Institutional Change through Faculty Advancement in Instruction and Mentoring (ICFAIM) Evaluation 2017

Rockman et al

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2017 Annual Report

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Executive Summary

Rockman et al. (REA), a San Francisco-based research and evaluation firm, conducted its third evaluation of the Institutional Change through Faculty Advancement in Instruction and Mentoring (ICFAIM) program. Launched in January of 2014, this professional development program is designed to: a) create sustainable institutional change by establishing a supportive infrastructure for improved faculty pedagogy, mentoring, and research opportunities for undergraduate STEM students; b) improve student learning and critical thinking skills, and c) increase the enrollment, retention and graduation rate of participating students. The purpose of the current study is to provide outcome data from ICFAIM's professional development program by summarizing evidence of the effect of program participation on faculty and students. Our analysis of the data collected leads to several conclusions about ICFAIM's impact during Year 3.

Faculty Participant Findings

- All participating faculty members responded very positively to the workshops offered, which covered the following topics: a) effective mentoring, b) ways in which students learn, c) pedagogical strategies for teaching success, d) designing courses for effective student learning, e) metacognition, and h) how to best incorporate STEM in the classroom.

- All participating faculty agreed that the workshops provided them with useful information and resources applicable to their teaching, and all participants would either "very likely" or "likely" use some the strategies or ideas learned from the workshops.

- Participating faculty, asked to what extent their participation in ICFAIM had enhanced their knowledge and skills, ranked better instructional methods highest. Asked to what extent changes they had made changes in their classrooms, faculty participants reported improving the cognitive challenge of activities, followed by taking approaches that would better cater to the needs of diverse learners.

- The biggest change reported in professional activities was participation in a committee focused on curriculum and instruction – 44% reported this change taking place once or twice a semester

Student Findings

- Statistically significant gains in students' critical thinking skills and self-efficacy skills were measured by the Motivated Strategies for Learning Questionnaire (MSLQ).

- Non-significant increase (in aggregate) was observed from pre to post Critical Thinking Assessment Test (CAT) scores. When looking at each individual class, two classes classes showed significant increases from pre to post while five showed significant decreases from pre to post

- In aggregate, statistically significant gains in science content knowledge (from pre to post) was observed during Semester 2 only.

- Statistically significant gains were seen in 6 of 17 science courses, minimal to moderate, non-significant gains were noted in the remaining 11 courses

- Statistically significant gains were seen in 3 of 18 science courses (Semester 2); minimal to moderate, non-significant gains were noted in the remaining 15 courses

- Physics I subject courses had statistically significant improvements in Semesters 1 & 2, compared to the other two courses, with General Science and Physics II showing non-significant gains/losses from pre to post

Conclusions and recommendations follow the summary of findings.

Introduction and Background

Program Overview

Institutional Change through Faculty Advancement in Instruction and Mentoring (ICFAIM) is an implementation project at Jackson State University (JSU) that builds on two previous implementation projects, the Mississippi Academy for Science Teaching (Project MAST) and MAST-5, both of which provided professional development for K-12 science teachers from more than twenty school districts in Mississippi over a period of 10 years. Funded by the National Science Foundation (NSF), ICFAIM's goal is to increase the retention of undergraduate students in the College of Science, Engineering and Technology (CSET) by helping its faculty members and graduate students improve their teaching and mentoring. This program focuses its efforts on the Department of Physics, Atmospheric Sciences and Geoscience (PASGS) by providing faculty professional development workshops in student-centered pedagogy and mentoring. This program also works to support the department's efforts to revise the content of entry-level physics courses and their respective labs.

By improving the efficacy of faculty mentoring and developing a research methods course, ICFAIM hopes to achieve the following:

- Increase STEM faculty capacity for learner-centered pedagogy, research mentoring, and a collaborative infrastructure, and
- Increase enrollment, retention and graduation rates of students through curricular improvement, improved pedagogy and formal research experiences, coupled with effective mentoring.

Literary Context

ICFAIM's program model (Figure 1) is rooted in recent literature on what constitutes effective PD for educators. In a comprehensive review of PD model analyses, Reviewing the Evidence on How Teacher Professional Development Affects Student Achievement, Yoon et al. (2008) identified five specific criteria that constitute "high quality" PD:

1. It is sustained, intensive, and content-focused.
2. It is aligned with and directly related to state and academic content standards, student achievement standards, and assessments.
3. It improves and increases teachers' knowledge of the subjects they teach.
4. It advances teachers' understanding of effective instructional strategies founded on scientifically based research.
5. It is regularly evaluated for effects on teacher effectiveness and student achievement.

In a more expansive take on Yoon et al.'s criteria, and one more evidence-based, Desimone (2009) provided a comprehensive framework for how best to evaluate the effects of PD, and for the most effective components that all PD programs should encompass. This approach has been supported by both theoretical literature and empirical studies. Desimone's model (2009) points to three main characteristics of PD evaluations that can better link teachers' and students' outcomes:

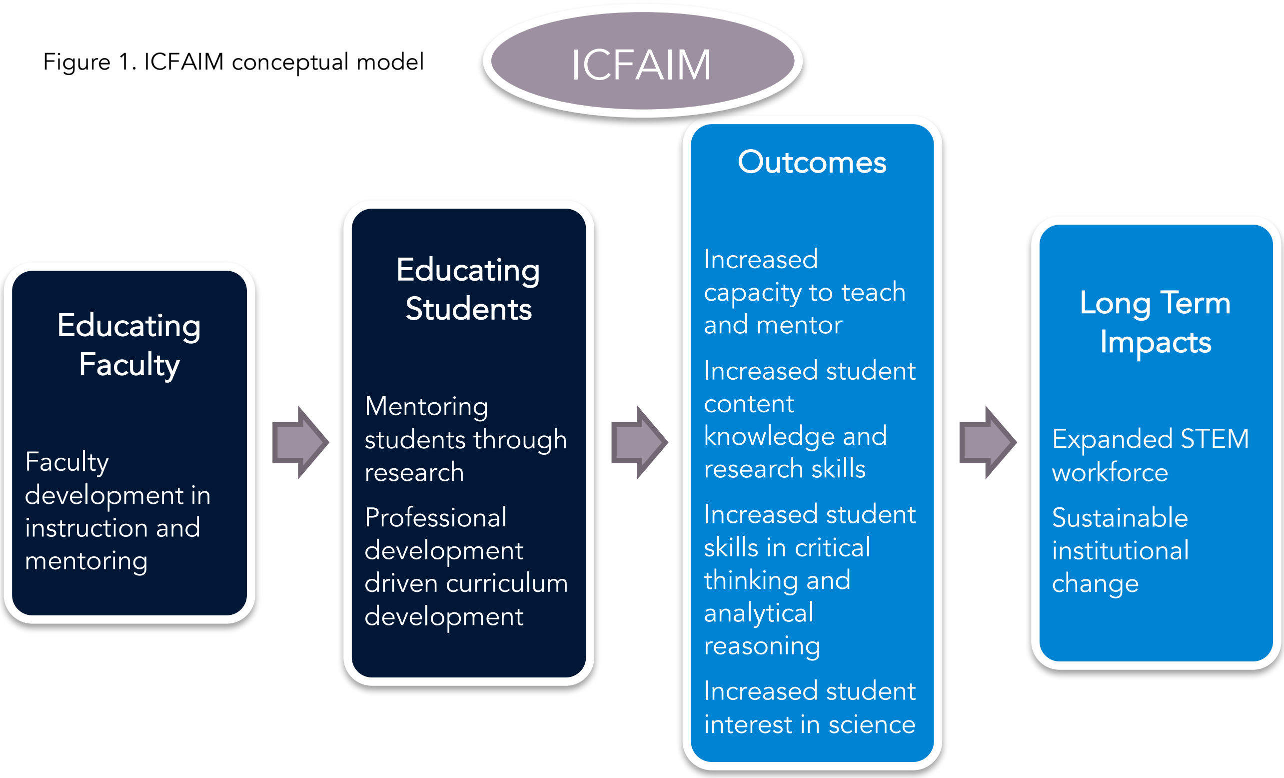
- Core features of effective PD must include: content focused, active learning, coherence, duration and collective participation;
- Examination of these core features should include how the PD affects a teacher's knowledge, teaching practices, and student learning; and
- Contextual factors such as teacher, student, and school characteristics are correlated to the effectiveness of the PD.

Hence, we found a few main ideas about "quality" PD to be universally accepted. First, PD should be viewed as an ongoing process, one most effective when it is extended beyond just a few days. Second, PD is of greatest effectiveness when it has been designed with the specific goal of improving student achievement and learning. Third, the context of the learners and the environment must be considered. Lastly, it entails "instruction that enables a wide range of students to learn" (Darling-Hammond, 2012). While many models of PD have been proposed (Bayar, 2014; Joyce and Showers, 1988; Desimone, 2009; Bell and Gilbert, 1996; Supovitz and Turner, 2000), we can situate the current ICFAIM study and evaluation within Desimone's (2009) conceptual framework.

The strength of Desimone's (2009) model is that it is a broad, macro-level view of PD that encompasses all core features that have received support, and yet it remains applicable to various settings. This model further encompasses all core features of quality training most relevant to teachers and their students, including, "…interactive, non-recursive relationships between the critical features of professional development." The theory of action proposed by Desimone (2009) includes the following attributes: (1) the PD should be content focused, and incorporate active learning, coherence, duration, and collective participation; (2) the PD should increase teachers' knowledge, skills, attitudes, and beliefs; (3) teachers should use their new knowledge, skills, attitudes, and beliefs to improve their teaching and/or their approach to teaching; and (4) the instructional changes will improve student learning. The ICFAIM PD model, intervention, and theory of change include all critical components of Desimone's (2009) model, including contexts of the PD and participants (e.g., teacher and student characteristics, school leadership, policy and reform initiatives). The previously discussed characteristics are aligned with those of many models shown to be consistent with an effective science PD program and opportunities for science teachers in particular (Supovitz and Turner, 2000; Duschl et al., 2007; Loucks-Horsley et al., 1998; Heller, Daehler, Wong, Shinohara, and Miratrix, 2012).

Like ICFAIM, summer professional development programs are the most commonly implemented type of "standardized PD" for in-service teachers; these "standardized" programs are defined as utilizing training sessions, the "workshop" model, conferences, and the "cascade" (or Train-the-Trainer) model (Gaible and Burns, 2005). ICFAIM's model differed slightly from such standard models in that it consists of a combination of pedagogical and content-based summer workshops, in addition to workshops offered during the school year, campus workshops, and year-round staff support. The program also provided participating faculty with ample opportunities for reflection, feedback to shape the content and quality of their PD experience, and lessons learned from previous years. Faculty attended a two-week workshop led by "experts" in the field of pedagogy, student learning, critical thinking, and assessment, including 3 workshops on science pedagogy and content from March, 2016 to May, 2017 and, in addition, received follow-up support from ICFAIM staff as they taught their assigned courses during the academic year. The total contact hours between the program and participants (workshops, support) ranged between 16-25 hours.

Figure 1. ICFAIM conceptual model



Current Study

The initial activities of this evaluation were to collect Year 3 data on participating faculty and students, as well as implementation data, so as to help guide faculty in addressing the learning and mentoring needs of undergraduate STEM students at JSU. The long-term goal of ICFAIM is to: a) expand this strategy and reach other science departments at CSET, and b) become a successful model that can be shared with the broader community of colleges and universities working to increase the number of minorities entering the STEM workforce.

The following research questions, both formative and summative, guided the current study:

1. How will participating faculty incorporate what they learn from ICFAIM workshops into their teaching, and what elements of the program do they think are most and least valuable, and why?

2. To what degree do the measured outcomes improve over the course of a semester and year (e.g., students' critical thinking skills, students' science content knowledge, students' motivational orientations and use of different learning strategies)?

3. What modifications were made to the program, based on previous findings and recommendations, that might improve outcomes?

Table 1 summarizes the project's outputs, outcomes and impacts from Year 1 to Year 5. Details about the research design and data collection follow the table.

Table 1. Evaluation constructs and measures

Objectives and Activities	Outcomes: Measures of implementation	Outcomes as a result of participating in project activities	Impacts (potential outcomes attributable to the project)
1. Increase STEM faculty capacity for: learner-centered pedagogy, mentoring, instruction in entry-level undergraduate courses	1. Faculty members' participation rates in ICFAIM's PD 2. Number of students taught by participants 3. Favorable reactions to ICFAIM's PD starting from baseline (measured by post-workshop surveys)	1. Participants implement what they learn from PD into practice 2. Students report greater value in courses 3. Statistically significant increases in student CAT scores, pre-post within a single class 4. Participants report greater value in program PD starting from baseline (measured by focus group/interview findings)	1. Retention of outcomes within a department over the course of the grant 2. Replication of changes in faculty teaching and student responses to courses as ICFAIM activities are scaled to additional departments
2. Increase enrollment, retention and graduation rates of students through curricular change, strong mentoring, and formal research experience	1. Number of faculty participants in workshops 2. Creation of, and student participation in, revised courses.	1. Favorable student reactions to research experiences 2. Favorable student reactions to courses 3. Improved relationships between faculty and students	1. Significant increases (from baseline) in enrollment and retention within classes and physical science majors 2. Significant increases in STEM graduates 3. Retention of outcomes within departments and replication of improvements

Research Design and Methods

REA employed a quantitative evaluation design with some qualitative components that triangulated several data sources (Table 2). This design offered a dual focus of providing formative evaluation information highlighting areas for potential improvement, and yielding summative evidence of the short-term outcomes of the ICFAIM program.

Table 2. Overview of Data Sources

Data Source	Date Collected	Data Type
Motivated Strategies for Learning Questionnaire (MSLQ) Student science content tests	September 2016 (pre), December 2016 (post); January 2017 (pre), May, 2017 (post)	Online and hard-copy surveys/assessments
Critical Thinking Assessment Test (CAT)	September 2016 (pre), December 2016 (post); January 2017 (pre), May, 2017 (post)	Hard copy assessments
Faculty post workshop surveys	March 2016–March 2017	Surveys collected by program staff. Mailed, entered by evaluators.
Faculty end-of-year reflection survey	May 2017	Online survey
Professional development observations	June 2016	Field notes taken by evaluators and use of observation protocols.

Participants

Our faculty sample originally consisted of 35 participants from PASGS and CSET (23 faculty members; 12 graduate students) (Tables 3 and 4). The aggregate student sample included 551 students enrolled in the faculty participants' STEM courses (315 from Semester 1; 302 from Semester 2). Demographic details of all student participants are summarized on page 22 of this report in the Student Findings section.

Table 3. JSU participants' professional titles (N=35)

Faculty title	f (%)
Professor	6 (17%)
Associate Professor	4 (11%)
Assistant Professor	8 (23%)
Adjunct Faculty	2 (6%)
Instructor	3 (9%)
Postdoctoral Fellow	3 (9%)
Doctoral/Graduate Student	9 (26%)

Table 4. Participant departmental distribution (N=35)

Department of ICFAIM Participants	f (%)
Chemistry	18 (51%)
Physics	8 (23%)
Biology	5 (14%)
Technology	2 (6%)
Computer Science	5 (14%)
Mathematics	1 (3%)

Instruments

Motivated Strategies for Student Learning Questionnaire (MSLQ)

Each semester, at its beginning and end, students were asked to complete the Motivated Strategies for Student Learning Questionnaire (MSLQ), designed to measure college undergraduates' motivation and self-regulated learning as they relate to a specific course (Pintrich & DeGroot, 1990). Students were asked to complete only two specific subscales of the MSLQ: a) Motivation Scale, which measures self-efficacy for learning and performance; and b) Learning Strategies Scale, which measures critical thinking and metacognitive self-regulation. These MSLQ subscales are aligned with courses specific to the ICFAIM PD programming content and faculty learning objectives.

Critical Thinking Assessment (CAT) Test

Evaluators assessed changes in students' critical thinking by administering (via JSU faculty) the Critical Thinking Assessment Test (CAT), an NSF-funded measure validated for undergraduates and in wide use across the country (Stein & Haynes, 2011). A selected group of ICFAIM faculty members were trained by CAT staff on how to score the instrument. In principle, if faculty participants are changing their instruction based on what they are learning, then student's critical thinking may be improved as a consequence. The pre-post CAT will be used as a measure of the influence of ICFAIM implementation, and it is possible that changes reflecting this influence could be captured across a brief semester. Furthermore, the evaluation design will depend, in part, on how faculty members plan to alter their teaching based on what they have learned in ICFAIM.

Science Content Tests

Evaluators and program staff measured student content knowledge learning gains over the course of two semesters by using content tests, designed by selecting item tests from standardized tests that were in alignment with the content covered and curriculum taught. These tests included multiple-choice items in physics and the physical sciences. Additional details about the content tests, including sample questions, appear later in this report.

Post Workshop Surveys

After a series of faculty and student workshops on various topics in teaching and learning (e.g., metacognition, increasing student motivation), post-workshop surveys were administered to all attendees. Attendees answered questions about their satisfaction with the workshop attended, their prior knowledge of the topic, the usefulness of the information covered, areas for improvement, and the likeliness that attendees would use strategies and ideas learned from the workshop. In addition, participating faculty completed a post-PD survey on the extent to which they had integrated what they learned from ICFAIM courses into their teaching.

Observations

Evaluators observed professional development workshops for faculty and graduate students at JSU. During these observations, evaluators collected data that provided evidence of: faculty learning and their teaching practices, graduate student learning and their teaching practices, inquiry-based learning, and team collaboration. Evaluators sought to triangulate observations with analyses of pre and post-intervention course syllabi (from participating faculty) in order to describe the effect of the program on faculty teaching.

Analysis

Evaluators analyzed all quantitative data by performing descriptive analysis, frequencies, and t-tests using SPSS (Statistical Package for the Social Sciences).

Findings

This section synthesizes the previously discussed data sources to illustrate the implementation and outcomes of the ICFAIM program and its potential benefits for faculty and students. We start with the post-workshop feedback from participating faculty, followed by post survey findings that summarize the degree to which faculty members integrated what they learned from the PD into their classrooms. Lastly, we summarize the quantitative student findings, including the MSLQ, CAT, and science content knowledge scores.

FACULTY FINDINGS

Post-Workshop Results

ICFAIM's cornerstone is providing workshops on instruction and mentoring to support faculty members during the school year. During the summer of 2016 and the spring semester of 2017, program staff coordinated workshops for the core group of PASGS faculty to help them reform their pedagogy and incorporate student-centered teaching into their repertoire. ICFAIM workshops were taught by faculty professors and professionals representing numerous academic institutions across the United States, including: Cornell University and Ithaca College, both in New York, University of Illinois Urbana, and White Mountain Science, Incorporated, in New Hampshire.

On the following pages, we present the findings from post-workshop surveys. These post-workshop findings are followed by a summary of the end-of-year PD reflection surveys, in which faculty participants reflected on the extent to which the individual courses had had an impact on their science teaching practices and content knowledge during the 2016-17 academic year. All workshops were ranked highly, with ICFAIM participants reporting either "A great deal" or "A moderate amount" when asked to what extent each workshop had helped improve their content knowledge, provided useful information applicable to their teaching, and given them new ideas and strategies on how to increase student learning. When asked to rate the likelihood of ICFAIM participants using some of the strategies learned from each workshop, most reported either "Very likely" or "Likely."

How People Learn: A Scientist's Perspective (April 6, 2015)
Dr. Jose Maestre (University of Illinois Urbana)

Dr. Jose Mestre presented an overview of human learning and problem solving in science, including the role that misconceptions play in learning, and why it is so difficult to get learners to transfer learning and knowledge from one context to another. This particular instructor was specifically chosen based on ICFAIM participant feedback from prior years, which suggested that the program address the challenges science faculty members face when dealing with varying learning styles in the classroom. The ideas presented by Dr. Mestre included ways to apply learning principles to a simple physics activity. The presentation concluded with a discussion of how that activity is aligned with the learning principles covered in the first half of the presentation, as well as its implications for promoting better health through increased immunizations.

Survey findings showed a statistically significant improvement in participants' knowledge from pre-session to post-session (Figure 2). Most participants (90%) reported that the information and knowledge presented helped "a great deal" and that they are likely to use strategies and ideas learned from the workshop (Figure 3).

Figure 2. Knowledge of the course topic – pre and post-workshop (N=26)

** statistically significant difference from pre to post, p<0.05*

Response scale: 1=I have no prior knowledge, 3=some knowledge, 5=I know a great deal about it

Figure 3a. How Students Learn – post-workshop feedback (N=26)

To what extent did participating in this workshop…

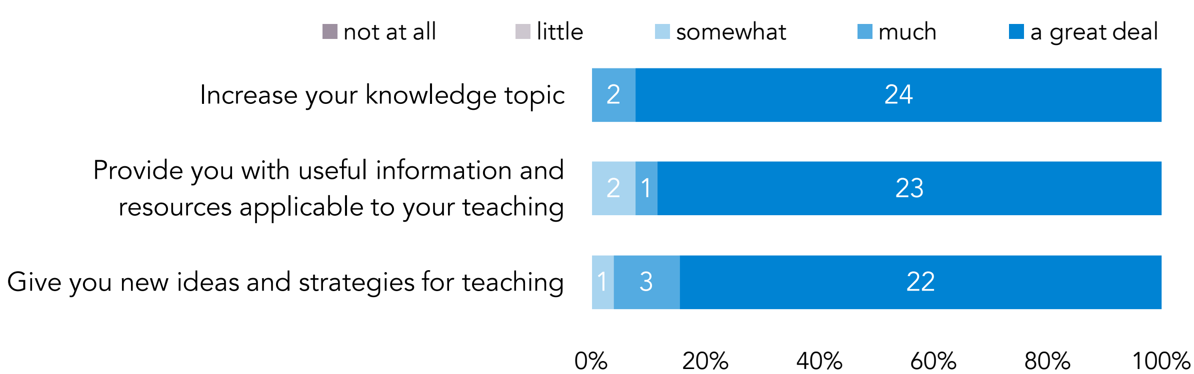
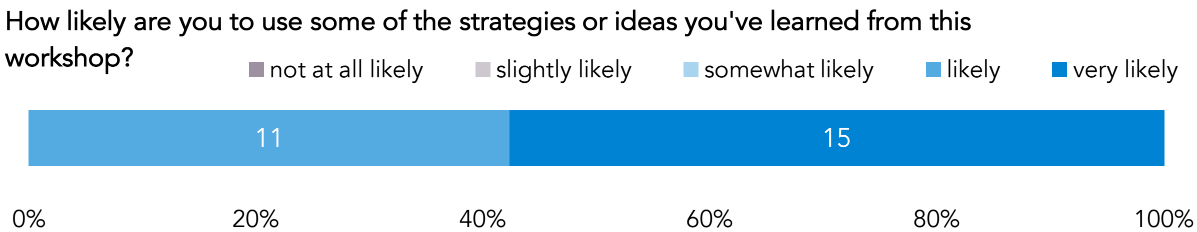


Figure 3b. How Students Learn - post-workshop feedback (N=26)



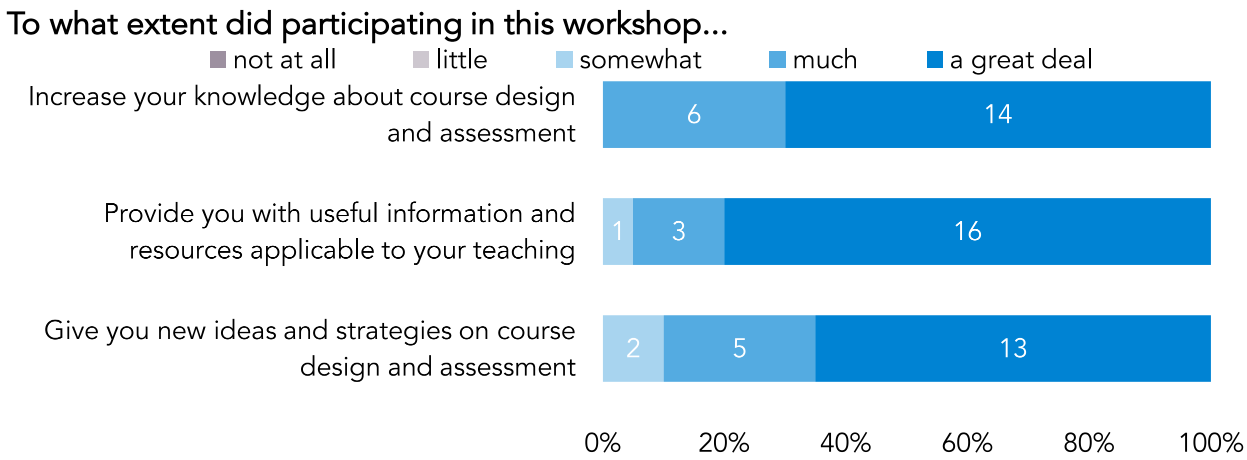
Enhancing Student Learning: Low Entry, High Ceiling
(May 9-11 2015) William Church and Steve Roberts (White Mountains Science, Inc., New Hampshire)

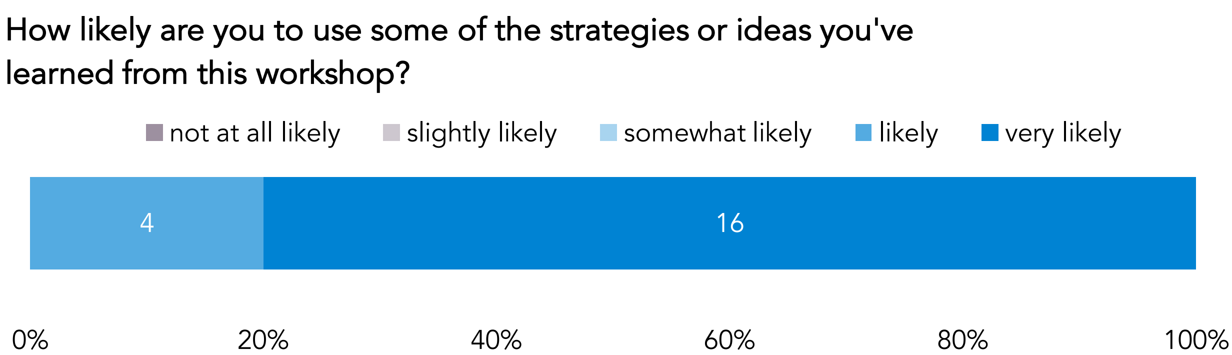
In this three-day workshop, participants were introduced to MINDSTORMS EV3 robotics education tools from the LEGO education modules. The teaching set was comprised of an embedded Linux-based robotics system, utilized in many Design and Measurement tasks across STEM disciplines. Participating faculty were also taught about Raspberry Pi, also a low-cost embedded Linux system that has been widely adopted for electronics prototyping, full product design and custom measurement systems. The Raspberry Pi is primarily used for the development of technologies under the "Internet of Things"(IoT), industrial internet label. The White Mountains Science instructors William Church and Steve Roberts have over 20 years of professional development experience in topics that range from Physics, Engineering Design, and Computer Science to Earth and Space Science. They facilitated this workshop with hands-on activities, examples of student work, and JSU faculty-led discussions to demonstrate how low entry, high ceiling tools can enhance research opportunities for JSU students. Post-workshop findings showed a statistically significant increase in knowledge gained (Figure 4), and most participants (80%) reported that they were "very likely" to use the strategies or ideas learned from the workshop (Figure 5).

Figure 4. Knowledge of the course topic – pre and post-workshop (N=20)

** statistically significant difference from pre to post, p<0.001*
Response scale: 1=I have no prior knowledge, 3=some knowledge, 5=I know a great deal about it

Figure 5. Enhancing Student Research: Low Entry, High Ceiling (N=20)





Pedagogical Considerations for Incorporating STEM into Classroom Instruction (May 12-13) Jim Overhiser (Cornell University)

ICFAIM participants were vocal in wanting this particular PD instructor, Jim Overhiser, to return to the program due to the quality of his instruction, depth of knowledge, and his ability to influence their perspective on teaching science. This two-day workshop covered pedagogical aspects of instruction, including the following topics:

- Teaching vs learning
- The power of misconceptions in STEM teaching
- Asking the right question (Instructional considerations)
- Starting with assessment: Designing rubrics
- Creating inquiry-based, student centered activities
- "Death by PowerPoint"

- Reformed Teaching Observation Protocol (RTOP) in teacher professional development
- Using videos as an interactive, instructional tool

Mr. Overhiser, an educator of over 35 years, holds a permanent certification in New York State to teach all areas of science. He has been part of several university outreach projects at Cortland State University, Binghamton University, Wells College and Cornell University. He was lead author on ten Cornell Laboratory for Accelerator-Based Sciences and Education (CLASSE) labs that are part of a national lending library network. As part of his role as CLASSE Institute for Physics Teachers (CIPT) master teacher, he has presented his lessons in Singapore, Qatar, Puerto Rico, India and annually at the Mississippi Academy for Science Teachers (MAST) at JSU. Jim has presented over 250 professional development workshops, and has served on the executive board of the Science Teachers Association of New York State. He currently teaches science education classes at Cornell University and Ithaca College. Post-workshop findings also showed statistically significant improvements in knowledge gained form pre-session (M=3.67) to post-session (M=4.52) (Figure 6). Ninety percent of attendees reported that were "very likely" to use the strategies or ideas learned during this workshop Figure 7).

Figure 6. Knowledge of the course topic – pre and post-workshop (N=31)

** statistically significant difference from pre to post, p<0.05*

<u>Response scale</u>: 1=I have no prior knowledge, 3=some knowledge, 5=I know a great deal about it

Figure 7a. Pedagogical Considerations for Incorporating STEM into Classroom Instruction (N=31)

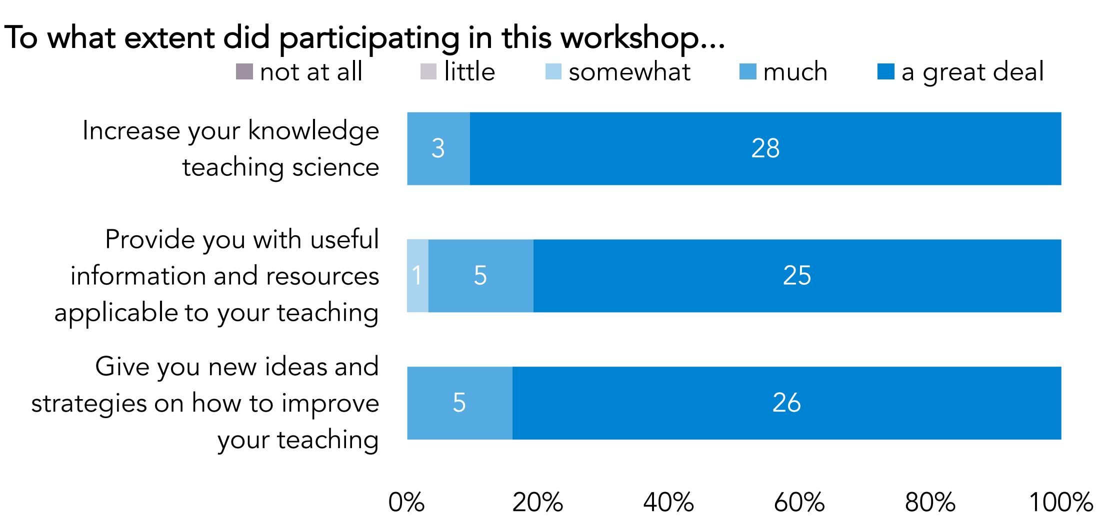
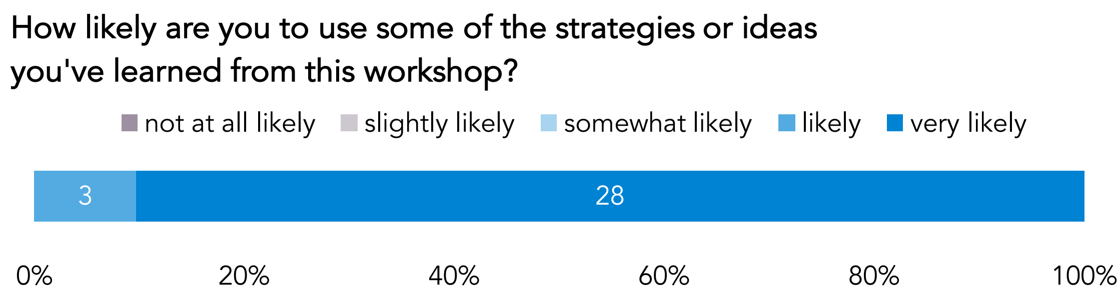


Figure 7b. Pedagogical Considerations for Incorporating STEM into Classroom Instruction (N=31)



OVERALL IMPACT OF ICFAIM PROGRAM ON FACULTY PARTICIPANTS - End-of-year survey findings

In June, after the completion of ICFAIM workshops during the 2016-2017 academic year and student data collection, participants were asked to complete an end-of-the-year reflection survey about the program's overall impact. A total of 18 faculty and graduate student participants completed this reflection survey. A summary of these findings is detailed below.

Thinking back, which session had the most impact?

Participants were first given a list of three of the PD courses they had taken for ICFAIM in the past year (in addition to the 2-week summer courses), and asked to select the one course that either: a) advanced their thinking on teaching science, or b) had or will have the greatest impact on their science teaching practices. Figures 8 and 9 illustrate which PD courses had the greatest impact. Half of participants selected the workshop led by Jim Overhiser, Pedagogical Considerations for STEM in Classroom Instruction, as advancing their thinking the most on teaching science. The same workshop was overwhelmingly selected (compared to the other two workshops) as potentially having the greatest impact on their science teaching practices.

Figure 8. End of Year Reflection (N=18)

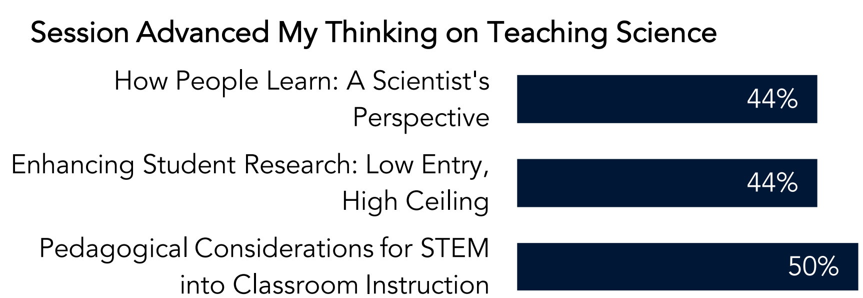
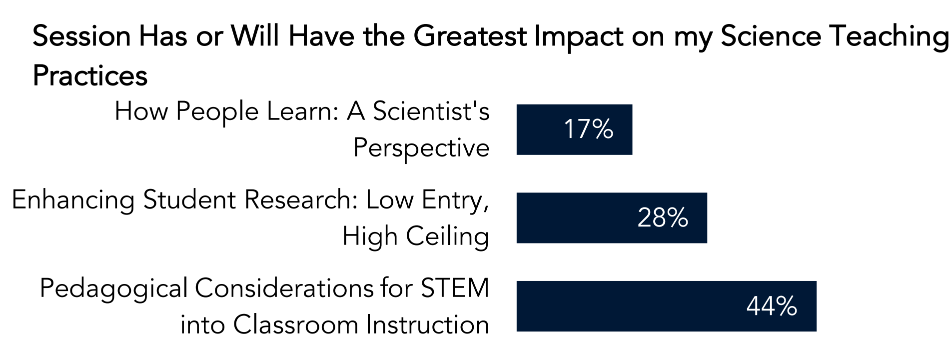


Figure 9. End of Year Reflection (N=18)



Some of the most rigorous studies on effective PD designs have established that *well-designed* PD can, when it is well-implemented, lead to changes in teacher practice and student outcomes (Bayar, 2014; Desimone, 2009). These studies have been built on an expansive body of literature and studies that have previously described positive outcomes from PD, mainly using methods such as teacher and student self-reports or observational designs. It must be stated, however, that self-reported satisfaction with PD sessions, and self-reported changes in teaching practice and content knowledge, do not necessarily lead to actual changes in behavior, outcomes, and ultimately student achievement. Research on self-reported methods for evaluating PD programs should continue to examine the kinds of professional learning environments that improve instruction and student achievement.

"Both instructors went above and beyond the content covered in our physics concept class. More importantly, they presented knowledge of how brain works, and how our learning is influenced physiologically. They told us, as physics teachers, that we can not only focus on course content. They pressed us to think about how students may think, based on their own life experience, within the context of these concepts. Such an approach may ensure the greatest success of knowledge transference - from instructors to students." (Associate Professor of Physics)

Reasons for Registering and Expectations

Retrospectively, ICFAIM participants reflected on why they chose to participate in the program, and whether their expectations have been met. All participants explained how they sought to improve their teaching and further develop their approach to teaching so that their students might benefit. The following quotes sum up all participants' reasons for registering for the program:

> *As a teacher, I am looking for an advancement in my teaching both technology wise and teaching learning strategy type. ICFAIM program is the professional development program for the faculty in various discipline in STEM. I attended the program which will give me more insight in teaching strategies which will enable my students to benefit from teaching.*
>
> *I choose to participate in the ICFAIM program because I am a recent graduate in chemistry and I need to develop and gain the skills to address students' learning challenges in STEM.*
>
> *To improve upon my teaching methods and styles to be more effective to student learning.*

One faculty member specifically addressed the program's intention to include "institutional change" as a crucial component of the program:

I was very curious to gain some knowledge on what kinds of "institutional changes", or "changes on old habits of ineffective science instruction", the program was designed to make, through what kinds of "faculty advancement in instruction and mentoring".

Just over 50% of participants commented that their expectations have in fact been met, and that their experience was beyond their expectations. Seventy-six percent of ICFAIM participants have previously been involved with similar PD programs at JSU (Mississippi Academy for Science Teaching, or MAST, for high school students; Mathematical Advancement in Teaching through Professional Development, or MAT-PD), and are familiar with the program structure, model, and potential outcomes. In addition, seven of the ICFAIM participants served as MAST or MAT PD classroom evaluators and observers for a number of years and have reported incorporating strategies learned during that experience.

Assessment of ICFAIM this year

Participating faculty and grad students were then asked to reflect on how the program went overall this year. The majority of respondents (87%) reported that the program had been going “smooth” or “very well.” Further, most responses (81%) included additional comments to address some of the self-perceived challenges the program has faced, mainly with regard to implementation. The following assessment from a grad student touched on the value of the resources and tools provided, but also mentioned how difficult it is as an instructor to find the time to implement what was learned during the PD:

The tools, resources, instruction for the workshops have gone smoothly. The workshops met my expectations and allowed for the discussion on improvement of student learning in STEM. Some of the barriers/challenges have been the available time to implement best practices, teaching strategies, assessment, and other activities into the classroom. The current classroom facilities, other duties that are evaluated more highly than instruction, and available resources in the chemistry department were also challenges to implementation. Research is an integral part of my job description and it has been a steep learning curve to enter the field of chemical education research. So the help that ICFAIM provides is welcomed.

Another faculty member praised the PD instructors, and the experience of learning how to implement inquiry-based learning, but also did not hesitate to talk about some of the related barriers:

ICFAIM has done a great job in bringing in a diverse group of facilitators that discuss student learning, how to implement inquiry based learning into the curriculum, and the implementation of technology in the classroom. Some of the barriers or challenges have been implementing some of the activities in higher education and larger classrooms.

One faculty member compared ICFAIM to other JSU PD programs, praising two instructors in particular, while also mentioning that some previous instructors did not fully grasp the meaning of frequently used terms in PD such as "hands on activities" and "inquiry-based learning." Consider the following comment:

The ICFAIM project actually is much better than other similar JSU PD projects, because ICFAIM invited some very professional instructors over to introduce many useful pedagogical strategies for the faculty to improve the subject matter instruction and mentoring, such as Dr. McGuire from LSU and Dr. Jim Overhiser form Cornell University, which were the two most impressive sessions that impacted me personally in improving my own teaching ability in great extent. The real hurdle the programs face is to locate and hire genuinely professional educators who fully understand the subject matter so deeply by heart to conduct concepts well-explained yet hands-on lab experiments or in-class demonstrations enhanced pedagogy in mathematics and sciences teaching. Consequently, otherwise, the participants or students will have a systematic view of the conceptual scope, understand the principles of the subject, and gain a long retention on the comprehension of the concepts for their future research or applications in life. Furthermore, since the programs respect the individual freedom of classroom teaching of the invited instructor, there has been phenomena of abusing the slogan of "hands-on" and "inquiry-based" pedagogy. Unqualified instructors introduced by word of mouth, without checking the background of the instructors, have taken advantage of the trust and kindness of the programs.

This comment explores critical components about how one can fully benefit from PD programs such as ICFAIM, including (but not limited to) instructor motivation, the willingness of instructors to want to improve, and challenging teachers to assume responsibility for their own unique PD experience (Desimone, 2009). In the same vein, one instructor commented on the new teaching methods learned, and the value of reflection and assessment, but also mentioned that some instructors seemed ill prepared, or would not be considered by this instructor to be experts in the field of science pedagogy:

From the program, I have learned several new instruction methods, and what helped me was sharing our own individual experiences and what worked for others. It's helpful to just talk about things. The methodology of instruction was *introduced from various perspectives, which has gone smoothly in the program. The organizer should bring new experts in the education field to the workshop, because at times I felt that they needed help with their content and the course overall.*

The challenges identified by participants, along with their assessment of the program this year, have led to some of the suggested improvements and modifications for ICFAIM to adopt.

Suggested Improvements to ICFAIM

Participants were asked specifically to provide feedback on how program organizers can improve the program. Comments ranged from wanting more PD sessions, having more qualified instructors, wanting more sessions on how best to integrate technology in the classroom, and providing more of a support system year-round for participants, to the problem with using vague terms (such as "hands-on" and "inquiry based") to organize and structure the workshops.

Many respondents (78%) mentioned wanting more sessions, either more in quantity or simply to have the sessions spread out over the course of the year and organized by major concepts. Hence, having sessions a few times a year may not provide sufficient instruction for participants to fully implement what they have learned. Some studies on effective PD models agree with this sentiment, supporting the view that educators need to attend regular courses over a duration of time, rather than sparsely scheduled workshops (Desimone, 2009, Bayar, 2014). In response to this point specifically, and to what should be improved about the structure of the program, one faculty member commented on the practicality of the PD schedule:

> *Although the program faces challenges such as activities are intensive especially for instructors, the nature of such training determines it is not practical to extend the trainings over longer period. However, for some activities, may be multiple-session of online training in the form of webinars can be employed.*

Another faculty member agreed and shared this sentiment on expanding the number of sessions:

> *The number of days of the program can be increased which will give us more insight into the different strategies of teaching students. More time to do hands on activities.*

A "booster training" was recommended by a participant, as a way to supplement the core PD sessions:

Additional booster training to be given during the regular semester.

Five participants questioned the experience of the PD instructors, asking for more strict background checks on those hired for the job. Consider one comment that highlighted the importance of quality lessons as they relate to one's professional background and knowledge expertise:

> *Establish a strict background qualification checking system on all invited instructors for the project to guarantee the quality of instruction on concepts, i.e., the correctness and systematic conceptual flow, etc. on the subject matter in mathematics and sciences.*

Another participant agreed that the program should bring in more experts in the field of science PD:

> *To invite more new experts to the workshop, so that JSU faculty will have more opportunities to learn the cutting edge teaching skill. Right now they are fine but I think they can be better. The teachers that come in should view their job working for ICFAIM as a real job, take it seriously, and really try to improve our skills so that our department can improve.*

Lastly, a few faculty members expressed concern about widely using terms such as "hands on" and "inquiry-based" as a way to frame such PD experiences, and noted that doing so may veer away from conceptually based instruction. One participant offered the following suggestions:

> *Modifying the narrative definition of the goal for the project from vaguely fashionable terms of "hands-on" and "inquiry-based" pedagogy in teaching mathematics and sciences to the more practical terms as "conceptual-based" "hands-on experiment" enhanced pedagogy instruction and mentoring. This definition would set the tone differently for the invited instructors and the participants to realize that the project is to advocate the urgently needed conceptual comprehension first; then, the conceptual understanding can be further enhanced by conducting "hands-on experiments" to gain longer retention on learned concepts to prepare the participants (the teachers) in their own classroom conceptual teaching in mathematics and sciences.*

When asked what ICFAIM should work towards in the upcoming years, participants candidly offered their suggestions on a refined direction for the program in 2017-2018. The following suggestions summarize the feedback from participants: a) have more self-directed learning where participants organize the scope of the PD instructions, b) as previously stated, hire more "experts" in the field of science pedagogy and student learning, c) offer more strategies on how faculty members can increase student motivation in STEM, d) address how to increase retention of science majors, e) offer guidance and practical steps on how to integrate technology in the classroom and bridge generational differences, and f) increase supportive outreach from program staff on how to better mentor students and keep them interested in research projects. The following comment identifies some of the long-term benefits of their instructor participating in PD:

> *Students will benefit by improved classroom instructions which could led to developing their critical thinking skills and assist them to become more effective learning. The long-term benefit to students is progress through their program with degree completion and being better prepared to attend graduate/professional school and/or enter the workforce.*

How will teachers and students benefit from ICFAIM?

Participants provided detailed explanations as to what kind of instructor might reap the benefits that ICFAIM has to offer to one's professional growth. Some themes that emerged on how faculty members might benefit from ICFAIM include the following program components: a) ongoing PD that keeps instructors up to date with current research and findings related to science pedagogy, b) strategies to improve science teaching, c) ways to teach science to underrepresented populations in the field, d) expanded knowledge on the benefits of mentoring, and e) the benefits of self-regulated learning and encouraging educators to choose what teaching strategies are best for them and their students. One faculty member discussed how the comfort levels of educators and their willingness to change should in fact be addressed before starting a PD program like ICFAIM. He went on to explain how educators need to be invested in a willingness to change so that PD programs, such as ICFAIM, will have a lasting impact, with educators thinking independently when it comes to facing the challenges of learning new instructional concepts, and not simply mimicking procedures:

> *Informing the participants to find out if, through years of their own teaching experience, they have any long term accumulated and unreleased anxiety to improve his or her own pedagogy in teaching, and address if they are willing to make changes before even starting the program. If so, then ICFAIM will be the savior in meeting their needs and they will benefit from it. Also, instructing the participants to be "independent deeper thinkers," not a group-thinker, to face the challenge the project presents to them in learning new and unfamiliar concepts, correlating concept to experimental procedures, concluding experimental results, by individual reasoning and concluding, not just following the instructions or mimicking.*

Another faculty member, who has participated in ICFAIM for multiple years, reflected on how it is ultimately up to the instructor to decide the best approach moving forward with his or her own students. He commented:

> *Faculty (who participated in the past) already have exposure to a variety of teaching methods that are proven to be effective. It is up to the faculty to implement the suitable approach provided limitations (time, incentive and other) are minimized.*

The independence that educators have, with regard to what to take from the PD and present to their students, was reiterated in the following comment:

> *All faculty will have possibility all different ways of teaching and choose the best way for them to teach them.*

Two faculty members reiterated the fact that many of the STEM educators were trained as researchers, and not so much as instructors. One participant mentioned that they are considered the experts in science content knowledge and do not need help in that particular domain – they simply need to know how to teach the content better. The following comment illustrates this point:

> *Most faculty in STEM disciplines were trained well as researchers but received little to no instruction in teaching strategies and how students learn. The current methods used by most faculty is outdated and don't engage the current students. The benefit to faculty is to provide the current strategies in teaching, best practices, current research, assessment of teaching, and a forum for collaboration and to start the discussion on teaching and student learning at the institution. ICFAIM has the potential to do this, but should place more emphasis on what works today. What is the current research saying? More emphasis should be put on teaching and I feel this can be done without decreasing research effort. Most faculty are not trained to approach teaching as a research topic to improve student learning outcome.*

"I was able to develop new modules for teaching physics and chemistry based on Raspberry Pi software and framework. I know I will approach my teaching differently and use the methods I learned from the support of ICFAIM and its instructors." – Assistant Professor of Physics

When asked how students will benefit from ICFAIM, participants agreed that if instructors participate in this type of PD, students will exhibit the following (organized by frequency of mention): a) they will be more motivated to learn (*f*=11), b) more involved in classroom participation (*f*=9), c) more interested in the concepts, and will then find the classes more enjoyable (*f*=5), d) will be faster learners (*f*=4), e) will demonstrate improved critical thinking skills, (*f*=4) and f) will know how to better use technology to support their studies (*f*=3).

Additional Changes in Knowledge, Practice, Professional Activities

When asked to what extent their knowledge and skills have been enhanced as a result of participating in ICFAIM, the highest response means reported were instructional methods *(M=4.51)* and strategies for teaching underrepresented students (*M=4.44)*, *(M=3.86)* (Figure 10). When asked to report on which changes they have made to their teaching practices as a result of participating in ICFAIM, most faculty selected "The cognitive challenges of classroom activities" (*M=4.81)* and the approaches taken to cater to diverse learning styles (*M*=4.79) (Figure 11). The biggest change reported in professional activities was participating in a committee focused on curriculum and instruction – 44% reported this change taking place once or twice a semester (Figure 12).

Figure 10. Improvements in Knowledge because of ICFAIM (N=18)

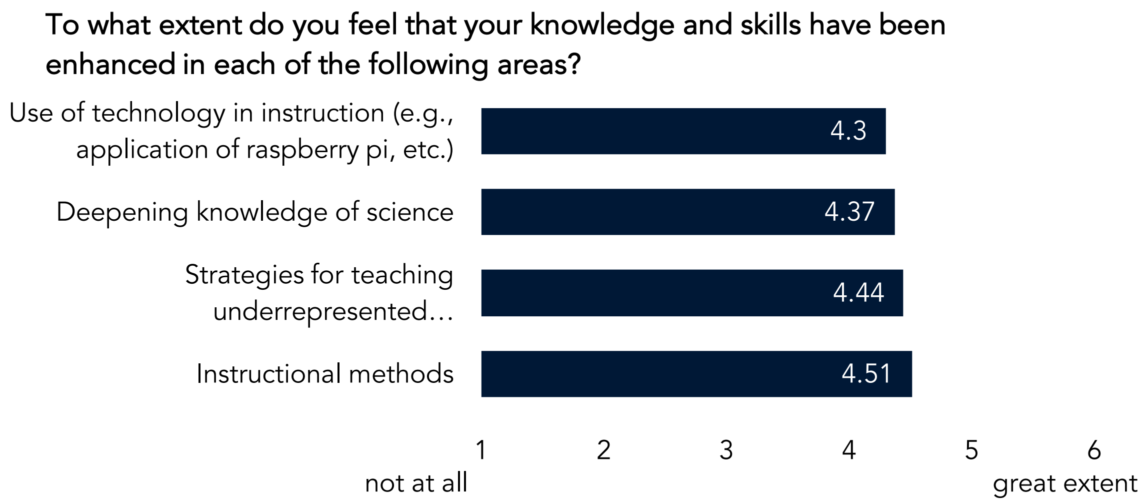


Figure 11. Changes in Teaching Practices because of ICFAIM (N=18)

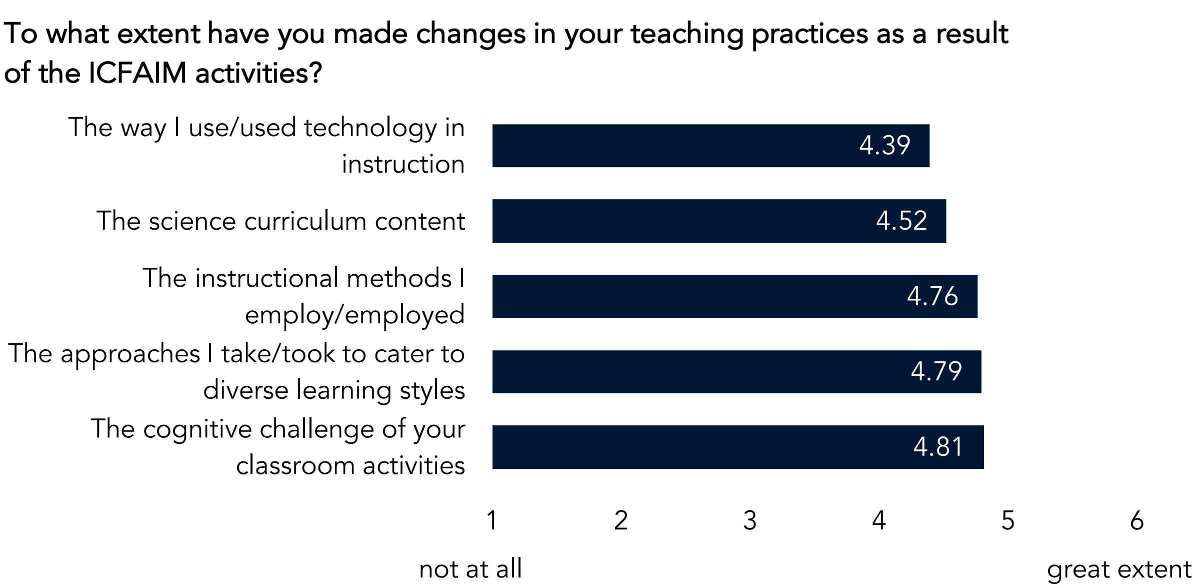
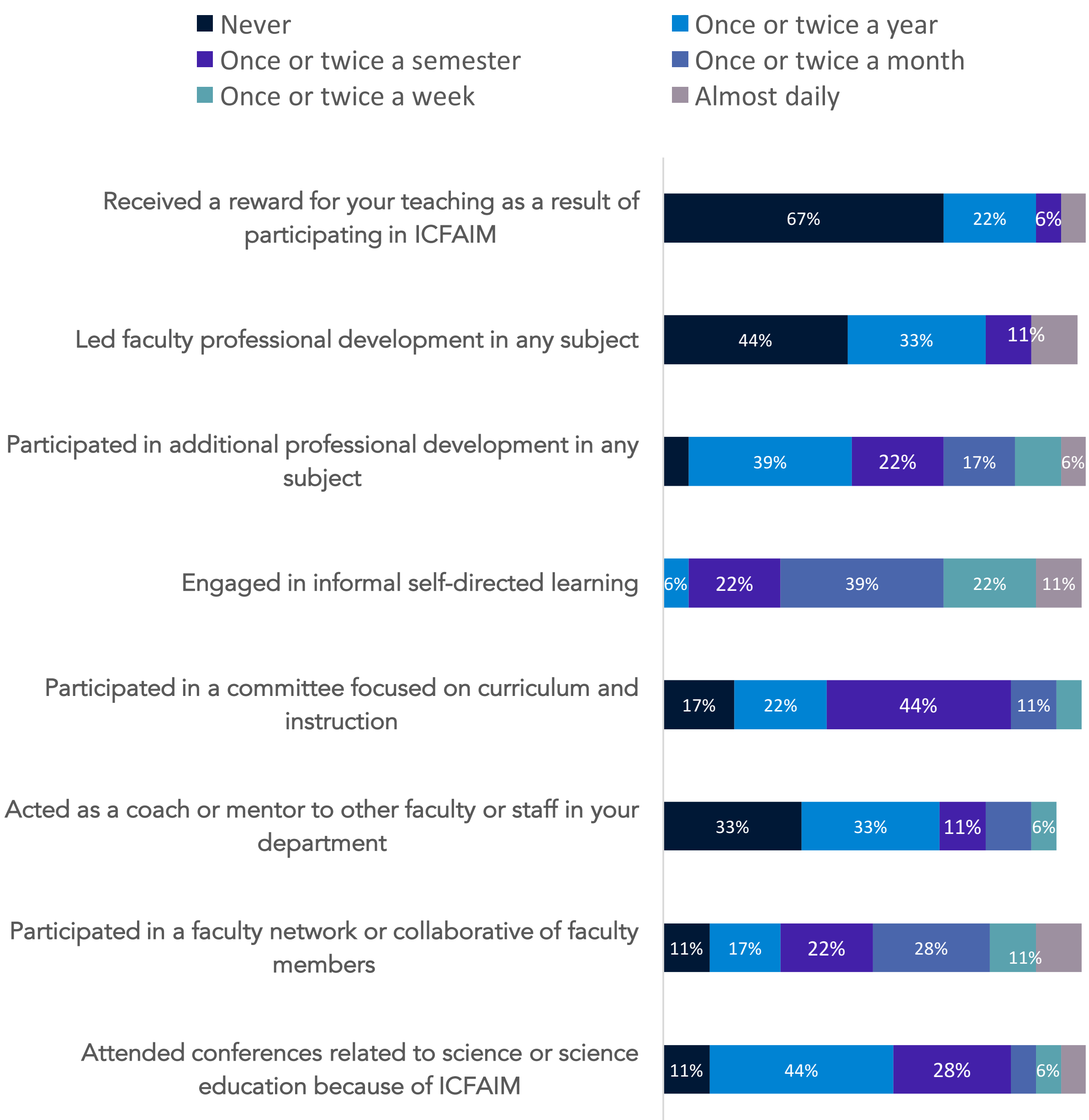


Figure 12. Changes in Professional Activities because of ICFAIM (N=18)

Between March of 2016 and March of 2017, how frequently have you engaged in each of the following activities related specifically to the teaching and learning of science because of your participation in ICFAIM?



Additional Faculty Impacts – Supplemental Research Initiative & CAT Administration Reflections

Supplemental Research Program

During the 2016-2017, ICFAIM introduced an additional research development opportunity for a select number of participants. This supplemental project reinforces ICFAIM's efforts by helping junior faculty members initiate their research programs, and increase the number of research opportunities for undergraduates. This effort has sought to strengthen the research capacity of the Department of Physics, Atmospheric Sciences and Geoscience by adding research areas in Raman imaging and solar cells at Jackson State University (JSU). This project aims to achieve the following goals: a) assist two experimentalist junior faculty members initiate research projects, b) increase the number of undergraduate research participants. Two, recently hired, junior faculty were selected to receive stipends to further develop their research labs, and recruit and retain undergraduate research students. These faculty members were asked to reflect on their experience and describe ways in which ICFAIM has influenced their professional development and overall experience as new educators at JSU, the PASG department, and ICFAIM.

The first junior faculty member detailed the ways in which ICFAIM has improved his teaching, including networking with other educators and sharing experiences and resources, learning ways to engage and motivate his students, and practical ways to integrate technology into his teaching:

> *ICFAIM held workshops and invited multiple experts to share their experience in teaching and mentoring. These speakers showed us what can be adopted to general physics classes, as well as new technologies using for teaching university physics. On the mentoring side, the speakers shared their opinion on how to improve the motivation of students in physics courses, especially for those physics is not the core course. For example, LEGO robots have been used at some school for engineering education. As the result of the training, I have now adopted a smart phone app that is recommended by one of the invited speakers, this app is called 'Reminds'. This free app allows me, as an instructor, to establish an effective communication method, in and out the classroom. For example, I use the app to receive immediate responses from in class quizzes from students. I also use the app to notify the class about class schedule modification or simply remind students about the upcoming tests.*

Support for his lab was also reported to have been extremely beneficial to his students and his ability to teach. With his stipend, he was able to purchase much-needed equipment to encourage advanced student research. The following reflection outlines some of the lab equipment purchased, and some resultant findings from experiments carried out in his revamped laboratory:

> *ICFAIM also supported my research lab through the purchasing of scientific instrumentation, such as the InGaAs based near infrared Raman spectrometer, which enable the laboratory to conduct research on characterization of biological specimen, and pumping laser at 532 nm for a Ti Sapphire oscillator, this laser greatly enhanced our capability to explore the possibility of global Raman imaging at macro scale (up to 10 mm in diameter) in signal snapshot. Research findings since the acquisition of these instruments include:*
>
> *In traditional Raman measurements, the excitation laser light is tightly focused through an objective lens. High magnification lenses with high numeric apertures are often selected in order to effectively collect the Raman signals. However, these lenses have small field of view (< 100 microns), and the laser power must be low to prevent sample damage. Acquiring a Raman image covering a much larger area (few millimeters) is critical for this project, therefore, we must use lenses with larger field of view. We have qualitatively found that, although the efficiency of the lenses (with large field of view) is reduced, the total amount of signal that is collected can be greater than that collected from high numeric objective lens by increasing the laser power. Quantitative assessment in this regard will be followed later.*

The second junior faculty member commented on how adding infrastructure, offering more funding, and his ability to better train students has improved his professional development significantly. One comment explains how ICFAIM's support led to better equipment, which, in turn, resulted in better research and more research proposals:

> *[Faculty] group generated some preliminary data by the research equipment, and the preliminary data were used to submit some external research funding. [Faculty] submitted 6 research proposals in 2016. Therefore, the enhanced research by ICFAIM makes our proposals more competitive.*

He also touched on how ICAIM's funding increased his lab's research capacity.

> *Solar cell fabrication and characterization system was purchased by this ICFAIM supplemental fund. This system allows Dr. Dai group to initiate solar cell research and enhance department research capacity. It is the first solar cell research group in JSU.*

On top of improved infrastructure, increased research capacity, and improved labs, the same faculty member projected upcoming publications because of these developments, stating, "More publications will be produced soon with the help of the research data. We are writing a manuscript supported by ICFAIM supplemental fund." These additional funding opportunities highlight the versatility of the program, and ways in which ICFAIM caters to participants based on programmatic needs.

CAT Administration, Training and Scoring Reflections

As stated previously, a select group of ten ICFAIM faculty members were trained during Fall, 2016 by the Critical Thinking Assessment (CAT) staff on how to administer and score the instrument, an NSF-validated assessment tool (Stein & Haynes, 2011). We hypothesized that if faculty participants change their instruction based on what they are learning through the ICFAIM program, then student's critical thinking might improve as a consequence. The pre-post CAT test was used to measure this influence

Our broadest opportunity to collect CAT data on ICFAIM influence lay in a single science course, the instructors of which are ICFAIM program participants. Many students enroll across the academic year in varying sections of this same course. We anticipated that, within a brief semester, the capture of meaningful changes reflecting student improvement from faculty ICFAIM participation would be difficult, but possible. Nevertheless, we decided to administer the CAT only during one single term. This decision was made to prevent students from taking the CAT at the beginning and end of two consecutive semesters, for a total of four identical tests during a single academic year.

The following findings summarize the ten faculty members' experience and views on that training.

Faculty participants were asked to rate their level of satisfaction with the CAT training they attended. Most attendees (70%) reported being extremely satisfied, while the remaining 30% reported being moderately satisfied. The same responses were reported when asked about the usefulness of the information and resources provided by the training, with 70% of attendees reporting that the information and resources were useful, and 30% reporting them to be moderately useful. Eighty percent of attendees reported learning new ideas and strategies for their teaching as result of participating in the workshops. Some comments included reflections on how students might perceive some of the critical thinking exercises learned during the training, as well as on strategies for integrating critical thinking activities into their teaching. The following comments support this feedback:

Excellent information. I will use this in my classroom tests and quizzes, and assignments. The students will gain a lot of useful skills with what I choose to integrate.

The technique can be used in creating regular assignments (content) and testing in addition to placing an emphasis on critical thinking.

It gave us good ideas on how to develop and think about the problems. For example in physics problems, there are many variables and constants linked to the given problem and sometimes students get confused as to what the question is really saying. In this CAT workshop, we discussed ways to generate short questions to understand problems in different ways.

Very good workshop. I have frequently asked students follow-up critical thinking questions while discussing a lesson. I now see that I should have students write responses to such questions as opposed to just answering them orally. This strategy will encourage all students to participate in the thinking process and not just those who are actively engaged in a given moment.

When asked to provide feedback on the most valuable aspects of the workshop, many participants highlighted the value of developing and testing grading rubrics, being given example on critical thinking strategies that can easily be integrated, and applying CAT applications to physics content. Consider the following comments that explain the value in some of the workshop components:

Showing us that critical thinking question can actually be applied to physics teaching.

The learning strategies demonstrated by applying the CAT applications to our physics content and also the various skills we can develop within our students based on real world problems, and solutions to the problems. These aspects of the workshop I enjoyed the most, and can be spread globally to make younger generations be accountable for their learning.

Given us very specific and straight forward guidance on question development and rubric development.

When asked how the workshop could be improved, none of the attendees felt that any improvements should be made. Eighty-nine percent of the workshop attendees reported having a very positive experience scoring the CAT assessments, using phrases such as “excellent” and “very positive” to describe what scoring was like.

My CAT scoring experience has been very positive. It provides an opportunity for me to spend time with colleagues in another department. It gives me a chance to see how students respond to critical thinking situations. The process can be quite tiring, but it is very informative.

> *Except the use of a few word (that can have more than one meaning and application), the grading rubric was very very helpful.*
>
> *Excellent. Exploring strategies for assessing students. Anticipate student responses through critical thinking.*

Some of the biggest challenges faculty members had with the CAT scoring included how many points to give students for their efforts, how to score vague answers while sill applauding students' efforts, and how to score correct answers that don't include detailed explanations. When asked what changes were made to their teaching as a result of scoring the CAT, most faculty members (89%) reported not many changes as of yet because it was a "work in progress" and "more time is needed." When asked how confident they felt integrating critical thinking in their courses, 50% reported feeling "extremely confident" while the remaining 50% reported feeling "moderately confident." Overall, the CAT workshop and scoring experience appeared to have been an extremely useful and eye-opening experience for participants. One faculty member summed up the reported experiences accurately, in stating:

> *I really enjoyed grading these papers. In gave me insight into how my students think, and where I need to support them as their instructor. Every second in scoring the papers I realize the way in which student knowledge can be demonstrated and assessed in so many different ways. Really was a wonder and pleasant time scoring the CAT and learning ways to integrate critical thinking into my courses. I've gotten to know my students better from these exercises.*

STUDENT FINDINGS

Student Demographic Survey

In the beginning of the fall, 2016 semester, and the spring, 2017 semester, 617 students of the ICFAIM participating faculty completed a survey about their academic background, including their interests, goals, academic level, and standing. The students were enrolled in five different physics or general science courses at JSU, with 2-3 courses per instructor. Of the students who completed the survey, 62% were female and 38% were male, with most students in their junior year. The average age of student participants as reported was 22 years of age. The majority of student participants identified as ethnic African American/Black (91%), and most students in the enrolled physics/ physical science classes listed their parents as having a high Bachelor's degree

(24%), and a high school diploma/GED (18%). Few students reported having parents with less than a high school diploma (3%), attended college, but did not finish (24%), or a Doctoral or professional degree (3%). The majority of students enrolled in the participating science courses as a requirement to graduate. Most students listed biology as their undergraduate major (59%).

Motivated Strategies for Learning Questionnaire (MSLQ) Results

Students were asked to complete three subscale items from the MSLQ scale (motivation and learning strategies) (Table 5); these subscale items measured students' critical thinking (e.g., "I often find myself questioning things I hear or read from this course"), self-efficacy for learning and performance (e.g., "I expect to do well in this class"), and metacognitive self-regulation skills (e.g., "When I become confused about something I'm reading for this class, I go back and try to figure it out").

Table 5. Motivated Strategies for Learning Questionnaire (MSLQ) Scales/Subscales

Scale	Subscale	Sample item	Number of items	Alpha
Motivation scales	Self-efficacy for learning and performance	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	7	Pre = .76 Post = .75

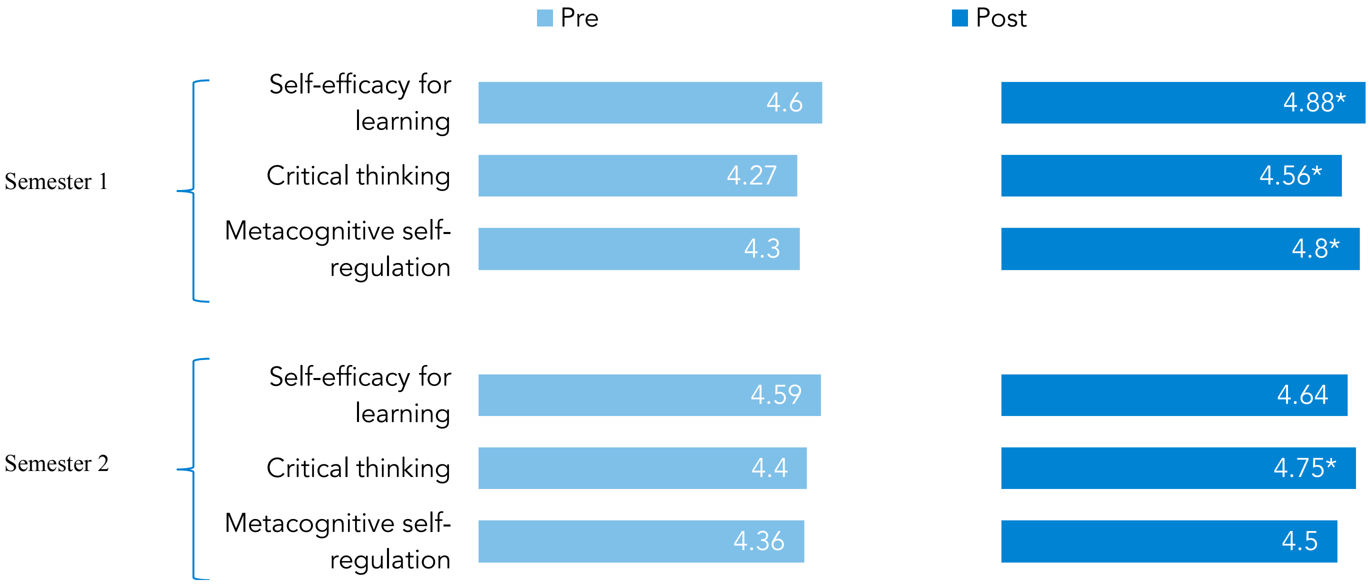
Scale	Subscale	Sample item	Number of items	Alpha
Learning strategy scales	Critical thinking	I try to play around with ideas of my own related to what I am learning in this course.	5	Pre = .74 Post = .79
	Metacognitive self-regulation	When I become confused about something I'm reading for this class, I go back and try to figure it out.	12	Pre = .7 Post = .74

We ran paired-samples t-tests for the entire student ICFAIM population, and found (Table 6):

- Statistically significant, moderate effects for the Semester 1 and 2 students' critical thinking skills;
- Statistically significant, large effect gains for the Semester 1 students' self-efficacy for learning scores; moderate gains for Semester 2;
- Statistically significant, moderate effect gain for metacognitive self-regulation skills during Semester 1; moderate gains for Semester 2.

Overall, scores increased in all scores from pre to post (both semesters) (Figure 13), Table 6), with four out of 6 semesters demonstrating statistical significance with relatively high power. The small sizes limited the power to detect significant effects. While some student scores were highest in self-efficacy and critical thinking, we would probably need to identify other covariates, such as faculty use of critical thinking curriculum (learned from the year-long PD), dosage of critical thinking activities, and active efforts to improve student self-efficacy to explore and explain the underlying causes of the group and subscale differences.

Figure 13. Student Scores on MSLQ Tests
(7 point Likert scale, 1=not at all, 7=very true of me)



statistically significant improvements from pre to post, p<.05

In aggregate, the results indicate that students are making small to medium, short-term shifts in their motivation and learning. Collectively, students of ICFAIM trained teachers are utilizing their critical thinking skills, though it is unclear from the MSLQ data alone how the PD is responsible for the observed outcomes.

Table 6. Student Scores on MSLQ Tests, Semesters 1 & 2

		Semester 1 (Fall 2016)					Semester 2 (Spring 2017)				
		Pre	Post	df	t	ES[1]	Pre	Post	df	t	ES
Self-efficacy for learning	Mean	4.6	4.88	313	1.97*	0.62	4.59	4.64	300	1.96*	0.48
	SD	1.6	1.59				1.76	1.71			
	N students	314					301				
	N teachers	10					10				
Critical thinking	Mean	4.27	4.56	312	1.76	0.52	4.4	4.75	301	1.97*	0.46
	SD	1.65	1.7				1.57	1.62			
	N students	313					302				
	N teachers	10					10				
Metacognitive self-regulation	Mean	4.4	4.8	311	1.9	0.17	4.36	4.5	301	1.88	0.39
	SD	1.54	1.59				1.6	1.67			
	N students	312					302				
	N teachers	10					10				

* $p < .05$

Note: Minimum and maximum scores are based on 7-point Likert scale (1=Note at all; 7=Very true of me)

Critical Thinking Assessment Tests (CAT) and Science Content Test Scores – Summary of pre and post findings

Critical Thinking Assessment Test (CAT) Findings

In addition to improving faculty members' capacity for learner-centered pedagogy, ICFAIM is also intended to improve students' critical thinking; this section uses CAT data to examine the extent to which students whose professors participated in ICFAIM demonstrate short-term gains in their critical thinking.

When we ran paired samples t-tests for the Semester 2 ICFAIM student population in aggregate we found no significant change from pre to post (Tables 7; Figure 14), but rather a decrease in scores from pre to post. Although the pre and post means decreased over one semester, by instructor, the changes were non-significant with the exception of one faculty member. When we examined CAT scores at a classroom and

[1] ES = Effect size, measured by Cohen's d. Traditional interpretations for Cohen's d are 0.2 for a small effect, 0.5 for a medium effect and 0.8 for a large effect (Green & Salkind, 2005).

subject level, we found that two of five classes showed larger, significant gains from pre to post. Five courses showed statistically significant drops from pre to post. It is important to keep in mind the various factors that could explain course-level or subject-level losses and gains for critical thinking score. For instance, some faculty members may have better strategies for incorporating elements of the ICFAIM PD, or it may be more difficult to incorporate these strategies with some science subject matter in a way that is effective.

Figure 14.

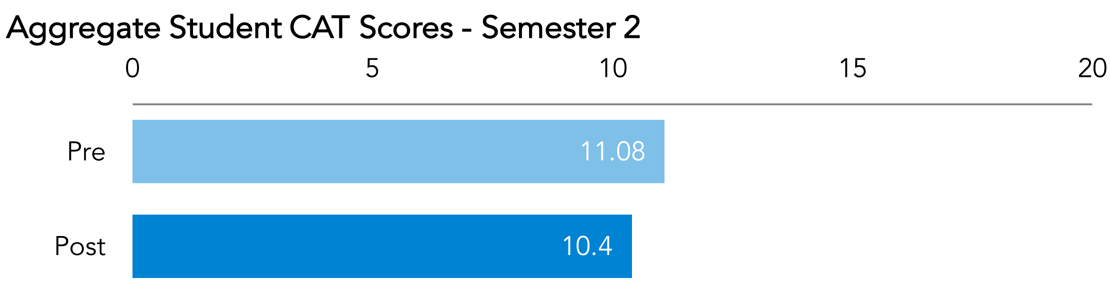


Table 7. Aggregate Student CAT Scores - Semester 2 (by individual course)

Instructor	Course (Section)	Student N	Pre	SD	Post	SD
Amos	General Science-201(1)	10	9	2.62	9	3.27
	General Science-201(9)**	6	11.83	5.04	9.5	4.37
	General Science-201(3)	14	6.86	2.91	6.5	3.55
Chang	General Science-201(2)	14	8.64	4.2	8.14	5.1
Demeritte	General Science-201(4)**	5	8	5.1	5.52	5.52
	Physics-202(4)**	12	14.25	6.2	10.17	6.46
Drake***	Physics-202(3)**	14	13	5.49	10.71	5.11
	Physics-202(2)	13	10.85	3.53	11.15	2.76
Karim	Physics-202(1)*	14	11.43	3.41	13.5	4.2
Khan	Physics-211(1)	14	9	3.7	9.93	4.65
Napolion	Physics-211(3)*	14	13.21	4.35	15.64	4.11
	Physics-212(2)	14	12.71	4.76	12.57	3.55
Shankar	Physics-212(1)	14	12.57	4.8	11.93	4.7
	Physics-201(2)	14	12.86	4.52	10.79	5.65
Yang	Physics-201(1)	14	10.79	3.81	10.57	5.24
Zhou	Physics-211(2)**	14	12.29	4.12	10.71	4.03

statistically significant increase, p<.05; ** statistically significant decrease, p<.05, * statistically significant decrease by instructor, p<.05*

Table 8. Aggregate Student CAT Scores - Semester 1 (by subject)

Course	Student N	Pre	Post	t-value
General Science 201	49	8.89	7.73	2.01
Physics 201	28	11.83	10.68	1.7
Physics 202	53	12.38	11.38	1.88
Physics 211	28	11.11	12.79	1.92
Physics 212	28	12.14	12.25	1.63

$^{**}p < .001$, $^{*}p<.05$

Our analysis of the student content test data and CAT data provides some evidence to support the objective of demonstrating significant increases of students' content test scores and CAT scores (summarized in the Table of Evaluation constructs and measures; page 9, Table 1). While less than half of participating classes showed moderate to significant gains from pre to post, that does not mean that ICFAIM is responsible for those outcomes. As we assessed content test scores and CAT scores over a course of one semester, any number of contextual factors (e.g., classroom composition, general end-of-semester improvements outside of ICFAIM, school climate) aside from ICFAIM may have affected these findings. In addition, the ICFAIM program workshops began later in the semester. Hence, exposure to the ICFAIM intervention was condensed and occurred within a period of just 3-4 weeks. In the future, we might attempt to assess students' content tests and CAT scores starting at the time that participating faculty members are exposed to the PD. Future analysis should also include measuring the extent to which ICFAIM participants include critical thinking in their curriculum; if (and the extent to which) some faculty members incorporate critical thinking exercises into their teaching more than others, we may see greater gains with students from those particular classes. It may also be feasible to manage "PD integration logs" of content and exercises learned from the PD, to show to what extent and dosage new strategies are being incorporated.

Content Test Findings

Among its goals, ICFAIM is designed to improve students' science content knowledge, as an indirect result of participating faculty having some improved content knowledge. This section uses content test data to examine the extent to which students whose professors participated in ICFAIM demonstrate short-term growth in science content knowledge. Evaluators measured students' science content knowledge with content tests, designed by selecting item tests from standardized tests that were aligned with the content covered and curriculum taught during that semester. These tests included multiple-choice items in physics and the physical sciences.

When we ran independent samples t-tests for the entire ICFAIM student sample, in each participating class, we found:

- In aggregate, statistically significant gains in science content knowledge (from pre to post) during Semester 2 only (Tables 9; Figure 15);
- Statistically significant gains in 6 of 17 science courses – all physics (Semester 1); minimal to moderate, non-significant gains in the remaining 11 courses (Figure 16).
- Statistically significant gains in 3 of 18 science courses (Semester 2); minimal to moderate, non-significant gains in the remaining 15 courses (Figure 17).

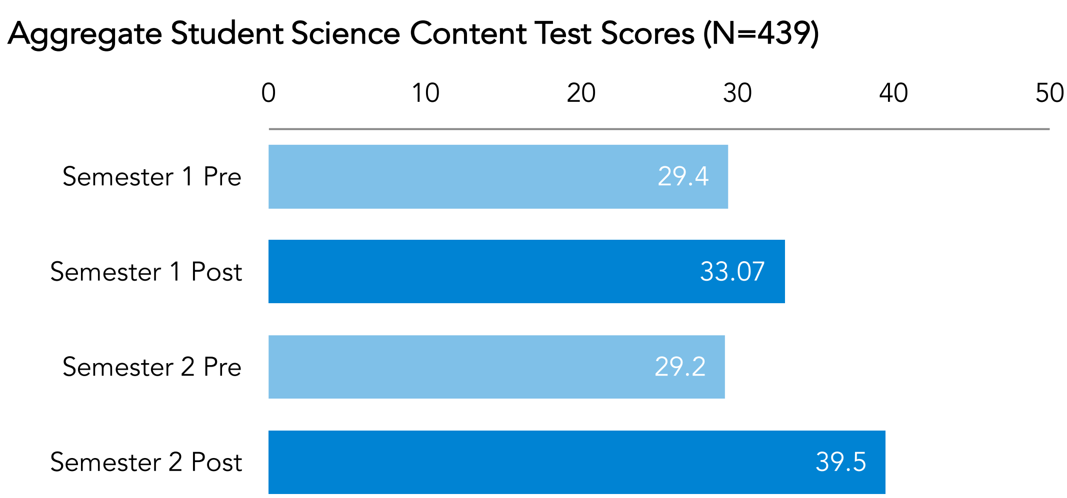
When we examined subject-level differences in aggregate from pre to post, we found that the Physics I subject courses had statistically significant improvements in Semesters 1 & 2, as compared to the other two courses, with General Science and Physics II showing non-significant gains/losses from pre to post. It is important to note that we are cautious in attributing gains in content knowledge to the ICFAIM program. While JSU's previous PD models for K-12 teachers have in fact been designed with Pedagogical Content Knowledge (PSK), or an integration of subject expertise and skilled teaching (Shulman, 1986), ICFAIM is less about content knowledge or PSK than it is pedagogy for faculty members who are highly knowledgeable in physics, chemistry, geoscience, and space science content. It is possible that, if the program shifted to incorporating more PSK and simple content, we may be able to attribute the program to outcomes related to content knowledge. Bayar (2014) argued that better content knowledge of teachers does not necessarily lead to improved content knowledge for students, but yet, does lead to higher "student achievement" in general. While research on connecting the dots between PD, teacher knowledge, and student outcomes is beginning to show several implications for student gains, research on the topic still remains scarce and empirical support is lacking.

Table 9. Student Scores on Science Content Tests, Semesters 1 & 2

	Semester 1					Semester 2				
	Pre	Post	df	t	ES[2]	Pre	Post	df	t	ES
Mean	29.4	33.07	438	44.7	0.56	29.2	39.5	427	5.15*	0.61
SD	10.79	10.9				11.12	11.4			
N students	439					428				
N teachers	12					12				

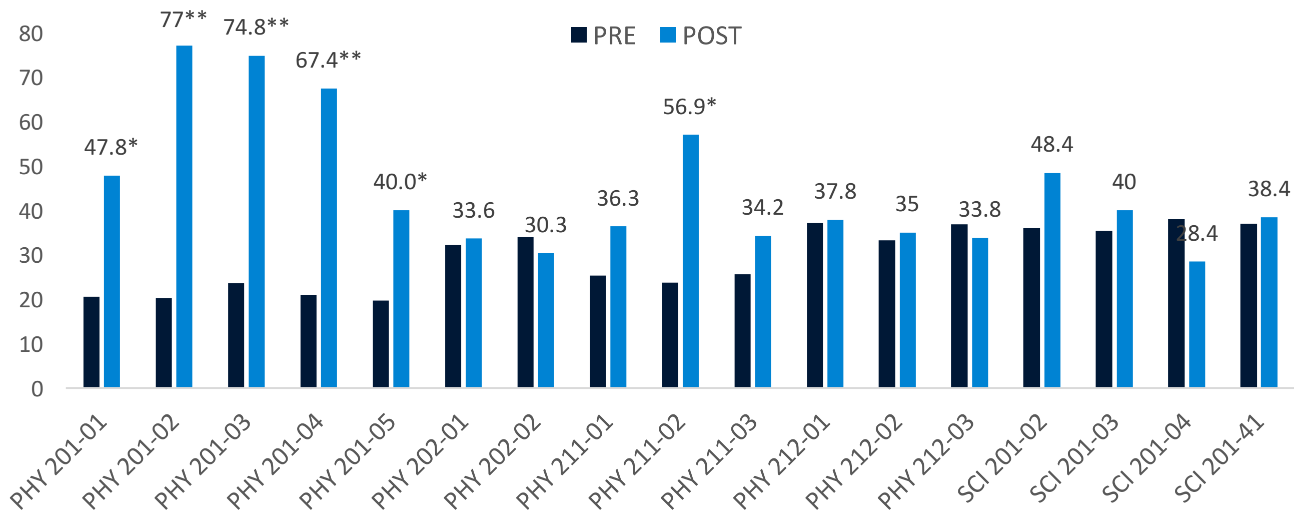
*p < .05

Figure 15.



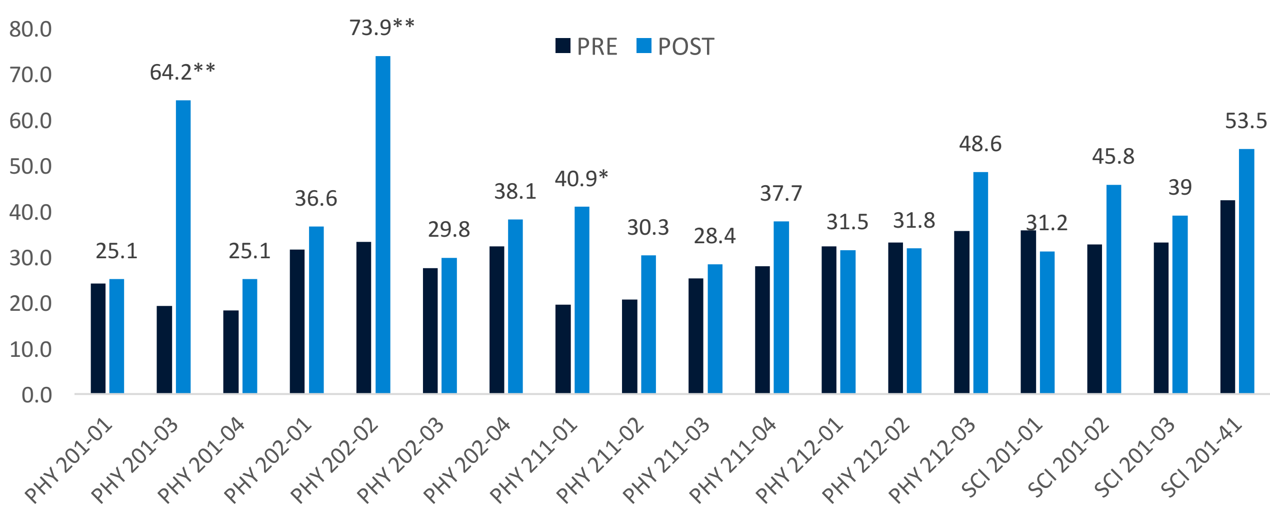
[2] ES = Effect size, measured by Cohen's d. Traditional interpretations for Cohen's d are 0.2 for a small effect, 0.5 for a medium effect and 0.8 for a large effect (Green & Salkind, 2005).

Figure 16. Aggregate Student Science Content Test scores – Semester 1 (by individual course)



***p < .05, *p<.001*

Figure 17. Aggregate Student Science Content Test Scores - Semester 2 (by individual course)



***p < .05, *p<.001*

Conclusions and Recommendations

The goal of this evaluation was to document what ICFAIM faculty members experienced and learned as a result of participating in ICFAIM. The findings, extracted from our post-workshop survey analysis—and consistent with our theory of change—show that participants are, in fact, utilizing what they learn from the PD. Faculty members reported changes in their teaching practice and changes in their science content knowledge. Furthermore, we found that students of ICFAIM-trained faculty improved their science content knowledge across physics and physical science, and moderately in their critical thinking and self-efficacy skills. Additional research is necessary to link these outcomes directly to ICFAIM. The aggregated information from the evaluation components appear, to REA, that the program is on its way to achieving its purpose: to increase faculty participants' capacity for learner centered pedagogy. As the program develops, our evaluation will also track enrollment changes, retention changes, and graduation rates of students through curricular change.

Further investigation is needed to connect student outcomes to what faculty members are learning from the ICFAIM PD. In the year to come, we will assess the various ways in which faculty participants are implementing what they learn and hope to associate these changes in knowledge, strategy, and skills with student performance. This limited implementation knowledge was the main limitation to this study and prevents us from attributing our findings to ICFAIM program efforts. Without extensive data on how faculty implement what they learn from ICFAIM into their classrooms, it is difficult to attribute any observed changes in teacher knowledge, skills, professional practice, and student outcomes to the PD.

One way to uncover how faculty members re-enact what they learn from ICFAIM is to ask all participants to plan and execute at least one "ICFAIM-learned lesson" during the academic year that can be filmed. Evaluators can utilize current research findings on the use of filming PD-lesson enactment. Additionally, this lesson should incorporate elements of ICFAIM so that evaluators can compare and contrast these same elements to what was taught during the PD (e.g., critical thinking exercises, use of technology, etc.). Evaluators might use lesson plans, observations and interviews to study how teachers replicated components of the PD during the "ICFAIM lesson." Comparing ICFAIM lessons to non-ICFAIM lessons can help explain the variations in lesson implementation, and illustrate ways in which teachers customize and adjust what is learned from the PD to better suit their students. Lastly, current research points to the usefulness of video footage analysis of instruction, specifically, collaborative video analysis of faculty peers and collaborative suggestions on teaching performance (Baecher, 2014). Using JSU's video archives and implementing new video recording tools for faculty members (of non-ICFAIM lessons vs. ICFAIM lessons), we may be able to better link improved teacher and student outcomes to the program by aligning newfound strategies and activities with those covered in the courses.

Many findings concerning similarly structured PD program, including the findings of the current study, have appeared to confirm what is already known and believed in the field of teacher PD. For instance, it is widely accepted that listening to guest speakers who are considered experts, or attending workshops a few times a year, will rarely lead to significant and continuous changes in teaching practices and, ultimately, student outcomes. However, this type of model is particularly popular in the United States and the most replicated (Desimone, 2009; Bayar, 2014). Many recent studies point to the idea that even extended learning opportunities do not necessarily lead to change (e.g., more workshops throughout an entire year for longer durations, more supportive groups or networks, more online resources for instructors to reflect and share experiences) (Yoo, 2016; Dixon, Yssel, McConnell & Hardin, 2014). Leading research in the field of teacher PD points to the importance of self-regulated learning, for teachers to construct and customize their own learning experiences, and, in turn, show students the effectiveness of collective expertise and learning environments (Peters-Burton, Cleary & Forman, 2015). While creating the amble learning environments and conditions for teachers to learn is challenging and complex, the current evaluation has provided us with some answers about ICFAIM's potential impact and implementation, and has given us more questions we would like to explore with programs using the same professional development model. We will continue to conduct research on this model, and disaggregate our existing data so that we can more fully explain how ICFAIM is working, for whom, and under what conditions.