Adoption of Additive Manufacturing Certifications and Metal Additive Manufacturing by Technology Programs

Dr. Ranjeet Agarwala, East Carolina University

Dr. Ranjeet Agarwala serves as an Assistant Professor in the Department of Technology Systems at East Carolina University. He holds a PhD in Mechanical Engineering from the North Carolina State University. Since 2001 he has taught courses in Engineering Design, Thermal and Fluid Systems, Digital Manufacturing, and 3D printing, GD&T, Electro-Mechanical Systems, Statics and Dynamics. His research interests are in the areas of Sustainability such as Renewable Energy and Green Manufacturing such as Additive Manufacturing

Dr. Robert A. Chin, East Carolina University

Robert A. "Bob" Chin is a faculty member, Department of Technology Systems, College of Engineering and Technology, East Carolina University. He is a past chair of the Engineering Design Graphics Division and as of the 2020 annual conference, he will be serving as the outgoing past chair of the Division. In 2015, he completed his second term as the director of publications for the Engineering Design Graphics Division and as the Engineering Design Graphics Journal editor. Chin has also served as the Engineering Design Graphics Division's annual and mid-year conference program chair, and he has served as a review board member for several journals including the EDGJ. He has been a program chair for the Southeastern Section and has served as its Engineering Design Graphics Division's vice chair and chair and as its Instructional Unit's secretary, vice chair, and chair. His ongoing involvement with ASEE has focused on annual conference paper presentation themes associated with the Engineering Design Graphics, Engineering Libraries, Engineering Technology, New Engineering Educators, and the Two-Year College Divisions and their educational and instructional agendas.

©American Society for Engineering Education, 2020

Adoption of Additive Manufacturing Certifications and Metal Additive Manufacturing by Technology Programs

Abstract

Additive Manufacturing (AM) certifications offered by seven entities were examined with respect to title, cost, content areas, and delivery mode. A total of twenty-four AM content areas were identified based on the seven entities that offer AM certifications and from the proposed AM course at the authors' university. Earlier findings that compare AM metal technologies is included in the discussion. The cost of AM certifications and the coverage of certification content areas vary greatly across the entities. AM certification offered by Society of Manufacturing Engineers (SME) had more content coverage while being affordable when compared to AM certifications offered by several other entities examined in this study. With respect to metal printers, a MarkForged Metal X printer is less expensive, has a higher build volume, and has similarities with Fused Deposition Modeling (FDM) technology and therefore can be adopted to introduce metal AM techniques to technology students. The findings, while they may not be generalizable across all technology programs, could still be useful to some programs conserving adoption of AM certifications and metal AM technologies for its students.

Introduction

The additive manufacturing market continues to advance with the advent of new and different techniques, materials, and machines and the implementation of Industry 4.0. Engineering and Technology programs are in a constant state of flux as they attempt to respond to market needs for those with knowledge and skills in additive manufacturing. Thorsteinsson and Page [1] discussed the evolution of 3D printing and Industry 4.0 and remarked that "Industry 4.0 is touted, by many, to change the lives of millions over the next several decades. Industry 4.0 is a term that seems to be synonymous with 3D printing, also known as additive manufacturing".

The literature suggests that students and graduates who possess direct metal additive manufacturing techniques knowledge and skills have a career advantage compared to students whose knowledge and skill base is limited to plastic printing [2]. Therefore, there has been a recent interest among institutions in direct metal additive manufacturing. Many institutions and programs are considering, and some have already added metal additive printers and additive manufacturing certifications as part of their curricular offerings [3]. Increasingly many manufacturing societies and metal additive manufacturing machine companies are offering certification programs through their training programs making it difficult to decide to adopt the right fit. The study focused on the examination and comparison of additive manufacturing (AM) certification across several entities and further discussed pervious findings [4] with regards to comparison AM metal technologies and its potential adoption by technology programs. Literature search did not reveal any previous studies with regards to investigations and comparisons of AM certifications.

Additive Manufacturing Certifications Investigation

Additive manufacturing certifications offered by seven different entities were examined. The study focused on the title, cost, content areas, and delivery mode of the certificate. Table 1 depicts the Entity, title, cost, and delivery mode of AM certificate. Figure 2 depicts the cost comparisons of entity offering AM certificate.

Table 1. Entity, title, cost, and delivery mode of AM certificate.

Entity	Certification/Certificate Title	Cost	Delivery Mode
Society of Manufacturing Engineering (SME) [5]	Additive Manufacturing Technician Certification	$269.00	Online
Dassault Systems Solid works corp. (DSSC) [6]	Certified Additive Manufacturing Associate	$49.95	Online
American Society for Testing and Materials (ASTM) [7]	Additive manufacturing	$900.00	Face to Face
American Society of Mechanical Engineers (ASME) [8,9]	Design for Additive Manufacturing with Metals	$2,495.00	Online
Texas A&M University (TAMU) [10]	Additive manufacturing	$5,990.00	Face to Face
Purdue University (PU) [11]	Additive manufacturing design	$832.00	Online
Massachusetts Institute of Technology (MIT) [12]	Additive manufacturing for innovative design and production	$1,950.00	Online

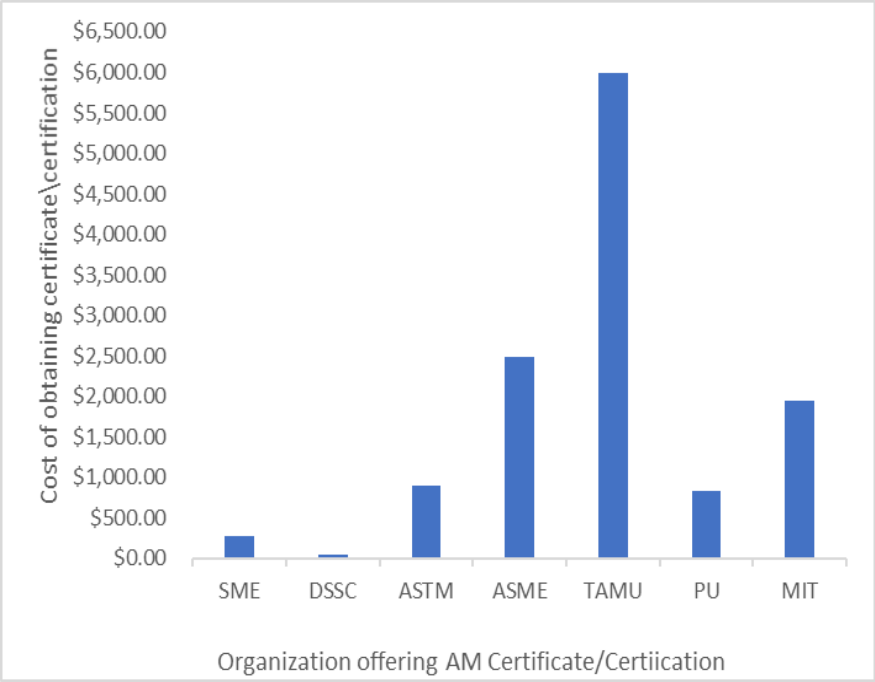

Figure 1. Cost Comparisons of AM Certificates.

Table 2 depicts the AM content area coverage of AM certificates across various entity. The twenty-four (24) AM content listed in here has been compiled from various entities that offer AM certificates. These content areas have also been drawn from the Rapid Prototyping course

taught at the authors' university. An (x) in a cell confirms the coverage. As an example, the AM certificate offered by SME covers twenty-one (21) out of a maximum of Twenty-four (24) AM content areas. Figure 2 depicts the AM content area coverage of each entity offering AM related certification.

Table 2. Content area coverage of AM certificates across entities.

Knowledge areas	Entity offering AM certificate/certification						
	SME	**DSSC**	**ASTM**	**ASME**	**TAMU**	**PU**	**MIT**
1. History of AM							
2. Developments in AM	X		X	X	X	X	X
3. Importance and benefits of AM	X		X	X	X	X	X
4. Applications of AM	X	X	X	X	X	X	X
5. Principles of AM and terminologies	X		X	X	X	X	X
6. AM Processes	X	X	X	X	X	X	X
7. AM secondary processes (pre and post)	X	X	X	X	X	X	
8. AM process chain	X	X	X	X	X	X	X
9. AM file formats and toolpaths	X	X	X	X	X	X	X
10. AM workflow	X		X	X	X	X	X
11. AM materials	X	X	X	X	X	X	X
12. AM in various industrial sectors	X		X	X	X	X	X
13. Design for AM (DfAM)	X	X	X	X	X	X	X
14. AM for Tooling: Jigs and Fixtures	X						X
15. Research and development in AM	X						
16. AM in Industry 4.0	X						
17. Direct metal AM				X			
18. Safety in AM	X		X	X			
19. Inspection for AM	X		X				
20. Non-Destructive Testing for AM (ASTM)			X				
21. Quality assurance in AM	X				X		
22. Evaluation for selection of AM technology			X	X	X	X	X
23. Business considerations for adopting AM	X			X	X	X	X
24. Maintenance aspects of AM	X						X

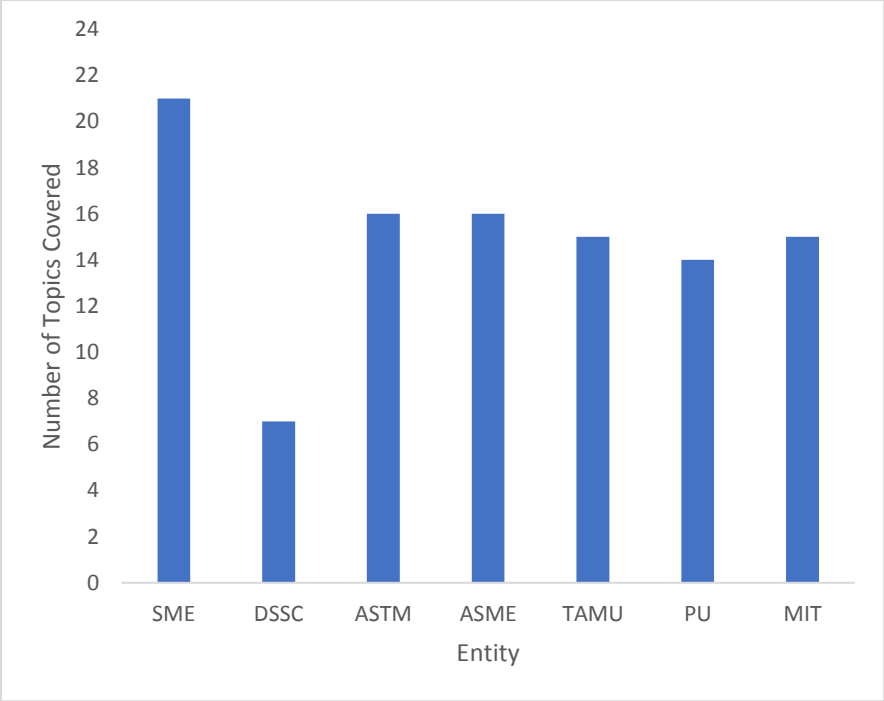

Figure 2. AM content area coverage of each entity.

Metal AM Adoption Discussions

Three metal printers, MarkForged Metal X, Desktop Metal, and GE Concept Laser Mlab Cusing R100, were examined. Table 3 depicts the build volume of the metal printers in mm, price factor comparisons in ratios, and print resolution in micrometers (µm). While MarkForged Metal X and Desktop Metal filaments are polymer infused metal and are akin to fused deposition modeling (FDM process), the GE Concept Laser is akin to selective laser sintering (SLS) process (layer by layer laser sintering of metal powder bed). The build volume of GE Concept Laser is around two and a half (2.5) times smaller compared to MarkForged Metal X and Desktop Metal. GE Concept Laser has a resolution advantage, but price disadvantage compared to remaining printers.

Table 3. Build Volume of 3D metal printers studied. [4]

3D Metal Printer	Width (mm)	Depth (mm)	Height (mm)	Price Factor	Print Resolution (µm)
MarkForged Meta X Printer [13]	300	220	180	1	50
Desktop Metal 3D printer [14]	305	205	205	1.4	50
GE Concept Laser Mlab Cusing R 100 [15]	90	90	80	2.2	30

Discussions and Conclusions

The cost of obtaining AM certifications and the content areas vary greatly across several entities. Figure 6 depicts the cost of obtaining certification versus AM content area coverage of each entity offering AM certification.

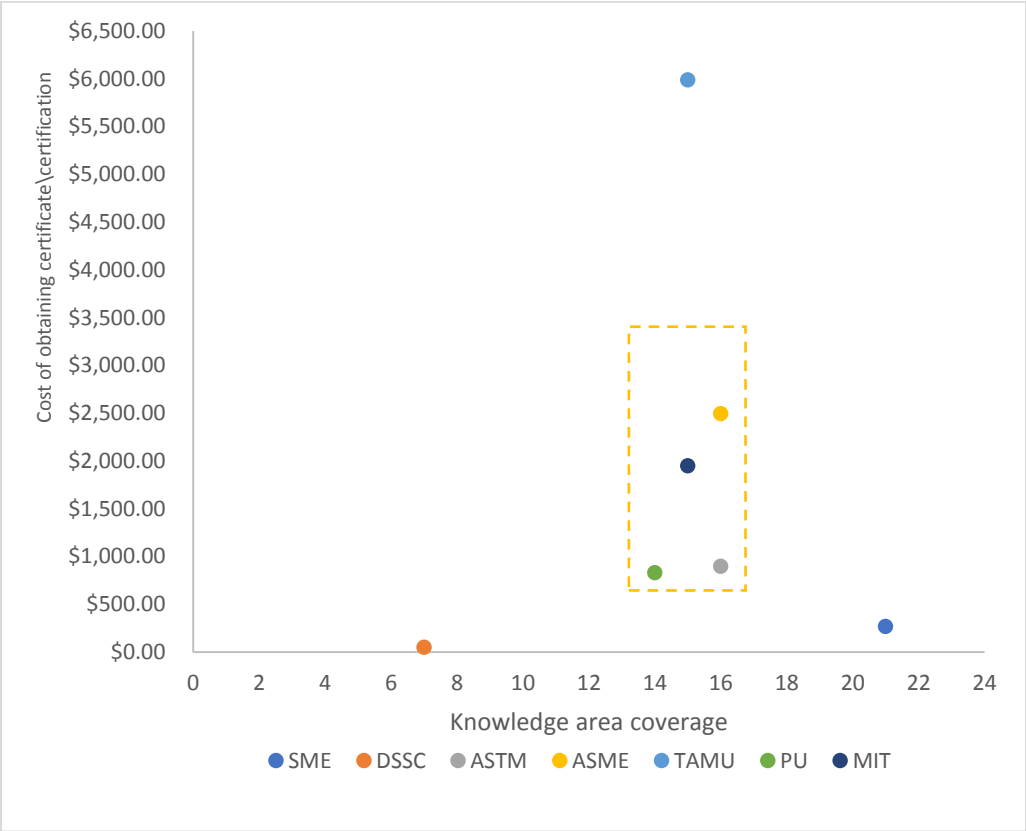

Figure 6. Cost of obtaining certification versus AM content areas

As Figure 6 and as the dashed line box suggests, most of the entities (PU, ASTM, MIT, ASME) offer certifications that have AM content coverage count from 14 to 16 and the average cost to get certified in these entities range from $500 to $2,500.00. DSSC has the lowest coverage and cost while TAMU AM certification is most expensive. ASME AM certification coverage is the broadest at a count of 21. Its cost is under $500.00. The history of AM is not included by the entities that were examined. It is recommended that history of AM be covered by all entities that offer AM certification so that certification seekers can appreciate how current AM technologies have emerged.

Future studies should examine the impact and effect of certification on the professional development and growth of those who possess those certifications. The goal of this study was to provide potential certificate seekers a mechanism to choose a certain type of certificate to fit their needs. An analysis of the AM metal 3D printers revealed that MarkForged Metal X printer offer the biggest build volume at a cheaper price and the initial steps of its operation is very similar to FDM technology. From the results of the study, it is evident that AM certifications cost, and coverage vary across entities that offer them. Although, the authors cannot make a

specific recommendation, it appears from the study that SME has more AM content coverage and is affordable. It also appears that ASME is the only entity that is currently offering metal AM certifications and hence can service those seeking metal AM certifications. Technology programs may look to MarkForged Metal X printer as a starter as it less expensive, has a higher build volume, and generally technology students may already be familiar with FDM technology.

This study is preliminary, and hence further studies are needed to evaluate the suitability of AM certifications and metal AM machines for technology programs. In the interim, it is anticipated that technology programs embarking on the journey of adopting AM certification and AM metals can benefit from this study.

References

1. Thorsteinsson, G., & Page, T. (2018). The Evolution of 3D printing and Industry 4.0. i-Manager's Journal on Future Engineering and Technology, 14(1), 1
2. Steele Michael (2017). New 3D Metals Printer Keeps EPIC on Cutting Edge of Product Design & Manufacture. http://www.bu.edu/eng/2017/06/01/new-3d-metals-printer-keeps-epic-on-cutting-edge-of-product-design-manufacture/
3. Weiss Charlotte (2019). How Two Universities Prioritize Additive Manufacturing Technology. https://markforged.com/blog/3d-printing-in-education/
4. Redacted for Blind Peer Review
5. Society of Manufacturing Engineering - Additive Manufacturing Technician Certification. https://www.sme.org/training/additive-manufacturing-certification/
6. Dassault Systems Solid works corp. (DSSC)- Certified Additive Manufacturing Associate. https://www.solidworks.com/sw/support/54427_ENU_HTML.htm
7. American Society for Testing and Materials (ASTM)- Additive manufacturing. https://amcoe.org/events/certification-program-in-additive-manufacturing-basic-am-certification
8. American Society of Mechanical Engineers (ASME)- Design for Additive Manufacturing with Metals https://www.asme.org/learning-development/find-course/design-additive-manufacturing-metals
9. American Society of Mechanical Engineers (ASME)- Design for Additive Manufacturing with Metals https://asmeldstorage.blob.core.windows.net/additive/am210/AM220_Outline.pdf
10. Texas A&M University (TAMU)- Additive manufacturing. https://tees.tamu.edu/education-and-training/professional-and-continuing-education/amcertificate/
11. Purdue University (PU)- Additive manufacturing design. https://engineering.purdue.edu/online/certifications/additive-manufacturing
12. Massachusetts Institute of Technology (MIT)- Additive manufacturing for innovative design and production. https://learn-xpro.mit.edu/additive-manufacturing
13. MarkForged Metal X, https://3d.markforged.com/
14. Desktop Metal 3D Printer: https://www.desktopmetal.com/
15. GE Concept Laser Mlab Cusing R 100: https://www.ge.com/additive/additive-manufacturing/machines/dmlm-machines/mlab-cusing-r