National Forum on AM Education and Training

Working Group and Brainstorming Session

THE LANTERMAN GROUP

Focus Area 1: Industry Education and Training Needs

Goals and Objectives

1. Group review and discussion (15 minutes)
   - Review industry unmet needs and recommendations for education and training initiatives
     - Educational Needs and Opportunities in Additive Manufacturing: Summary and Recommendations from and NSF Workshop; April 2014
     - America Makes WEO Roadmap; September 2016
     - America Makes ACADEMI; September 2016
     - National Forum on AM Education and Training: AM in Industry: Education and Training Needs; October 2016
   - Discuss additional unmet needs
2. Working teams discussion (45 minutes)
   - Training solution delivery discussion and outbrief
     - Industry constraints, considerations, options

Educational Needs and Opportunities in Additive Manufacturing: Summary and Recommendations from a NSF Workshop: April 2014

Summary of AM topics and frequency of appearance on participants' mind maps

	Topic	*Freq.*
Additive Manufacturing	Terms, processes & technologies, pros & cons	40
	Business considerations: supply Chain, economics, lifecycle analysis & sustainability	21
	Design for AM; File formats	16
	AM Materials & Material-Process relationships	13
	Knowledge about applications, successes & careers	6
Engineering Fundamentals	Material science; computational mechanics; metallurgy; material selection; polymer chemistry	19
	Manufacturing technologies: overview of traditional processes (machining), nano	16
	Metrology, Quality Control, Testing and inspection, Verification & validation	13
	Engineering modeling, analysis, & statistics	8
	Systems thinking	6
	Math	6
	Vocational / hands-on skills	6
	Mechatronics	1
	Engineering economics	1
	Programming	1
	Biomedical	1
	Safety	1

	Topic	*Freq.*
Professional Skills	Problem solving & critical thinking	11
	Teaming & collaboration; Cultural awareness	10
	Entrepreneurship, technology transfer; Customer service & marketing	10
	Learning how to "Fail Forward"	7
	Achieving breadth and depth: a "T-shaped" engineer or a "da Vinci"	2
	Decision making	2
	Teaching skills	1
	Communication	1
	Adaptability	1
Engineering Design	Computer Aided Design Software	22
	Design Process	13
	Topology Optimization	3
	Finite Element Analysis	3
	Quality Functional Deployment	1
	Geometric dimensioning & tolerancing	1
	Reverse engineering	1
Creative Skills	Art, Industrial Design, STEAM, art for designers	6
	Ideation / creativity techniques / design thinking	6

Recommendations

- Ensure that AM curricula provide students with an understanding of:
  - AM and traditional manufacturing processes to enable them to effectively select the appropriate process for product realization
  - The relationships between AM processes and material properties
  - "Design for AM", including computational tools for AM design as well as frameworks for process selection, costing, and solution generation that take advantage of AM capabilities
- Promote K-12 educational programs in STEAM (STEM plus the arts) and across all formal and informal learning environments in order to leverage the unique capabilities of AM in engaging students in hands-on, tactile, and visual learning activities.
- Provide support for collaborative and community-oriented maker spaces that promote awareness of AM among the public and provide AM training programs for incumbent workers and students seeking alternative pathways to gain AM knowledge and experience.
- Establishment of a national network for AM education that, by leveraging existing "distributed" educational models and NSF's ATE Programs, provides open source resources as well as packaged activities, courses, and curricula for all educational levels (K-Gray).

America Makes - ACADEMI

Industry Unmet Needs

Current workforce is not sufficiently skilled or trained to produce commercially ready AM products, because:

- Current training tends to be superficial; without linkage made between additive manufacturing process, materials, machines, and part quality
- Training lacks integration of diverse disciplines, including advanced concepts such as materials, process, design simulation, biomimicry, reverse engineering, and others needed to unlock the value of additive manufacturing
- Current training often fails to connect the AM processes to the economic/ business case
- In some cases, training providers lack objectivity, pushing the benefits of certain AM processes/ technologies at the expense of teaching the best AM approach for a given situation
- Training environments tend to be more theoretical and lecture based than hands-on and application based

National Forum on AM Education and Training: AM in Industry: Education and Training Needs

Industry Recommendations

- Provide more cost effective delivery mechanisms and/or approaches (i.e., practicum is a great model but not effective for 55,000 people)
- Develop inspirational case-studies to be used as motivation and context for training
- Develop training approaches to meet the needs of learners in larger companies
- Provide training methods that are more ‘problem-based’
- Embed creativity elements in training to help unlock AM benefits
- Provide training and support tools to decision makers who need to be convinced of additive’s long-term value
- Develop distinct training approaches for existing workforce vs. new employees
- Develop training courses that can be used for a diverse set of roles (team sport)
- Teach learners how to execute trade studies comparing AM to traditional manufacturing
- Develop DfAM-based methodologies and specific training
- Provide more tooling-based application training

Team Exercise: Industry Training Solution Delivery Constraints

Questions (15 minutes each)

1. How do you think about whether to build vs. buy additive manufacturing training?

2. How do determine whether the engagement with the training needs to be hands-on?

3. What are the considerations for sending someone to off-site additive training?

4. How do you think about the level of investment you are willing to make (i.e., time and money) in additive training?

Question #1 - How do you think about whether to build vs. buy additive manufacturing training?

Summary

- In general, this depends a lot on the internal expertise that is available and the culture and infrastructure needed to support training within the organization. Traditionally, there are significantly larger amounts of training dollars invested in engineers than in technicians. Additionally, companies are already investing with printer OEMs in service contracts which are supposed to train technicians.
- Companies take different approaches when handling incumbent training vs. new engineers. Smaller companies do not really have an option and have a hard time evaluating which external training option is best for them.
- Terminology: Learning = outside education, Training = internal education.

Buy Decisions

- When there are no internal capabilities or SME’s
- Because there is risk in allowing internal development team to fail
- Because there is significant time required to make material
- If generic training works, great. But if you have specific applications for which there are no curricula, you have to develop in-house
- When the exposure to additional AM technologies and platforms are not accessible internally
- When access to internal machines may be limited to production
- If a valuable “certification” element is included

Build Decisions

- When customization for industry or materials is required because of trade secrets, Internal protocol, specialized process and tools
- Because some industries don’t expect external training to understand their application well enough or better than they do
- When not cost efficient (usually for large numbers of learners)
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- When not cost efficient (usually for large numbers of learners)

Question #2 - How do determine whether the engagement with the training needs to be hands-on?

Summary

In general, hands-on training is preferred when:

- A organization needs to prove the technology works
- They are trying to build, reinforce and retain highly technical tasks vs. just acquire knowledge
- When there are element of safety involved – its preferred to engage in a hands-on training to eliminate any risks ahead of time

However, sending someone to hands-on training depends on the role of person and the AM technology they are looking to be educated on:

- Technicians tend to need to have time on machines vs. engineers who need time on software and can learn via prototyping
- Metals expertise needs more hands-on than polymers

Question #3 - What are the considerations for sending someone to off-site additive training?

Summary

In general, organizations prefer to send people off-site when a combination of the following conditions are met:

- When they do not have access to the right AM equipment or cannot afford to have the equipment on-site
- When the economics of off-site training (plane vs. drive, hotel cost, meals, and time) make sense based on the number of learners they are sending
- And there are clear takeaways that can be used to manage the expectations with management

Additionally:

- Smaller companies have less time and less people to train, so off-site training is the only option and has more of an immediate impact
- Organizations who need to train lots of people prefer to transition to a “train-the-trainer” approach after the course
- When people are away from office, the outcome is generally more focused and positive since learners are allowed to focus on the training
- If company invests more in differentiation of resources (culture and organizational structure), they might be more willing to invest in off-site training

Question #4 - How do you think about the level of investment you are willing to make (i.e., time and money) in additive training?

Summary

Organizations want tangible ROI for their training dollars and ideally, would like to know how soon they can realistically forecast additional revenue from sending someone to AM training

- Its usually more expensive ($6k-$8k), than other classes
- For many larger companies, getting training approved can take a long time
- Organizations felt they would have more broader adoption if production case-studies were shared during training since most of the lions share of training is in rapid prototyping
- They would place additional premium's if the course offered a training certification
- Some organizations expressed that it’s often faster to hire vs. grow-your-own
- When they own the design authority (redesigned for AM will open up the need) – DfAM is a longer-term, AM training is a more worthy investment and this helps build the ROI case
- Companies that are leading forward and willing to take risk to adopt technology place a higher premium on AM training