# utilizing a hybrid approach to school-based wood instruction

**A hybrid approach to school-based wood instruction blends elements of traditional wood processing such as hand and manual power tool processes with current technology such as CNC routers, lasers, and 3D printing.**

By Justin Egresitz and Alex Johnson

Change is inevitable in today's world of rapidly evolving technologies. As educators, we are tasked with the often difficult job of finding ways to prepare our nation's youth for the uncertainty of an ever-evolving future. For programs that have curriculums in material processing, such as wood instruction, it can be difficult to decide which processes are most critical to include in the course. This can be a major concern when you consider the types of technologies that are commonly used within the woods industry such as computer numerical control (CNC) routers and lasers, and even three-dimensional (3D) printing is being used for prototyping and fixturing (Atwater, 2018). For many programs the high cost of this type of equipment can put its use out of reach. Even if funding is available to acquire the equipment, determining the best strategies for implementing it into the curriculum in a safe and effective manner can prove challenging. For a program that wishes to stay on top of technological advancements it would seem wise to focus instruction on modern trends and reduce, or even eliminate, processes often viewed as outdated, or that could be a liability risk, such as hand- and power-tool processes. There are, however, many good reasons for incorporating both the old and the new into the existing curriculum.

As educators we want our learning environments to be viewed as authentic; or in other words, creating environments that center around authentic tasks and real-world problems (Nicaise, Gibney, & Crane, 2000). For many academic programs, achieving authentic learning environments is difficult because existing learning activities are often structured around artificial contexts and presented in ways that fail to connect with the students in ways that they perceive have value in their lives (Luo, Murray, & Crompton, 2017). As a result, these inauthentic learning environments oftentimes only achieve superficial learning. With all the current focus on high-technology operations such as CNC machining, 3D printing, and laser cutting, it may be perceived that implementing a table saw or block plane in the curriculum would create an inauthentic and potentially hazardous learning experience for students. The truth is that many industries, Gibson Guitars for example, utilize a variety of production methods to produce their products.

At Gibson, a visitor is as likely to see a part being produced on a high-tech CNC router as they are a worker carefully sculpting the neck of the guitar using a hand rasp (Premier Guitar, 2019). Though students may never need to use a table saw or a wood rasp in their future career paths, there are benefits to teaching them how to use these tools appropriately and they can learn valuable lessons in the process. If, during the course of the lesson, attention is focused on helping students see how these processes are each used in real-world applications, it can go a long way towards helping them

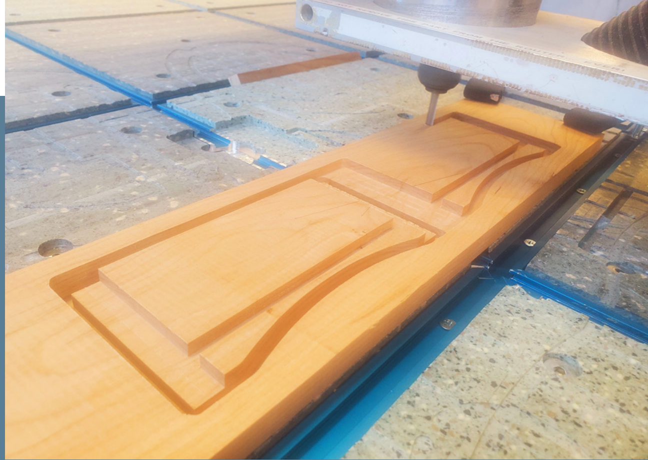

**Figure 1.**

**Figure 2.**

connect with the material, which is essential when establishing an authentic learning environment. A hybrid approach to school-based wood instruction is an effective and safe way of blending these traditional, foundational skills—and the educational benefits that comes from learning to use them—along with more modern concepts such as computer-numerical control (CNC), three-dimensional (3D) printing, and a host of other technologies that are needed by students as they move towards the future.

## Working in a Digital World

A hybrid approach to school-based wood instruction blends elements of traditional wood processing such as hand and manual power tool processes with current technology such as CNC routers, lasers, and 3D printing. The hybrid approach is about choosing the best process to complete a task and most importantly, helping students to understand the selection process, which will teach them how to make successful decisions when tasked with complex problems. It is true that many educational programs lack some, or perhaps all, of this equipment; however, lack of resources should not present an insurmountable barrier to exposing students to current forms of technology. While still lacking true equity across the entire education landscape, 75% of American classrooms surveyed by the 2018 Global Education Census Report reported that they had, and prominently used, desktop computers in their classrooms (Cambridge Assessment International Education, 2018). Having access to desktop computers presents many opportunities when paired with free computer-aided design (CAD) and computer-aided manufacturing (CAM) software that is readily available. With these programs students can learn how to work within design constraints to ideate and design solutions with the end goal of producing them digitally. Vectric Aspire, a popular CAD/CAM software package, allows students to program tools like a CNC router and view the cutting operations in a virtual simulation (Vectric, 2020). This level of mass technology adoption, while imperfect, presents an opportunity for technology and engineering educators to teach relevant and forward-looking skills, engaging students in safe practices, building technical depth, and exposing students to the engineering design process while utilizing the resources available to them in their programs.

Within the scope of a general education technology and engineering education classroom, all students can accrue benefits from these hybrid approaches. These benefits emanate from the use of technologies that support a design-based curriculum. Through the use of CAD and 3D modeling software, all students can learn about the designed world. For example, they can acquire design-thinking skills, learn how household objects are created and assembled, and develop math skills through measuring and design. Bringing aspects of more traditional elements into the hybrid curriculum, such as the use of hand and power tools, can help students develop a better understanding of the evolution of technology, which can provide a better understanding of the way that complex, modern production systems operate. Furthermore, many of the basic hand and power tool processes are still widely used in modern industry; many would be surprised to see how prevalent their use is for secondary manufacturing operations. Gibson Guitars, one of the premier manufacturers in the world, uses a variety of automated processes to produce its various shapes of guitars and necks; however, a video tour of its facility shows workers utilizing powered tools and hand tools such as rasps, rotary tools, and wide-belt sanders to perform many secondary operations as well (Premier Guitar, 2019). A hybrid approach also facilitates the development of life and job skills. These skills, such as collaboration and communication, are useful in many facets of a student's academic, private, and professional life. These skills can be developed through team activities and projects that simulate the structure of the working world and develop the so called "soft skills" coveted by employers (Dean & East, 2019).

## Selecting Suitable Projects

A common, novice-level project that is used to teach basic woods processes and joinery is a jewelry/dresser valet box. There are myriad styles of jewelry boxes with endless levels of complexities. Plans are

**Figure 3.**

widely available in books, magazines, or in online repositories. These timeless designs often come with instructions on how to craft the object and reflect the use of commonly available tools at the time of their writing. These projects have always been a tremendous starting point for educators when crafting their curriculum and remain in use to this day.

Many of the aforementioned projects that have served educators well in the past can still provide the same jumping off point for educators interested in using a hybrid approach. As one may have previously taken the plans and adapted them for the available tools or practices they wanted to teach, much the same can be done when incorporating CNC machines. As educators evaluate the steps required to create the project, they may decide that a certain process is well suited to the use of CNC, power tools, or hand tools.

In an advanced-level woodworking classroom, where the emphasis shifts from basic skill development to development of expertise with the engineering design process and more skillful techniques, educators can use project plans to build a set of broad constraints for students to work within. These constraints could be related to the style of a particular era or using period correct techniques for joinery and finishing. In addition to constraints, the educators can now hand over the decision-making process regarding tool choice to students, which adds an additional dimension to their engineering design process as well.

## Decisions, Decisions

There are a variety of considerations that need to be considered when selecting an appropriate project or set of constraints for a hybrid approach. These decisions are, in part, influenced by the available resources, experience level of the educator and students, and learning objectives and outcomes of the course. Though a completely unique, custom project can be developed, it is generally better from a time-saving standpoint to work with an existing project, preferably one that has already been used within the program in the past and with which the educator is familiar. This level of familiarity will be important when evaluating the project with regard to determining the best strategy to use when deciding which process to use for a particular part. A jewelry box with an Arts and Crafts period theme was selected as the example for this article. This project was selected because it was familiar to the authors, one of whom had used it in previous classes. From a practical standpoint, it is inexpensive to produce since it only uses about four board feet of material; however, it has enough complexity in the design to both challenge students and serve to illustrate a variety of techniques, providing students a broad overview of wood processing and finishing. Lastly, in practice, the project has continued to prove popular with students, who look forward to building this particular project, as it provides an intrinsic reward to those who complete it.

Using a predetermined project was chosen for this project, as the population of students who would be attempting it have few, if any experiences with tools. As such, teaching basic operation and safety content is of paramount importance. In subsequent projects, after a baseline of skills has been developed, students are exposed to the engineering design process and work within a set of criteria and constraints as outlined by *Standards for Technological and Engineering Literacy* (ITEEA, 2020). By engaging with skill development first and then engaging with engineering design, students work more safely and have a better understanding of the processes available to them once in an engineering design environment.

When evaluating a project for use with a hybrid approach, one must first determine the best method to use for each step of the process when crafting the project. In the case of the above-mentioned jewelry box, the plans were broken down for the purposes of teaching, demonstrations, and processes. They were then matched with conventional and CNC tools as well as hand-tool operations. The design features a square body that uses rabbet joints for its construction. The authors saw this as an opportunity for using CNC to machine the four sides and joinery in a safe and consistent way. While the rabbets could be cut on the table saw using repeated single cuts or a dado stack, using the CNC router was a safer and more efficient tool, as it could cut the side profile and joinery with one operation (see Figure 1).

Another benefit of this process is that it helps to build confidence for students who have had little or no prior experience with woodworking. The joinery involved with this project can be difficult to achieve in a clean, precise manner using traditional power tools. By utilizing the CNC router, one of the more difficult aspects of this project can be accomplished with precision by even the most novice student—resulting in a more professional-looking project that helps build students' confidence, which studies show yields better learning outcomes (Norman & Hyland, 2003).

Conversely, when planning the process to cut the large-beveled pieces that make up the lid, the authors chose to use the table saw. To use a CNC to produce the bevel would be a very time-intensive process that would be ultimately inefficient. As with any process in the laboratory, all procedures for the safe operation of the machine are covered while also discussing the relevance of how a particular machine or process is currently being used in industry (see Figure 2). Building these connections between what takes place in the classroom and real-world issues, problems, and applications is a critical component when creating an authentic learning experience (Rule, 2006)

Hand tools are frequently utilized in industry as a form of secondary operation (Atwater, 2018). To highlight the use of hand-tool operations with this project, a small chamfer is applied to the underside edge of the lid of the jewelry box. As with previous operations, there are a multitude of ways to create this chamfer, including the use of a router table. The router table may be the most efficient, if set up for all students; however, the opportunity to learn to use a block plane while also not tying up equipment for a period of time as students complete their lids was viewed as most appealing. A shortcoming of the router table is that once set up, it can have its set up broken and then a student may put the incorrect size chamfer on the lid. As a way of learning a tool, tool geometry, and a new process while also managing machine availability, it was decided to use a hand-tool method to apply the chamfer (see Figure 3).

The jewelry/dresser valet box example effectively illustrates the value of using a hybrid approach to woods-based instruction. By looking at the processes individually and viewing the different tool options not as constraints but as available options for best practice, safety, and desired learning outcomes, all machining processes become valuable contributors to the overall learning. This strategy also helps prevent students waiting at machines for availability and provides an exposure to a wide variety of processes that can spark their creativity for other projects. There is also the potential for students to practice their design and collaboration skills, while also using science and math knowledge through open-ended design challenges, once basic skills have been taught.

## STEL Alignment

With the creation of *Standards for Technological and Engineering Literacy (STEL)* (ITEEA, 2020) comes an opportunity to create up-to-date curriculum that reflects the new imagining of our content. When viewing a hybrid approach to woods-based instruction through the lens of *STEL*, there are several ways in which this approach can contribute to the attainment of prescribed standards and practices within the context of material conversion and processing at the middle and high school levels. In the hybrid approach, students learn to think through and choose the best tool or process to create the part they are making. By tasking students with making tooling choices the hybrid approach can contribute toward the attainment of several standards.

STEL standard 4M prescribes that students "devise strategies for reducing, reusing, and recycling waste caused from the creation and use of technology" (ITEEA, 2020, pp. 40). The hybrid approach contributes to the attainment of this standard when students consider material waste as a factor for choosing a tool for their work. Standard 5G asks that students "evaluate tradeoffs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors" (ITEEA, 2020, p. 46). Implementation of the hybrid approach contributes to the attainment of this standard by tasking students with deciding and prioritizing competing factors, such as efficiency, safety, and thoughtful use of materials. Lastly, standard 6F asks educators to "relate how technological development has been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge" (ITEEA, 2020, p. 50). By focusing on a diversity of processes in the hybrid approach, from traditional hand tools up through digital tools, students learn about the evolution of production processes and of the tools that power them. It should be noted that if open-ended design challenges were used in concert with the hybrid approach there would be opportunities to incorporate many more *STEL* standards and broaden the impact of the curriculum.

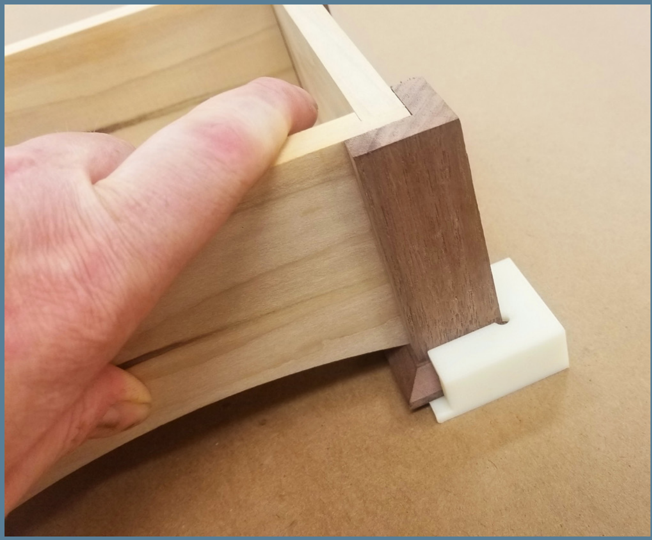

**Figure 4.**

## Technology Limitations

Given the great diversity of tool availability within the field of technology and engineering education, some educators may be limited in their options. It is more common that a technology and engineering education classroom may be outfitted with traditional machine tools and hand tools than it would be to see one or more digital tools, such as a CNC or laser engraver. As such, there are many classrooms that do not have digital tools at their disposal. In the event that a classroom is equipped with digital tools, there may be barriers to effective implementation such as size of machine and number of machines.

While there are technological limitations such as these, a hybrid approach can still be applied in these situations. In classrooms where there are digital tools, but they are limited in capacity and/or number, an educator could use them as a part of the process of making but in a different way. In lieu of having each student use the tool for a similar process, the students could collaborate and use the CNC router, laser, or 3D printer to create, design, and fabricate a fixture or piece of tooling that aids in the making of a part of their project (see Figure 4).

In classrooms where capacity of the tool is an issue, instead of using the tool to create a large part, have students create engravings or embellishments. Digital tools can be used to engrave names, designs, or even create beautiful marquetry by cutting highly accurate pieces of veneer and matching patterns in pieces of wood. These processes can allow students to engage creatively and personalize their projects, which often leads to higher satisfaction and investment into their work.

For educators who do not have access to digital tools, but who still believe that teaching in a hybrid way is useful, many of the theoretical benefits of a hybrid approach can be gained by using free CAD/CAM software with simulation features. A popular CAD/CAM software company, Vectric, offers a free trial software that has no time limitations and collects no information (Vectric, 2020). The software features a CNC router simulation mode that will allow the user to design or import shapes, create various types of toolpaths, and run a robust graphic simulation of the shape being machined on a CNC. This simulation allows the user to see if the design and toolpaths would create a successful part or not and create a job sheet that could be submitted for grading. Educators may also take the files to community business partners who have the equipment and machine them out without great pain of file conversion. Using software and simulation in this way can allow schools without access to physical machines the opportunity to glean benefits from a hybrid approach to woods-based instruction.

## Conclusion

The world we live in is constantly changing. With the rapid changes brought about by educational reforms and technological advancements, it is easy for educators to lose sight of their ultimate goals—to promote learning to all students. Areas such as school-based wood instruction can be difficult subject areas to teach since they can cover so many different facets but, when handled effectively through a hybrid approach, can be immensely rewarding to students by helping them develop confidence, soft skills, and problem-solving abilities that are critical in every career and educational experience alike. When coupled with the newly created *Standards for Technological and Engineering Literacy* (ITEEA, 2020), the hybrid approach offers educators an exciting opportunity to develop curriculum that both meets these standards and creates an authentic, forward looking learning environment for students.

## References

Atwater, M. (2018). *Materials and manufacturing: An introduction to how they work and why it matters*. New York: McGraw-Hill Education.

Brown, R. (2019, May 24). *How ancient woodworkers sculpted civilization*. Retrieved from www.ancient-origins.net/history-ancient-traditions/woodworking-0011950

Cambridge Assessment International Education. (2018, November 14). *Three out of four US students now use smartphones in the classroom*. Retrieved from Cambridge Assessment International Education: www.cambridgeinternational.org/news/news-details/view/three-out-of-four-us-students-now-use-smartphones-in%20the-classroom-14nov2018/

Dean, S. A., & East, J. I. (2019). Soft skills needed for the 21st-century workforce. *International Journal of Applied Management and Technology, 18*(1), 17-32.

International Technology and Engineering Educators Association (ITEEA), (2020). *Standards for technology and engineering literacy: Defining the role of technology and engineering in STEM education*. [PDF]. Retrieved from www.iteea.org/STEL.aspx

Luo, T., Murray, A., & Crompton, H. (2017, November). Designing authentic learning activities to train pre-service teachers about teaching online. *International Review of Research in Open and Distributed Learning, 18*(7).

Nicaise, M., Gibney, T., & Crane, M. (2000, March). Toward an understanding of authentic learning: Student perceptions of an authentic classroom. *Journal of Science Education and Technology, 9*(1), 79-94.

Norman, M., & Hyland, T. (2003). The role of confidence in lifelong learning. *Educational Studies*, 29, 261-272.

Premier Guitar. (2019, August 29). *Gibson factory tour 2019* [Video]. Youtube. https://youtube.com/watch?v=0w8sNA8wdLA&t=605s

Rule, A. C. (2006, August). Editorial: The components of authentic learning. *Journal of Authentic Learning, 3*(1), 1-10.

Vectric. (2020, July 10). *Aspire*. Retrieved from Vectric: Passionate about CNC: www.vectric.com/products/aspire?gclid=EAIaIQobChMItqT7mp_G6gIVzQiICR0pVgcOEAAYASAAEgJt2_D_BwE

**Justin Egresitz** *is a Graduate Teaching Assistant at North Carolina State University pursuing a Ph.D. in Teaching and Learning in STEM. He can be reached at* jcegresi@ncsu.edu.

**Alex Johnson** *is an Assistant Professor in the department of Applied Engineering, Safety, and Technology at Millersville University of Pennsylvania. He can be reached at* alex.johnson@millersville.edu.

***This is a refereed article.***