2.4 million unfilled positions puts US$2.5 trillion at risk over next 10 years

**FIGURE 1**
The skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028

- **2.69M** jobs open from retirements
- **1.96M** new jobs due to natural growth
- **4.6M** manufacturing jobs to fill from 2018-2028
- Only **2.2M** jobs are likely to be filled

**2.4M** (53 out of 100) open positions lie vacant due to a skills shortage in the US manufacturing industry

*Calculated on the basis of 52.7% of the skilled manufacturing positions that are unfilled (per the 2018 survey)*

**Retirement age of 66**

Source: BLS Data, OEM (Oxford Economics Model), Deloitte and Manufacturing Institute skills research initiative.

Deloitte Insights | deloitte.com/insights

Skills shortage could put US$454 billion of manufacturing GDP at risk in 2028 alone
Solution: Hire more people!

But we don’t have enough skilled people in manufacturing, yet!

Five key skills expected to be needed in the fourth industrial revolution:

- Technology and computer skills
- Programming skills for robots and automation
- Critical thinking
- Working with tools and techniques
- Digital skills
Where to find potential manufacturing workforce?

**STEM students in universities and community colleges: ~6 million**
- Train them well for a career in advanced manufacturing.
- Retention rate for community college = ~60%: one of the three reasons is **hard coursework**.
- **Q: How do we improve student’s understanding, learning and retention?**

**Underemployed people: ~22 million**
- Many are univ. graduates, in low paying jobs.
- Motivated for high-paying and in-demand jobs.
- **Q: How do we provide necessary education & training for non-majors?**

https://www.payscale.com/data-packages/underemployment/degree-and-major
https://www.americashealthrankings.org/explore/annual/measure/Underemployed/state/ALL
Can we use computer games to improve student’s engagement and retention?

- **Active learning**
- **Freedom to explore**
- **Instant feedback**
- **Freedom to fail**
- **Immersive**

- **Passive learning**
- **Needs motivation to explore**
- **Delayed feedback**
- **Failures are tough**
- **Distraction is easy**

Computer games in this context means any kind of digital game, played on any platform (PC, mobile, tablet) etc.
Can we use computer games to improve student’s engagement and retention?

Active learning

Freedom to explore

Needs motivation to explore

Immediate feedback

Freedom to fail

Distraction is easy

Passive learning

Gamification in manufacturing education

Computer games in this context means any kind of digital game, played on any platform (PC, mobile, tablet) etc.
Why computer games?: they appeal to our target audience!!

Game penetration: general U.S. population^

Play an average of 6 hours/week**!

Male/Female ratio*: 55/45

If people are used to playing games, why not make them learn in the same framework?

"The role of a teacher and the role of game rules are roughly equivalent. A teacher wants to exert influence on students to encourage certain behaviours; to reward the positive and discourage the negative. In games, rules are designed to guide players through a level or stage in an intuitive manner."

– Steven Lumpkin, Senior Designer, RollerCoaster Tycoon World

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**https://www.limelight.com/resources/white-paper/state-of-online-gaming-2018/
Some examples from my experience

Fourier Transforms

\[ X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-i2\pi kn/N} \]

\[ x_n = \frac{1}{N} \sum_{k=0}^{N-1} X_k \cdot e^{i2\pi kn/N} \]


Stereographic Projection

Some examples from my experience

### Fourier Transforms

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### Stereographic Projection

Potential to become complete instructional tool via
- **Learning objective**
- **Feedback and evaluation**


UT Dallas introduces Minecraft for Polymer Chemistry (2014)

- The “Polycraft World” modification allows “Minecraft” players to create flamethrowers. But to do so, players learn about plastics processing in order to refine and fabricate the necessary components to build them.
- “Fun and learning do not have to be diametrically opposed”

CMU’s Professor Rebecca Taylor introduces card game (May 15th 2019)

- Students learn contract manufacturing and negotiation while navigating a student-inspired card game that reveals challenges and successes during the product development process.


https://www.youtube.com/watch?v=KKyJ2rPXV9M
Many pilot studies elsewhere: strong belief in gamification techniques


'Gamification' Techniques Increase Your Employees' Ability To Learn By 40% - Business Insider

Many industries actively uses AR/VR techniques for training employees

Many pilot studies elsewhere: strong belief in gamification techniques

Lack of framework for gamification of manufacturing education

Many industries actively uses AR/VR techniques for training employees

Research Needs to develop framework for in mfg. education

- Explore game design concepts (and tools, platforms) for mfg. education
- Develop feedback mechanism: how and when?
- What can be gamified and how? Develop best practices
- How to balance classroom v/s gaming content?
- What data to collect and how to best use?

Instructors (many fields)
- Computer scientists
- Gaming researchers
- Pedagogy researchers
- Psychologists
- Statisticians
Improve student’s engagement, learning and retention by introducing gaming elements in delivering manufacturing education.

Universities and industry, together, create a rich gamified curriculum to impart manufacturing skills in-demand. Creation of curriculum such as “manufacturing for non-majors.”

Use of big data to (a) improve learning experience, (b) target untapped potential, and (c) connect workforce to opportunities.

Develop the manufacturing workforce of the future by changing the ways of delivering education today.
Thank You!

2.4M (53 out of 100) open positions are vacant due to a skills shortage in the US manufacturing industry.

Manufacturing Institute

Manufacturing GDP