12-2017

Applying the Diffusion of Innovation Theory to Characterize STEM Faculty Attending Professional Development Programs

Dihua Xue
University of Nebraska-Lincoln, dxue2@huskers.unl.edu

Applying the Diffusion of Innovation Theory to Characterize STEM Faculty Attending Professional Development Programs

by

Dihua Xue

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Chemistry

Under the supervision of Professor Marilyne Stains

Lincoln, Nebraska

December 2017

Applying the Diffusion of Innovation Theory to Characterize STEM Faculty Attending Professional Development Programs

Dihua Xue, M.S.

University of Nebraska, 2017

Advisor: Marilyne Stains

Instructional practices in undergraduate STEM courses have been static for decades, with a primary focus on lecture. Over the last twenty years, extensive research on how people learn science has led to the development of innovative instructional strategies that have been shown to enhance students' learning and interest. These in turn have led to calls to reform instructional practices in STEM fields at the undergraduate level. However, evidence shows that these research-based instructional strategies have largely not been incorporated into classes. The promotion of these new strategies has been mostly conducted through workshops. Although numerous studies have evaluated the impact of these workshop on raising awareness and uptake of these practices, few studies have focused on characterizing workshop attendees and the relationships between uptake of strategies and attributes of the strategies. We thus conducted a study exploring the type of faculty who attended workshop-based professional development programs focused on two evidence-based instructional practices (EBIPs): Peer Instruction (PI) and Just-in-Time Teaching (JiTT). We leveraged Rogers' Diffusion of Innovation theory to characterize the distribution of types of adopters participating in each professional development program. Our data consist of open-ended and Likert-scale questions collected longitudinally over the course of a year via online surveys. The results indicate

that workshop participants can mostly be categorized as early adopter traits and early majority. We also found that the distribution of adopter types as well as workshop participants' movement through the innovation decision process is dependent on the attributes of the EBIP being taught. Implications for designing professional development programs that aim at propagating EBIPs will be presented.

ACKNOWLEDGEMENTS

I would like to thank my advisor Prof. Marilyne Stains for the opportunity to work on this research project. For being such a great mentor who guided me through the entire process, I really appreciate the probing questions she asked whenever I came with problems, which led me to think thoroughly. Instead of just telling me the right or wrong answer, she helped me identify the gap in my understandings and walked me through with details and examples.

I would also like to thank Dr. Trisha Vickrey, Dr. Jordan Harshman, Dr. Robert Erdmann and Dr. Jonathan Velasco for their feedback, comments and suggestions from the data analysis to the paper writing. I feel so grateful to have their devoted time and valuable input.

Table of Contents

CHAPTER 1

Introduction

Calls to reform instructional practices in Science, Technology, Engineering and Mathematics (STEM) fields at the undergraduate level has increased in the United States over the past decades.[1–6] These calls primarily came from observations that results from Discipline-based Education Research (DBER) had limited impact on classroom practices.[2,7] In particular, there is a realization that instructional practices that emerged from this work – often called evidence-based instructional practices (EBIPs) since empirical studies have demonstrated that they have positive impact on students' conceptual understandings and attitudes toward STEM – have not propagated on a wide scale.

Much attention has been dedicated to investigating the circumstances behind the low uptake of EBIPs. Studies in physics and chemistry have demonstrated that short workshops are effective at raising awareness of these practices, which is a fundamental step for uptake.[8–11] Several studies have focused their attention on the identification of factors that inhibit or promote the uptake of EBIPS. For example, *Henderson and Dancy 2007* who surveys over 700 physics instructors across the country found that faculty perceived factors mostly outside the control of the instructors (e.g. classroom size, content coverage, etc.) to be major impediments to implementation. *Brownell and Tanner 2012* pointed out the tensions between scientists' professional identity and the pedagogical change. Essentially, how professors view themselves and their work within their disciplines and how they define their professional status can be critical to the

pedagogical reform. Reform efforts can be particularly challenging when training cultivation is primarily focusing on research; when scientists are afraid to come out as teachers and when the professional culture of science rates research over teaching.[12] *Shadle et.al. 2017*, on the other hand, looked at the drivers of pedagogical change.[13] The most frequently noted driver in the study is "expand on current practices", which indicated that the faculty themselves or colleagues were already engaged in changing their instructional practices.

Although this body of work demonstrates the necessity to address barriers and levers into the design of professional development experiences, it does not look at the adoption trajectories of workshop participants during the learning experience and the extent to which the focus of the workshops impact uptake. It is important to know the characteristics of the faculty who voluntarily attend pedagogical workshops and their rationale and expectations in attending these workshops. This information could help explain the low uptake of EBIPs by faculty who otherwise had shown a genuine interest in implementing these practices. Moreover, there is little evidence showing whether certain EBIPs appeal to certain adopters more than others.[14] By knowing the characteristics of potential adopters as well as the key features of instructional strategies that influence their adoption decisions, we can design workshop-based professional development programs accordingly which can potentially enhance the widespread adoption of EBIPs. This study addresses these gaps in the literature by categorizing types of adopters for individual workshop participants and showing how different features of EBIPs relate to the types.

CHAPTER 2

Theoretical Framework and Research Questions

2.1 Theoretical Framework

Rogers' theory of Diffusion of Innovations helps with seeking reasons and explanations behind the spread of innovative ideas and technology. Some studies have incorporated the theory into adopting active learning strategies decisions made by faculty.[14,15] In the current study, three models from Rogers' theory that include types of adopters, innovation-decision process and attributes of innovations will be applied.

2.1.1 Rogers' Types of Adopters

Rogers (2003) defined adopter type as, "the classification of members of a social system on the basis of innovativeness".[16] The types of adopters include 1) innovators, 2) early adopters, 3) early majority, 4) late majority, and 5) late adopters. Each adopter type is distinguished by unique features. Innovators are creators and inventors; they are the developers of the novel innovations. Early adopters are the leaders, who not only test the innovations at an early stage but also call for other people to join them. Leadership is the salient feature within an early adopter that differentiates them from the next type of adopter. According to Rogers' adopter categorization toward the innovation, the approximate percentage of individuals for innovators and early adopters is relatively small when compared to early majority, who are those who follow the lead from early adopters and seldom convey their own thoughts or opinions. The late majority, similar in size to the early majority, takes a relatively long time to overcome worries and challenges and comes late to the innovation. Late adopter is the last type in the category. They are

comfortable with traditional approaches and are resistant to make changes in terms of adopting an innovation.[16] In this study, we categorized workshop participants into the different types of adopters.

2.1.2 Rogers' Innovation-decision Process

Having laid out a typology for the various kinds of adopters, Rogers also described the process of decision-making in response to an innovation. This innovation-decision model involves five sequential stages: knowledge, persuasion, decision, implementation and confirmation. Knowledge is the stage when individuals become aware of an innovation and begin to understand how it works. Persuasion stage is where individuals shape their attitudes either favorable or unfavorable toward an innovation. After attitude is formed, decisions will be made on whether to adopt the innovation or reject it, so called the decision stage. This is followed by the implementation stage; in this stage, individuals test the innovation. The last stage is confirmation, during which individuals wrap up their thoughts and experience with the innovation and finally confirm whether they want to adopt the innovation for the long term. Rogers defined this innovation-decision process as "an uncertainty reduction process".[16] In other words, the less uncertainty people hold, the more likely they will adopt an innovation. In this study, we look at the differences in workshop participants' progression through this process for two different EBIPs.

2.1.3 Rogers' Five Attributes of Innovations

Finally, the likelihood that a participant will successfully adopt an innovation depends on attributes of the innovation as perceived by the potential adopters. The five attributes of innovations are relative advantage, compatibility, complexity, trialability and

observability. How individuals perceive the attributes of an innovation affect its rate of adoption. Relative advantage is the advantage that an innovation has when compared with other approaches it supersedes. Compatibility shows how well the innovation can resonate with individuals' existing believes and values. The greater the compatibility, the less uncertainties individuals will hold. Complexity refers to the relative difficulties for individuals to understand and use the innovation. An increase in difficulty will make the adoption less likely to happen. Trialability is how easily an innovation can be tested. Observability is the extent to which results of the implementation of the innovation are visible to others. Rogers also discussed the relations between trialability and types of adopters.[16] Relatively earlier adopters tend to place greater value on trialability than late adopters since most of them are the pioneers who tend to try things out. In this study, we applied this model to the two-different innovative instructional strategies taught within two different professional development programs to explore how their distinctive features' impact adoption decisions.

2.2 Research Questions

The three components of Rogers' theory described above help us address the following three research questions:

i. What are the types of adopters attending two semester-long professional development workshops, each focused on one specific instructional innovation?

ii. To what extent do the features of the instructional innovations relate to adopters' progress on the innovation decision process?

iii. To what extent do the features of the instructional innovations relate to the types of adopters?

CHAPTER 3

Methods

The aim of this study is to characterize the types of adopters who attended EBIPs-focused workshops and the extent to which the instructional innovations appeal to certain types of adopters and impact progress along the innovation-decision process.

3.1 Participants

Study participants were STEM faculty from a Midwestern public research university, who participated in two different professional development programs. 49 of the 69 (71%) workshop participants volunteered to participate in this study. Three of the 49 faculty took both workshops simultaneously.

3.2 Two EBIPs-Focused Workshop Series

Peer Instruction and Just-in-Time Teaching are the two EBIPs targeted in the workshop series. Each EBIP had its own workshop series, which consisted of 8 1.5-hr meetings spread throughout a semester. Study participants came from the first four offerings of these workshop series.

Peer Instruction is intended to promote deep conceptual understanding and help students alleviate misconceptions.[17] Instructors pose a conceptual question in multiple-choice formats and have students vote individually through a personal classroom response system. Depending on the degree to which students understand the concept, instructors can either: allow students to discuss the concept and revote; or else provide brief explanations and move on to other content.[18]

Just-in-Time Teaching requires students to fulfill pre-assignments before class. Instructors collect those answers ahead of the class, analyze students' responses, and integrate major issues in their instructional design for that class.[19,20]

3.3 Data Collected

Data collection in this study was done via Qualtrics. Online surveys were collected a week before the start of the workshop series (Pre), right after the workshop series (Post) and a year later (Follow-up). The survey contained Likert-scaled and open-ended questions to measure the following constructs (See **APPENDIX A&B**): participants' familiarity with PI and JiTT, their reasons for attending and expectations of the workshop series, likelihood to implement and recommend to others the strategies, departmental values and attitudes toward instructional reforms, previous attendance to professional development programs, general feedback on conducting the workshops and barriers they perceive to implementation of the EBIP.

3.4 Data Analysis

We leverage the characteristics of the different types of adopters laid out in Rogers' theory to develop a coding rubric (See **APPENDIX A**) that allowed us to classify participants in one of the adopter category. In particular, we coded: a) the degree to which faculty participants were familiar with PI and JiTT; b) the likelihood they were to implement the strategy; c) whether they would recommend the strategy to colleagues; d) how they felt their departments and colleagues value alternative instructional strategies, as well as e) the extent of participant pedagogical training prior to the workshops. **Table 1** shows how these codes were used to classify faculty in different groups of adopters..

Table 1. Categorization criteria for adopter types (Colors highlight the distinguishing features between types of adopters.)

	Early adopter	Early majority	Late majority
Has the implementation occurred?	✓ (Pre)	✓	✓
Likelihood to implementation	✓	✓	Undecided/ unlikely
Leadership	✓	—	—
Previous pedagogical training	✓	✓	—
Traditional teaching style in all level of peer valuation	—	—	✓
Same teaching style in all level of peer valuation	—	✓	—
Alternative teaching style in all level of peer valuation	✓	✓	—

The degree to which faculty perceived their departmental chairs' and colleagues' attitudes toward alternative teaching practices can be divided into low, medium and high. We use the term "peer pressure", where low peer pressure corresponds to low departmental expectations to use EBIPs or active learning strategies. Individuals who showed enthusiasm for early implementation, even though they perceived that the majority of their colleagues did not value the innovative strategies, fit into early adopter or early majority type. On the other side, we classified individuals who maintained a traditional way of teaching practice in a department with high peer pressure as late majority. By following the designed coding rubric, one researcher coded each profile and two others double-checked for consistency.

The Pre-survey used two open-ended questions to gain perspectives on the motives and expectations workshop attendees had about their participation in the workshop series (See **APPENDIX A)**. We read the open-ended answers, memoed each and developed codes iteratively. We then looked for patterns into the code developed. The following five themes emerged as a result of this iterative process: 1) self-efficacy (e.g. enhance confidence in teaching); 2) teaching community (e.g. engage with other instructors); 3) enhancement of students' experience; 4) desire to change their current teaching and 5) to learn new information, knowledge and/or methods (See **APPENDIX B**). We employed the same analytical strategy to identify participants' perceived barriers to implementation of the EBIPs. Themes that emerged were 1) structural barriers, 2) time management, 3) mechanics of the strategy, 4) student concerns, and 5) no difficulties expected (See **APPENDIX B**).

CHAPTER 4

Results

4.1 Types of Adopters

From the analysis of the data emerged the need to split early majority into two sub-categories as *early majority with early adopter traits* and *early majority with late majority traits*. As indicated in Table 2, we combined *early adopters* with e*arly majority with early adopter traits* into one category (*early adopter traits*) and *early majority with late majority traits* with *late majority* to form the *late majority traits* group. A major distinction that assisted in categorization of early adopter vs. *early majority with early adopter traits* is leadership, which is an exclusive feature for early adopter. This classification helped us capture more nuances in the type of adopters while providing sufficient sample size in each main category to gain more meaningful insight.

Indication of implementation of the EBIP on the Pre-survey distinguishes *early majority with early adopter traits* from early majority. We also classified individuals who were undecided about the implementation as *early majority with late majority traits*; this feature differentiated early majority with late majority traits from early majority, who were likely to implementation the strategies. We also considered a new classification called non-adopters, for faculty members who never implemented the innovative strategy. In particular, two of them reported not having proper teaching contexts, while the rest didn't provide Follow-up surveys to help us draw conclusions about their level of implementation and had still not implemented the strategy on the Post survey. Finally, the theory clearly indicated that we would not found Innovators in our pool of participants.

These modifications to Rogers' theory along with representative examples from the participants are shown in **Table 2**.

Table 2. Types of adopters with features in details

Type of adopters		Description	Features in example
Early adopter traits	Early adopter	Activists; leaders	"I have taken a lead in engaging faculty in teaching luncheons, so my responses reflect this role." (Biology)
	Early majority with early adopter traits	Experienced	"I have used Peer Instruction in introductory physics courses for years, including this semester. The workshop gave me some ideas to improve on certain PI techniques which I want to implement in future semesters. " (Physics)
Early majority	Early majority	Fall-in-line	"I am convinced that JiTT techniques are a way to more successfully engage students in the course materials and thus improve their depth of learning." (Chemistry)
Late majority traits	Early majority with late majority traits	Having some concerns	"JiTT seems like a potentially useful method to improve student outcomes. The organization, scheduling, and development of questions are barriers to successful implementation, and stand in the way of a 'very likely' rating." (Civil Engineering)
	Late majority	Hesitant	"I think it sounds like it will take too much time and am still not 100% sure how to implement it." (BioMed)
Non-adopters	Non-adopters	Never try out or never had the chance to try	"I am teaching lab course only at this time. If I am involved in lecturing in the future, I am very likely to implement what I've learned in PI " (BioChem)

The distribution of adopters in this study (See in **Figure 1) was** shifted more towards early adopters compared to the distribution expected by Rogers. (i.e. normal distribution centered on Early and late majority). The number of those with early adopter traits (35%) is nearly as high as early majority (37%), while the number of late majority traits (18%) is relatively small. 10% of non-adopters were also observed.

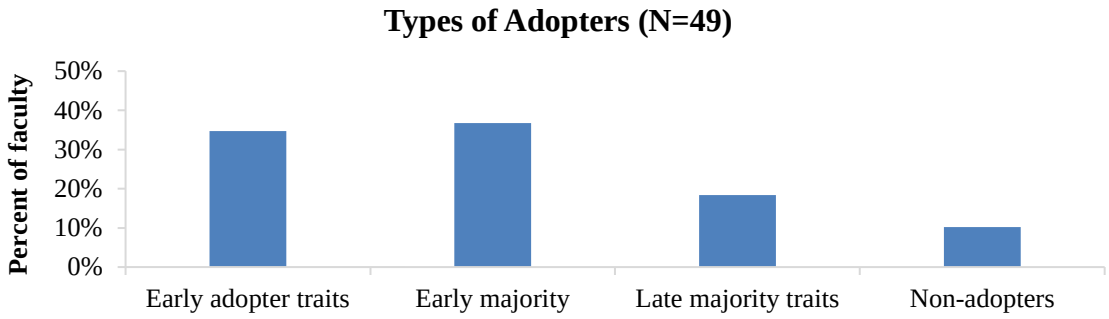

Figure 1. Type of adopters in total (N=49)

As each adopter type has unique features, it can be interesting to see whether their reasons and expectations for workshop attendance are distinguishable (See in **Figure 2**). When asked why they were attending the workshops, the two main reasons provided were desire to learn new information or gain new knowledge about teaching and an interest in changing their current practices. However, nuances in what they wanted to change were observed by category of adopters. For example, 33% of those with early adopter traits expressed an interest in learning or improving the implementations of EBIPs. As one noted: "I have started to do Peer instruction and want to know how to do more". On the contrary, 91% of early majority adopters cared about general development and enhancement of instructional practices and approaches: "I wanted an opportunity for professional development and to improve my teaching or at least have another avenue for evaluating my teaching." Interestingly, late majority were primarily interested in changing their practice (83%).

Expectations on what participants hoped to gain from the workshop series were not always aligned with their reasons for attending the workshop series. For example, learning new information or gaining new knowledge about teaching was mentioned to the same extent as a reason and an expectation of their participation by early adopter traits and early majority traits; however, this was mentioned more often as an expectation than a reason for late majority traits. There was also an increasing misalignment for "to change their current teaching practices" between reason and expectation from early adopter traits to late majority traits. In particular, there was a decrease of 14% for early adopter traits, 25% for early majority and 33% for late majority traits between the frequency of mentions of "to change their current teaching practices" as a reason versus

an expectation. This indicates that more skeptical adopters have lower expectation for the impact of their participation in the workshop series on their teaching. Interestingly, the late majority traits were the main group that expected the workshop series to enhance their teaching self-efficacy. Finally, early adopter traits showed greater interest in using the workshop series as a mean to be engaged in a teaching community than other types of adopters; here is an excerpt from one of the early adopter traits: “In addition to acquiring new tools, I look forward to discussing challenges within education in the STEM fields with other faculty.” It is notable that a desire to enhance the students’ experience in the classroom was not a significant motivation for any of the adopter types.

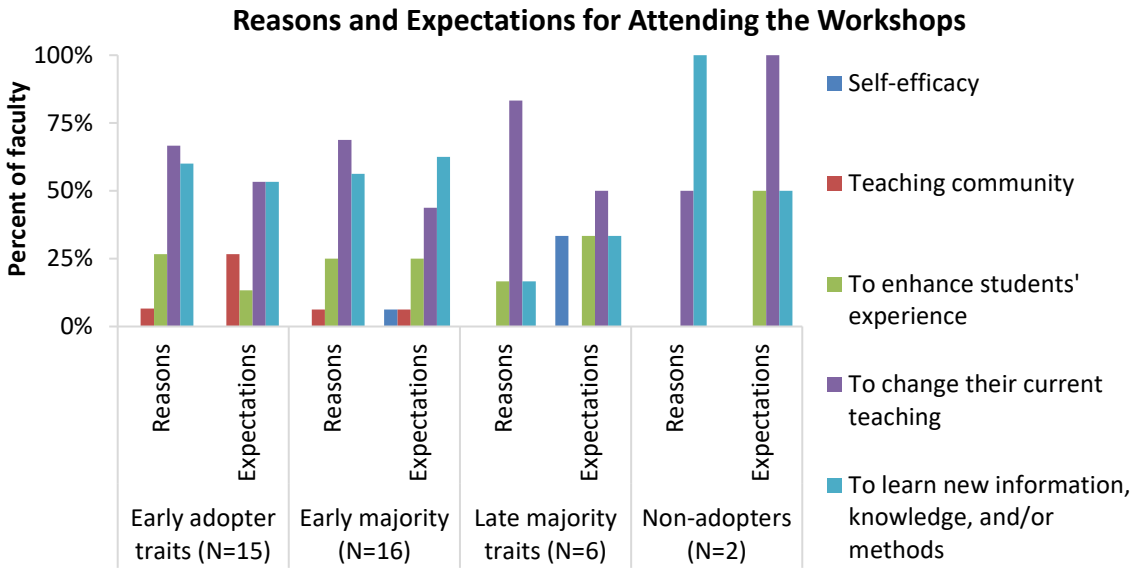

Figure 2. Reasons and expectations associated with workshop attendance, broken by type of adopters

4.2 Features of Instructional Innovations Relate to Adoption Progress

Our second research question explored the relationship between the EBIP being taught and the progress on Rogers' innovation decision process participants made. We capture each participant's pace based on their indication of familiarity with and use of PI or JiTT on each of the survey. We adapted slightly the five stages that Rogers presented based on the data we collected. As described by Rogers, the knowledge stage assumed that the instructor is initially unknowledgeable about the innovation. However, some of the participants in our study started with an awareness of the EBIP taught in their workshops. As a result, we separated the knowledge stage into Unawareness and Awareness. The Persuasion stage corresponds to participants attending and learning about the EBIPs during the workshop series; we did not collect data related to this stage during the workshop and therefore that stage is not represented in our data. We relabeled the decision stage 'Positive decision' to qualify where the participants stood at this stage; this stage corresponded to the choice "I am familiar and plan to implement it" on the survey. Finally, participants who reached the Implementation stage after the workshop and still indicated "currently use all or part" of the strategies in the Follow-up survey were classified at the Confirmation stage.

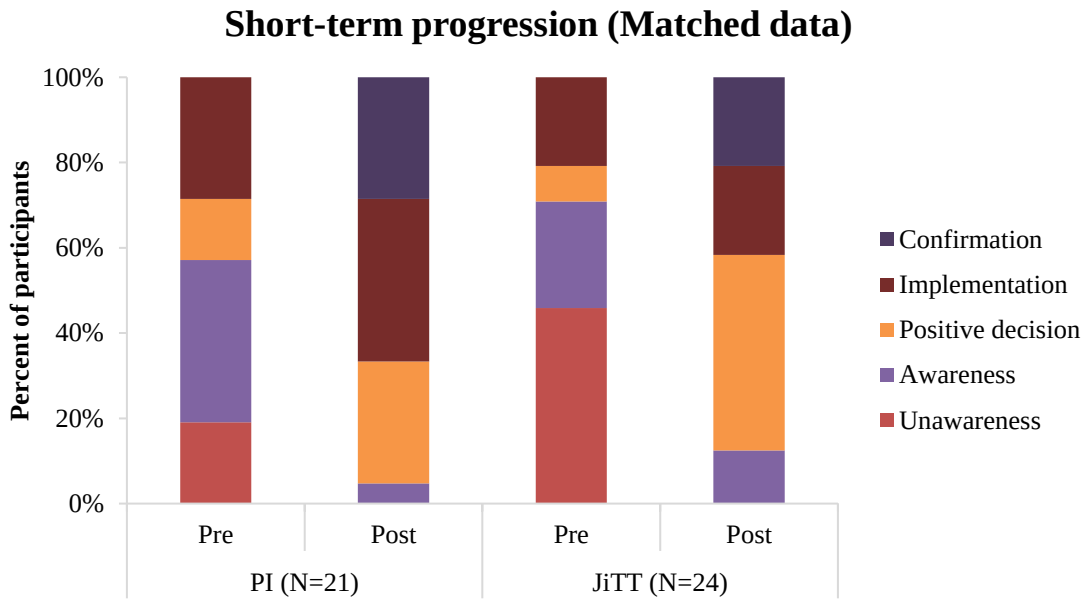

Figure 3. Short-term innovation-decision process

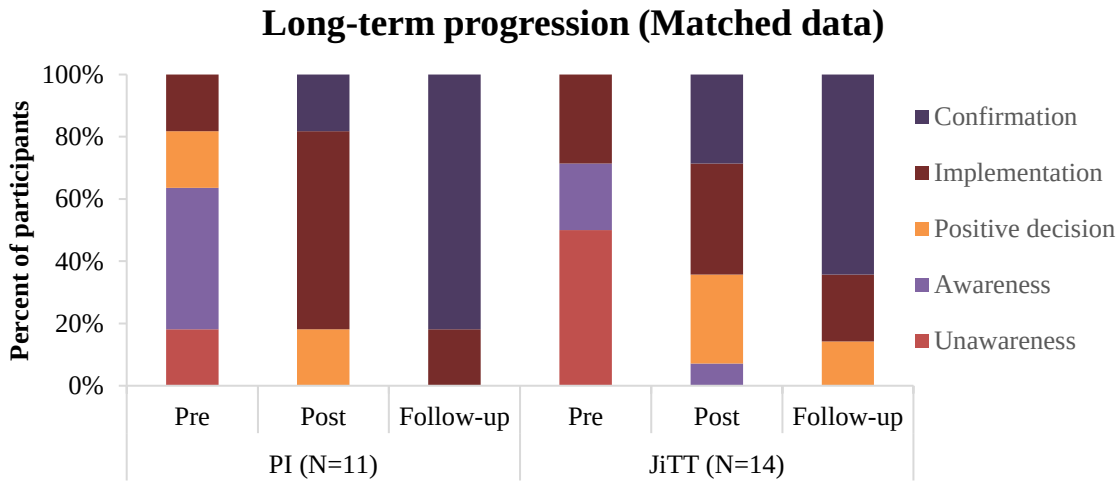

Figure 4. Long-term innovation-decision process

The short-term (difference between Pre and Post surveys**)** and the long-term progresses (difference between Pre, Post and Follow-up surveys) are presented in **Figure 3** and **4** respectively. The Pre data indicates that participants started the workshop programs at different stages of the innovation-decision process. In both workshop series, there were participants who had never heard of the EBIP being taught and participants who were already implementing them. Although both workshop series had a similar number of participants at the implementation stage at the beginning of the workshop (29% for PI and 21% for JiTT), a higher proportion of PI workshop participants were at the awareness stage than the JiTT participants, 38% versus 25% respectively (**Figure 3** and **4**).

Analyses of the short and long-term progressions show that participants in the two different workshop series also moved at a different pace along the innovation-decision process. As **Figure 3** indicates, 38% of the PI participants were at the implementation stage by the end of the workshop series versus 21% for JiTT. The Follow-up data show that 82% of the PI participants who responded to all three surveys (11 total) were passed the trial stage and had committed to the integration of PI in their practices. This rate was larger than the JiTT workshop series with only 64% of the participants at the confirmation stage. However, another 21% of the JiTT participants were testing the strategy one year after their workshop participation.

In conclusion, although workshop participants were less familiar with JiTT than PI, the JiTT workshop series was able to move its participants to a similar level of implementation when compared to the PI workshop but the progress was slower than it was for PI.

4.3 Features of Instructional Innovations Relate to Type of Adopters

When relating adopter types to different innovative instructional strategies (PI or JiTT), the distribution between the two strategies turns out to be different. As is shown in **Figure 5** and **6**, the largest number of PI adopters showed early adopter traits, while in JiTT the largest group was early majority. The second largest groups were early majority (PI) and late majority (JiTT).

When we looked at the reasons for attending the workshop series, 89% of the PI participants indicated that they wanted to change their teaching practices versus 56% for JiTT participants (See in **Figure 7**). The second reason which was equally mentioned in both workshop series was learning new information, knowledge, and/or methods (50% of the participants in both workshop series mentioned it). There was a clear misalignment between reasons and expectations for the PI series. A third of the participants who identified changing their practices as a reason for attending did not mention it as an expectation of the workshop series. This misalignment was present with the JiTT series but to a much smaller extent (17%).

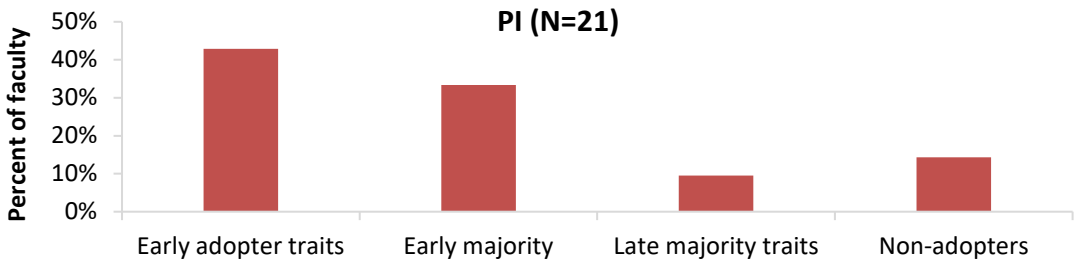

Figure 5. Type of adopters in PI (N=21)

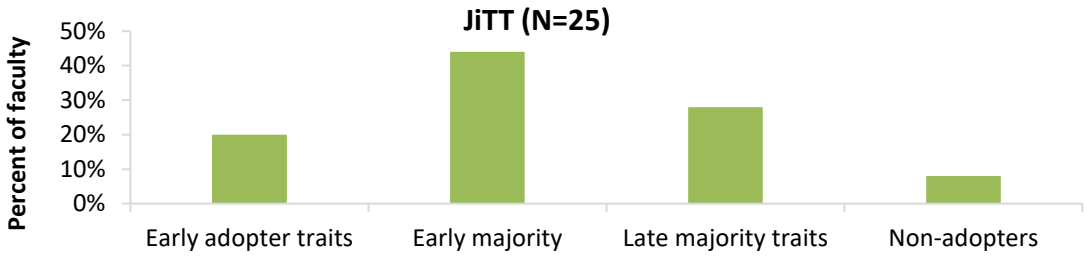

Figure 6. Type of adopters in JiTT (N=25)

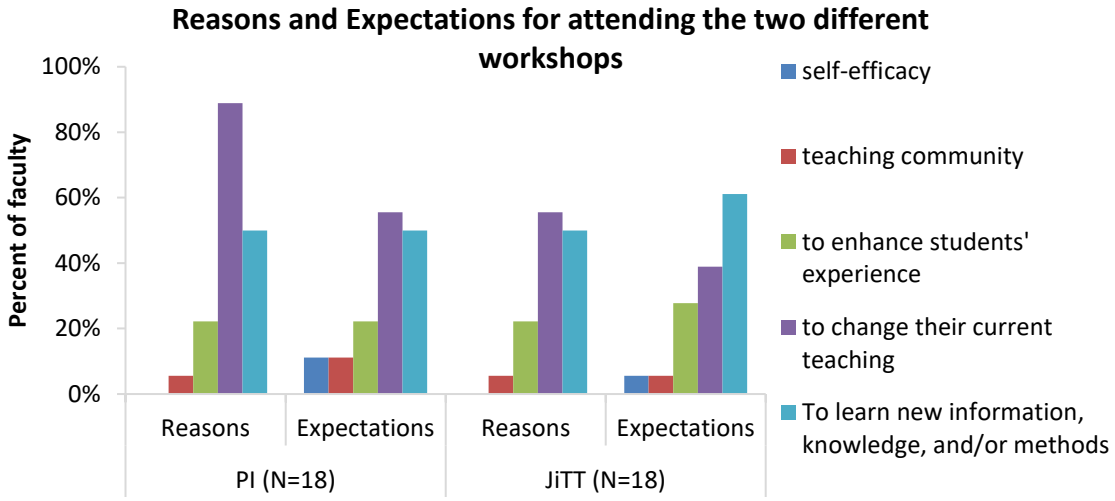

Figure 7. Reasons and expectations on attending workshops between PI and JiTT workshops

Finally, we were also interested in characterizing whether differences between the two workshop series existed in the nature of the barriers to implementation participants expected. **Figure 8** reports how perceived barriers were related to different instructional innovations. “Mechanics of the strategy”, for example, writing good questions and incorporating the methodology into their ongoing practices, is a major concern for both PI and JiTT participants. JiTT participants perceived more time management issues than PI participants, while PI participants raised more concerns over students’ engagement and participation. One JiTT participant who raised a few typical concerns when implementing JiTT described the following:

> “Designing effective JiTT questions, especially ones that can be used in subsequent semester. Two related problems. I tend not to teach the same course repeatedly. Even when I repeat the same course, one can cover the same fundamentals in many different ways; I rarely teach courses the same way from year to year. Will the JiTT prep time become overwhelming? Time management in the classroom will be a problem for me or should I say exacerbate the problem for me”.

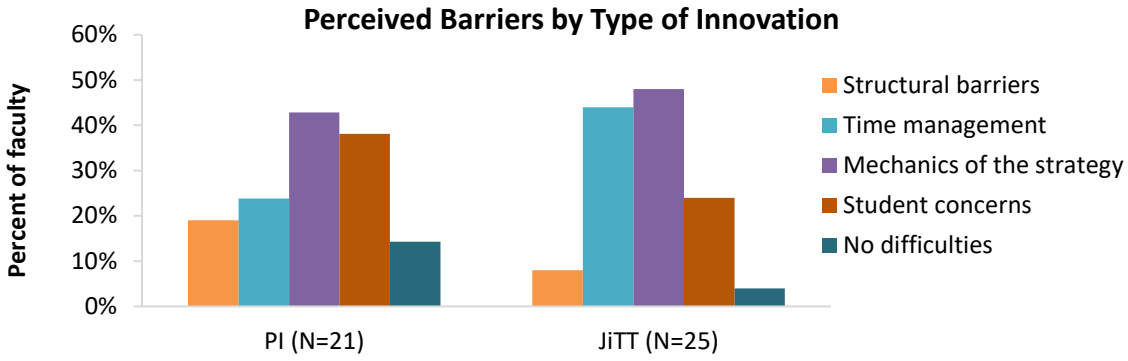

Figure 8. Perceived barriers regarding to type of instructional innovations

CHAPTER 5

Discussion

This study analyzed faculty members who attended two pedagogical workshop series focused on two different EBIPs. Rogers' theory of Diffusion of Innovations was leveraged to categorize the study participants in terms of their decisions toward innovation adoption. We found that different instructional innovations appeal to different faculty participants, and that this has an impact on the pace of adoption.

5.1 What Are the Types of Adopters?

Rogers' types of adopter model help frame the categories of workshop participants in this study. Early majority is one of the major types in Rogers' model, however, we found some discrepancies in early majority among our study participants. We have a number of early majority who had implemented the EBIPs before the workshops, but showing no signs of being leaders; we thus created a new category *early majority with early adopter traits*. In contrary, another group of participants among early majority who indicated their concerns and hesitations toward implementing EBIPs are captured as *early majority with late majority traits.* We assigned subtypes within early majority for better capturing the nuances among the workshop participants.

In terms of the distribution of different adopters, early adopter traits, which includes early adopters and *early majority with early adopter traits*, and early majority were the dominant groups in our sample, while in Rogers' model, early and late majority are the two major types. Rogers' model applies to the whole population of potential adopters. However, in our study, we only have a sub-sample of the population: all the

study participants voluntarily chose to attend the workshops; they wanted to make some changes in their current teaching to some extent, which is expecting to have fewer late majority. *Blumberg 2016* who also classified faculty members into Rogers' categories of adopters of learning-centered teaching did not found a fit to the Rogers' bell-shaped curve even though her population was more aligned with the population modeled in Rogers' theory.[14] They had a large number of faculty members falling into the middle of the curve but fewer at either end of the distribution.

In summary, as can be expected, faculty who voluntarily attended the EBIPs-focused workshops were far from the resistant types of adopters, which explains why we have fewer late majority and laggards than predicted by Rogers' theory. Non-adopters exist due to either improper teaching contexts or insufficient survey replies. The reasons and expectations indicated by workshop participants also aligned with these results, as with changes their current teaching being one of their primary goals.

5.2 How Do the Features of the Instructional Innovations Matter?

We noticed that the starting point of implementing EBIPs was different along the innovation decision process. The PI workshop had more knowledgeable people from the beginning and therefore the implementation and confirmation occurred sooner than JiTT. However, both workshop participants reached similar adoption level a year later. Peer instruction and Just-in-Time Teaching are known as innovative instructional strategies with different functional procedures.[17,20] In considering the resources and time required for implementation with fidelity[18], PI and JiTT are quite different. PI concentrates more on engaging with in-class activities based upon either planned or extemporaneous questions or discussion issues. In contrast, JiTT relies heavily on pre-class activities

requiring the instructor to distribute a set of questions or topics to probe student misconceptions, to analyze the responses, and to use those responses to alter or supplement subsequent lectures and discussions.[17,19] Complexity, as one of the attributes of innovation that Rogers (2003) defined, is "the degree to which an innovation is perceived as relatively difficult to understand and use",[16] can explain this scenario. Because JiTT requires a much greater amount of pre-class preparation, potential adopters may step back from the implementation. As one JiTT participant commented: "I think it sounds like it will take too much time and am still not 100% sure how to implement it". Another factor, trialability, also explains the implementation discrepancies between PI and JiTT. Peer Instruction fundamentally comes down to: coming up with questions; polling students; and, depending upon whether the fraction of students with misconceptions is high enough, allowing the students to engage in peer discussions followed by a revote. This process is relatively straightforward compared to JiTT, which relies less on student participation in the strategy, and can be tested without making commitment to it. Faculty participants seem to be more likely to try the innovative instructions if they minimally disrupt their current practices. Innovative instructional strategies perceived to be less complicated are more likely to be implemented, and instructors are more likely to move forward the innovation decision process. Since JiTT requires relatively more time and efforts to prepare before the class, potential adopters who value the time for other things might not actively get involved toward implementation. Therefore, innovative instructions with unique features appeal certain adopters accordingly.

Two widely perceived barriers in JiTT are “mechanics of the strategy” (e.g. difficulties on finding/writing good questions, etc.) and “time management” in terms of analyzing student responses and using the results information to shape the class. This aligns with the findings of “time constraints” and “instructional challenges” that other studies identified for faculty adoption of EBIPs.[15,21] The results also resonate with a fact that complexity of a strategy is related to how fast potential adopters will do the uptake.

PI and JiTT participants reported that a desire to change current teaching practices and interest in learning new information as the two major reasons and expectations associated with attendance at the workshop. Our study results (See **Figure 7**) show that, within each strategy, there is a gap between reasons and its corresponding expectations. The most frequently mentioned reason (10 participants) -for attending the PI workshop was a desire to enhance current instructional practices. However, only two people kept the enhancement as their expectations. The two people who aligned their reasons with expectations are from the type of early adopter traits. No further information can help to explain why expectations are lower than reasons, which need further research exploration.

CHAPTER 6

Conclusions and Implications

We identified four types of adopters among the study participants based on Rogers' Diffusion of Innovation theory. Early adopters traits and early majority were the two dominant categories, indicating that most faculty members who voluntarily attended the workshops held positive attitudes toward the EBIP targeted in the workshop series and implemented it eventually. We also found that features of EBIPs had an impact on how faculty participants moved through the innovation-decision process. The EBIP with less complexity and more trialability tended to be adopted more quickly.

Taken together, the results of this study have important implications for professional development facilitators. First, this study demonstrates that different types of adopters attend professional development programs. Characterizing and leveraging the type of adopters present in the group of participants can enhance the effectiveness of the program and increase adoption. For example, early adopters can help those people who hold concerns and hesitations toward adoptions like late majority. Moreover, the need for each group of adopters can be targeted during the professional development program. The study also highlights that not all EBIPs can be taught the same way and that it is important to take into consideration their characteristics and focus on those that are likely to be considered as barriers to adoption.

CHAPTER 7

Limitations

Small sample size is one issue that exists in the current study, which makes it harder for us to report any statistical significance within our findings. Nevertheless, few studies have looked at the characteristics of potential adopters through Rogers' Innovation Diffusion model to figure out the slow uptake of innovative instructions.

This study relied on self-reported surveys. Although self-report of teaching practices is a common and popular evaluation method,[22] it may not be utterly accurate.[23] Yet, if designed questionnaires can look through the lens from more than one perspective, it can still lead to the right direction. In this study for example, some faculty claimed to be aware of the strategy before attending the workshop. However, the reasons they provided for attending the workshops revealed that they had little knowledge about the EBIPs which made us realize they were actually at unawareness knowledge stage.

APPENDIX A Types of adopters Coding rubric

I. Indicated familiarity with PI or JiTT

Survey components	Innovation decision process (5 stages)
I have never heard of it	Unawareness knowledge
I have heard the name but don't know much else	Unawareness knowledge
I am familiar but have not used it	Awareness knowledge
I am familiar and plan to implement it	Positive decision
In the past, I have used all or part of it but I am no longer using it	Decision or Implementation, depending on teaching context
I currently use all or part of it	Implementation or Confirmation

II. Likelihood toward implementation and recommendation; previous pedagogical training

Survey questions	Survey answers	Adopter types
What is the likelihood that you will implement the strategy that you learned in the workshop in one of your course?	Very likely/likely	Early adopter/early majority
	Undecided	Early majority
	Very unlikely/unlikely	Late majority
Would you recommend the workshop to a colleague in your department?	Yes, with indicated initiatives to propagate to others	Early adopter
	Yes, without the criteria listed above	Early/late majority
	Yes, with reservations	Early/late majority
	No	Late majority
Have you previously participated in program(s), workshop(s) and/or course(s) on teaching?	Yes	Early adopter
	No	Early/late majority
Did you participate in program(s), workshop(s) and/or course(s) on teaching this semester (aside from the scientific teaching workshop)?	Yes	*Specific answers dependent**
	No	Early/late majority

**Depends on the factors of teaching style, awareness and use of EBIPs*

III. Departmental and colleagues' values toward professional development training programs and alternative teaching methods/styles

Integrated factor	Survey questions	Survey answers		
Positive peer pressure		**Low**	**Medium**	**High**
	Will your department value your participation in the workshop?	Definitely/probably no	Probably yes	Definitely yes
	To what extent has your department been engaged in improving teaching practices of faculty within the last two years?	Not at all; A little	Somewhat	Very; Extensively
	How much do your departmental colleagues have expectations for your teaching methods? •Use techniques other than lecturing •Have students be actively involved in class •Use a variety of teaching methods	Not at all; very little	some	quite a bit; a great deal
Teaching style		**Traditional**	**The same**	**Alternative**
	How would you rate your teaching style compared to other colleagues in your department?	Significantly/ a little more traditional	About the same	Significantly/ a little more alternative

Positive peer pressure	Teaching style	Adopter types
Low	Traditional	Late majority
	The same	Early/late majority
	Alternative	Early adopter
Medium/high	Traditional	Late majority
	The same	Early/late majority
	Alternative	Early majority

APPENDIX B Reasons, Expectations and Perceived Barriers for Attending the Workshops

Why did you apply to the Scientific Teaching workshop?

What do you expect to gain out of your participation in the workshop?

Integrated responses	Codes
To enhance confidence in teaching	Self-efficacy
To engage in a teaching community	Teaching community
To enhance students' learning To enhance students' engagement	To enhance students' experience
To improve current implementation of EBIPs To learn how to implement EBIPs To learn how to implement teaching methods To enhance current instructional practices To develop an effective instructional approach To develop interactive instructional practices	To change their current teaching
To learn about EBIPs (research, theory, practice) To evaluate the fit of new teaching methods with one's own teaching To learn about teaching To learn about teaching methods To expand knowledge of assessment strategies	To learn new information, knowledge and/or methods

What do you anticipate to be the main difficulties in the implementation of the strategy?

Integrated responses	Codes
Class design/infrastructure limitation Inappropriate teaching context	Structural barriers
Finding/writing good questions Managing student responses/answers Planning class How much time taken up during the class In general	Time management
Difficulty writing or finding questions/resources Processing student responses/answers in real time Difficulty incorporating with current practices Pacing change over time	Mechanics of the strategy
Concern over student engagement/participation Cause of student engagement/participation Students' attitudes toward EBIPs	Student concerns
No difficulties	No difficulties

REFERENCES

(1) Rothman, F.; Narum, J. Then, Now, & in the Next Decade: A Commentary on Strengthening Undergraduate Science, Mathematics, Engineering and Technology Education. **1999**.

(2) Singer, S. R.; Nielsen, N. R.; Schweingruber, H. A. *Discipline-Based Education Research*; 2012.

(3) National Science Foundation. *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology.*, In N. S. F.; Arlington VA, 1996.

(4) President's Council of Advisors on Science and Technology. *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.*; 2012.

(5) Project Kaleidoscope. *Report on Reports: Recommendations for Action in Support of Undergraduate Science, Technology, Engineering and Mathematics.*; Washington D.C., 2002.

(6) Project Kaleidoscope. *Report on Reports II: Transforming America's Scientific and Technological Infrastructure: Recommendations for Urgent Action.*; Washington D.C., 2006.

(7) Talanquer, V. DBER and STEM Education Reform: Are We up to the Challenge? *J. Res. Sci. Teach.* **2014**, *51* (6), 809–819.

(8) Henderson, C. Promoting Instructional Change in New Faculty: An Evaluation of the Physics and Astronomy New Faculty Workshop. *AIP Conf. Proc.* **2007**, *951* (2008), 120–123.

(9) Henderson, C.; Dancy, M.; Niewiadomska-Bugaj, M. Use of Research-Based Instructional Strategies in Introductory Physics: Where Do Faculty Leave the Innovation-Decision Process? *Phys. Rev. Spec. Top. - Phys. Educ. Res.* **2012**, *8* (2), 1–15.

(10) Baker, L. A.; Chakraverty, D.; Columbus, L.; Feig, A. L.; Jenks, W. S.; Pilarz, M.; Stains, M.; Waterman, R.; Wesemann, J. L. Cottrell Scholars Collaborative New Faculty Workshop: Professional Development for New Chemistry Faculty and Initial Assessment of Its Efficacy. *J. Chem. Educ.* **2014**, *91* (11), 1874–1881.

(11) Lund, T. J.; Stains, M. The Importance of Context: An Exploration of Factors Influencing the Adoption of Student-Centered Teaching among Chemistry, Biology, and Physics Faculty. *Int. J. STEM Educ.* **2015**, *2* (1), 13.

(12) Brownell, S. E.; Tanner, K. D. Barriers to Faculty Pedagogical Change: Lack of Training, Time, Incentives, And...tensions with Professional Identity? *CBE Life Sci. Educ.* **2012**, *11* (4), 339–346.

(13) Shadle, S. E.; Marker, A.; Earl, B. Faculty Drivers and Barriers: Laying the Groundwork for Undergraduate STEM Education Reform in Academic Departments. *Int. J. STEM Educ.* **2017**, *4* (1), 8.

(14) Blumberg, P. Factors That Influence Faculty Adoption of Learning-Centered Approaches. *Innov. High. Educ.* **2016**, *41* (4), 303–315.

(15) Andrews, T. C.; Lemons, P. P. It's Personal: Biology Instructors Prioritize Personal Evidence over Empirical Evidence in Teaching Decisions. *CBE Life Sci. Educ.* **2015**, *14* (1), 1–18.

(16) Rogers Everett M. *Diffusion of Innovation*; Free Press: New York, 2003.

(17) Mazur E. *Peer Instruction*; Prentice Hall: Upper Saddle River, NJ, 1997.

(18) Vickrey, T.; Rosploch, K.; Rahmanian, R.; Pilarz, M.; Stains, M. Research-Based Implementation of Peer Instruction: A Literature Review. *CBE Life Sci. Educ.* **2015**, *14* (1), 1–11.

(19) Simkins S.; Maler M. *Just-in-Time Teaching: Across the Disci- Plines, and Across the Academy*; Stylus: Sterling, VA, 2009.

(20) Novak, Gregor M., Evelyn T. Patterson, Andrew D. Gavrin, and W. C. *Just-In-Time Teaching: Blending Active Learning with Web Technology*; Prentice Hall: Upper Saddle River, NJ, 1999.

(21) Henderson, C.; Dancy, M. H. Barriers to the Use of Research-Based Instructional Strategies: The Influence of Both Individual and Situational Characteristics. *Phys. Rev. Spec. Top. - Phys. Educ. Res.* **2007**, *3* (2), 1–14.

(22) Hines, S. R. How Mature Teaching and Learning Centers Evaluate Their Services. In *To improve the academy*; 2011; pp 277–289.

(23) Henderson, C.; Dancy, M. H. Impact of Physics Education Research on the Teaching of Introductory Quantitative Physics in the United States. *Phys. Rev. Spec. Top. - Phys. Educ. Res.* **2009**, *5* (2), 20107.