

Education Perspectives and Outreach IFPRI 2020 AGM

- Education trends, needs, opportunities

$$\begin{bmatrix} \text{Modular} \\ \text{Process} \end{bmatrix} \times \begin{bmatrix} \text{Matrix} \\ \text{Learning} \end{bmatrix}$$

- Elsevier Powder Technology, IFPRI Corner
- Review opportunities
- Systems Framework

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Dept of Materials Engineering,

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7/1/2020

PURDUE
UNIVERSITY.

Personal perspective

- IFPRI representative for Procter & Gamble, 1995-2018
 - Particle Formation ————| Granulation, Extrusion, Compaction
 - Dry Flow ——————| Dense flow rheology (Tardos, Behringer, Daniels/Vrend); IFPRI Collaboratory
 - Systems |
- Continuing IFPRI association
 - Elsevier outreach (IFPRI Corner) ————| Perspectives and reviews: academic/industrial partnership
 - Consultant: Systems / Education
- Purdue University, 2019-current
 - Department of Materials Engineering
 - Center for Particulate Products and Processes (CP3)
 - Training and education
 - Research, systems focus (modular processes, PAT, control)
 - Industrial outreach

Strong IFPRI influence on teaching and research

Trends in Education

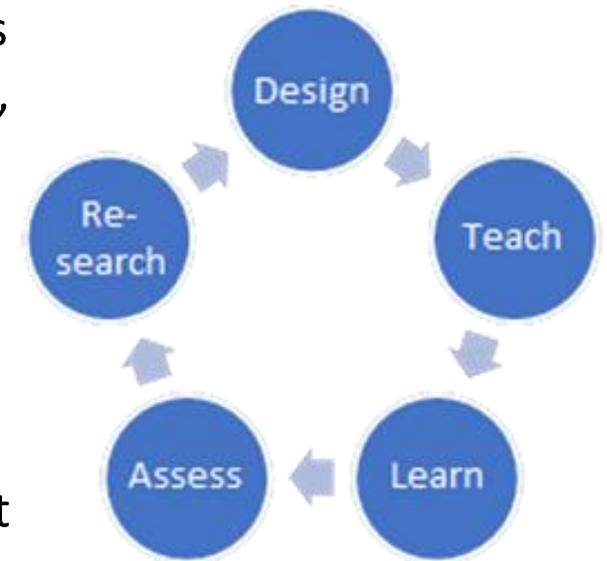
- On-line is here:
 - Synchronous and
 - Asynchronous, on-demand
 - Higher Ed “iron triangle” of inter-dependent challenges: affordability, accessibility, excellence.
 - Added pandemic challenge
 - Professional and continuing education:
 - On-line can be integrated with on-campus.
- 
- On-line content enables:
 - Diverse population of students having a broad range of background and experience levels
 - Business and educational innovation:
 - Research renewal.
 - Knowledge changes more rapidly than careers.
 - Lifetime education.

Online Curriculum Development

Continuous improvement on a regular frequency.

Example, Georgia Tech programs developed to meet needs of business and industry (Computer Science, Data Analysis, Cyber-security):

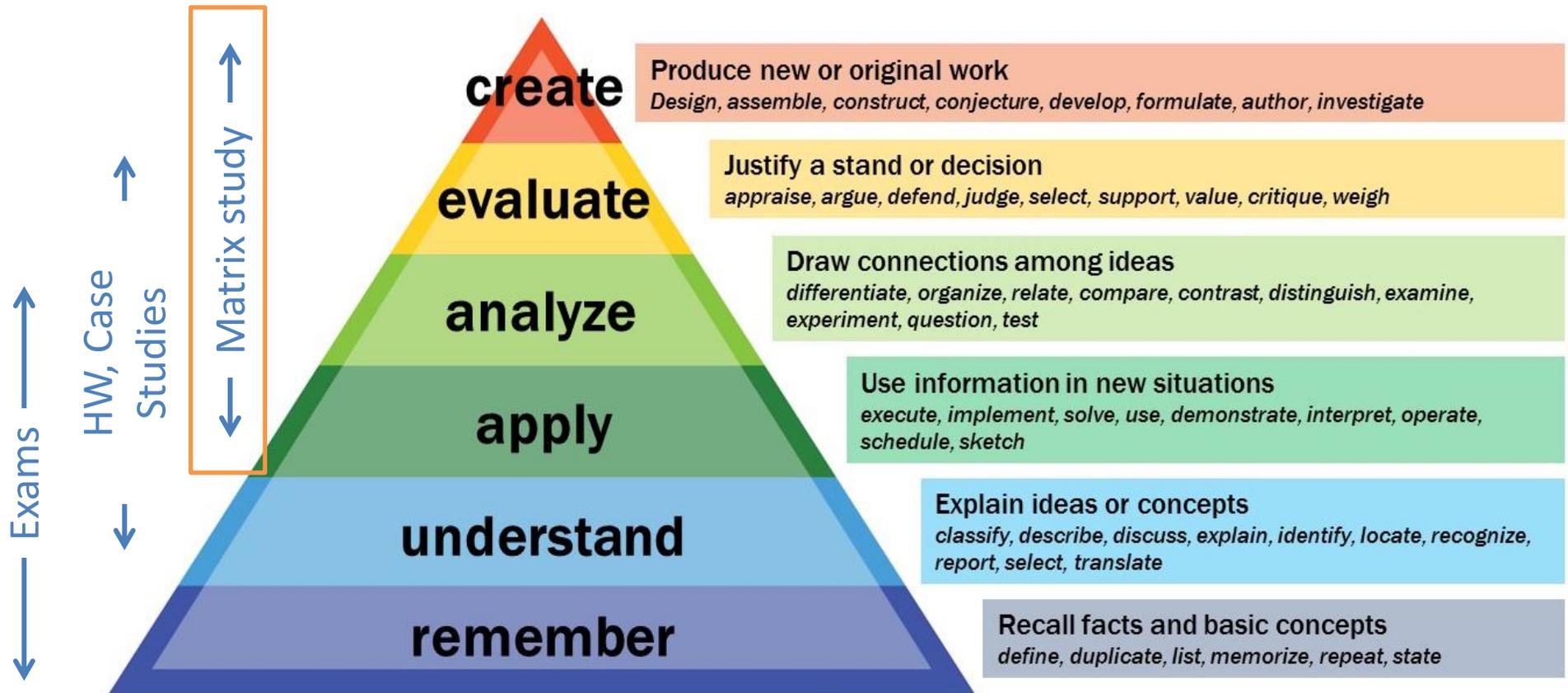
- 4 to 5-month development period with a multi-functional team including subject-matter and production experts
- 3-year refresh and renewal cycle where the development cycle is re-applied to include new content and other changes.
- ~50:1 student/TA ratio. Experimenting with AI agents as TA's.
- Matrix design, i.e., customization of content
- Credit for accomplishments
- Blockchain transcript, with student input (i.e., to add additional content) and institutional validation.



Matrix Study:

A deep dive into specific area of student's need or choosing

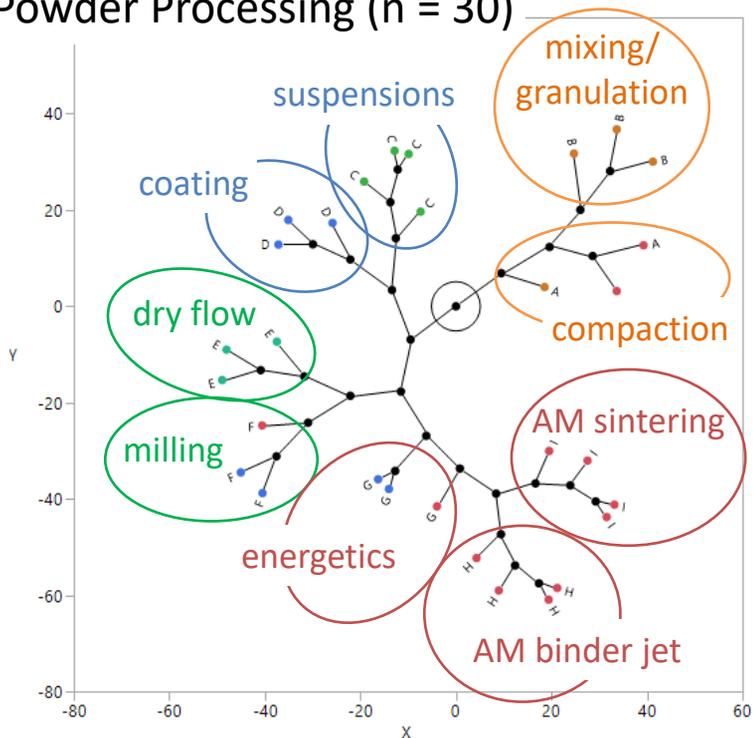
...in context of Bloom's Taxonomy



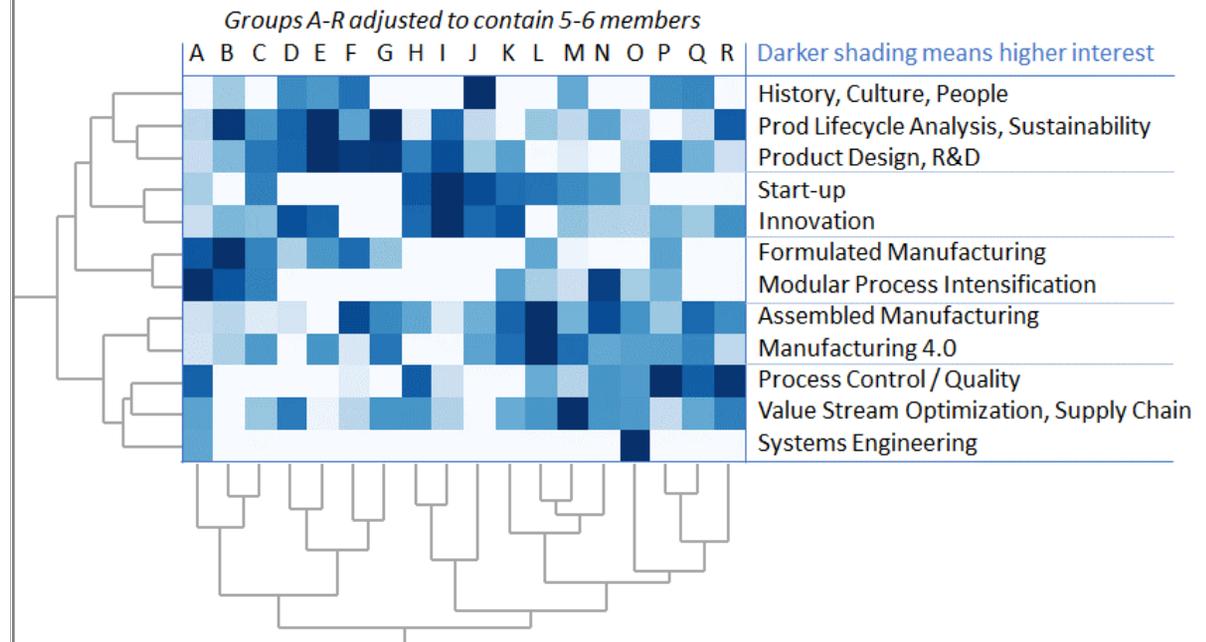
Matrix Study: Deep dive into specific interest area

- Individual survey assignments according to students' specific areas of interest.
- Form groups based on content clustering of individual specific interest areas.
 - Hypothesis: Group work clustered by common interests can foster a sense of identity within each group & access the value-in-diversity of group members.

Powder Processing (n = 30)



Lean Mnfg (n = 100: 60 on campus, 40 on-line)



✓ Positive feedback, especially from on-line students, most of whom were working in industry.

“modular solids process”

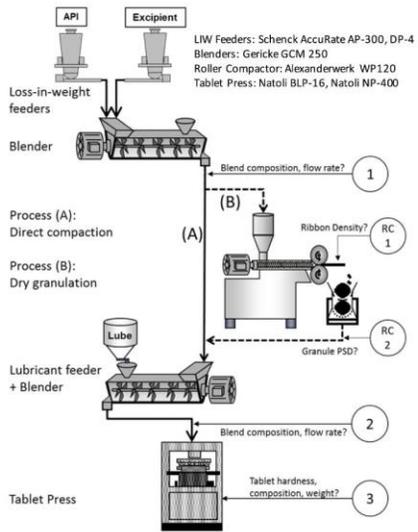
- Small footprint, plug & play
- Effective throughput
- Continuous flow
(process intensification)
- Instrumented for remote sensing and control

- Matrix of processes, systems focus
- On-line access

Consider as a topical focus and enabler for IFPRI educational outreach

Purdue CP3

Continuous Tableting at Purdue Pilot Plant – Direct Compaction + Dry Granulation



6 modules, stackable
3-high

FLEX building High-Bay,
Purdue Discovery Pk



- Education,
- Training,
- Research,
- Industrial outreach

PCMM

Portable, Continuous,
Miniature and Modular

Modular Technologies & Integration

- Formulation components
- Material Transfer Systems
- Gravimetric Feeders
- Vertical Powder Mixer
- NIR Feed Frame probe
- Rotary Tablet Press
- Integrated Control w Real-time decision making
- POD-based facilities

Dan Blackwood, Pfizer



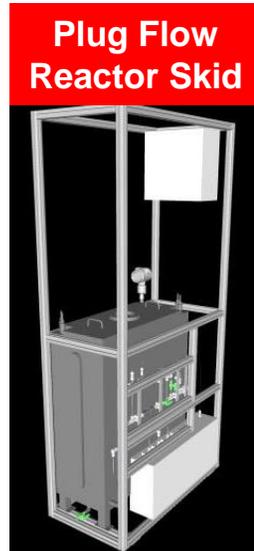
Breakthroughs that
change patients' lives

Modular processing in Pharmaceutical Manufacturing

Paul Collins, Eli Lilly



CSTR Skid



**Plug Flow
Reactor Skid**



**Feed System
Skid**



Skids are part of a platform to support chemical unit operations in any product

- Modular to be combined into unit operations (ie, mix and match as needed).
- Flexible and adaptable – simple skids with standard components (where possible)
- Plug into Distributed Control System (DCS)

Integrated Continuous Manufacturing, Salvatore Mascia, Continuous Pharmaceuticals

nature



A drug-making facility built from bespoke parts takes up no more space than a boxing ring. Credit: Studio Baraldi sas

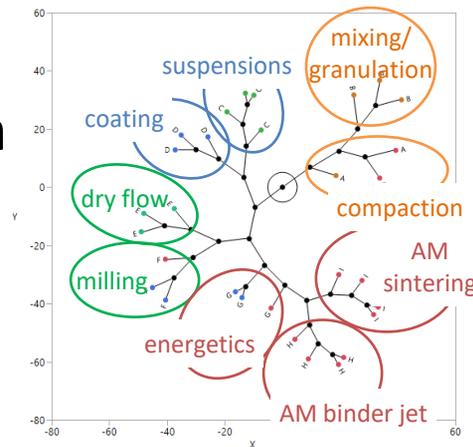
CHEMISTRY · 20 DECEMBER 2019

Mini-factory churns out drug cheaply and at a furious pace

A small, fully automated assembly line can produce 4,800 tablets an hour and could make drugs more widely available.

IFPRI Educational Outreach

- On-line capability
 - Broad access
 - Diverse participation
- Industry pull
 - Research renewal
 - Continuing education, training
- Continuous improvement
 - Regular content renewal
 - Explore using matrix approach (w/ clustering)



Modular approach & matrix design, enablers for education:

- Product-Process relations and models
 - Attribute definition,
 - Characterization
- Modular systems, matrix of processes
 - Plug & play
- On-line access
 - Monitoring & control
- Accessible toolkits
 - Hands-on



Elsevier update, Powder Technology

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> CiteScore: 6.4 ⓘ

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IFPRI Corner

J. Michaels, J. Litster,
K. Jacob

Particle technology education in the 21st century

In April 2017, IFPRI sponsored a workshop at the University of Sheffield to assess the current state of global particle technology education and chart a course forward. There is a clearly demonstrated need for trained graduates at all levels across a broad spectrum of industries.

Launch of IFPRI Corner

We are pleased to inform that a new section called the “IFPRI Corner” is launched in Powder Technology. The “IFPRI Corner” highlights pre-competitive research, perspectives, and topical reviews that are industrially relevant.

Highlights pre-competitive research, perspectives, and topical reviews that are industrially relevant.

- Grinding Aids Review in progress (Kwade & Prziwara)

Elsevier provides 1-yr open access

Consider review pipeline in association w/ Powder Technology

Selected Powder Technology review articles since June 2019 (1 year):

- P. Bhalode, M. Ierapetritou, “[A review of existing mixing indices in solid-based continuous blending operations,](https://doi.org/10.1016/j.powtec.2020.06.043)” doi.org/10.1016/j.powtec.2020.06.043.
- S. Tang, J. Huang, L. Duan, P. Yu, E. Chen, “[A review on fractal footprint of cement-based materials,](https://doi.org/10.1016/j.powtec.2020.05.065)” doi.org/10.1016/j.powtec.2020.05.065.
- L. Taylor, D. Skuse, S. Blackburn, R. Greenwood, “[Stirred media mills in the mining industry: Material grindability, energy-size relationships, and operating conditions,](https://doi.org/10.1016/j.powtec.2020.04.057)” doi.org/10.1016/j.powtec.2020.04.057.
- M. Ahmed, M. Pasha, W. Nan, M. Ghadiri, “[A simple method for assessing powder spreadability for additive manufacturing,](https://doi.org/10.1016/j.powtec.2020.04.033)” doi.org/10.1016/j.powtec.2020.04.033.
- R. Maharjan, S. H. Jeong, “[High shear seeded granulation: Its preparation mechanism, formulation, process, evaluation, and mathematical simulation,](https://doi.org/10.1016/j.powtec.2020.03.020)” doi.org/10.1016/j.powtec.2020.03.020.
- D. Minglani, et al, “[A review of granular flow in screw feeders and conveyors,](https://doi.org/10.1016/j.powtec.2020.02.066)” doi.org/10.1016/j.powtec.2020.02.066.
- S. Wang, et al, “[Numerical investigation on the effects of operating conditions and configuration parameters in industrial risers,](https://doi.org/10.1016/j.powtec.2019.12.043)” doi.org/10.1016/j.powtec.2019.12.043.
- S. K. Nielsen, M. Mandø, A. B. Rosenørn, “[Review of die design and process parameters in the biomass pelleting process,](https://doi.org/10.1016/j.powtec.2019.10.051)” doi.org/10.1016/j.powtec.2019.10.051.
- R. de Souza Lima, M.-I. Ré, P. Arlabosse, “[Drying droplet as a template for solid formation: A review,](https://doi.org/10.1016/j.powtec.2019.09.052)” doi.org/10.1016/j.powtec.2019.09.052.
- R. Sharma, G. Setia, “[Mechanical dry particle coating on cohesive pharmaceutical powders for improving flowability - A review,](https://doi.org/10.1016/j.powtec.2019.08.009)” doi.org/10.1016/j.powtec.2019.08.009.
- W. Goossens, “[Review of the empirical correlations for the drag coefficient of rigid spheres,](https://doi.org/10.1016/j.powtec.2019.04.075)” doi.org/10.1016/j.powtec.2019.04.075.

A sampling of unsolicited reviews: Powder Technology

Academics have offered to write reviews. Are any of interest to IFPRI members?

- “Powder-based 3D printing of pharmaceuticals: excipient properties and their influence on the drug product,”
 - J. Quodbach, Heinrich Heine University, Germany.
 - J. Lindh, Uppsala University, Sweden.
- “Additive Manufacturing of Metal Alloys by Selective Laser Melting of Elemental Metal Powders,”
 - P. Gokuldoss, Tallinn University of Technology, Estonia
- “A review on gas-solid cyclones,”
 - E. Dehdarinejad and M. Bayareh, Shahrekord University, Iran.
- “Effects of different geometric, kinematic, material and physical quantities on the coefficient of restitution,”
 - K. Hashemnia, Shiraz University, Iran.

Closing comment, Systems Framework

- Final report on Systems Framework is still pending
- Focus of the report: Compare and contrast of optimization and regression methods for analysis of particle size and shape data (2D image analysis)
- Multimodal analysis:
 - Simplified analysis via residual regression and optimization;
 - System perspective, modal dynamics in integrated processes.
- Seeking collaboration, test data, input formats, etc.
- Outcome: Make analysis tools available to membership.

