ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 26, NO. 3, 40-56

College STEM Faculty Teaching Practices: The Influence of a Professional Development

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ABSTRACT

In this paper, we present the influence of a professional development, including a faculty learning community (FLC), on STEM teaching practices at a southern US liberal arts college. We used a quasi-experimental mixed-method design to collect information about teaching practices and the influence of the professional development. The Reformed Teaching Observation Protocol (RTOP) was used to evaluate the faculty teaching strategies. The RTOP ratings indicated that most faculty used some sort of active strategies. Further, faculty who attended the professional development had significantly higher RTOP scores than their counterparts. Results from interviews show that faculty were willing to make changes to their teaching approaches based on the workshop. Results from this study contribute to the knowledge base describing the influence of professional development on STEM college faculty teaching strategies.

Keywords: professional development, STEM, RTOP, FLC, quasi-experiment

Introduction

Colleges need to produce graduates who are independent, able to apply their knowledge, solve complex problems, and work in teams among other attributes (Gijbels et al., 2006). This requires learning environments that focus on the acquisition of these skills, such as reformed teaching and learning approaches, that encourage the use of active teaching techniques for holistic student learning (Piburn & Sawada, 2000). For this reason, evidence-based practice has been encouraged because it emphasizes the importance of research in teaching and learning (Masters, 2018). Researchers have been tasked with informing educators of effective strategies to enhance students' learning (Masters, 2018; Slavin, 2002). According to Georgiou et al. (2020), evidence-based practice is critical because it bridges the gap between research and practice. To this end, some colleges and universities provide professional training for their faculty to be familiar with evidence-based practice. In the present case, a professional development (PD) was designed around participation in a faculty learning community (FLC) that promoted the use of learner-centered strategies to foster student engagement (Harris & Cullen, 2008). In this study, we explore the effect of participation in a PD with a FLC on STEM college faculty's use of learner-centered teaching strategies.

Reformed (Learner-Centered) Teaching Approaches

According to MacIsaac and Falconer (2002), reformed courses are courses that are "taught via the kinds of constructivist, inquiry-based methods advocated by professional organizations and researchers so that these future teachers would be taught as they were expected to teach" (p. 479). Reformed classrooms focus on lesson designs that encourage students' exploration using alternative approaches, use of thought-provoking activities, active classroom communication, respectful group interactions, and students' reflections of the learning material (MacIsaac & Falconer, 2002). According to the Geological Society of North America (GSNA, 2016), reformed teaching entails that faculty shift from teacher-centered to learner-centered approaches that emanate from evidence-based research.

As a result of this paradigm shift, many colleges and universities are now promoting the transformation of faculty teaching strategies from passive, to learner-centered environments. These environments include activities that can be described as active, constructive, and interactive (Chi, 2009). Meaningful learning is encouraged through active interaction between the students and instructors and among the students (Chi, 2009). Teachers in these environments use group work to encourage active questioning from students and discussion among students. Group activities help foster teamwork and camaraderie among students while distributing cognitive load (Chi, 2009; Weinstein, 2002). In a reformed classroom, teachers ask questions that intentionally promote students' conceptual understanding. An effective teacher listens and probes students' understanding (Ruiz-Primo & Furtak, 2007) to challenge the students and make them seek deeper responses to the questions. Effective reformed classrooms also require instructors to understand the students' conceptions before learning a new concept to challenge their understanding (National Research Council, 2000). Kranzfelder et al. (2019) observed that teachers in reformed classrooms guide as students are working and encourage both group and whole-class discussions before summarizing the material to the whole class. Further, Maclsaac and Falconer (2002) encourage using activities that will "anchor student dialogue in a shared, negotiated, and explicit external representation" (p. 484).

Faculty Professional Development

According to Pesce (2015), graduate schools have not focused on preparing students for college teaching jobs. This necessitates a need for faculty PD in higher education. PD programs are vital, as they enable college faculty to adopt new active and research-based teaching practices. For instance, a meta-analysis conducted by Bilal et al. (2019) found that PDs improve pedagogical knowledge and competence among faculty. Based on the meta-analysis, Bilal et al. (2019) encouraged institutions to include PDs in the faculty support system to enhance teaching, leadership, and administrative skills. While faculty welcome PD, Hott and Tietjen-Smith (2018) found that they need incentives to encourage them to get involved in the PD activities (e.g., contribution to tenure portfolio). Pesce (2015) found that faculty were more willing to get involved in PD when they collaborate with colleagues. Therefore, PD programs involving FLC are becoming more popular because they provide a supportive learning environment for participating faculty, and they model the strategies used in active-learning classrooms. FLCs involve a group of faculty members who meet regularly throughout the semester or year to address a topic or actions related to teaching (Richlin & Essington, 2004). Brydges et al. (2013) recommended that a group of 8-12 faculty should meet biweekly for 90 minutes each meeting. Orzech (2021) has suggested that facilitators of FLCs must have a clear vision that is shared by the group and encourage input from the members. Cox (2004) defines FLCs as "a cross-disciplinary faculty and staff group of six to fifteen members who engage in an active, collaborative, year-long program with a curriculum about enhancing teaching and learning and with frequent seminars and activities that provide learning, development, the scholarship of teaching, and community building" (Cox, 2004, p. 8). Cox (2004) identified two types of FLCs: (1)

cohort-based, which is a group of a specific cohort of faculty (e.g., first-year faculty), and (2) topic-based, which focuses on a specific issue that needs to be addressed for effective student learning. For instance, groups can focus on an innovative teaching approach, syllabi redesign, and action research.

A study by Richlin and Essington (2004) provides an overview of the extent of the availability of FLCs in the US and Canada. This study found that about 132 higher education institutions in the US and 308 in Canada have been involved in FLCs. In a study of the outcomes of participation in FLCs at six universities, Beach and Cox (2009) found that instructors involved in an FLC used nontraditional teaching practices in their classes. While traditional teaching approaches (e.g., direct lecture) focus on faculty telling students what to know, nontraditional approaches rely on evidence-based theories that advocate meaningful learning through students' active engagement in the learning process (Freeman et al., 2014). Another study by Brydges et al. (2013) also reported that faculty used nontraditional teaching practices and others planned to use these practices in their subsequent classes after participation in an FLC. Further, Genc and Ogan-Bekiroglu (2004) have argued that faculty who are involved in PD activities are more likely to use nontraditional teaching practices. Cox (2018) indicated that faculty who are involved in an FLC use active learning/teaching techniques such as cooperative and collaborative learning, discussions, and students' centered learning in general. Pelletreau et al. (2018) echoed these sentiments when they found that faculty from different backgrounds were able to teach using active approaches after collaboratively developing a unit on the "potential effect of mutations on DNA replication, transcription, and translation" (p. 1). In this study, the authors also found that students who learned through the developed unit performed significantly better on the exam than those who did not. Hopkins (2020) also found that faculty at a community college believed that PD had an impact on how they designed, taught, and assessed their courses. In another study by Tinnell et al. (2019), faculty indicated that FLCs were responsible for their decision to either begin using or focusing on students' collaborative learning. These authors also found that the FLC enhanced positive faculty collaboration. This can influence students' learning as Schmitz et al. (2018) found that students improved in some aspects of their learning outcomes after their faculty joined an FLC. In a study by Schmidt et al. (2018), faculty believed that FLCs improved their "knowledge and skill-building for creating more equitable learning environments for their students" (p. 99). This was echoed by Hirst et al. (2021) who found that FLCs increased faculty awareness of the needs of students from diverse backgrounds. In the present study, we developed a PD program with an FLC component to encourage the faculty's use of active teaching practices.

Purpose of the Study

The purpose of this study was to explore the science, technology, engineering, and math (STEM) faculty's use of active teaching techniques at a liberal arts college. We also compared the teaching approaches between faculty involved in the PD with a FLC (workshop participant) and those not involved (comparison group). In doing this work, we addressed the following research questions:

- How is participation in a PD project using an FLC associated with changes in faculty use of student-centered approaches to teaching?
- What aspects of participation in an FLC are perceived by STEM college faculty as being important?

Methods

Research Design

This research study is a treatment-control group, quasi-experimental mixed-method design (Creswell, 2003; Tashakkori & Teddlie, 1998). This study describes the teaching practices of STEM college faculty at a southern, rural liberal arts college and explores the extent of the use of active approaches in teaching to determine the influence of a PD project. The Reformed Teaching Observation Protocol ([RTOP], Piburn & Sawada, 2000) was used to structure the ratings of classroom observations of faculty in both the PD and comparison groups. In total, nineteen faculty members were observed, thirteen in the PD and eleven in the comparison group. Additional data were collected from five participants before and after the PD. These members are present in both treatment and control groups and participated in structured interviews designed to expose their knowledge of, and dispositions toward, teaching. Tables 1 and 2 describe the characteristics of the faculty members.

Table 1

Participants and Their Disciplines

	PD Group			Comparison Group
Discipline	PD Group	2014 Cohort	2015 Cohort	
Biology (BIO)	2	1	1	3
Chemistry (CHM)	3	2	1	3
Computer Science (CSC)	3	2	1	1
Math (MAT)	2	1	1	3
Physics (PHY)	3	2	1	1
Total	13	8	5	11

Table 2

Participants Characteristics

	PD Group (*N* = 13)	Comparison Group (*N* = 11)
Mean teaching years	13.1 ± 7.3	10.8 ± 7.9
Tenured	8	6
Nontenured	5	5
Male	8	9
Female	5	2

Professional Development

The PD was designed and carried out by an invited post-secondary STEM education expert who administered the workshop and a STEM PD expert from the host college. This was a two-stage PD model promoting the adoption of reformed teaching methods in post-secondary STEM classrooms. Faculty self-selected into the project. The project began with a four-day course redesign workshop at the end of the academic year in May 2014 and 2015. The workshops took three full days (9:00 am – 3:30 pm) and one-half day (9:00 am – 12:00 pm). During these summer workshops, participants were exposed to learner-centered pedagogies (e.g, Fink, 2003) that were designed to target deep learning approaches, while redesigning the syllabus for a course they intended to transform for the following academic year. Workshop themes included student motivation, significant learning goals and objectives, learner-centered assessment, major non-traditional assignments, and objective-assignment alignment. The following year, participating faculty were supported by ongoing participation in a bi-weekly FLC of one and half hours each meeting. Throughout the following academic year, during these regularly scheduled gatherings, faculty discussed the challenges they were facing, learned about potential sources of data describing teaching effectiveness, and watched occasional videos of each other's classroom instruction. Participation in the FLC was encouraged but not mandatory. The majority of FLC meetings were attended by all PD faculty, with one or two members missing an occasional meeting.

The Teaching Context

The courses observed were mainly for students majoring in math and the sciences, which include chemistry, physics, biology, computer science, math, and statistics. Some of the courses such as chemistry, physics, and biology had associated compulsory laboratory components. The lecture component for each course, where the observation took place, had a 70-minute time limit, three days per week. Although most of the observed courses were 100-level entry courses, some were 200-level courses.

Classroom Observations

The classroom observations were rated using the RTOP (Piburn & Sawada, 2000). Observations were documented through running-record notes, which were then rated using the RTOP. See Table 3 for observation frequencies of participants. The RTOP has been widely used as an observational tool for reformed practices in colleges and universities (Lakshmanan et al. 2011; Lund et al. 2015; Park et al. 2011). The RTOP is a five-point Likert scale instrument that has been well validated (Sawada & Piburn, 2000). The instrument has a total of 25 items with a maximum score of 100. The instrument has three major sections: lesson design, knowledge, and classroom culture. The knowledge section is further subdivided into propositional and procedural knowledge, while classroom culture is subdivided into communicative interaction and student/teacher interactions. This makes a total of five RTOP sections. The lesson design section looks at how the lesson aims to engage students, while the propositional knowledge section looks at the content and how it is presented to students for conceptual understanding. The procedural knowledge focuses on the actions students are encouraged to do for conceptual understanding. The communicative interactions focus on teacher/student communications and student/student communications within the lesson. Lastly, the student/teacher interactions show how the teacher's actions encourage active participation of students in the learning process.

Before conducting the observations, the two observers conducted a two-step inter-rater reliability process. The first step involved training to use the RTOP. This was done by the two observers watching three RTOP videos and rating them independently, then comparing the rating to the suggested rating from the RTOP training guide. In the second step the two researchers, who are both science educators, observed five classes simultaneously and rated them separately for comparison. During the comparison, differences were discussed with reference to the training videos to ensure accuracy in the RTOP rating. Afterward, individual researchers observed and rated the rest of the classes.

In total, 19 faculty members were observed. The comparison group had eleven faculty while the PD group had thirteen faculty. Of the thirteen faculty in the PD group, five had been observed as part of the comparison group in the previous year, before these faculty attended the second workshop and joined the participant group. The observations were conducted concurrently with the ongoing FLC, with the first observations carried out about four weeks into the semester and a second observation occurring late in the term. See Tables 3 and 4 for observation information. To discern which changes in classroom practice were associated with participation in this faculty development program, data were gathered from both PD faculty and a comparison group consisting of non-participating STEM colleagues (see Tables 1 and 2).

Table 3

Observation Frequencies of Various Categories

Category	Participants	Participants with	
		3 observations	2 observations
Fall 2014 semester	12	9	3
Fall 2015 Semester	12	4	8
Treatment	13	7	6
Control	11	6	5

Table 4

Treatment and Control Groups Observations Each Semester

Semester	PD faculty	Comparison faculty
Fall 2014	6	6
Fall 2015	7	5

Data Analysis

Minitab software was used for data analysis. The Kolmogorov-Sminorv (KS) test was used to determine the normality of distribution of RTOP scores. T-tests were used to compare sample means and Cohen's *d* provided the effect size. One-way ANOVA with Bonferroni correction was used to compare means from different sections of the RTOP. Mean RTOP scores of the observations for faculty were used to calculate the difference between the participant group and members of the comparison group.

Interviews

Emails were sent to faculty members who participated in the PD and FLC asking them to volunteer to be interviewed. Six faculty members volunteered for individual interviews and all six participated in the interviews. The semi-structured interviews sought to determine what changes in their practice, if any, had occurred since the workshop. The interviewees answered two questions: (1) what changes have you made to your class this semester and (2) in what ways did the workshop influence those changes.

Results

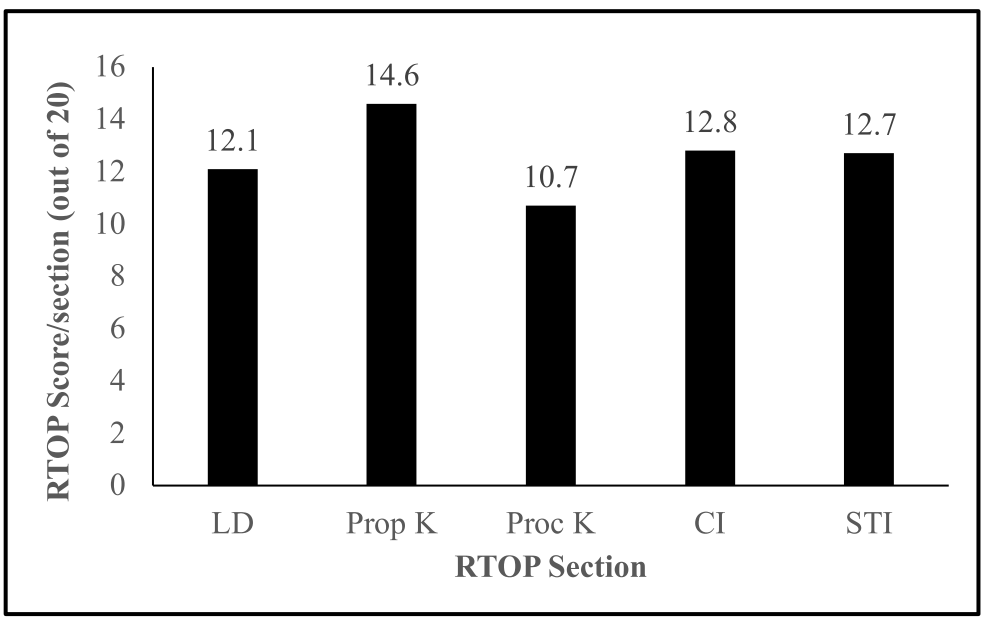
We conducted a hypothesis of normality to determine if the population this sample is drawn from is normally distributed using all the RTOP scores. The null hypothesis was that RTOP scores of this sample belong to a normal distribution. Using a Komolgorov-Sminorv test, we found $D = 0.11$, $p = 0.99$ for workshop participants ($N = 13$) and $D = 0.20$, $p = 0.72$ for the comparison group ($N = 11$) and D = 0.2, p = 0.4 for all the participants (N=19). Therefore, we accepted our null hypothesis. Using an ANOVA, we found that teaching experience ($F= 1.12$, $p = 0.37$), faculty discipline ($F = 2.63$, $p = 0.08$), and observation cycle did not influence the RTOP scores.

To What Extent Did Faculty Use Reformed Teaching in Their Classrooms?

Each sub-section of the RTOP is scored out of 20 possible points, making the total possible score 100. From all the RTOP observations, the mean score was 63.5 with a range of 36-81. This implies that the faculty in this study generally used reformed teaching approaches (GSNA, 2016). We also investigated the mean scores for different sections of the RTOP. The RTOP sections are Lesson design (LD), Propositional Knowledge (Prop K), Procedural Knowledge (Proc K), Communicative Interactions (CI), and Student/Teacher Interaction (STI) as shown in Figure 1. The mean scores in Figure 1 represent both PD and comparison faculty with the data collected after the PD workshop.

Figure 1

Mean Scores Based on RTOP Sections From 19 Science Faculty



As might be expected, the trend from Figure 1 shows that faculty displayed the highest propositional knowledge and lowest procedural knowledge. We also observed that both sections of the classroom culture have relatively high scores. An ANOVA ($F = 14$, p = 0.000) indicated that there was a significant difference in the scores among the sections. Follow-up tests with Bonferroni correction indicated that scores on propositional knowledge were significantly higher than the scores in the other categories. Further, scores on procedural knowledge were significantly lower than scores in the other categories.

What Is the Effect of Workshop Attendance?

Since the *F*-test (p = 0.01) showed that variances between the participating faculty and the comparison group were different, Welch's t-test was used. Participating faculty had higher RTOP scores than those in the comparison group. See Table 5 for this information. A significant difference was observed (t = 4.03, p = 0.000) with a large effect size (d = 1.74). Furthermore, when compared against the comparison group, a *t*-test with Bonferroni correction indicated statistical differences in all the RTOP sections between the two groups. See Figure 2 for this information. Although these tests show that participating faculty taught in a more reformed way, they are unable to show that participating in the project affected the difference because there is no pre-test data for most of the faculty members. For that, we looked at five faculty who were in the control group during the first phase of data collection and were in the PD group during the second phase of data collection (Table 5). These participants provided data for pre- and post-workshop. Further these participants represented the disciplines, with one faculty member each, from physics, chemistry, biology, computer science, and mathematics. We conducted a repeated-measures *t*-test of these five faculty members RTOP scores collected before and after they attended the workshop (see Table 6). There was an observed significant improvement on the faculty instructional approach (t = 3.40, p = 0.03) with a large effect size (d = 1.04). Table 7 provides a summary of the observations of one of the five faculty members to demonstrate how their changes were coded on the RTOP.

Table 5

Comparison of RTOP Scores Between Groups

Group	N	Mean	SD	Range	*t*	*p*	*d*	Grand mean
Participants	13	70.4	5.4	60-81	4.03	0.001	1.74	63.5±11.4
Comparison	11	55.3	11.3	36-70				

Table 6

RTOP Repeated Measures t-test of Observations From Five Science Faculty

Observation	N	Mean	SD	*t*	*p*	*d*
Pre	5	63.2	6.3	3.40	0.03	1.04
Post	5	68.5	3.3			

Table 7

Sample Observation Summary Depicting an Observed Change in One Faculty's Approach

Before the workshop	After the workshop
• The class addressed important concepts in the subject • Students' participation was not encouraged during the lecture time • There was some group work • Minimal exchange of ideas between teachers and students was observed • The class was mostly teacher talk with some teacher ↔ student interaction • Connections between class content with both other content and real-world not observed • Probing of students' understanding was rarely used	• The class addressed important concepts in the subject • The class encouraged students' participation • Crossover of students between groups was encouraged. • The teacher respected students' ideas: students respected each other's ideas • Student-Student talk was encouraged, although the teacher dominated the discussion. • Some connections between content and real world observed. • Probing of students' understanding was observed.

Figure 2 shows scores between the PD and the comparison group for different sections of the RTOP. The results show that the PD group had better scores than the comparison group among the different sections of the instrument. Statistical analyses indicated that all these differences were significant at the alpha level of 0.05.

Figure 2

Mean Scores Based on RTOP Sections for Workshop (N = 13) and Comparison (N = 11) Groups After PD

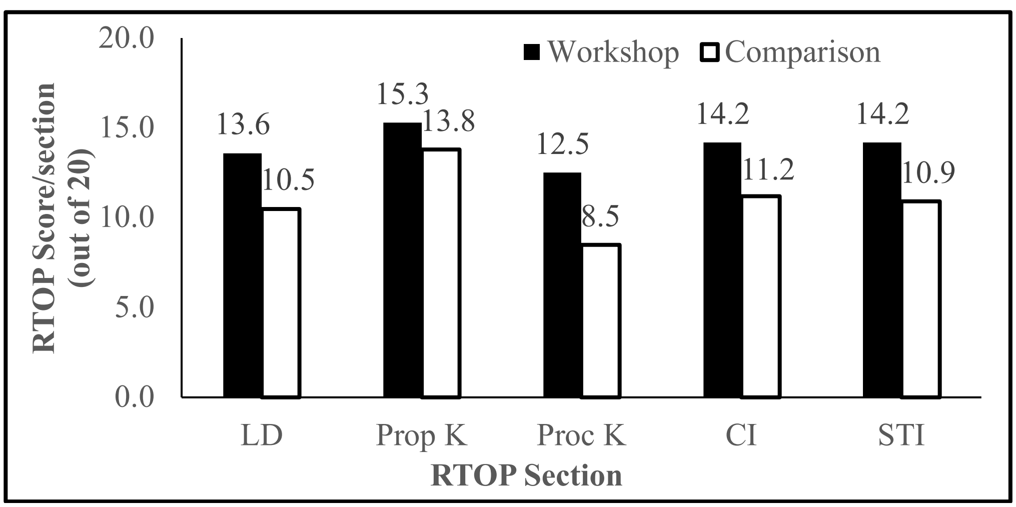
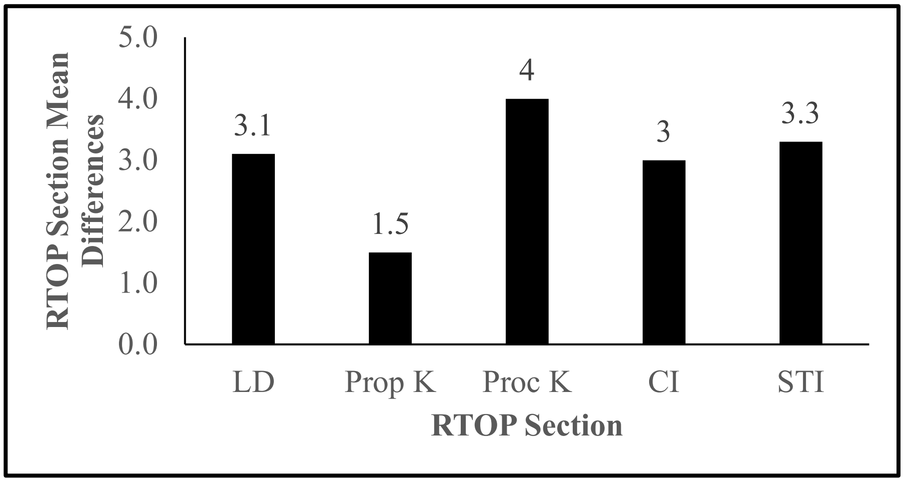


Figure 3 shows differences in RTOP scores in each section, with each value indicating how much the faculty in the PD section scored higher than the faculty in the comparison group. The largest difference in mean section scores was observed between Procedural Knowledge (Proc K) scores seconded by Student-Teacher Interactions (STI). The smallest difference in mean section scores was observed between Propositional Knowledge (Prop K).

Figure 3

Mean Scores Differences Between the Workshop and Comparison Groups for Different RTOP Sections



What Was the Effect of the FLC?

Analysis was also done to determine changes in the RTOP scores within the semester to see how the FLC influenced instructional approaches. In this case, the first and last observations were used. For inferential statistics, the repeated measure *t*-test and its *p*-value were calculated to determine statistical significance. All these results are presented in Table 8 and for reference, data for the comparison group is also included. Although there was a small increase of 2.5 in the RTOP scores for the PD group between the first and last observation, this increase was not statistically significant. A decrease of 4.3 was observed for the comparison group between the first and last observations, which was also not statistically significant.

Table 8

Analysis of RTOP Mean Scores for First and Last Observation

Measurement	PD Group	Comparison Group
N	13	11
First Observation mean score	68.6	56.9
Second Observation mean score	71.1	52.6
p	0.36	0.27

The Interview Data

The qualitative data answered questions regarding changes to the faculty teaching practice and how the workshop influenced that change. These questions were aimed at supporting results from the quantitative section of this study. Below is a summary of responses from the six participating faculty members. They are identified by an abbreviation for their discipline followed by a designated participant number for the study.

CSC1 redesigned a course as part of an ongoing plan to include more outside assignments and process oriented guided inquiry learning (Simonson, 2019) activities. However, the workshop provided ideas that helped design some of these classroom activities and deal with the classroom dynamics, such as the placement of students in various groups. CSC1 stated:

> The workshop has given me some new ideas about how I can construct some particular activities. I think I was already kind of pretty far ahead of the curve in terms of active learning. I am making some changes to how I structure teamwork that I think has grown out of the meetings, so they have been valuable.

MAT1 moved the class to a new room that was conducive to facilitating group classroom interactions. He reported that having an appropriate space enabled him to have a kind of classroom that facilitates the kind of activities he has always wanted to do with his students. In this case, the workshop helped him articulate his learning objectives and construct a syllabus that was reflective of what he wanted the students to accomplish in class. The workshop encouraged him to formalize activities that he could not do regularly but now had become a regular part of his course due to the workshop. MAT1 said:

> What I did get out of the workshop is that you can take those one-time things, those things that I do sort of every once in a while, and make them more systematic. That's why I think the workshop has helped me, to take the thing that I do throughout the class and make it an actual part of the class, right, and make it more of an expectation of the students as opposed to some technique that I am doing.

CHM2 reported that he transformed his syllabus and added more active learning assignments to his class based on the workshop. As a result, he attempted to cover all (or most) of Bloom's taxonomy in his learning objectives and classroom activities. He talked about Bloom's taxonomy in terms of alignment of assignments and classroom goals. The workshop changed his mindset about how he viewed himself in the classroom, from a scientist who is teaching, to a teacher who is a scientist. He had more recognition that students were looking at him as a model and not just at their classroom notes. He said:

> One of the things that I have modified a little bit, but it's still work in progress, is changing my mindset from being a scientist who is in the classroom to a teacher who is a scientist, recognizing that students are looking to me for more than just notes … you know, thinking about the taxonomy in order to be able to really address all six areas, I have to approach it differently than an old straight lecture.

BIO1 reported adding some model assignments to improve students' interactions and made some changes to her syllabus as a result of the workshop. Although she had used process oriented guided inquiry learning before, the workshop provided ideas about learning goals and how to effectively use them. She indicated that the transformed learning goals provided support for developing activities and working with the teaching assistant, who also happened to attend the workshop. The workshop provided more confidence in facilitating activities that she already had in mind, but was a little bit reluctant to undertake that road. Furthermore, the FLC was also a great experience for this faculty member because participants shared different experiences in their classrooms. When asked what prompted her to change, she answered:

> Well, this WIDER grant thing … I had similar things, so I knew the premise of it, but it got me to thinking at a better level of trying to pick a couple of … Starting with the learning goals, I mean stuff that I know how to do but it really forced me to fit into it starting with the learning

goals for the class and really thinking about what those really are. And then trying to come up with a couple of activities.

CHM3 reported interspersing his classes between lectures and group activities. He emphasized "student-directed learning" and de-emphasized 'the role of flow of knowledge." Facing pushback from some students who were uncomfortable with having more responsibility, he is still determined to keep on improving because it is worth it. PHY1 believed that working with other faculty members to effect changes in their classrooms is an important experience because participants can affirm each other's practices through a series of meetings. She did not change much in her classroom practice because she has been familiar with active teaching practices before the workshop.

Responses from the interview activities demonstrate that the workshop had an influence on faculty teaching practice both in the classroom and how they prepared for teaching. In summary, the workshop provided confidence to the instructors as they tried to increase students' responsibility in their classrooms, through appropriate learning objectives and activities.

Discussion

In this study, we explored the college faculty's use of active instructional approaches and what influenced their approach to teaching. We used the RTOP to investigate their teaching practices and interviews to determine what influenced their teaching approaches. We further investigated the influence of a PD with a FLC on their instructional approach. According to GSNA (2016), the RTOP cut-off scores are described as follows in Table 9:

Table 9

RTOP Rating Criteria According to GSNA (2016)

Type of Teaching	RTOP Score
Traditional/Teacher centered	0-30
Transitional/Teacher-guided	31-45
Transitional/student-influenced	46-60
Reformed/student-centered	61-100

Our results show that most of the faculty members used reformed teaching approaches. The mean RTOP score on our observations (63.5) is consistent with the mean score of faculty who went through the Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT) workshop training (Piburn & Sawada, 2000), thus indicating that faculty in this study generally used a reformed teaching approach.

When we compared the two groups of faculty, the PD group (RTOP score = 70.4) used reformed or student-centered approaches while the comparison group (RTOP score 55.3) used a transitional/student-influenced approach based on a GSNA (2016) rating. The comparison tests have shown that faculty who participated in the PD with a FLC had significantly higher RTOP scores than their counterparts who did not participate. Further analysis showed the workshop participants performed better on all sections of the RTOP. Possibly, among other experiences, participation in the workshop may have influenced their teaching approach. From our observations, the faculty involved in the workshop asked more probing questions, required students to use prior knowledge as suggested by the National Research Council (2000), and provided more opportunities for students to work on their problems than their counterparts. These are issues addressed in the workshop. Further, the workshop addressed teaching for deeper learning, where students are encouraged to take charge of their learning to understand the material better (Haitte, 2012; Lombard, 2018; Marton & Saljo, 1976). This type of learning involves making hypotheses, discussing ideas, and making reflections. More of these characteristics were observed in classes taught by faculty who attended the workshop and were involved in the FLC than in classes of non-participating faculty. Brydges et al. (2013) also observed similar changes after a PD with a FLC in that several faculty members adopted non-traditional teaching styles or planned to adopt them. This also agreed with results by Beach and Cox (2009) and Pelletreau et al. (2018). Further, Cox (2018) has indicated that faculty involved in PD with a FLC generally use active learning techniques, which were observed in this study. The faculty in the control group either used direct lecture or some group discussions mainly to solve textbook problems. Students were not generally encouraged to make predictions, hypotheses, or reflect upon their learning.

In addition, although the faculty in the PD group performed better in all sections of the RTOP, the biggest difference was observed in the procedural knowledge, seconded by student-teacher interactions. This makes sense because the purpose of the workshop, and the FLC that followed, was to change the faculty's mindset about teaching and to guide them towards reformed approaches to teaching. Procedural knowledge focuses on making predictions, engaging in thought-provoking activities, challenging ideas, and reflecting upon the learning process. These skills are important in reformed approaches to learning. Specifically, the workshop addressed these issues by encouraging faculty’s use of higher-order objectives, assessments that addressed these objectives, and the classroom activities that would align with the objectives and the assessments. Franklin and Chapman (2012) made a similar observation of physics faculty in workshop classrooms. The smallest difference was observed in propositional knowledge. As Franklin and Chapman (2012) discerned, understanding the fundamental concepts of the lesson is valued in both traditional lecture classes and reformed classes. Therefore, the smallest observed difference in this category makes sense.

A 2.5-point increase in faculty RTOP scores was observed between the first and last observation to determine the impact of the FLC. Although this difference is not significant, it shows that the faculty members did not slide back from using reformed approaches to teaching throughout the semester. This makes a lot of sense when this 2.5-point increase is compared to a 4.3-point decrease in RTOP scores for the comparison group between the first and last observation. It is possible for faculty to slide back and teach using direct lecture, especially towards the end of the semester, when there is so much to cover with very little time to spare. In this case, it is possible that the FLC might have put faculty in the PD group on their toes on using reformed teaching since they already had high RTOP scores at the beginning. Furthermore, the first data set was collected four weeks into the semester when the first FLC meeting was already conducted. Therefore, the first observation may have already reflected the influence of the FLC.

Interviews with the faculty indicated that the workshop helped them to make changes in their teaching practice. These changes included formulating objectives that facilitate more student involvement in the learning process, objectives that aligned with Bloom’s taxonomy, and creating activities that aligned with these objectives. Further, the participants reported that the workshop enhanced their confidence in designing and facilitating active learning environments. This may help explain why these participants had higher RTOP scores than the comparison group. Our classroom observations indicated that the PD participants designed their lessons to enhance students’ participation. These included providing varied learning experiences, encouraging students to make predictions, encouraging group discussions and communications among students, and encouraging meaningful hands-on experiences and students’ reflections. Results from this study concur with those reported by Genc and Ogan-Bekiroglu (2004) who found that teachers who participate in some sort of PD or training are likely to use student-centered learning. In addition, Tinnell et al. (2019) found that faculty used reformed teaching approaches, such as collaborative learning, after undergoing PD with a FLC. Further, Viskupic et al. (2019) observed that faculty who undergo at least 24 hours of PD are likely to change their teaching approach. In the case of this research, faculty underwent four days of PD, which might have brought about meaningful changes in their teaching approaches.

Limitations of the Study

Three limitations that may affect the results in this study consist of (1) a lack of pre-workshop results for all observed faculty members, (2) a small sample size, and (3) a selection effect. In the first case, not all faculty participating were observed before the workshop. This limits the extent to which we can associate potential changes in teaching practice with participation in the project. However, data from five faculty members who were observed before and after the workshop showed a significant improvement in teaching practice. The second limitation is that the sample size is small, especially for the five members who had both PD and comparison data, which may also affect the results and interpretation of the data. In the third case, there may be a selection effect in that the faculty who chose to go through the faculty development may have been primed to incorporate student-centered teaching even if they had not done so before.

Conclusions and Recommendations

Results from this study have shown that the faculty observed at this liberal arts college have transitional teaching approaches. Further, the workshop participants had higher RTOP scores than the comparison group. These results show that there is potential for further improvement in the use of reformed teaching practices with more PD activities. Studies by Hauck (2012) and Viskupic et al. (2019) showed that faculty who frequently attend PD activities are likely to use reformed teaching practices. Therefore, we propose more PD activities and an expansion of these activities to more faculty at this and other colleges.

This research has significance to the scientific community because we have added to the knowledge about how PD with a FLC influences instructors' use of learner-centered approaches. Results from this study will, therefore, inform science educators and administrators on the importance of appropriate PD for effective undergraduate education. Further, determining what influences faculty's teaching approach is crucial to designing appropriate PD activities that either address any gaps in the teaching practice or reinforce the existing practices.

This work was supported by the National Science Foundation award DUE-1347645.

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