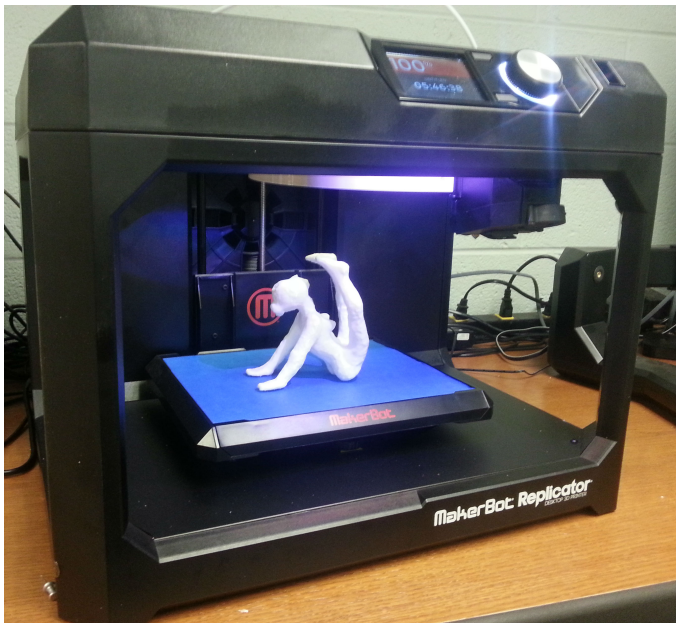
Pricing for cold cut saws remains reasonable and realistic for collegiate shop budgets. Most models land in the $1,200 to $1,800 range with cheaper and more expensive units on each end. In terms of theatrical productions, the cost of a cold cut saw is less than one non-musical productions scenic budget in any category. If a shop has a high volume of metal work, then the foreman and technical director no doubt will

[41] *Ferrous and Non-ferrous refer to iron based and non-iron based materials such as steel and aluminum respectively. The term is derived from the Latin root, Ferrum (Ferrous).*

appreciate the investment in cold cut saws as they produce a fraction of the decibel output associated with abrasion saws. Likewise, operators will enjoy cut lists fulfilled with greater accuracy. The remainder of the shop will appreciate the lack of sparks that accompanies abrasion saws and their indiscriminate shower of burning metal fragments.

e. 3D Printer

3D printers have quickly taken the DIY market by storm as models range from affordable, desktop versions to large scale, industrial machines. The theater industry, scene shops and prop shops alike, have also taken note of these new 3D printing technologies.



Picture 8 - 3D Printer at the University of Virginia

While the application of 3D printers is most relevant to prop shops, scene shops can make use of the technology as well. 3D printers vary in their methods, but essentially, the process requires a plastic filament to be melted and passed through a nozzle; the nozzle then moves about a coordinate plane placing the molten plastic in position within horizontal slices, building upwards ("What is 3D Printing?" 1).

There are several parameters you must decide when printing. Most obvious, one must design, in 3D visualization software, an object that fits on the print table or break larger objects into pieces that can be printed then assembled.

Picture 8 - 3D Printer at the University of Virginia

Once these files are prepped, the user must specify the fill percentage, ranging from 0-100%, this instructs the 3D printer how dense to weave the interior honeycombing when it is printing the layers. Finally, the user must select what type of filament and its color. Filaments range from "biodegradable plastic filament PLA to ABS plastic to Nylon" ("What is 3D Printing?" 1). Colors are available in standard versions of most colors, such as red, yellow, blue, black, white, and other hues.

Much like the CNC technologies, 3D printers are plagued with time issues. Like with CNC geometry, the 3D printer and design software break an object in to thousands of micro-movements that quickly stack up. Small statues with relatively light fill can take hours to print barring any interruption or machine faults. Fortunately, 3D printers do not find themselves as forlorn if they do not know programs such as Solidworks or Google SketchUp. Websites such as thingiverse.com are full of downloadable, print-ready files, though not all are as well crafted as others. As in any tool with nozzles, tubing, or adhesives, 3D printers find themselves suffering from clogged nozzles and issues with the heating elements. The sophistication of these items includes self-monitoring sensors to aid troubleshooting; however, from personal experience, these are not always foolproof.

For all their benefits and challenges, 3D printers are slowly gaining momentum in the theater world. Collegiate shops in all three categories own or use 3D printers in their production process amounting to 31.7% of survey participants. Right above the survey average, Category A reported four shops, 36.4%, while Category B fell just shy of the average with five shops, 31.3%. In Category C, one shop possessed or utilized a 3D printer representing 12.5% of that grouping.

Pricing for 3D printers exist on a very wide scale. Some models are intended for light use in the home for hobbies and enthusiasts. These models are relatively affordable costing a few hundred dollars to a thousand; however, these purchases would not hold in the high-volume theater application. Larger print deck models more appropriate for prop shops and theater application past model making, tend to find themselves in the higher price range costing anywhere from $1,500 to over $6,500. In terms of scenic budgets, these tools can be a nominal expense or a significant expenditure representing more than a Category A musical production's scenic budget: $6,242.

ii. Stage Automation Technologies

Stage automation has burgeoned into an entire sub-section of our industry. Corporate entertainment icons such as Cirque du Soleil continue to amaze audiences and theater technicians alike with their achievements. From Ka's entirely kinetic stage to a small revolve at a liberal arts college, automated scenery consistently finds its way into modern designs and visions. Employers across the board search for candidates with experience both in using and developing automated systems. Props artisans, carpenters,

and stage technicians must be well versed in the vernacular and equipment the automation manufacturers are providing in order to remain competitive.

Specifically, theater finds itself primarily utilizing three automation concepts: revolves, linear travel, and flight. Automation dates back to at least the Baroque period. Theaters, like the one found in Cesky Krumlov, CZ, contain intricate engineering solutions for moving massive amounts of scenery from below the stage. A series of manually operated winches controlled scenery "attached to sliding shutters that move backwards and forwards through grooves in the floor" (Gayford). In actuality, the fundamentals of stage automation have not changed drastically. The mechanics have. Over the years, solutions have resulted in hydraulic, pneumatic, cable driven systems, and many more, but all look to the same end: moving scenery from point A to point B.

For the purposes of this paper, Creative Conners' equipment will be examined. Creative Conners' full line of products addresses all three of the primary automation applications mentioned above. The equipment produced by Creative Conners' relies on mechanical systems and are relatively self contained. Their flagship products include the Revolver, the Pushstick Winch, and the Spotline Winch. All of these items operate through a control system designed by Creative Conners' called Spikemark that uses their affectionately named Stagehand unit to provide universal control of the motors and 3D visualizations of your stage and moving elements.

All three units require the Stagehand equipment and Spikemark software. The Showstopper console features hard buttons for many of the commands in Spikemark. E-Stop, Cue Go, Cue Load, and navigation buttons simplify the running of shows.[42] The

[42] *E-Stop refers to an Emergency Stop button.*

Stagehand equipment is the brain of the system. It houses the computer boards, communication hubs, and power distributions. The Stagehand has manual controls for jogging winches and revolver with no spikes or memory. Spikemark operates on a separate PC one must provide, but acts as the user interface for advanced control of the winch or revolver.

The revolver is a turnkey option for executing rotating stages. The unit is mounted to the floor and can drive the turntable from the perimeter or the center axel. Deciding where it drives from is important. The unit is more precise if driven from the perimeter as the larger circumference provides more options for braking. In this regard it is very similar to pixels and HD technology; the more pixels, the more defined an image can be, but fewer pixels, or a smaller circumference in our example, means each pixel has to produce more of the image.

The revolver has two wheels, both spring loaded. The first and larger wheel is a rubber drive wheel that provides the force needed to move the turntable. The second, smaller wheel is known as the encoder wheel. This wheel rides along the same surface as the drive wheel. The encoder wheels movement is monitored by the software and allows for seamless tracking of the unit's position. Creative Conners' intentionally designed this system with two wheels to ensure precision. If the drive wheel functioned as the encoding wheel, the system would ghost move if the drive wheel slipped on turntable's edge.[43]

A major drawback to the revolver system, though not its fault, is the lack of a safety. Theoretically, the only failsafe is the operator, which is historically inadequate. Because of the revolvers modular nature, existing outside the designs of any particular

[43] *Ghost movement refers to a situation where the digital data reflects movement that did not actually occur.*

turntable, the equipment is in no way aware of what is happening on the turntable deck and edges. The Showstopper console could make steps towards addressing this by making the Cue Go button a dead-man's switch.[44] Even then, the system still relies on the operator as the primary failsafe. This is challenge that pervades all three products and their respective systems.

The Pushstick winch, despite its name, is a drum wench that uses cable to pull objects, presumably scenery. The workhorse of stage automation, these drums can be wrapped with cable on both ends creating a closed loop. With the drum wrapped appropriately, the scenery following a track in the stage, an operator can drive the drum forward, or in reverse, and pull scenery on and off stage with ease, "ensuring that the most mind-numbingly complex sequences of scene changes can happen at the touch of a button" ("Automation {Scenic}").

The motor powering the wench has four limit switches on it to ensure safety within your system. Two switches apply to each direction the drum can roll, either forward or reverse. These switches are known as the hard limits as they are physical switches that engage when the drum travels a certain distance. These hard limits are set by automation technician during set up and include a hard limit, where the drum should not pass, and universal hard limit, which will not allow movement until the winch is manually reset. Typically these limits are placed just shy of each other and prevent the winch from dragging scenery into areas or objects they should not be. These limits are paired with soft limits inside the Spikemark software. These soft limits exist only digitally, much like patching in modern lighting boards. Nothing prohibits these limits

[44] *Dead-man's switch is an term implying that a process will execute if the switch is released, requiring the operator to engage the switch until the process is terminated.*

being identical to the lesser hard limit, but a soft limit cannot be outside the range of the hard limits.

While these limits provide a degree of safety, ultimately the responsibility for safe and effective use of the equipment once again falls to the operator creating another opportunity for the Showstopper console to integrate a dead-man's switch. The major drawback to the Pushstick winch is its inability to perform overhead lifting due to safety concerns. The Pushstick winch does not have a redundant load braking system. This means that should the motor fail, the cable will be susceptible to the gravitation pull of its load; in laymen's terms, what goes up, must come down. This leaves those looking to automate scenery vertically, or fly units that may even have people on them, are left looking for an alternative.

To answer this demand, Creative Conners manufacturers its Spotline winch. A brother to the Pushstick winch, the Spotline operates using the Stagehand, Spikemark, and a drum with cables. The key design feature that allows the Spotline to lift scenery overhead is its redundant load brake. Should the motor fail, the drum will not release, maintaining the trim height of any objects already in the air. With vertical lifting in mind, the Spotline's specifications reflect this: travel speeds up to 36 in/sec, dual brakes, 75 feet of cable on the drum, and engineered for heavy, theatrical lifting.

All of the Creative Conners equipment share similar drawbacks centered on learning curve and cost. The Spotline addresses the Pushstick's most significant limit. Once a team or user learns the Spikemark program the programming of different Creative Conners equipment is relatively universal. The revolver's encoder wheel can struggle with inconsistent turntable edges, one of the reasons automation and CNC technologies

are advancing together, and calibrating the revolver for the first time can be challenging. Creative Conners provides effective, individualized customer support to alleviate the stress of integrating their equipment into one's productions.

The biggest deterrent is cost. None of these automation technologies represent a minor investment. The Spotline winch, no accessories, data cables, or Showstopper console, runs $20,000, or nine non-musical scenic budgets. Remember, both winches and the revolver require their own Stagehand unit with a ticket price of $4,000 or $7,000 depending on model. Pushstick winches and Revolvers require a capital investment of $20,000 as well. Each of these can be purchased in a starter kit that includes the data cables, Showstopper, Spikemark, and Stagehand for around $30,000 or six seasons of Category C musical budgets, all departments: $5,625.

Of the surveyed schools, 32.5% own Creative Conners equipment. While the survey did not define which Creative Conners products were owned, one can assume that means there is at least one product and starter kit, costing approximately $30,000, at each of the thirteen institutions. Collectively, the surveyed universities have invested at least $390,000 into Creative Conners automation equipment. The majority of these schools are in Category B, seven to be exact, representing almost half of Category B, 43.7%. In Category A, three schools, representing 27.3% of the group, own Creative Conners equipment. Category C schools maintained the trend with CNC equipment as 0% of the group owned Creative Conners equipment.

Schools are likely making these investments as automation equipment has direct influence on the parameters of a production. The return is tangible; audiences are impressed by seamless transitions and physics bending scene changes such as flying

doors. Student familiarity and expertise in programming and designing automated systems will make them more marketable in the professional market and when applying for graduate studies. The department will be able to foster new partnerships outside the university as other programs focusing on automation will likely lend and borrow equipment and ideas. While the actual, dollar cost represents large budget shares for most schools participating in the survey, in order to produce graduates ready for the ever-evolving theatrical landscape, they should prioritize the acquisition of Creative Conners and similar automation equipment.

IV. Shop Safety

The survey asked shops to share information regarding safety in their shops and practices. Safety practices and infrastructure were assessed two-fold. First, what PPE, Personal Protective Equipment, is provided to the carpenter by the shop? Second, what facility features and procedures are in place to reduce and respond to workplace injuries and environmental impact? Many of the responses directly correspond to the type of work the shops endeavor to do. For instance, some of the shops that do not provide welding equipment or invest in vent hoods, do not focus on metal work and may even be shops that do not own the equipment at all.

A shop that exhibits safety, in its practices, procedures, and equipment, can expect improvements in productivity attributable to efficient and engaged, healthy team members critically assessing their work and workspace to prevent accidents and injury. These same principles will translate to the exponentially more dangerous realms of rigging and automation as students will learn to problem solve in a safety conscious

manner. Running a shop that revolves, and evolves, around safety, sets the tone and expectations for anyone who enters the space and cultivates a culture that permeates the entire department or company.

The first step in establishing this culture is to provide basic safety equipment to workers. If safety is encouraged and the equipment conveniently on hand, carpenter use will become second nature. In the table below, survey responses are listed as percentages of shops providing specific equipment.

Personal Protective Equipment Provided By Shops, All Categories			
Safety Equipment	***Percent of Shops Providing***	***Safety Equipment***	***Percent of Shops Providing***
Safety Goggles/Glasses	100.0%	Dust Mask	100.0%
Work Gloves	93.3%	Respirators	46.7%
Nitrile/Sterile Gloves	77.7%	Knee Pads	62.2%
Disposable Ear Plugs	91.1%	Back Support	6.7%
Earmuffs	86.7%	Hard Hats	68.8%
Welding Jacket	80.0%	Hi-Visibility Jackets	4.4%
Welding Helmet	93.3%	Fall Arrest (General Use)	68.9%
Welding Gloves	93.3%	Fall Arrest (Individual Use)	13.3%

Figure 22 - Personal Protective Equipment Provided By Shops, All Categories

As exhibited, every shop provides safety glasses or goggles as well as dust masks. All three of these items are the foundation for safe shop practices; safety glasses and goggles are intended to protect one's eyes from immediate damage. Dust masks block particles from entering your respiratory system during work, which may seem more of a convenience or comfort than a safety concern, but respiratory exposure to wood dust can result in immediate health issues ranging from allergic reactions to long term concerns such as nasal cancer (McCann 1).

Other long-term exposure health concerns are addressed by provided PPE. Scene shops are loud as a reflection of the processes occurring in them. Cutting metal and

hardwoods is never quiet and produce high decibel levels with close proximity to our students and workers. 91..9% of shops offer some form of hearing protection, with disposable earplugs the preference of most shops. These are economic, sanitary options for addressing noise control.

Interestingly, less than three-quarters of shops provide hard hats even though carpenters routinely work underneath riggers, electricians, and other carpenters. In 2009-2010, the average cost of a head and central nervous system workplace injuries was $82,382 (Miller 67). Head injuries in general industry accounted for over 60,000 incidents in 2010 (Miller 78). Knowing that theatrical work involves simultaneous overhead crews and onstage crews, hard hats are an effective strategy to ensure a shop does not contribute to these statistics.

With only 6.7% of shops providing back support, the academic theater community may very well be setting itself up for major incidents. In 2010, the Educational and Health Services industry experience over 49,000 non-fatal, loss-time back injuries. Of all injuries by body part this industry experienced, back injuries occur more often than any other body region (Miller 78).

In contrast, the surveyed shops exhibit healthy trends in Fall Arrest protection. 68.9% of shops provide fall arrest harnesses and presumably light training. In 2010, there were 646 fatal falls in general industry representing 13.8% of all fatal incidents (Miller 72). On top of these fatalities, falls contributed over 208,000 cases with loss-time representing 22.3% of all loss-time cases (Miller 72). Theatrical rigging and lighting call for unique solutions in extraordinary situations, often placing crew more than 50 feet in

the air. Taking the time properly secure oneself can literally save one's life, assuming the equipment is provided and the team member has been trained.

Simply providing the equipment is not sufficient in establishing a culture of safety in a shop. While frequent and consistent training aids in creating this atmosphere, daily procedures and practices have an enormous impact on the effectiveness of a shop's safety mantra. For example, training a student to always use PPE may be rendered ineffective if the student can use the table saw without supervision since the shop is not equipped with a shop power lockout box or without a Tool Training Program. To that extent, the survey looked at what precautions and procedures were common amongst collegiate shops.

Shop Safety Features and Procedures, All Categories			
Feature or Procedure	***Percent of Shops***	***Feature or Procedure***	***Percent of Shops***
Locked Access	**86.6%**	**First Aid Kit on Shop Floor**	**95.6%**
Shop Power Lockout	**26.6%**	**Eyewash Station**	**60.0%**
Lockout/Tagout for Repairs	**37.8%**	**Tool Training Program**	**88.9%**
Reporting Repairs Protocol	**57.8%**	**Injury Reporting Protocol**	**95.6%**
Controlled Access Tool Lockup	**71.1%**	**Designated First Repsponder**	**40.0%**
Welding Shields	**73.3%**	**Posted Evacuation Plan**	**53.3%**
Vent Hood	**57.8%**	**MSDS Sheets (Up to Date)**	**80.0%**
Dust Collection System	**86.7%**	**Biohazard/Chemical Disposal**	**66.7%**
Explosives Cabinet	**35.6%**	**Hazardous Materials Cabinet**	**82.2%**

Figure 23 - Shop Safety Features and Procedures, All Categories

Universally, 85% or more, surveyed shops provide the following safety infrastructure: a First Aid kit on the shop floor, an injury reporting protocol, a tool training program, locked access to the shop, and dust collection systems. Impressively, four of the five of these are inherently preventative. Only the First Aid kit is a reactionary measure, but that is the nature of its purpose. As was presented earlier regarding potential hazards of sawdust, the fact that 86.7% of shops are equipped with dust collection systems supports a culture of safety that assesses long-term exposure risks as much as immediate injuries.

Areas of improvement for the survey pool include many easily remedied shortcomings. Eyewash stations are essential to the three theater shops: scenic, props, and paint. Protective eyewear handles large particles and protect primarily against impact, but are effective against dust and smaller particles as well; however, steel dust, saw dust, lacquers, sealants, paints, and other chemicals pose a very real danger in the every day work of these shop. Only 60% of surveyed shops are equipped with an eyewash station; meanwhile, there are many options for eye wash equipment ranging from sink add-ons to stand alone stations.

Similarly, only 26.6% of shops feature a shop power lockout feature. These boxes break the electrical circuit running to a shop's stationary tools. This feature ensures no unauthorized use of equipment such as radial arm saws, table saws, panel saws, or even convenience outlets if desired. Safety is as much about prevention as it is about controlling the situation and being able to inhibit the use of dangerous, powerful equipment when desired is critical.

40% of shops reported a designated first responder contact. In an emergency, time is invaluable and designating a contact, prior to the incident, speeds up the process of getting medical attention to the injured party. This is imperative in a professional shop setting while many collegiate shops may rely on campus emergency dispatch services as directed or preferred. Either way, communicating to staff and students the proper protocol for emergency response will save lives and reduce liability in an accident.

The survey also looked into disposal procedures of biohazard chemicals in the shop. As Figure 19 shows, 66.7% of shops in the survey have established practices for removing these items from inventory. Many of these schools rely on internal, university

sponsored recycling and waste programs. In these cases, Environmental, Health, and Safety, EHS, departments pick up or receive these hazardous materials and manage their recycling and disposal. Many schools do not use their EHS or similar departments for paint disposal. Most schools use the traditional method of adding a hardener, sawdust, cat litter, etc…, and allow the cans to dry. They then dispose of them through regular dumpsters and trash removal. The wide variety of methods here is most likely attributable to state and institutional regulations. For instance, California has very stringent laws and regulations about paint, spray paint, acetone, and other scenic painting products disposal, so it is not uncommon for the EHS or similar department to handle all disposal and recycling.

In general, the surveyed shops are excellent examples of safety conscious environments. The majority of the listed PPE is readily available in most of the shops and the key safety infrastructure is in place as well. With room to improve, these shops lead the way in creating cultures of safety, which, in the end, is the investment that continues returning. A safe shop is a productive shop and a happy one at that.

V. Conclusion

Having collected, analyzed, and synthesized the data within this report, three themes have surfaced out of the plethora of statistics and information. First, Safety and its consistent and supervised practice is the investment that always yields returns. Second, technology is man's means to enhance skills and subsequently improve their craft. Lastly, modernization is inevitable, yet sustainable in strategically planned intervals with clear and concise tangible goals.

A key element to institutional and shop stability is workplace safety. Much as we find in technology, with safety, it rarely pays to be behind the curve. Workplace injuries not only defeat team morale and dissuade team members from developing and learning new equipment, but also translate to a massive cost in loss-time, money, and institutional resolve. Identifying where a shop is deficient in safety protocols, procedures, and equipment reveals how an institution can revolutionize its safety culture and promote a positive, safe, and productive work atmosphere.

The research has provided significant insight in to the spending patterns and combined buying power of higher education theater through the lens of the survey participant schools. The data has informed lists of tools and safety equipment that TD's can reference when developing plans for shop growth and change. From the survey responses, it is apparent that collegiate theater programs look for substantial funding outside of their annual budget in the form of grants and donations, as well as through state specific programs such as the Virginia Equipment Trust Fund.

With this combined information, shop administration can use empirical data, based on actual shop statistics and operations, to work with department and university officials to pursue new technologies, such as the one's discussed in this document, or to clean house and remove obsolete tools and unsafe work procedures.

Success and planning go hand-in-hand and being able to objectively look at the composition of peer programs and programs similar to the vision one has for their own shop provides a blueprint, encouraging calculated and sustainable improvements. As various department heads debate and earmark future funding, the context found in the research will empower technical directors and shop foreman to avoid the confusion and

potentially wasteful spending of catalog shopping and impulse purchasing by referencing established programs and their inventory.

The sustainability that comes with incremental, statistically proven growth will bring shop leadership face to face with new and emerging technologies. Whether today, tomorrow, or a decade from now, understanding current advances in equipment, such as CNC, Water Jet, tool safety, and automation, compels leadership to weigh all the options, their benefits and disadvantages, prior to acquiring new tools.

Understanding sustainable acquisition of new equipment and technology, staying up to date and informed of technological advances, both production and performance related, and keeping safety squarely in front of any production pressures, a TD will undoubtedly answer the previously mentioned, age-old question successfully: "What's the right tool for the job?"

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Appendix A

"The Survey"

Scenic Technology and Resources

1. **Scenic Tec...**

Thank you for your participation in this comprehensive look at Scenic Technology and Resources available in Higher Education. The purpose of this thesis project is to identify the resources currently in our institutions and understand which technologies are being prioritized for procurement by Scene Shops and theater professionals around the country. Your involvement and transparency will help the data collected to reveal trends in technological investment and needs for the shop of the 21st century.

The survey is 7 pages and uses simple answer formats for the participant's ease. I appreciate the attention and time you are investing and look forward to reviewing your's and other industry professional's responses.

Austin Manning
MFA, Technical Direction (2015)

Page 1

Scenic Technology and Resources

2. ...

Please answer the following inquiries to the best of your ability. The information provided will allow for a holistic view of the Resources and Technology your department and shop utilize.

1. Institution (ex. University of Virginia)

2. State where Institution is located?

3. Please indicate how many of the following you have in your program.

	Number of
Administrative/Clerical Members	
Professional **Staff** Members	
Theater **Faculty** Members	
Theater **Staff** Members	
Theater **Graduate** Students	
Theater **Undergraduate** Students	

4. In reference to your Undergraduate enrollment:

	How Many?
Majors	
Minors	

5. Please select the appropriate Title and Degree for the Instructor of Record for each of the following courses.

	Title	Highest Degree Held
Intro to Scenic Technology or equivalent		
Advanced Scenic Technology or equivalent		
Scenic Design or equivalent		
Advanced Scenic Design or equivalent		

Scenic Technology and Resources

3. ...

Please answer the following questions with your Scene Shop in mind.

8. What is the approximate size of your shop? (ex. 2500 sq. ft.)

9. What is the approximate ceiling height of your shop? (ex. 40 ft.)

10. Do you own Personnel Lifts? (Genies, etc...)

- ○ Yes
- ○ No

11. What material is your shop floor?

- ☐ Concrete
- ☐ Wood
- ☐ Other (please specify)

Scenic Technology and Resources

12. Please check all safety features of your shop that apply.

- ☐ Locked Access
- ☐ Shop Power Lockout
- ☐ Lockout/Tagout or Red Tag/Green Tag system for equipment repairs
- ☐ Protocol for reporting damaged tools and necessary repairs
- ☐ Controlled Access Tool Lockup
- ☐ Welding Shields
- ☐ Vent Hood
- ☐ Dust Collection System
- ☐ First Aid Kit on Shop Floor
- ☐ Eyewash Station
- ☐ Tool Training Program/Regimen
- ☐ Protocol for reporting workplace injuries
- ☐ Designated First Responder contact
- ☐ Designated and Posted Evacuation Plan
- ☐ MSDS Sheets (available and up to date)
- ☐ Procedure for disposal of Biohazards/chemicals
- ☐ Explosives Cabinet
- ☐ Hazardous Materials Cabinet

13. What procedure do you follow for disposal of paints?

Scenic Technology and Resources

14. Please check all Safety Equipment your shop provides to workers.

- ☐ Safety Goggles
- ☐ Work Gloves
- ☐ Nitrile/Sterile Gloves
- ☐ Hearing Protection (Disposable)
- ☐ Earmuffs
- ☐ Welding Jacket
- ☐ Welding Helmet
- ☐ Welding Gloves
- ☐ Dust Masks
- ☐ Respirators
- ☐ Knee Pads
- ☐ Back Support
- ☐ Hard Hats
- ☐ Hi-Visibility Jackets
- ☐ Fall-Arrest Harnesses (Generic)
- ☐ Fall-Arrest Harnesses (Designated for Indviduals/Fitted)
- ☐ "Saw-Stop" table saw

Scenic Technology and Resources

15. Please select of all the Stationary Equipment in your shop.

- ☐ Table Saw
- ☐ Radial Arm Saw
- ☐ Compound Miter Saw
- ☐ Miter Saw
- ☐ Band Saw
- ☐ Router Table
- ☐ Bench Grinder
- ☐ Bench Sander
- ☐ Planer/Jointer
- ☐ Drill Press
- ☐ Lathe
- ☐ Panel Saw
- ☐ Scroll Saw
- ☐ Pipe Bender (manual)
- ☐ Pipe Bender (hydraulic)

16. Please select all Metal Specific Equipment in your shop.

- ☐ Metal Cutoff (Abrasion) Saw
- ☐ Flux Welder
- ☐ MIG Welder
- ☐ TIG Welder
- ☐ Port-A-Band Saw
- ☐ Plasma Cutter
- ☐ Arbor Press

Scenic Technology and Resources

17. Please check all of the following tools you either have, or have access to, in your shop.

- ☐ CNC Router
- ☐ CNC Plasma Cutter
- ☐ Laser Cutter
- ☐ Vacuform
- ☐ 3D Printer
- ☐ Cut-All
- ☐ Large-Format Inkjet Printer
- ☐ Large-Format Plotter
- ☐ Other (please specify)

18. Please list any tools, non-hand tools, that you have or use in your shop that were missed above. Especially, please list those tools that you rely on or find yourself incorporating into your process.

Scenic Technology and Resources

4. ...

Please answer the following questions with Scene Shop Labor Pool in mind.

19. Please indicate the percentage each degree category makes in your overall Shop Labor Pool. {Do not include Lab Students/Students in class. Do include all volunteers and compensated employees. (work-study,hourly, stipend, etc...)}

	Approximate Percentage of Shop Labor Pool
GED	
High School Diploma	
Associate's Degree	
Bachelor's Degree	
Master's Degree	
Master's of Fine Arts	
Ph. D.	

20. Please indicate approximately how many workers you have in each of the following categories in your Shop Labor Pool.

	Approximate Number of Employees in Category
Volunteers	
Student- Class/Lab Hours	
Student- Work Study	
Student- Hourly Employee	
Graduate Student- Stipend/Hourly	
Staff- Hourly	
Staff- Salary	
Faculty	

Scenic Technology and Resources

21. Please check any of the following certifications that are in your Shop labor pool.

- ☐ First Aid
- ☐ CPR/AED
- ☐ EMT (B, I/85, I/99, P)
- ☐ Associate Welding Inspector
- ☐ Welding Inspector
- ☐ Senior Welding Inspector
- ☐ SAFD Certified Teacher
- ☐ SAFD Fight Director
- ☐ SAFD Fight Master
- ☐ General Contractor
- ☐ IATSE Affliation
- ☐ USITT Affiliation
- ☐ ETCP Rigger
- ☐ ETCP Electrician

22. Are there any other relevant certifications you or your labor pool hold?

Scenic Technology and Resources

5. ...

Please answer the following questions relating to your In-House Productions as best as possible. The information collected will help provide a holistic view of your program.

23. Production Basics

	Number of	Average Show Budget (All Departments)
Department Productions (excepting Musicals)		
Musicals		

24. What is your Average Scenic Budget for Non-Musical Productions?

25. What is your Average Scenic Budget for Musical Productions?

26. Please check all of the following that applies to your Productions.

- ☐ We contract Rigging Services
- ☐ We contract Performer Flying Services
- ☐ We contract Outside Construction Services
- ☐ We rent Automation Equipment
- ☐ We rent Lighting Equipment
- ☐ We rent Rigging Equipment
- ☐ We rent Backdrops and Scenic Elements
- ☐ We design Automated Scenery for our productions
- ☐ We own Drum winches
- ☐ We use Digital Media in our productions
- ☐ We have designated, permanently mounted Projectors
- ☐ We use SMPTE for show control/synchronization
- ☐ We use MIDI for show control/synchronization
- ☐ We operate JR Clancy equipment
- ☐ We operate Creative Conners equipment
- ☐ We operate Fischer Theatrical Services equipment

Scenic Technology and Resources

6. ...

Please answer the following inquiries to the best of your ability. The information provided will allow for a holistic view of the Resources and Technology your department and shop utilize.

27. Please fill in the following table in regards to grants your Scene Shop has received.

	Percentage of all Grant Monies Received
Federally Funded	
State Funded	
City/County/Local Funded	
Home Institution Supported	
Third-Party, Non-Profit	
Third-Party, Commercial	

28. How often do you receive gifts earmarked for the Scene Shop?

	Annually	Once a Term	A few times a term	Monthly	Weekly	N/A
Monetary Gifts	○	○	○	○	○	○
Tool Donations	○	○	○	○	○	○
Materials Donations	○	○	○	○	○	○
Furniture Donations	○	○	○	○	○	○
Consistent/Long-term Volunteership	○	○	○	○	○	○

29. Please indicate if your Scene Shop receives these other funding sources.

- ☐ Box Office Receipts
- ☐ Student Activity Fees

Other (please specify)

30. Approximately how much do you recieve in gifts or are awarded through grants annually? (Three Year Average)

Scenic Technology and Resources

31. Does Scene Shop retain budget surplus at the Fiscal year close?

- Yes
- No

Other (please specify)

*** 32. Are you a Virginia Institution that applies for or receives Virginia Equipment Trust Funds? (ETF's)**

- Yes
- No

Scenic Technology and Resources

7. ...

Please answer the following inquiries to the best of your ability. The information provided will allow for a holistic view of the Resources and Technology your department and shop utilize.

33. How often do you apply for ETF's?

34. How often are you awarded ETF's?

35. What is your average requested amount for an ETF?

36. What is the average amount awarded from the ETF?

37. Please list any siginificant tools/equipment that an ETF has enabled your department to purchase. (ex. Table Saw, Genie, Welder, etc...)

38. Please list any significant Facilities Improvements that an ETF has enabled your department to complete. (ex. New Soft Goods, Automated Fly System, etc...)

Scenic Technology and Resources

8. ...

Thank you again for taking the time to participate in this survey. Your answers will allow for a comprehensive view of Scene Shop Technology and Resources in Higher Education. Please contact me with any questions or additional information you may feel relevant to this research.

Austin Manning
M.F.A. Technical Direction, 2015
University of Virginia
wam5hs@virginia.edu

Appendix B

Respondent List by Category
With Key Data

Appendix B							
Institutional Categorical Ranking							
	Institution	*APC*	*PBP*	*MBP*		*Div.*	*NCAA Conference*
	Category A						
1	University of Nebraska	18	28	N/A		1	Big 10
2	Ball State University	14	60	57		1	Mid-American
3	Univ. Cincinnati, Conservatory of Music	13	20	32		1	American Athletic
4	Texas Tech University	11	90	N/A		1	Big 12
5	Univ. of Southern California	11	54	16.5		1	Pac 12
6	Connecticut College	11	48	96		3	New England Small College
7	Radford University	11	N/A	N/A		1	Big South
8	Northern Illinois University	10	50	N/A		1	Mid-American
9	Texas State University	10	40	28		1	Sun Belt
10	Northwestern Universtiy	10	28	26		1	Big 10
11	Dartmouth College	10				1	The Ivy League
	Category B						
12	North Carolina School of the Arts	9	35	17		N/A	N/A
13	University of Utah	8	80	80		1	Pac 12
14	Arizona State University	7	25	30		1	Pac 12
15	Universtiy of Virginia	6	64	70		1	Atlantic Coast
16	Christopher Newport University	6	60	67		3	Capital Athletic
17	Universtiy of Michigan	6	50	60		1	Big 10
18	College of William and Mary	6	48	48		1	Colonial Athletic
19	University of Memphis	6	48	35		1	American Athletic
20	University of Delaware	6	47	N/A		1	Colonial Athletic
21	University of Illinois	6	36	22		1	Big 10
22	University of Connecticut	6	28	32		1	American Athletic
23	Louisiana State University	6	26	34		1	Southeastern
24	University of North Texas	5	80	55		1	Conference USA
25	Central Michigan University	5	80	70		1	Mid-American
26	University of Arkansas	5	30	43		1	Southeastern
27	University of Indianapolis	5	19	16		2	Great Lake Valley
	Category C						
28	University of Mary Washington	4	80	80		3	Capital Athletic
29	Texas A&M University	4	64	N/A		1	Southeastern
30	Allegheny College	4	63	N/A		3	North Coast Atlantic
31	Oklahoma State	4	53	56		1	Big 12
32	University of Miami	4	50	70		1	Atlantic Coast

33	Illinois Wesleyan University	4	50	70		3	College Conference of Illiinois and Wisconsin
34	University of Idaho	4	40	56		1	Sun Belt
35	California State University-San Bernardino	N/A	29	29		2	California Collegiate

Institutions below participated in the survey but could not be categorized for lack of data.

	Linfield College					3	Northwest
	California State University-Fresno					N/A	N/A
	Dalhousie University					N/A	N/A
	University of Pennsylvania					1	The Ivy League
	Carroll College					N/A	N/A
	University of Texas-Austin					1	Big 12
	University of Maryland-Clarice Smith Performing Arts Center					1	Big 10

The NCAA Division and Conference information source can be found on the Works Cited page; Information was obtained from the NCAA website, www.ncaa.com/schools

Appendix B

Appendix C:

Definition of Categories

Goal: To identify and group like institutions in an umbrella identifier in order to find trends and similarities in their resource and technologies outside of the key data points.

Criteria: Three key data points are used to determine a respondent institutions category for the purpose of this research: *Annual Production Count, Production Budget Percentage (Average Production v. Scenic/Shop)*, and *Musical Budget Percentage (Average Musical v. Scenic/Shop).*

Process: Using primary statistical data collected in a Fall 2014 survey, all participating institutions were ranked relative to one another based on three of the aforementioned criteria in the order listed: *Annual Production Count, Production Budget Percentage, and Musical Budget Percentage,* herein referred to as APC, PBP, and MBP, respectively. After a comprehensive ranking, floors and ceilings were established and the categories formed. Essentially, the rankings were derived from institutional comparison with preferential bias towards APC, PBP, then MBP. Categories were established based on APC and institutions were ranked within these categories by their PBP and MBP respectively.

Category A

APC:
Range [10+]
High (18); Low (10); Average (11.7)

PBP:
High (90); Low (16.5); Average (40.3)

MBP:
High (96); Low (16.5); Average (32.4)

Definition of Categories (cont.)

Category B

APC:
Range [5-9]
High (9); Low (5); Average (6.1)

PBP:
High (80); Low (19); Average (39.6)

MBP:
High (80); Low (16); Average (46.9)

Category C

APC:
Range [1-4]
High (4); Low (4); Average (4)

PBP:
High (80); Low (29); Average (51.5)

MBP:
High (80); Low (29); Average (60.7)

Please see **Appendix B** *for the complete listing of participant institutions and data used to determine averages.*

Appendix D:
Categorical Statistics

*All statistics are derived from respondent answers to "The Survey" included in **Appendix A** of this report.*

Category A *(11 Shops)*

Institution and Facilities Key Data:

Total Undergraduate Enrollment: **833**
Average Undergraduate Enrollment: **75.7**
Total Graduate Enrollment: **200**
Average Graduate Enrollment: **18.2**
Total Undergraduate/Graduate Enrollment: **1,033**
Average Undergraduate/Graduate Enrollment: **93.9**
Total Faculty/Staff count: **352**
Average Faculty/Staff count: **32**
Average Student to Faculty/Staff Ratio: **2.9:1**
Percentage of Institution with Graduate Programs: **63.6%**
Average Undergraduate to Graduate Student Ratio: **4.2:1**
Have Proscenium: **90.9%** (10)
Have Thrust: **36.4%** (4)
Have Arena: **0%** (0)
Have Black Box: **90.9%** (10)
Have with 3 or more spaces: **72.7%** (8)
Hosts Conventions, Tours, etc.: **36.4%** (4)
Have Trap Rooms: **63.6%** (7)
Have Pit Lift/Elevator: **63.6%** (7)
Have Full Loft: **90.9%** (10)
Have Automated Fly System: **27.3%** (3)
Have Paint Frame: **45.5%** (5)
Have Paint Shop (Separate or Removed from Shop): **18.2%** (2)
Have Designated Metal Shop/Work Area: **63.6%** (7)
Have Properties Shop: **63.6%** (7)

Scene Shop Basics Key Data:

Average Shop Size: **3,243.2 *sq.ft.***
Average Shop Ceiling: **19' 1 ¼"**
Own Personnel Lifts: **90.9%** (10)
Concrete Floors: **45.5%** (5)
Wood Floors: **9.1%** (1)
Combination Floors: **45.5%** (5)
Table Saw: **100%** (11)
Compound Miter Saw: **100%** (11)
Band Saw: **100%** (11)
Drill Press: **100%** (11)
Bench Sander: **100%** (11)
Bench Grinder: **90.9%** (10)
Panel Saw: **81.8%** (9)
Radial Arm Saw: **63.6%** (7)
Router Table: **63.6%** (7)
MIG Welder: **100%** (11)

TIG Welder: **36.4%** (4)
Abrasion Saw: **90.9%** (10)
Port-A-Band Saw: **90.9%** (10)
Plasma Cutter: **72.7%** (8)
CNC Router: **63.6%** (7)
CNC Plasma Cutter: **9.1%** (1)

3D Printer: **36.4%** (4)
Cut-All: **54.3%** (6)
Laser Cutter: **9.1%** (1)
Vacuform: **18.2%** (2)
Large-Format Printer: **45.5%** (5)
Large-Format Plotter: **63.6%** (7)

Productions Key Data:

Average Non-Musical Budget (all depts):	**$6,861**
Total Non-Musical Budget (all depts):	**$61,750**
Average Non-Musical Budget (scenic):	**$2,766**
Total Non-Musical Budget (scenic):	**$24,900**
Average Musical Budget (all depts):	**$19,285**
Total Musical Budget (all depts):	**$135,000**
Average Musical Budget (scenic):	**$6,242**
Total Musical Budget (scenic):	**$43,700**

Contract Performer Flying:	**63.6%** (7)
Rent Automation Equipment:	**0%** (0)
Design Automated Scenery:	**45.3%** (5)
Own Drum Winches:	**27.3%** (3)
Own Creative Conners Equipment:	**27.3%** (3)
Use Digital Media:	**90.9%** (10)
Designated, permanently Mounted Projectors:	**36.4%** (4)

Category B *(16 Shops)*

Institution and Facilities Key Data:

Total Undergraduate Enrollment: **1,060**
Average Undergraduate Enrollment: **66.3**
Total Graduate Enrollment: **150**
Average Graduate Enrollment: **9.3**
Total Undergraduate/Graduate Enrollment: **1,210**
Average Undergraduate/Graduate Enrollment: **75.6**
Total Faculty/Staff count: **375**
Average Faculty/Staff count: **23.4**
Average Student to Faculty/Staff Ratio: **3.3:1**
Percentage of Institution with Graduate Programs: **50%**
Average Undergraduate to Graduate Student Ratio: ***8.1:1***
Have Proscenium: **93.8%** (15)
Have Thrust: **37.5%** (6)
Have Arena: **12.5%** (2)
Have Black Box: **81.3%** (13)
Have 3 or more spaces: **50%** (8)

Hosts Conventions, Tours, etc.: **43.8%** (7)
Have Trap Rooms: **56.3%** (9)
Have Pit Lift/Elevator: **56.3%** (9)
Have Full Loft: **87.5%** (14)
Have Automated Fly System: **12.5%** (2)
Have Paint Frame: **31.3%** (5)
Have Paint Shop (Separate or Removed from Shop): **37.5%** (6)
Have Designated Metal Shop/Work Area: **56.3%** (9)
Have Properties Shop: **56.3%** (9)

Scene Shop Basics Key Data:

Average Shop Size: **2,831 *sq.ft.***
Average Shop Ceiling: **23' 8 ¼"**
Personnel Lifts: **93.8%** (15)
Concrete Floors: **43.8%** (7)
Wood Floors: **25%** (4)
Combination Floors: **18.8%** (3)
Table Saw: **100%** (16)
Compound Miter Saw: **100%** (16)
Band Saw: **93.8%** (15)
Drill Press: **100%** (16)
Bench Sander: **87.5%** (14)
Bench Grinder: **81.3%** (13)
Panel Saw: **62.5%** (10)
Radial Arm Saw: **75%** (12)
Router Table: **68.8%** (11)
MIG Welder: **93.8%** (15)
TIG Welder: **43.8%** (7)
Abrasion Saw: **87.5%** (14)
Port-A-Band Saw: **68.8%** (11)
Plasma Cutter: **62.5%** (10)
CNC Router: **37.5%** (6)
CNC Plasma Cutter: **6.3%** (1)
3D Printer: **31.3%** (5)
Cut-All: **81.3%** (13)
Laser Cutter: **25%** (4)
Vacuform: **37.5%** (6)
Large-Format Printer: **81.3%**(13)
Large-Format Plotter: **50%** (8)

Productions Key Data:

Average Non-Musical Budget (all depts):	**$7,655**
Total Non-Musical Budget (all depts):	**$114,830**
Average Non-Musical Budget (scenic):	**$3,033**
Total Non-Musical Budget (scenic):	**$48,530**
Average Musical Budget (all depts):	**$11,696**
Total Musical Budget (all depts):	**$163,750**
Average Musical Budget (scenic):	**$5,482**
Total Musical Budget (scenic):	**$76,750**

Contract Performer Flying:	**31.3%** (5)
Rent Automation Equipment:	**6.2%** (1)
Design Automated Scenery:	**43.8%** (7)
Own Drum Winches:	**56.2%** (9)
Own Creative Conners Equipment:	**43.8%** (7)
Use Digital Media:	**81.3%** (14)
Designated, permanently Mounted Projectors:	**18.8%** (3)

Category C *(8 Shops)*

Institution and Facilities Key Data:

Total Undergraduate Enrollment: **523**
Average Undergraduate Enrollment: **65.4**
Total Graduate Enrollment: **30**
Average Graduate Enrollment: **3.8**
Total Undergraduate/Graduate Enrollment: **553**
Average Undergraduate/Graduate Enrollment: **69.1**
Total Faculty/Staff count: **107**
Average Faculty/Staff count: **13.4**
Average Student to Faculty/Staff Ratio: **5.2:1**
Percentage of Institution with Graduate Programs: **25%**
Average Undergraduate to Graduate Student Ratio: ***17.4:1***
Have Proscenium: **62.5%** (5)
Have Thrust: **37.5%** (3)
Have Arena: **12.5%** (1)
Have Black Box: **75%** (6)
Have 3 or more spaces: **12.5%** (1)
Hosts Conventions, Tours, etc.: **25%** (2)
Have Trap Rooms: **75%** (6)
Have Pit Lift/Elevator: **12.5%** (1)
Have Full Loft: **50%** (4)
Have Automated Fly System: **12.5%** (1)
Have Paint Frame: **50%** (4)
Have Paint Shop (Separate or Removed from Shop): **0%** (0)
Have Designated Metal Shop/Work Area: **12.5%** (1)
Have Properties Shop: **12.5%** (1)

Scene Shop Basics Key Data:

Average Shop Size: **1,862.5** ***sq.ft.***
Average Shop Ceiling: **24' 4 ½"**
Own Personnel Lifts: **62.5%** (5)
Concrete Floors: **75%** (6)
Wood Floors: **12.5%** (1)
Combination Floors: **12.5%** (1)
Table Saw: **100%** (8)
Compound Miter Saw: **100%** (8)
Band Saw: **100%** (8)
Bench Sander: **87.5%** (7)
Bench Grinder: **87.5%** (7)
Drill Press: **100%** (8)
Panel Saw: **87.5%** (7)
Radial Arm Saw: **62.5%** (5)
Router Table: **62.5%** (5)
MIG Welder: **87.5%** (7)
TIG Welder: **12.5%** (1)
Abrasion Saw: **75%** (6)
Port-A-Band Saw: **62.5%** (5)
Plasma Cutter: **50%** (4)
CNC Router: **0%** (0)
CNC Plasma Cutter: **0%** (0)
3D Printer: **12.5%** (1)
Cut-All: **37.5%** (3)
Laser Cutter: **12.5%** (1)
Vacuform: **12.5%** (1)
Large-Format Printer: **37.5%**(3)
Large-Format Plotter: **100%** (8)

Productions Key Data:

Average Non-Musical Budget (all depts):	**$5,043**
Total Non-Musical Budget (all depts):	**$40,350**
Average Non-Musical Budget (scenic):	**$2,600**
Total Non-Musical Budget (scenic):	**$20,800**
Average Musical Budget (all depts):	**$5,625**
Total Musical Budget (all depts):	**$33,750**
Average Musical Budget (scenic):	**$3,416**
Total Musical Budget (scenic):	**$20,500**
Contract Performer Flying:	**25%** (2)
Rent Automation Equipment:	**0%** (0)
Design Automated Scenery:	**0%** (0)
Own Drum Winches:	**37.5%** (3)
Own Creative Conners Equipment:	**0%** (0)
Use Digital Media:	**37.5%** (3)
Designated, permanently Mounted Projectors:	**0%** (0)

Appendix E:

Figures and Supplemental Visual Aids

Listed in order of their appearance, the following figures offer a brief description of data source and means for creation.

Figure 1: All Survey, APC v. Enrollment

Using data collected for Annual Production Counts and the total program enrollment, graduate and undergraduate, the table below was created.

Survey Category	APC	Enrollment
Category A	11.7	93.9
Category B	6.1	75.6
Category C	4	69.1

Figure 2: Percent Ownership Stationary Tools

Using the data collected in Question 15 of the survey, the following info graphic was created to show Percent Ownership of specific tools from all respondent schools, and not just the 35 categorized schools. In the "Word Cloud", created through www.wordle.com, the larger the text, the more instances a response had. In other words, the bigger the word, the more often owned by an institution. Table Saws for example, enjoy a 100 Percent Ownership from all respondent schools (45).

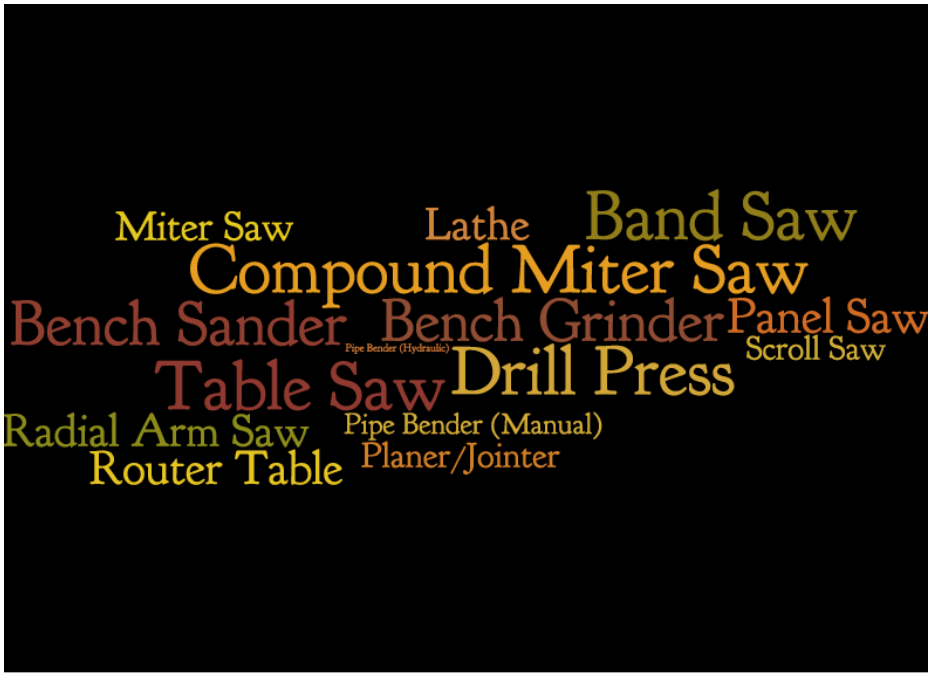

Figure 3: All Survey, Stationary Tools

This table depicts the percent ownership of each stationary tool of all shops surveyed.

Tool	% Owned
Compound Miter Saw	100
Table Saw	100
Drill Press	100
Band Saw	97
Bench Sander	91
Bench Grinders	86
Panel Saw	71
Router Table	69
Radial Arm Saw	67
Wood Lathe	67
Miter Saw	60

Figure 4: All Survey, Metal Tools

This table depicts the percent ownership of each metal tool of all shops surveyed.

Tool	% Owned
MIG Welder	97
Abrasion Saw	93
Portable Band Saw	75
Plasma Cutter	60
TIG Welder	38
Flux Welder (Stick)	32
Arbor Press	0

Figure 5: Shop Floor Materials Comparison

Using the Data collected from Question 11 of the survey, the following bar graph, created through the NCES graphic generator, illustrates the number of shops with the different materials for flooring. The total response count was 43, but due to the mixed-medium shops, the total number of answers was 54.

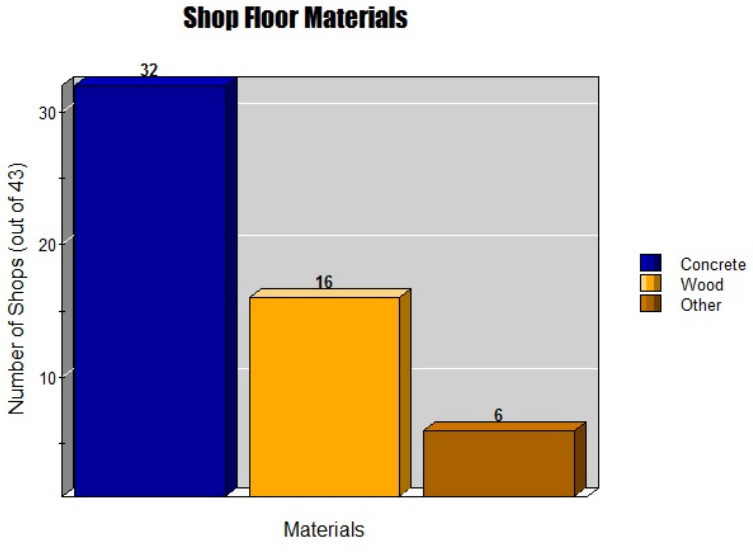

Figure 6: Virginia ETF Statistics

This table depicts the frequency of ETF awards at each of the 5 applicable survey respondents. It also rates their success rate in garnering solicited grant monies through the ETF program. This was calculated using the dollar amounts they applied for and the dollars received.

Virginia ETF Participants and Statistics		
School	Frequency Awarded	% Awarded
Radford University	1	77
University of Mary Washington	1	50
Christopher Newport University	1	N/A
University of Virginia	3	33
College of William and Mary	4	50

Figure 7: Tool Percentage, Category A

By adding the total number of responses from all 9 tools, 88 tools were determined to be on Category A shop floors from our Top 9 tools. The Wood Lathe is the tenth tool and was omitted from this data point. After determining the combined quantity of tools, 88, each tool count was divided by the total to determine percentage.

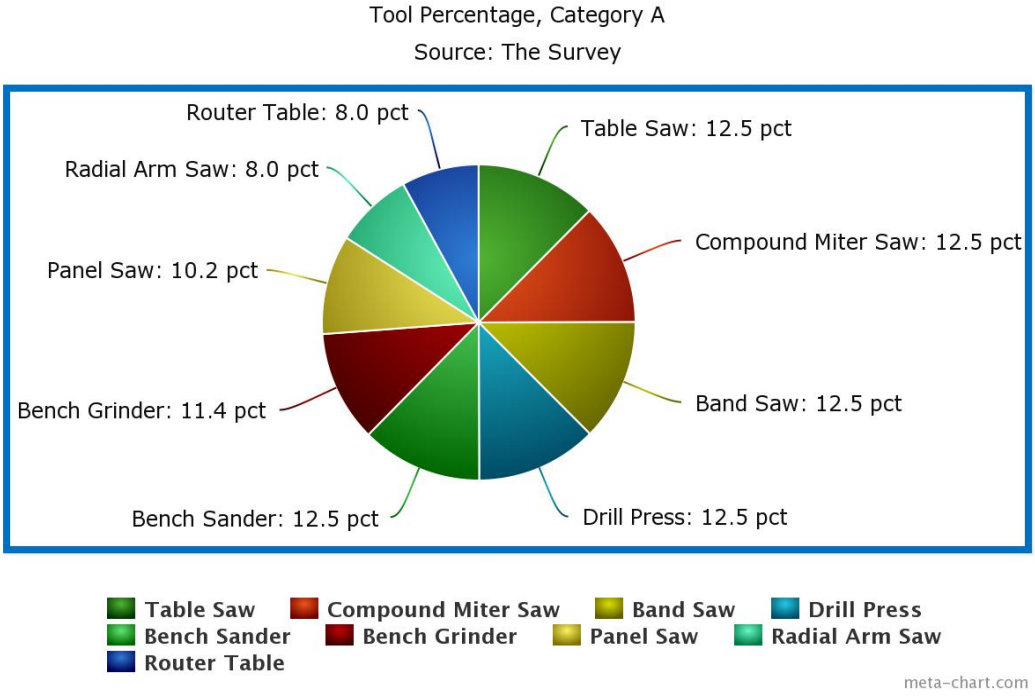

Figure 8: Category A Metal Tool Comparison

After establishing the percentage of institutions in Category A owning each of the tools, the bar graph was created through www.meta-chart.com's multi-chart generator to provide a quick visual reference for Metal Specific tool ownership compared in Category A to the survey Average

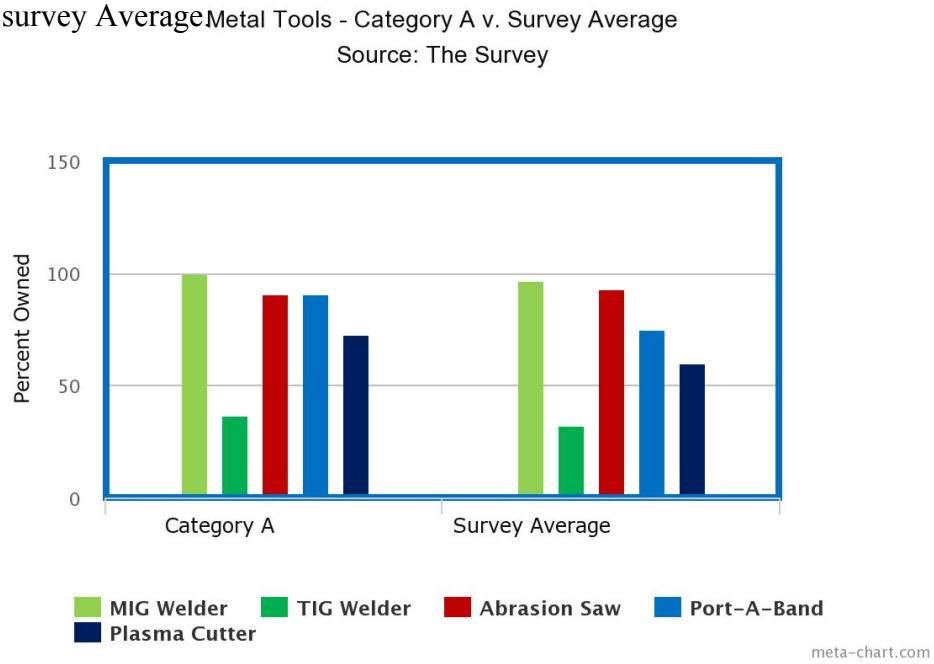

Figure 9: Theater Types in Category A Schools

The Bar Graph, created with meta-chart.com, references the raw data for total responses to each of the theater types. In the survey, institutions were asked to identify if their facilities included the following: Proscenium, Thrust, Arena, Black Box, or more than three venues. Out of 11 schools in the category, total responses for each venue type are compared below.

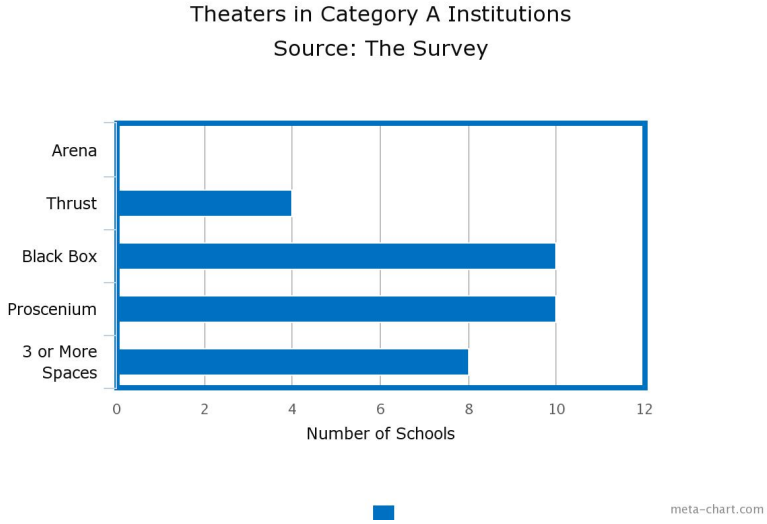

Figure 10: Category A Budget Shares, Non-Musical

Calculated as percentages, the Scenic Budget shares reported were compared to the total, all department budgets for a typical non-musical production using meta-chart.com's pie chart generator.

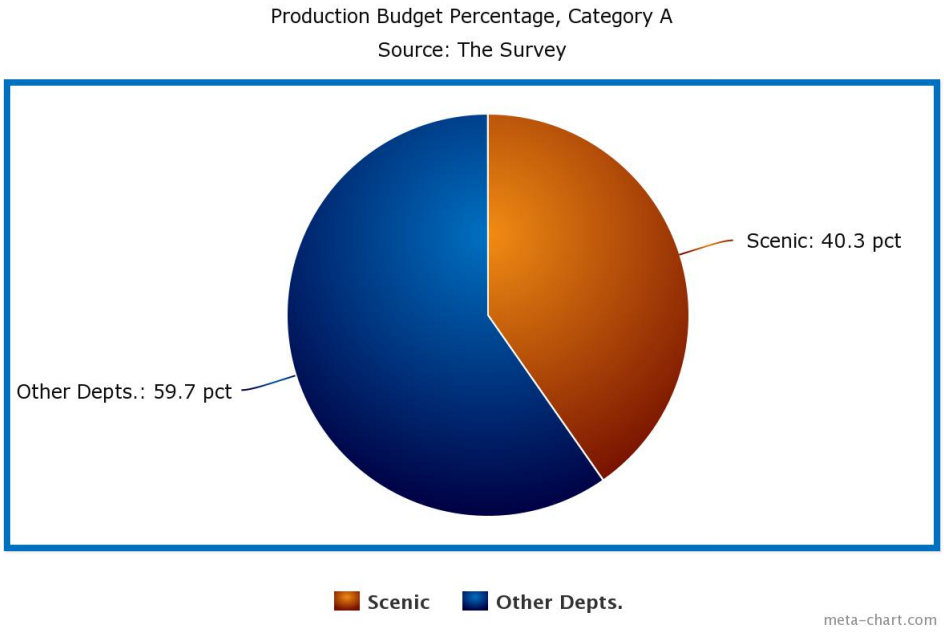

Figure 11- Category A Budget Shares, Musicals

The survey collected budget averages from each of the respondent institutions regarding musicals. The pie chart below, created by meta-chart.com, depicts the scenic budget share of the overall, all department budget for a musical.

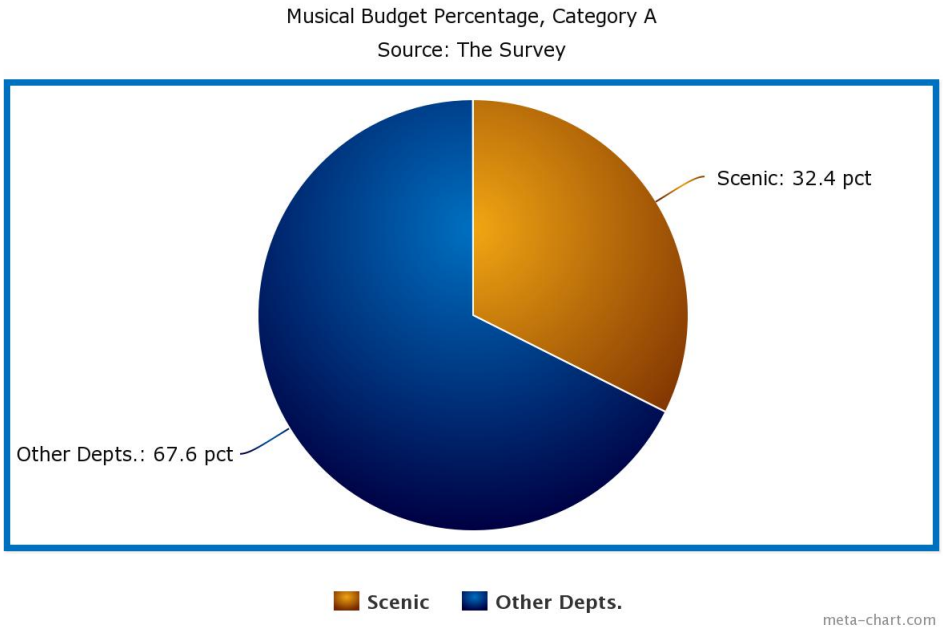

Figure 12 - Theater Types in Category B Schools

The Bar Graph, created with meta-chart.com, references the raw data for total responses to each of the theater types. In the survey, institutions were asked to identify if their facilities included the following: Proscenium, Thrust, Arena, Black Box, or more than three venues. Out of 16 schools in the category, total responses for each venue type are compared below.

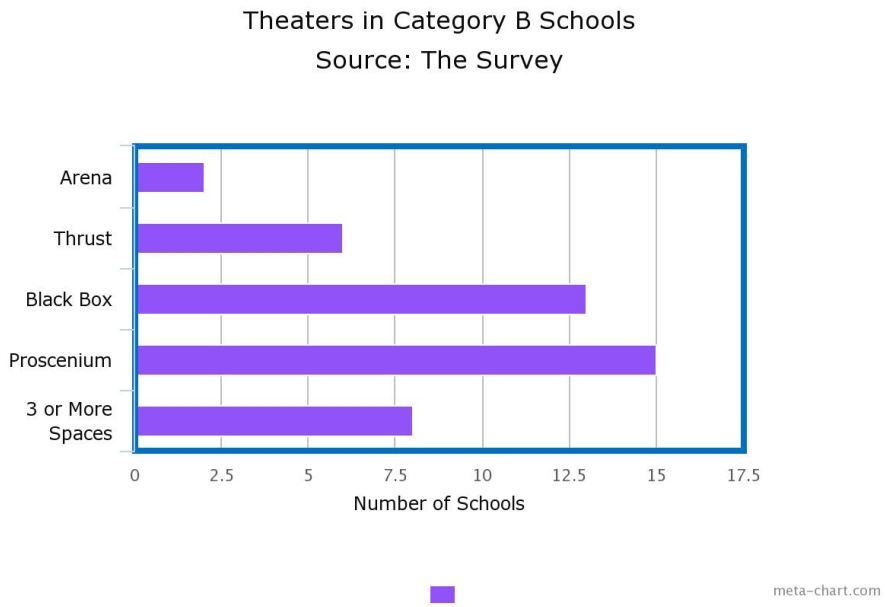

Figure 13 – Category B Budget Shares, Non-Musicals

Calculated as percentages, the Scenic Budget shares reported were compared to the total, all department budgets for a typical non-musical production using meta-chart.com's pie chart generator.

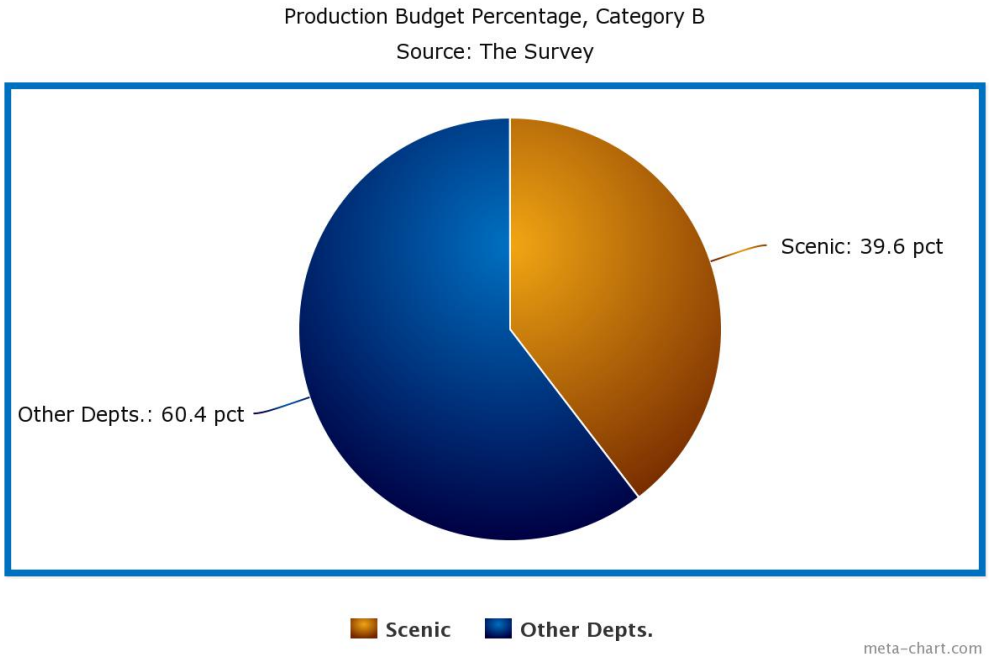

Figure 14 – Category B Budget Share, Musicals

The survey collected budget averages from each of the respondent institutions regarding musicals. The pie chart below, created by meta-chart.com, depicts the scenic budget share of the overall, all department budget for a musical.

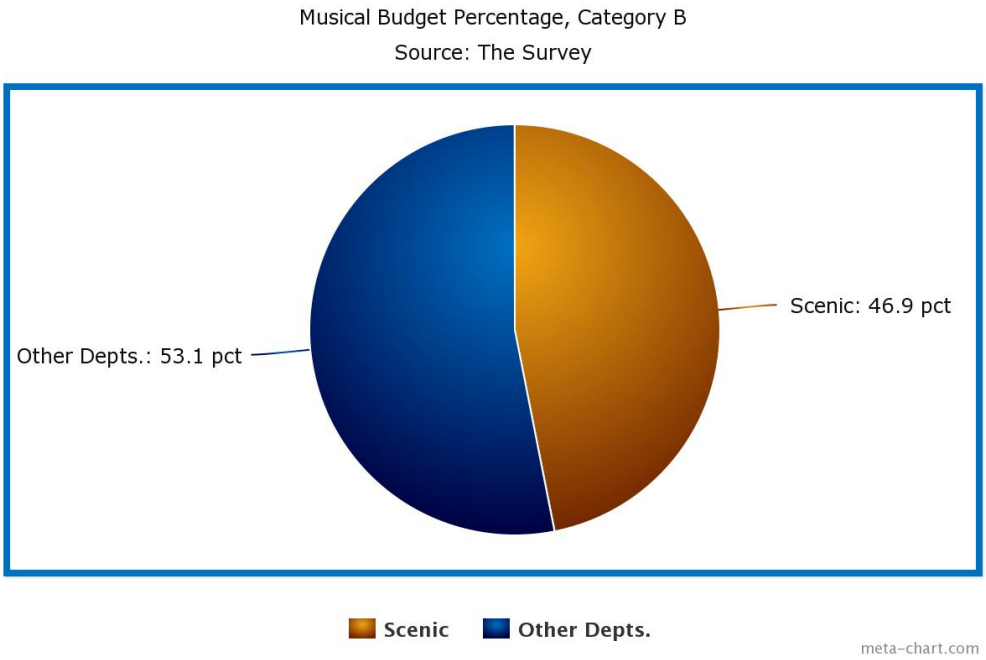

Figure 15 – Tool Percentage, Category B

By adding the total number of responses from all 9 tools, 123 tools were determined to be on Category B shop floors from our Top 9 tools. The Wood Lathe is the tenth tool and was omitted from this data point. After determining the combined quantity of tools, 123, each tool count was divided by the total to determine percentage.

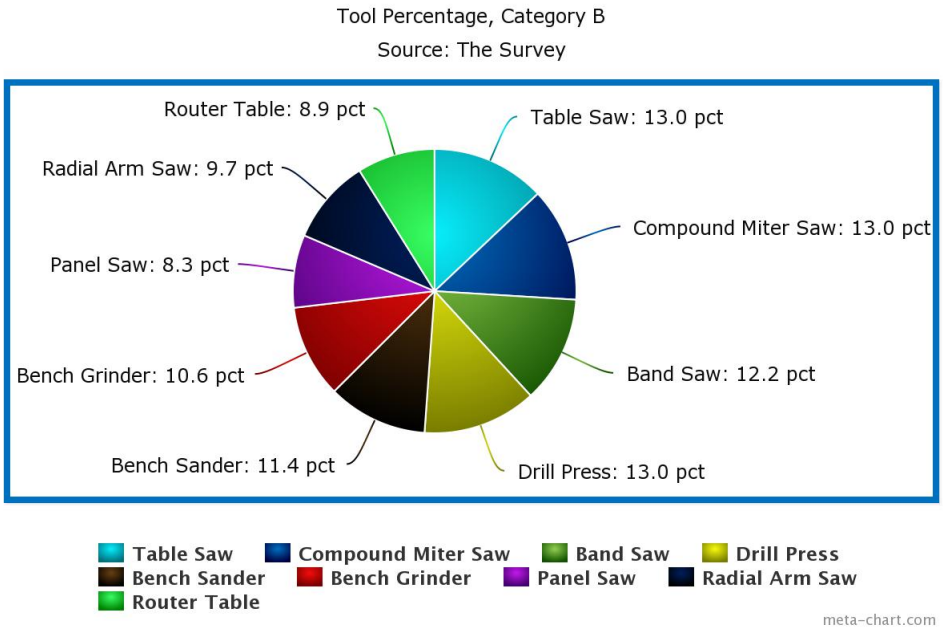

Figure 16- Category B, Metal Tool Comparison

After establishing the percentage of institutions in Category B owning each of the tools, the bar graph was created through www.meta-chart.com's multi-chart generator to provide a quick visual reference for Metal Specific tool ownership compared in Category B to the survey average.

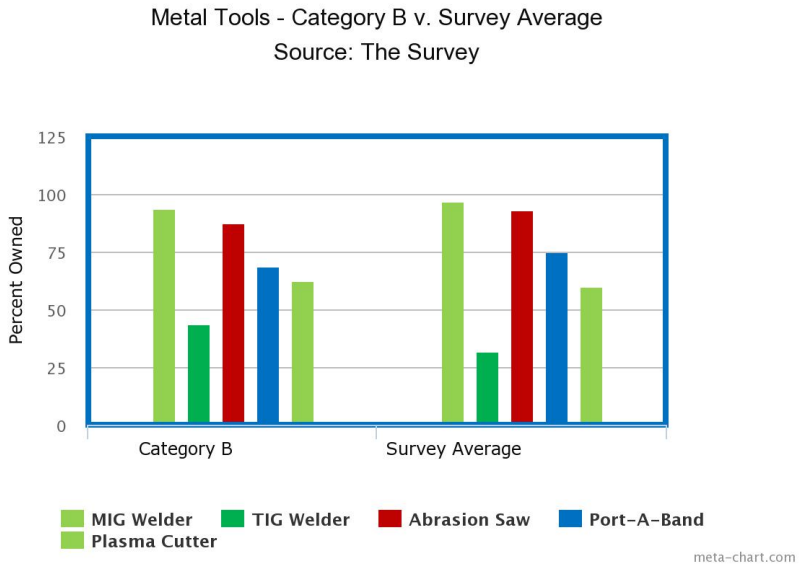

Figure 17 – Tool Percentage, Category C

By adding the total number of responses from all 9 tools, 63 tools were determined to be on Category B shop floors from our Top 9 tools. The Wood Lathe is the tenth tool and was omitted from this data point. After determining the combined quantity of tools, 63, each tool count was divided by the total to determine percentage.

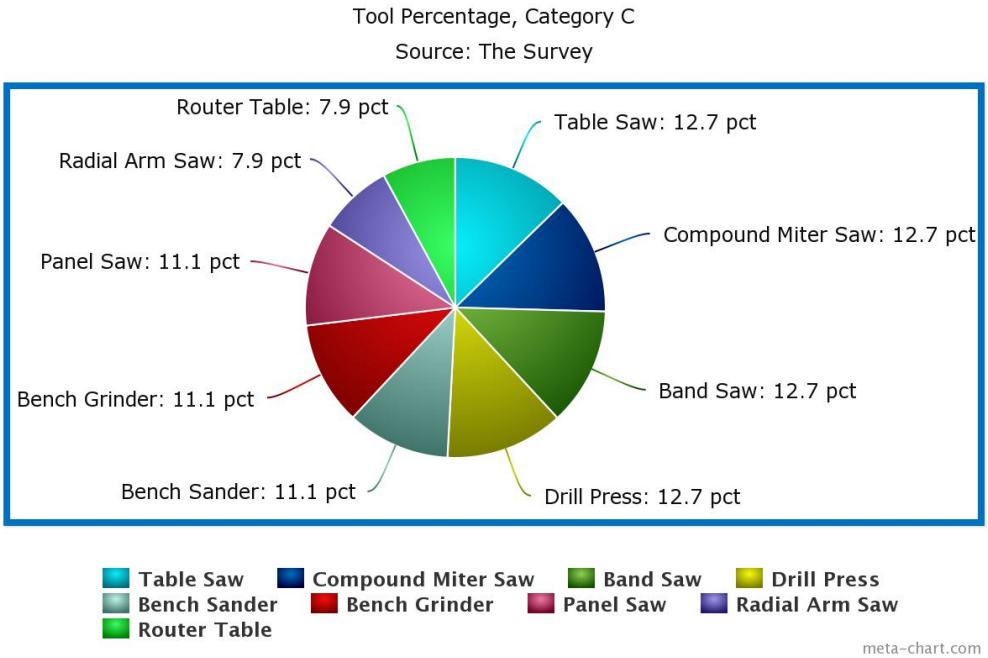

Figure 18 – Category C Metal Tool Comparison

After establishing the percentage of institutions in Category A owning each of the tools, the bar graph was created through www.meta-chart.com's multi-chart generator to provide a quick visual reference for Metal Specific tool ownership compared in Category C to the survey average.

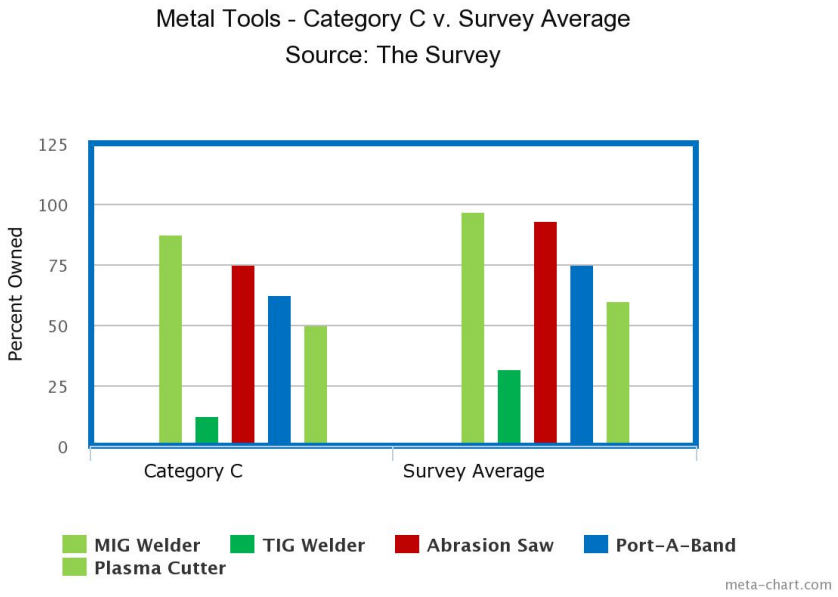

Figure 19 – Theater Types in Category C Schools

The Bar Graph, created with meta-chart.com, references the raw data for total responses to each of the theater types. In the survey, institutions were asked to identify if their facilities included the following: Proscenium, Thrust, Arena, Black Box, or more than three venues. Out of 8 schools in the category, total responses for each venue type are compared below.

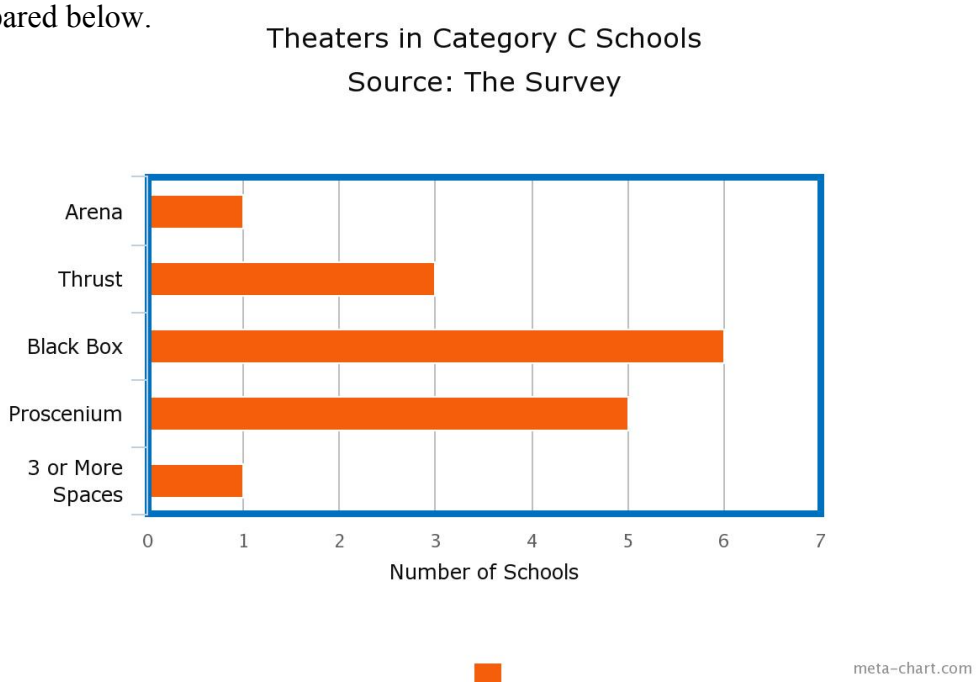

Figure 20 - Category C Budget Shares, Non-Musicals

Calculated as percentages, the Scenic Budget shares reported were compared to the total, all department budgets for a typical non-musical production using meta-chart.com's pie chart generator.

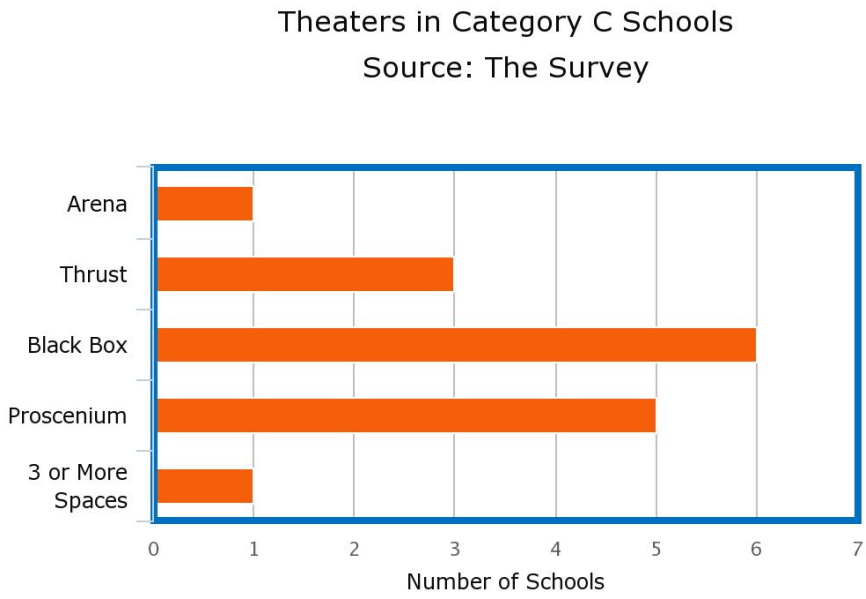

Figure 21 – Category C Budget Shares, Musicals

The survey collected budget averages from each of the respondent institutions regarding musicals. The pie chart below, created by meta-chart.com, depicts the scenic budget share of the overall, all department budget for a musical.

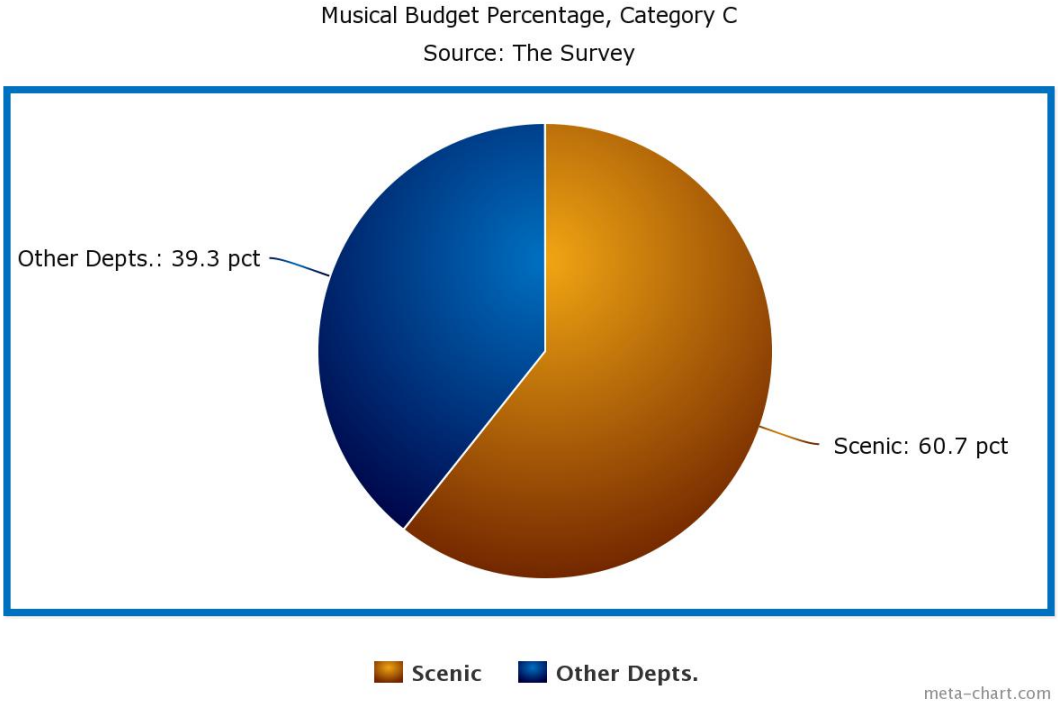

Figure 22 – Personal Protective Equipment, All Categories

The following chart lists the rate at which PPE, personal protective equipment, is provided to students and shop employees across all survey participants.

Personal Protective Equipment Provided By Shops, All Categories			
Safety Equipment	***Percent of Shops Providing***	***Safety Equipment***	***Percent of Shops Providing***
Safety Goggles/Glasses	100.0%	Dust Mask	100.0%
Work Gloves	93.3%	Respirators	46.7%
Nitrile/Sterile Gloves	77.7%	Knee Pads	62.2%
Disposable Ear Plugs	91.1%	Back Support	6.7%
Earmuffs	86.7%	Hard Hats	68.8%
Welding Jacket	80.0%	Hi-Visibility Jackets	4.4%
Welding Helmet	93.3%	Fall Arrest (General Use)	68.9%
Welding Gloves	93.3%	Fall Arrest (Individual Use)	13.3%

Figure 23 – Shop Safety Features and Procedures, All Categories

The following chart lists the rates at which shops are equipped with specific safety measures across all survey participants.

Shop Safety Features and Procedures, All Categories			
Feature or Procedure	***Percent of Shops***	***Feature or Procedure***	***Percent of Shops***
Locked Access	86.6%	First Aid Kit on Shop Floor	95.6%
Shop Power Lockout	26.6%	Eyewash Station	60.0%
Lockout/Tagout for Repairs	37.8%	Tool Training Program	88.9%
Reporting Repairs Protocol	57.8%	Injury Reporting Protocol	95.6%
Controlled Access Tool Lockup	71.1%	Designated First Repsponder	40.0%
Welding Shields	73.3%	Posted Evacuation Plan	53.3%
Vent Hood	57.8%	MSDS Sheets (Up to Date)	80.0%
Dust Collection System	86.7%	Biohazard/Chemical Disposal	66.7%
Explosives Cabinet	35.6%	Hazardous Materials Cabinet	82.2%