Project Summary for IAL Website

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Project Title:	Mastery in the Digital Age: Reconceptualizing Expertise, Developing Deep Technical Mastery, and Accelerating Effective Workplace Learning
Project Number:	GA 18-01
Year of Approval:	2019
Funding Source:	WDARF
Objectives and intended outcomes of the project:	- To advance the academic field on workplace learning and expertise by conducting an ethnographic study on the impact of digitalization on the work of technical professionals - To provide practical recommendations and insights on how the Chemicals and Energy and Precision Engineering sectors have been and are transforming with digitalization - To provide related recommendations on education and workplace learning to ensure resilience for the workforce of the future - To synthesize research findings into a framework that can help organizations, policy makers, and individuals think about mastery in the digital age, and help them identify potential gaps or issues they must prepare for
Project Team	
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Summary of Project (up to 300 words)	

This research explored the mastery of technical professionals when jobs and workplaces are being digitalised. The very core of what it means to be good at one's job is challenged and may fundamentally change when technology takes over crucial tasks. In the 4IR, change happens at an increasingly faster pace. However, mastery has long been understood as the step-by-step, incremental development of skills over a long period of time as individuals gradually progress from novice to expert. This poses a paradox that suggests the need to re-evaluate the meaning of mastery given the implications it has on Singapore's policies involving workforce development.

We draw on ethnographic data collected between September 2019 and April 2021, focusing on technical professionals from the Chemicals and Energy and the Precision Engineering sectors. We conducted 65 interviews, 9 focus groups, and 250 hours of observations at a Chemical Engineering pilot plant within one of Singapore's polytechnics and at two companies in the Precision Engineering sector.

Our findings show how the modern workplace involves many relationships between humans and machines, with a fluid division of labour. Technical professionals coordinate and collaborate across a network of people and technologies. To do their jobs, they need to access expertise distributed across this network. This distribution has been accelerated by the digital age, and how well professionals navigate this network reflects how deep and wide their expertise is. By identifying these specific interactions, between people-people and people-technology, that characterize the work of technical professionals, we

show how exactly expertise is distributed and what professionals can do to develop their mastery in a digital age. This is an important update to the prevalent view on mastery as a linear and incremental process, and advances both practice and literature on how workers can create robust and customized pathways to a resilient future.

Summary of Project Findings, Deliverables and Impacts (up to 500 words)

The *Mastery in a Digital Age* study explored how digitalization is transforming the nature of expertise in Singapore's Chemicals and Energy (CE) and Precision Engineering (PE) sectors. Through extensive fieldwork, including interviews, focus groups, and observations, the study introduced the concept of "Distributed Mastery"—a model that views expertise as spread across people, technologies, and systems, rather than residing solely within individuals.

Key Findings:

1. Distributed and Multi-Faceted Mastery:
   Mastery is increasingly distributed across networks of people and technologies, requiring professionals to integrate both domain-specific knowledge and digital competencies effectively.
2. Interpersonal and Interdisciplinary Expertise:
   Mastery now demands the ability to collaborate across disciplines and hierarchies, emphasizing inter-generational and inter-disciplinary expertise.
3. Impact of Technology on Foundational Skills:
   While digital tools enhance efficiency, they also risk eroding core domain skills, highlighting the need to balance digital skills with deep domain expertise.
4. Challenges of Invisible Mastery:
   As expertise becomes more embedded in systems, the "invisible" nature of mastery makes it harder to assess and develop skills effectively.

Key Deliverables:

- Multi-Faceted Mastery Model: A new framework emphasizing distributed expertise across networks.
- Practical Guidelines for Mastery Development:
  Actionable strategies for companies to assess and cultivate mastery in a digital context, focusing on mentorship, cross-functional teams, and continuous upskilling

The impact of the *Mastery in a Digital Age* study has been profound and far-reaching, providing a strategic foundation for multiple subsequent projects that have transformed approaches to skills development and innovation across diverse sectors. With the rapid rise of Generative AI, the study's insights—particularly its emphasis on distributed mastery and interactions-centric learning—have gained renewed relevance. By redefining expertise as a networked phenomenon that integrates human and digital capabilities, the study has anticipated and directly addressed Singapore's evolving demands.

1. *Future of Manufacturing Project*

The *Future of Manufacturing* project, initiated by NTUC, built directly on the *Mastery in a Digital Age* study, using the Distributed Mastery model to explore skills development in the manufacturing sector. Based on 11 targeted interviews and two surveys with 600 manufacturing workers and 1,000 workers

from other industries, the study introduced the concept of "Skills Security"—ensuring a balanced mix of domain-specific and digital skills to safeguard workforce resilience.

The project also proposed the "Multivitamin Strategy" to diversify career pathways and reduce skill vulnerabilities, reinforcing the importance of bridging skills highlighted in the original study. These insights have directly influenced strategies for workforce retention and upskilling aligned with Singapore's Manufacturing 2030 goals.

2. *SKI Project on Learning from Failure*

Building on the *Mastery in a Digital Age* study's emphasis on learning from failure as a core aspect of distributed mastery, the SKI (SUTD Kickstarter Initiative) project at SUTD explored how embracing failure can drive innovation in design thinking. Through comprehensive surveys and targeted interventions, the study revealed that students who developed a higher tolerance for failure showed significantly greater originality and were more willing to tackle complex challenges.

The project also highlighted the power of reflective practices—such as structured feedback and journaling—in transforming setbacks into learning opportunities. These findings reinforce the original study's insights on the need for educational strategies that not only build technical skills but also cultivate adaptability and resilience. By demonstrating how failure tolerance can directly enhance innovative capabilities, the SKI project has informed new approaches to teaching design thinking at SUTD.

3. *DesignZ Future of Innovation Lab*

Building on the *Mastery in a Digital Age* study's emphasis on distributed mastery and interactions-centric approaches, the *DesignZ Future of Innovation Lab* was launched to redefine human-AI collaboration in the workplace. This project introduced the "Working As ONE" model, which moves beyond the traditional competition between humans and AI, advocating instead for a collaborative approach that harnesses the strengths of both.

At the core of this project is the 10:10:10:1 framework, which systematically evaluates the performance of humans, AI, and human-AI teams across ten domains and tasks. Early findings suggest that collaborative approaches significantly enhance productivity, creativity, and decision-making, validating the original study's insights on the power of distributed expertise.

By framing AI as a complementary partner rather than a competitor, the project has set a new direction for AI integration strategies at SUTD and beyond, highlighting the potential for AI to amplify human agency and innovation in a rapidly digitalizing world.