Abstract

The manufacturing industry is experiencing robust digital changes that necessitate new kinds of training. The adoption of technologies, from an increase in high voltage vehicles in the automotive industry to the development of smart factories, requires constant training and professional development of employees at every organizational level. Due to these shifts, self-motivated learners have the best chance of achieving high levels of expertise in new learning areas. This being said, rapidly training and retraining a workforce can be daunting; industrial organizations face the threat of losing competitiveness with each new technological development. Through the process of evaluating training needs, educating the right personnel with expert content, and integrating a learning and development program into organizational culture, organizations can thrive as they transition into the future of manufacturing.
Contents

ABOUT THE TÜV SÜD EXPERT........................................................................................................ 2
1 INTRODUCTION..................................................................................................................... 3
2 EVALUATE.................................................................................................................................. 4
3 EDUCATE.................................................................................................................................. 5
4 INTEGRATE............................................................................................................................ 8
5 CONCLUSION.......................................................................................................................... 10

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1. Introduction

With Industry 4.0 and Industrial Internet of Things (IIOT) altering the landscape of global industry, organizations are discovering that to remain competitive they must become experts in training their employees. Due to new business models being enabled by technological developments, personnel across organizational levels must become trained to excel in this new environment. As facilities begin to phase out antiquated manufacturing technologies, data systems, and management processes, rigorous training is required to maintain quality standards and a competitive advantage.

A company’s level of competitiveness is contingent upon the knowledge-level of its managers and employees. The use of new learning technologies alone is not enough to transform staff into experts capable of thriving in the Industry 4.0 environment. A comprehensive learning organization will maximize every opportunity to empower personnel.

Instructor-led, blended, and self-paced learning focused on manufacturing-specific content development and shaped with instructional design theory creates an opportunity for learning and development managers to offer meaningful training to managers and employees. Niche training platforms that specialize in quality systems, manufacturing processes, and data security are positioned to generate Industry 4.0 content while encouraging learners to take ownership of their professional development. The goal of any training agenda in this era must focus on cultivating a knowledge-seeking workforce capable of transferring new information from the training environment, whether live, blended, or online, back into the workplace.
2. Evaluate

A comprehensive learning program begins with evaluation of organizational performance. This starting point can reveal gaps in knowledge and even forecast where future training opportunities might arise. A detailed evaluation of learning needs within an organization can allow managers and employees to gain insight into manager and employee motivation to learn, gaps in knowledge, and the organization’s training culture. These insights can assist an organization with designing a purposeful learning and development program.

2.1 Motivation to learn

The skills and abilities of learners who rapidly excel in new training situations are often determined by the learner’s willingness to personally invest in the learning experience. Intellectual autonomy is a result of the learner’s intrinsic motivation, the internal desire to acquire new knowledge. Extrinsic motivation, conversely, is when external influences motivate the learner’s experience: pay, fringe benefits, and other external conditions influence training motivation. Motivation is based on learners’ expectation for learning as well as interpretations of the potential for success within a learning environment. Managers and employees who feel empowered to learn and to self-regulate their learning are more likely to associate training activities with learning and development, and then transfer the value of the learning experience into the work environment.

Knowledge transfer, moving usable knowledge from one area, such as a training environment, and applying that knowledge in other areas within the organizations is a key outcome for training programs. The intention to transfer knowledge can be linked to a learner’s level of intrinsic motivation. Within an organization, training readiness, which influences knowledge retention and transferability, is influenced by a supervisor’s positive outlook on training. In this way, intrinsic and extrinsic motivation begin to blur as the individual’s internal motivational spectrum becomes influenced by organizational community. Training readiness and facilitating a positive, high-level organizational view of training and learning, links workforce development goals with motivation to learn.

2.2 Knowledge gaps

In a world where compliance with the International Organization for Standardization (ISO) is essential, accurate and detailed training on ISO content is more urgent than ever. As global industry evolves, so do the ISO standards. Learning and development managers need to evaluate industry needs to ensure their teams are well-trained and capable of maintaining compliance prior to auditing cycles.
2.3 Training culture

Learning and development managers interested in maximizing training resources should audit organizational culture and community to determine how internal views on training and knowledge development are perceived, embraced, and propagated. A top-down, healthy-minded view of training options can motivate managers and employees to take ownership of their professional development as systems and technologies continue to evolve with Industry 4.0. With the right framing, training can become a common part of organizational values.

3. Educate

The technological and systemic changes associated with Industry 4.0 require careful attention to learning design and outcomes. Content, ranging from ISO standards to management best practices is only useful if mindfully taught. Education that delivers results should focus on learner-centered design. In addition, learning opportunities should be infused with a depth of trust between the education provider and the learner. Confidence that the content being provided is expert-level ensures the learner’s time spent away from work during training will be time well spent and worthy of personal and organizational investment.

3.1 Adult Learning Theory

In the age of Industry 4.0, learning and development managers should turn to training organizations that are invested in instructional design best practices that amplify the goals of adult learning theory. The value of partnering with such an organization is that learning and development managers will know that the right training material is being delivered to their employees using learner-centered best practices that deliver results.

Knowles developed a theory of andragogy to tailor learning design toward an adult audience. His theory emphasizes insights about the conditions that frame adult learning.\(^4\)
To paraphrase, adult learners seek out meaningful learning experiences that have function and that enhance their already expansive subject matter knowledge. To fulfill the adult learner’s needs, strategically designed training programs would approach instruction through the lens of Vygotsky’s Zone of Proximal Development (ZPD). ZPD is a growth-based theory where instruction initiates from a basic question: what does the learner already know?

Adult learners across industries enter training situations with ample professional knowledge and insights. ZPD, when applied to training and professional development programs, encourages training and learning that is both internal and inherently social. When an ISO standard receives an update, the assumption can be made that employees who worked with the previous iteration of the standard will be able to start with that knowledge and work collaboratively to gain a deeper understanding of the updates.

3.2 Bloom’s Taxonomy of Learning

Instructional design is the systematic approach to developing instructional materials that are audience-appropriate by employing methods that are scientifically tested. An instructional design model enacts a specific perspective instructional design theory. By connecting ZPD with andragogy within a thoughtful instructional framework, trainers will be able to deliver content in a way that inspires intent to retain knowledge as well as to transfer knowledge back into the workplace.

Bloom’s Taxonomy of Learning offers a cognitive development approach that grafts instruction onto thinking, effectively providing a means for joining instruction and learning so to encourage cognitive development. It is a learning model that encourages learner participation, and it requires that learners internalize knowledge before they can progress through the lesson plan. This progressive learning requirement makes Bloom’s model ideal for organizations that prioritize safety and minimizing risk.

A learner-centered training program will include a variety of activities and questions that allow students to navigate through the various levels of each taxonomy. This approach embraces verbs that correspond with each taxonomy to motivate thinking and behaviors that will encourage retention and transfer. It
There are five principles of instructional design put forward by Merrill that extend naturally from the synthesis of literature on andragogy, ZPD, and Bloom’s Taxonomy. Merrill’s research was designed to analyze a range of instructional design models to determine similarities and differences. Figure 2 illustrates the conceptual framework of problem-oriented instruction, which is the conceptual result of his synthesis of theories. In his overview of the literature on instructional theories, Merrill concludes that his “survey of instructional theories and models demonstrates that these theories do include first principles of instruction that are similar, regardless of theory or philosophical orientation.”

Adapted from Merrill.

**FIGURE 1: BLOOM’S TAXONOMY OF LEARNING**

1. **Know/Remember**
   The learner can recall and recognize facts. **Key verbs:** list, recite, outline, draft, name, match, quote, recall, identify, describe, recognize.

2. **Comprehend/Understand**
   The learner can understand the meaning of presented facts and concepts. **Key verbs:** illustrating, inferring, summarizing, paraphrasing, classifying, explaining, interpreting.

3. **Apply**
   The learner can apply facts, rules, concepts, and ideas in new situations. **Key verbs:** calculate, predict, apply, solve, illustrate, use, demonstrate, model, perform, present.

4. **Analyze**
   The learner can break down information into component parts. **Key verbs:** classify, categorize, analyze, diagram, illustrate, criticize, simplify, associate.

5. **Evaluate**
   The learner can judge the value of information or ideas. **Key verbs:** choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.

6. **Synthesize/Create**
   The learner can combine parts of a concept to make a new whole. **Key verbs:** Design, formulate, build, invent, create, compose, generate, drive, modify, develop.

**FIGURE 2: PHASES FOR EFFECTIVE INSTRUCTION**

- **Integration**
- **Activation**
- **Problem**
- **Application**
- **Demonstration**

Adapted from Merrill.
As a result, Merrill distills the field of instructional design theory down to five principles and posits that new knowledge is promoted when:

1. Learners are engaged in solving real-world problems
2. Existing knowledge is activated as a foundation for new knowledge
3. New knowledge is demonstrated to the learner
4. New knowledge is applied by the learner
5. New Knowledge is integrated into the learner’s world

Combined, andragogy, ZPD, Blooms Taxonomy, and Merrill’s five principles allow trainers to develop student-centered learning environments that empower learners to embrace their investment in developing within this fourth industrial revolution.

4. Integrate

Integrating learner-centered training programs into manufacturing organizations can promote quality, safety, and sustainability. As industry standards evolve, productivity is directly linked to how well training platforms are integrated into organizational culture.

The rapid integration of technological developments in manufacturing requires that learning and development managers train and retrain managers and employees. In this new environment, learning and development managers know that what is good for employees is good for the organization. Instructor-led sessions, which can sometimes run the duration of a work week, have the potential to include active student collaboration and participation in the learning process. But what happens when committing such extreme amounts of time is not practical?

“As industry standards evolve, productivity is directly linked to how well training platforms are integrated into organizational culture.”
4.1 Digital training

E-learning in the form of digital courses is an opportunity for learners to engage with training materials remotely from any computer with internet access. This allows learning and development managers to provide personnel with content that is self-paced and convenient to access. Research indicates that learning and development managers prefer self-paced, on-demand courses as the most efficient way to bring industry updates to personnel. Rapid insights into updates on quality standards and compliance requirements can swiftly accelerate the development of specific skills and awareness.

A limitation of digital education occurs when instructional designers attempt to graft the instructor-led, lecture model onto a digital platform. The result is pure misery for learners. Online learners do not sit passively listening and reading, they require interactive activities and quizzes that allow them to test their knowledge in the moment of learning. The most necessary and important content can be rendered immediately indigestible by learners when it lacks interaction and engagement.

4.2 Instructional design & digital training

Applying Bloom’s Taxonomy and Merrill’s five principles to digital, self-paced courses need to provide interactive moments that allow the learner to build upon previous knowledge and retain valuable lessons. With thoughtful instructional design application, online training can be meaningful and functional. Interactive elements in an e-learning platform should be based on Bloom’s levels and integrated across lower order thinking (LOTS) while transitioning into higher order thinking (HOTS) across knowing/remembering, understanding, applying, analysis, evaluation, and creation. E-courses would then, upon merging in Merrill’s problem-solving framework, be developed with a minimum level of interaction based on Bloom’s action words (see figure 1) to generate integration, activation, application, and demonstration within the context of problem-solving, as illustrated in figure 3.

**FIGURE 3: MERRILL’S PRINCIPLE OF INSTRUCTION IN E-LEARNING COURSE DESIGN**

- **TRANSFER**
  - new knowledge with project tasks embedded within the e-learning design so learners use their knowledge in a new context.
- **ENGAGE**
  - learners by presenting them with real-world problems.
- **DEMONSTRATE**
  - new knowledge by providing examples in videos, tutorials, and infographics.
- **APPLY**
  - new knowledge with interactive, problem-solving tasks.
- **ACTIVATE**
  - new knowledge by linking it to pre-existing knowledge through real-world examples, case studies, and stories.
Content developed for a self-paced digital course should follow the principles and knowledge trajectory established by Bloom and Merrill so to ensure that learners are enhancing comprehension while maintaining motivation to retain new knowledge.

4.3 Microlearning

Experienced learners might find value in receiving quick bursts of focused knowledge. Microlearning is designed to expand the familiar user interface of social media platforms in quick, three- to five-minute knowledge insights. It has the potential to deliver targeted information to the right learners with the right level of detail at the right time. It can be used as follow-up training after larger online, blended, or instructor-led programs. This innovative approach to e-learning attempts to integrate learning and professional development into the lifeblood of the workplace so that knowledge acquisition becomes both social and immediate. New learners entering an ISO subject matter for the first time would benefit from a more comprehensive online or blended learning experience. Microlearning options work most effectively as a retraining tool by targeting specific learners with specific informational updates.

4.4 Blended learning

Blended learning merges online training with instructor-led training. In this setting, learners gather in an online meeting space to interact with the instructor and other students. In addition, the online environment offers the benefits of digital courses. Content can be easily downloadable, and portions of the learning experience can be accessed remotely outside of the training course meeting time. However, course meeting time, as with traditional instructor-led courses, becomes a limitation. Industry 4.0 is a global industrial revolution. Blended learning courses require training participants to meet at specific times, which means some learners will be required to attend at inconvenient times.

5. Conclusion

Remaining competitive in the age of Industry 4.0 will be measured in how well organizations evaluate their workforce learning needs, educate personnel, and integrate education programs into the industry culture. Thriving in this technology-driven environment requires adapting to the rapid changes and advances that are reshaping the manufacturing industry. A well-trained, adaptable workforce ensures the next wave of global industrial developments will be implemented safely and successfully. Without question, learning and development is at the core of this transition process.
5.1 Industry 4.0 learning and development

Corporate perception of training can empower employees to embrace the technological changes that are revolutionizing manufacturing processes. As learning and development management teams seek solutions to training problems, they may be best served by fueling their professional development programs with a combination of e-learning and blended learning strategies. Motivating employees to engage with learning programs and encouraging employees to self-identify as active learners within their careers will help to facilitate knowledge acquisition.

FIGURE 4: TÜV SÜD AMERICAS ACADEMY INDUSTRY 4.0 LEARNING MODEL

Develop accurate content by partnering with industry experts.

Empower learners by acknowledging they already possess knowledge to build upon.

Expert content that involves solving real-world problems related to manufacturing processes & international standards.

Involve learners in applying new knowledge so to integrate knowledge into the work environment.

Industry 4.0 is a dynamic, robust movement. Learning programs that embrace the technological and data-driven changes that are transforming the global industry landscape will position their managers and employees to lead the transition into the future of manufacturing.
GLOSSARY OF ACRONYMS

IIoT – Industrial Internet of Things
ISO – International Organization for Standardization
ZPD – Zone of Proximal Development
LOTS – Lower order thinking skills
HOTS – Higher order thinking skills

ENDNOTES


[5] Ibid.


[8] Ibid.


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