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How Standards Facilitate Innovation and Benefit Society

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Abstract

This paper attempts to present the primary ways that the exercise of standardization streamlines innovation by maximizing value-added portions of research efforts and by fostering collaboration through efficient communication of ideas. Also discussed are important benefits of standardized engineering practices and products and the resulting positive impacts on society. The supporting arguments for these claims are taken from some historic examples, but more importantly, from personal experiences of the author as an engineer and researcher. This narrative presentation style is intended to sharply contrast the rigid concept of uniformity to propose that despite its many benefits, standardization of human experience would stifle creative thought and innovation. However, the following arguments will encourage maintaining a diverse familiarity of standardized methods and products from a variety of topics to tackle complex interdisciplinary challenges and to protect the wellbeing of society.

Part I: Facilitation of Innovation

Perhaps the most important way that standards positively impact research and engineering is by reducing non-value-added work. This is done in two distinct ways: by standardizing products and by standardizing practices.

Standard products are useful in that their fit, form, and function are guaranteed. The first such widespread application of this concept is the idea of interchangeable parts. On November 20, 1790, French academics, military officials, and politicians attended a stunning demonstration in which Honoré Blanc assembled several gunlocks from a random selection of parts. They were just a few of the thousands of identical mechanisms produced in Blanc's experimental facility. The innovative process negated the need for skilled craftsmen to exact a final fit of each component [1].

Interchangeability has been expanded in the intervening years through many forms of standardization. A perfect example of this is a fastener. Standardized fasteners including bolts, nuts, washers, pins, and screws are now completely interchangeable regardless of application as long as the components satisfy their respective standard. One very important feature of a standard specification of a socket head cap screw, for example, is the dimensional tolerance information [2]. The allowable variation in geometrical dimensions can be precisely anticipated and the computer-aided design adjusted to guarantee a proper fit. The concepts of fit and tolerance and the way the intentions are communicated are standardized as well by the American Society of Mechanical Engineers [3]. The effort of foresight prevents the extra time associated with rework during production and can help to prevent catastrophic failures [4].

Standardized components or materials must also have consistent function. Predictability of strength, for example, allows the designer to create more robust simulations, such as finite element models. The standard specification for AMS 6061–T6 and –T651 aluminum sheet and plate calls out specific strength values for given thicknesses, ranges of composition, and specific heat treatment requirements [5]. Having reliable information at the beginning of the development process shortens the design cycle and minimizes test iterations.

Standard practice is a concept that can encompasses many ideas including processing techniques, terminology, testing methods, and presentation of results. Though much of the benefit of having standard practices is of a benefit to society, which will be covered in the second section, there can still be benefits to the process of innovation. Most importantly standard practices can facilitate the transfer of knowledge, which can have direct and indirect impact on productivity. A very simple example of this effect is when an innovative technique becomes an industry standard, as is the case for the Jominy test of hardenability of steels. This test is an ingenious technique in which a steel sample is cooled on one end from a prescribed temperature. This produces a gradient in the cooling rate along the length of the sample. After the sample is cooled, the hardness of the steel is measured and is plotted against distance. From a single test, a large quantity of data is extracted and can be used to determine several important parameters in design [6]. The "hardenability curve" is now readily available for any commercial steel product such as AISI 4340 [7]. From this comprehensive collection of data, one not only has the information needed for design with a single steel alloy, but also the ability to easily compare one alloy to another. In this profound way, the innovative Jominy test assists an entire industry of engineers working on their own inventions. This level of impact from a single idea is the gamble that the National Aeronautics and Space Administration has bet upon with its NASA Technology Reporting (NTR) program. NTR reports can eventually lead to industry patents, and highlight technologies developed at NASA centers for very non-standard applications [8].

In technical fields that are filled with jargon, certainty of definitions is critical. Without standard terms, it is clear that even a simple experiment could be reported in an improper manner, which would occlude the scientific value of the information. Standard terminology specifications are common; one for design of experiment [9] shows how collecting and presenting innovations and ideas in a standard way can facilitate transfer of these ideas. Beyond terminology, jargon might also include the symbols used to describe dimensioning and tolerancing.

Consistent terminology within a field is commonly one of several goals of technical societies. These entities often have journal publications that serve to share and standardize the quality information presented through peer review. With higher quality comes better dissemination and transfer of knowledge. The mission statements of these organizations clearly state their intentions: "spreading knowledge, strengthening skills and promoting plastics" for the Society of Plastics Engineers [10]; "pursue… technology advancements through Collaborative Research and Development" for the American Iron and Steel Institute [11]; and "promote public health and safety" and "contribute to the reliability of materials, products, systems and services" for ASTM International [12]. These entities exist by their own decree to facilitate innovation and for the benefit of society.

Part II: Benefit to Society

An indirect way that standards benefit society is through reference standards. An entire agency of the U.S. Department of Commerce is devoted to this aim. The National Institute of Standards and Technology was created in 1901 to correct the industrial deficiency in measurement standards to better compete with European economies [13]. It could also be argued that innovation facilitated by better measurements in science, technology, and industry is beneficial to society by widening the scope of understanding of humanity. However, the most direct and arguably important way that standardization benefits society is by improving safety. In this aspect, standards take on a different form of codified laws, which are enforced by responsible agencies. For example, railway safety in the late 1800s to early 1900s in the United States was extremely hazardous. The most perilous job was that of a brakeman, and between 1908 and 1910, it was reported that 11.41 out of 1,000 workers were killed on the job while 3.92 were injured [14]. The surprising fact is that these statistics were a reduction from when the first numbers were officially published in 1889 by the Interstate Commerce Commission. In 1893, Congress passed the *Safety Appliance Act* in response to the problem, which stated that new inventions such as the air brake and automatic coupler would be mandatory for railcars [15].

This type of regulation can tend to obscure the requirements and applicable rules intended to protect society or the environment. There is a process wherein all the related information is condensed down into a standard list of rules, or codes. This is known simply as codification, with the most famous early example, though not the oldest, being the Code of Hammurabi [16]. The code was a collection of rules to follow and the punishment for disobedience and dated to the 18th century B.C. Some codes explicitly protected public welfare, such as the life of a homeowner as quoted below:

> *§ 229.*
> *"If a builder build a house for a man and do not make its construction firm, and the house which he has built collapse and cause the death of the owner of the house, that builder shall be put to death"*[17].

From such simplicity and harshness of enforcement, the beginnings of modern building codes have evolved considerably. Lengthy and extremely detailed documents are commonplace such as the 68-page

Technical Code 2010 supplied by the City of Birmingham, Alabama, which governs housing structures within the city [18].

It is often difficult to understand the benefit of the progression from simple decrees to complex and lengthy requirements. A specific example of a document with numerous, specific requirements is the American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Code. By following the detailed guidelines, a designer, fabricator, or inspector can be better assured that components, systems, and facilities for critical applications such as nuclear energy will perform properly and safely. ASME maintains the Code with the help of 950+ volunteer engineers to keep the information "live" with new editions every three years [19].

As technology progresses, it is important that standards maintain applicability to the new technologies being created and the challenges and dangers that might arise. The wooden products industry has grown from humble beginnings to modern globalization while incorporating new ideas such as composite products and ever-evolving test methods [20]. The relatively new field of nanotechnology, on the other hand, is only beginning to lay down the groundwork of a completely new and unimaginable future [21]. It is the responsibility of each individual and the standards community as a whole to provide the stewardship required to continue technological advancement of the new and exciting while maintaining due scrutiny of the ordinary and well-understood to safeguard and benefit society as a whole.

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