IFPRI Education: IFPRI prioritization and funding of Educational Content

This proposal creates a category for IFPRI members' prioritization and funding of educational content as part of the broader portfolio of IFPRI research projects, reviews, collaborations and workshops. The intent is to formally initiate the inclusion of Education Briefs as part of the IFPRI program, whereby briefs for Education Content Modules (ECM's) can be developed, vetted, and selected among IFPRI members and contracted for production.

On members' approval of this proposal, IFPRI initiates a process whereby ECM briefs are developed, vetted, and selected for placement with a contractor. As a starting point, members agree to select up to 3 briefs per year. The proposed procedure will treat ECM development in the same way that IFPRI currently manages Reviews, i.e., to recommend a set of possible contractors, with the IFPRI VP negotiating the placement. The payment for and ECM is set at [amount]. Once delivered to IFPRI, the members have up to [time] exclusive access to its content, afterward the contractor can publish said content publicly.

The success of IFPRI ECM's depends on their effective utilization. To maximize opportunities for success, we must be aware of inherent challenges. On one hand, it is desired to have ECM's that are quick and easy to digest; on the other, ECM's should be insightful and creative. On one hand, ECM's must be easily accessible (e.g., an on-line video); on the other, hands-on learning improves retention and leads to lasting impact. Ideally, IFPRI Education can tap the collective knowledge and experience of members to turn these challenges into opportunities, a balance of technical excellence, accessibility, and adaptability. An effective program meets both immediate and long-term needs of members, with influence across broader industrial and academic communities.

Context, IFPRI Education Survey and Round Table

As an outcome of a survey of the members and Round Table meeting (7-Oct-2021), IFPRI member companies stated needs for educational content that is not currently available as a standard part of university curricula. This proposal establishes a framework for IFPRI to guide the development of said content, distribute among member companies, and eventually to the external particle science, engineering, and technology community.

The primary objective is to develop educational content that can be productively shared among and within IFPRI member companies, said content being prioritized based on the needs of the members. For the purpose of this proposal, the development of Educational Content Modules (ECM's) will conform with IFPRI guidelines for projects and reviews, being: a) pre-competitive in scope; and b) sharable with the broader public following a period of member-only exclusivity.

Based on the Member's Survey and Education Round Table (see appendix), the preferred form of content is to have relatively short (i.e., < 60 min, preferably < 30 min) video-based content that is easily shared within member organizations. Beyond these criteria, the format is

not prescriptive. Acceptable formats can include narrated slide presentations, video lectures, and even demonstrations (e.g., in a lab) to make it feel "hands-on".

While specific content must be selected by members, priority is likely to be in areas that are not well covered in science and engineering courses. At the same time, flexibility is needed to adapt content situationally, meeting the needs of individual companies and organizations within companies. Hence, the primary strategy is to develop multiple ECM's that can be mixed and matched to provide a more conventional course for an individual or group, or used situationally as needed.

Additional flexibility is needed in applying ECM's to various target audiences, for example plant operators, engineering, R&D, sales, and technical support functions within companies. This proposal suggests that we get started developing ECM's without being overly prescriptive about their audience.

Additional flexibility may be needed regarding feedback. Typically, review authors present a lecture at the AGM, and take feedback before submitting their final report. It is to be determined whether there is room in the AGM to accommodate presentation of an ECM to a large audience, or whether an alternative review process will be more effective. This needs to be determined – for example, IFPRI may select a "mentor group" of companies to provide more frequent small-group feedback with an ACM contractor.

Updated IFPRI Brief Template

The IFPRI Brief Template will be updated to include an "Education" checkbox. Otherwise, ECM's use the same format as other proposals.

Check One:	**☐Project**	**☐Review**	**☐Collaboration**
	☐Workshop	**☐Education**	**☐Other**

Appendix 1:

Summary of IFPRI Education Survey on Particle Science, Engineering, and Technology

Survey written by Tim Bell and Karl Jacob, results compiled by Paul Mort
24 responses from 23 IFPRI Member Companies, Oct 2, 2021

1) To determine the method of course delivery that is most likely to be used, enter the number of people that you think would participate from your company for each of the following types of class:

Course Delivery	
388	Pre-recorded modules (0.5 hour each)
310	Pre-recorded modules (1 hour each)
230	Zoom meeting with live participation
46	2-day in-person in the US
30	Calculation tools or apps
27	2-day in-person in Europe

2) What is the primary method for particle technology training in your company today? Note, this has been rescaled for numerical ranking, highest (green) being the most prevalent method.

Current mode of training	
22.0	Individuals self-taught or mentored
7.9	Short courses at trade shows or within Working Party groups
7.5	Individuals had substantial training at university
6.6	Workshops held at universities
6.6	2-day courses from AIChE, or other professional societies
3.3	Internal training, short courses, e-learning
1.0	Informal consulting / advisor network[1]
0.8	Training by instrument developers/vendors*
0.2	External collaborations*

3) Who would be the target audience for the training?

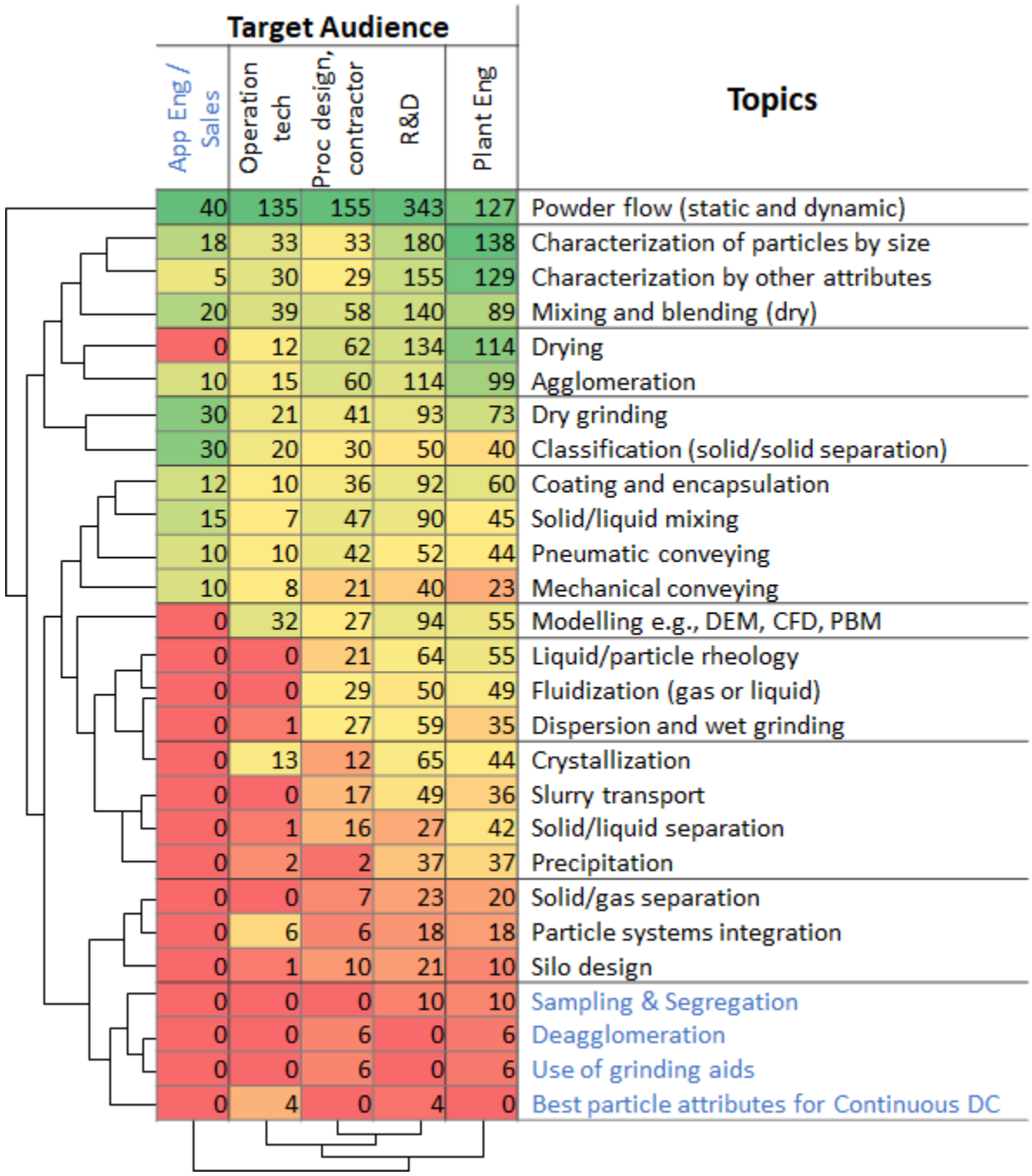
Target audience, new modes of training	
19	R&D people
14	Plant engineers and chemists
8	Process designers and design contractors
4	Operating technicians
1	Applications engineers*
1	Machine sales*

[1] Line items identified as “other”

4) Training priority

Topics by category	
399.5	Powder flow (static and dynamic)
201	Characterization of particles by size
174	Characterization of particles by attributes other than size
173	Mixing and blending (dry)
161	Drying
148.5	Agglomeration
129	Dry grinding
105	Coating and encapsulation
104	Modelling such as DEM, CFD, population balance
102	Solid/liquid mixing
84.5	Classification (solid/solid separation)
79	Pneumatic conveying
69.5	Liquid/particle rheology
67	Crystallization
63.5	Fluidization (gas or liquid)
60.5	Dispersion and wet grinding
51	Mechanical conveying
50.5	Slurry transport
42.5	Solid/liquid separation
39	Precipitation
25	Solid/gas separation
24	Particle systems integration
21	Silo design
10	Sampling & Segregation*
6	Deagglomeration*
6	Use of grinding aids*
4	Best particle attributes for Continuous DC*

Clustering: Training topic x Target audience



Target Audience					Topics
App Eng / Sales	Operation tech	Proc design, contractor	R&D	Plant Eng	
40	135	155	343	127	Powder flow (static and dynamic)
18	33	33	180	138	Characterization of particles by size
5	30	29	155	129	Characterization by other attributes
20	39	58	140	89	Mixing and blending (dry)
0	12	62	134	114	Drying
10	15	60	114	99	Agglomeration
30	21	41	93	73	Dry grinding
30	20	30	50	40	Classification (solid/solid separation)
12	10	36	92	60	Coating and encapsulation
15	7	47	90	45	Solid/liquid mixing
10	10	42	52	44	Pneumatic conveying
10	8	21	40	23	Mechanical conveying
0	32	27	94	55	Modelling e.g., DEM, CFD, PBM
0	0	21	64	55	Liquid/particle rheology
0	0	29	50	49	Fluidization (gas or liquid)
0	1	27	59	35	Dispersion and wet grinding
0	13	12	65	44	Crystallization
0	0	17	49	36	Slurry transport
0	1	16	27	42	Solid/liquid separation
0	2	2	37	37	Precipitation
0	0	7	23	20	Solid/gas separation
0	6	6	18	18	Particle systems integration
0	1	10	21	10	Silo design
0	0	0	10	10	Sampling & Segregation
0	0	6	0	6	Deagglomeration
0	0	6	0	6	Use of grinding aids
0	4	0	4	0	Best particle attributes for Continuous DC

5) Much of the need for industrial training in particle [science, engineering, and] technology (PSET) is the result of a lack of its inclusion in undergraduate curriculum. What can IFPRI do to change this situation?

- Some universities include PT elements in their Master's program (ETH Zurich, TUHH Hamburg).
- I think IFPRI should first focus on leveraging knowledge for IFPRI members. With turnover in companies, there will be always some needs! Concerning leveraging in University, I do not think this is the role of IFPRI, and on top, it will means choosing some universities rather than others, creating unbalanced opportunities across countries and continents.
- If the face-to-face courses resume, I suggest visiting the home university to give a lecture of PT - I have done that in the past with much success. When these are recorded, we already have a database of lectures available.
- Continued knowledge upgrade through learnings in IFPRI/Influence academia and curriculum
- Offer internships or fellowships for undergraduates at IFPRI member companies. Sponsor undergraduate research programs.
- Encourage industrial members to be guest lecturers for local universities providing research for IFPRI, provide annual travel budget for some undergraduates to attend AGM.
- Work with universities spearheading the powder technology research and co-sponsor short courses to start with
- Advocate for powder transport and size characterization in undergraduate programs. For more detailed understanding advocating for Masters programs or certification programs at a 'center of excellence' type of universities may yield the best payoff.
- Directly engage educators at university's with active research in area to incorporate into general class curriculum
- Eminent academics among the IFPRI membership are likely to have more influence on undergraduate curricula than most of us. How we can use them to influence the topics taught in their departments, starting with a review of the status quo at their institutions?
- Make a strong case to accreditation organizations:
  - Sponsorship of undergraduate (UG) programs
  - IFPRI to offer its own accreditation certificate
  - IFPRI to design a generic UG program for ChemE, MechE, etc. that includes Particle Technology fundamentals
- Too many countries involved with different education systems and accreditation systems
- It's difficult to see Universities to making Powder Technology a full degree program but it may be possible to encourage a number of them to create minors or program emphasis in powder technology in the way the Chem E's can choose emphasis in Bio or Traditional programs.
- I think the best we can hope for at the moment is to convince already well established departments (i.e., Materials Engineering, Chemical Engineering, Mechanical Engineering,

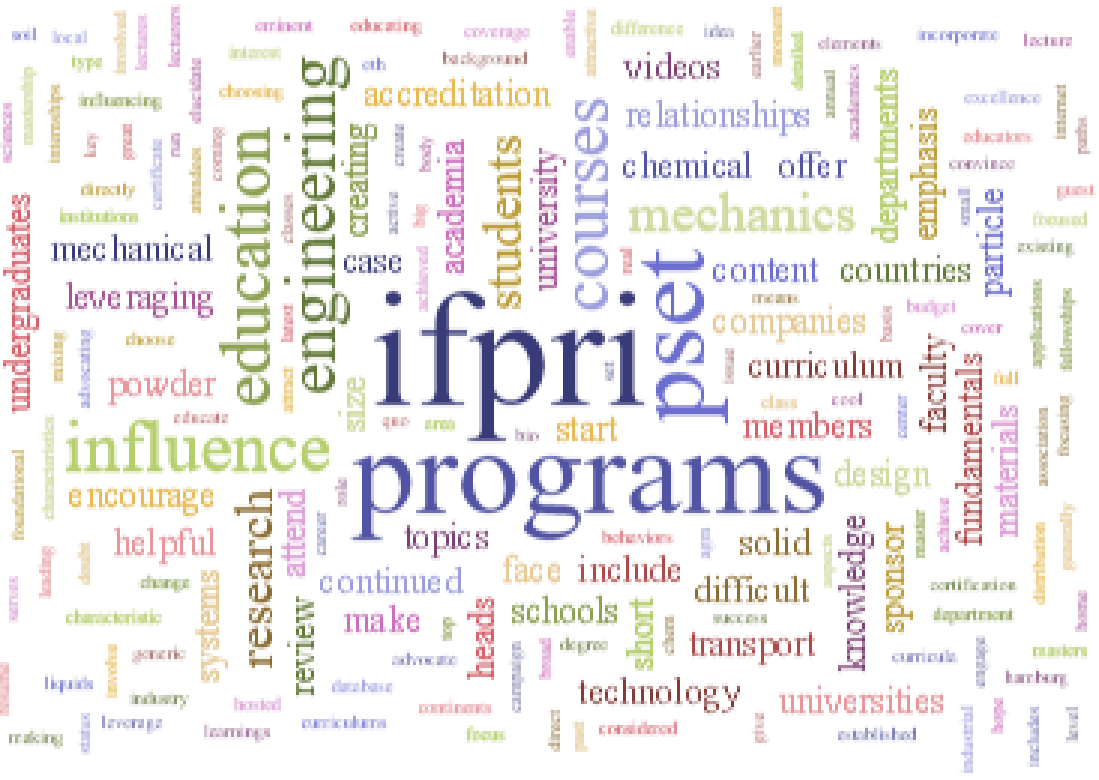
etc…) to include courses in their respective curriculums targeted at PT. I think this can only be achieved by creating great relationships with Universities and the Department Heads of the various schools of engineering and the sciences. Of course, there also needs to be interest from students to attend these courses, which is a much more difficult proposition to achieve.

- Summer schools for undergrad students on selected topics; direct influence to faculty heads
- Include this content in more foundational classes, even potentially influencing textbook content.
- Leverage existing IFPRI relationships with academia to influence change.
- Partner with Key Universities to develop PT course of study (certificate/minor) focused on advanced materials/manufacturing for national security applications
- Industry partnerships with academia:
  - Sponsored courses/content, internships, etc.
  - Student interest in these activities can be high if it is a good resume building activity or if it helps them build relationships that can be valuable for building their future careers.
- I think this is a better question for the professors/academics within IFPRI to answer - I'm not sure I understand the inner workings of how college courses are altered or are 'born'
- Offer relevant curriculum related to real world experiences

6) Do you have other thoughts about education needs in particle technology that have not been captured in this survey? We'd be most interested in those that IFPRI may be able to help with.

- Material science is missing. I doubt that focusing only on technology aspects can enable mastership of processes and product properties design.
- Generally speaking, IFPRI should not be the body for educating students - there are universities for this. Maybe a "teaching the teachers" project would be something which could be considered?
- Could it be an idea to do a short review on which education on the subject is actually already available as small videos on the internet?
- Post real-world case-studies online for use by university faculty. Make YouTube videos showing how cool powder technology is, and run a publicity campaign.
- Specifically talking about the powder mechanics, most of the fundamentals are taken from soil mechanics and involve general solid mechanics principles. In order to educate people coming from different background, it will be helpful to start with a brief coverage of solid mechanics to level set.
- Courses hosted by IFPRI but "in association with" leading universities and/or companies who are also IFPRI members would certainly attract attendees
- Particle segregation is a big issue

- I think it would be really helpful if we could clearly elucidate the difference between powders and liquids in terms of key behaviors and characteristics such particle size/shape/distribution (where there is no comparable characteristic), rheology, mixing, and, possibly, transport.
- Any PT curriculum will need to be broad in potential applications to be the most versatile/attractive to students whose career paths may not be focused on any particular industry, especially earlier in their education.
- I think the undergraduate education only serves as basis and continued education is required to keep up with the latest scientific progress → courses for specific topics cover this need best.



Appendix 2: Getting started – a PSET syllabus

The intent of this appendix is to provide a starting point for deeper discussions of ECM topics. It is based on the syllabus of Purdue MSE512, Fall '21.

Course notes are available on request.

- Introduction, Syllabus & interest survey
- Interfacial phenomena: surface forces
- Dispersion stability, DLVO: electrostatic & steric
- Brownian motion, suspension rheology
- Dense suspension rheology
- Weakly-attractive systems, colloidal gels
- Characterization: particle size
- Image analysis – size and shape
- Size and shape distributions – display and analysis
- Surface area, sorption isotherms
- Wetting, surface tension, capillary forces
- Guest, David Scott: Characterization by Light Scattering
- Porosity & permeability
- Guest, F. Fazelpour, Physics of Granular Rheology
- Quasi-static powder flow
- Orifice flow
- Bin Design
- Midterm Review
- Gas/solid fluidization
- Drying and moisture analysis of powders
- Mixing and Segregation
- Mixing Quality, Scale of Scrutiny
- Shrinking core reaction models (calcination, dissolution…)
- Size reduction: wet & dry milling
- Synthesis: Precipitation and Crystallization
- Separation, filtration
- Extrusion, pastes
- Spray Drying
- Mixer granulation, powder-binder
- Mechanical layering and coating
- Fluidized bed granulation
- Dry granulation, roll compaction
- Compaction
- Sintering
- Additive manufacturing
- Systems integration
- Product development
- Student presentations
- Final Review