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Examining real-world IT-immersion teacher education experiences through the lens of two teacher roles[1]

Cathlyn Stylinski[1], Caroline Parker[2] and Carla McAuliffe[3]
[1]University of Maryland Center for Environmental Science, [2]Education Development, [3]TERC

INTRODUCTION

With information technology (IT) a fundamental component of most U.S. businesses and industries, classroom students need to engage with IT in ways that better match computer literacy skills and applications in today's workplace (e.g., robotics, computer modeling and simulations, digital animation and multimedia production, biotechnology, and geospatial technologies). We call these "innovative applications of technology" because their use in K-12 classrooms is still quite limited (e.g., Bebell et al. 2004, Dexter 1999). Because they are novel to the classroom, teacher professional development focused on innovative applications of technology faces unique and significant challenges including poor alignment with education standards, considerable time and effort to prepare teachers, and schools with insufficient technology resources. However, only a few studies have explored how best to prepare teachers to incorporate real-world IT applications into their K-12 curriculum (e.g., Vrasidis & Glass 2005). Our exploratory research study is examining the design of teacher professional development experiences focused on innovative applications of technology, teachers' perception of these experiences, impacts on their knowledge and skills, and any subsequent changes in teaching practices. This paper focuses on the first phase of our study—the design of IT-immersion teacher professional development.

Professional development designs often vary in terms of the role that teachers have in shaping curricular materials. Some prepare teachers to implement high-quality materials without any changes; some focus professional development activities on adapting provided materials for local classroom environments (e.g., Singer et al. 2000); and some prepare and help teachers design and develop their own curricular materials (e.g., Wiggins and McTighe 1998). The role that teachers have in the professional development can impact their instructional planning (Penuel et al. 2009) and possibly their classroom implementation. Differences in teacher roles with regard to curricular materials might be particularly relevant for IT-immersion professional development because of the significant challenge of learning sophisticated IT applications and integrating these applications into the classroom. Thus, our first research question for this paper is as follows: *Are these two teacher roles (adopter/adapter versus developer) relevant for*

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IT-immersion teacher professional experiences, and how do these roles influence the design of these experiences?

In addition to teacher role, we are reviewing the design of IT-immersion teacher experiences in the context of commonly cited practices of effective professional development. Although researchers and teacher educators in science, technology, engineering and math (STEM) fields have identified many different characteristics or "best practices," there is considerable overlap and agreement among these. Characteristics repeatedly cited include active learning; opportunities to collaborate with peers and reflect on teaching practices; collective participation (e.g., from the same school or teaching similar subjects); a focus on content (e.g., STEM) knowledge or a particular curriculum; proximity to classroom practices; coherence with teachers' professional lives; strong alignment with educational standards; and sufficient time to implement what has been learned (Desimone et al., 2002; Garet et al., 2001; Loucks-Horsley et al., 2003; Penuel et al., 2007). We are interested in seeing if these characteristics or others are relevant to teacher professional development focused on innovative applications of technology. Thus, our second research question for this paper is as follows: *In addition to teacher roles with regard to curricular materials, are there other common themes of these IT-immersion experiences, and how do these compare to typical best-practices in teacher professional development?*

Our methodology applies Penuel et al.'s (2007) recommendation to focus on a specific professional development design by using projects funded through the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program as our study group. These IT-immersion teacher professional development projects are ideal for our research because they focus on one or more innovative application of technology and share a common design (as required by NSF) that has been implemented in unique ways.

DESIGN AND ANALYSIS

To explore approaches of these IT-immersion teacher professional development projects, we collected two forms of data—an online survey completed by ITEST project principal investigators (PI) and follow-up semi-structured phone interviews with these PIs. In some cases, we also reviewed written artifacts (project websites and annual reports) to clarify information. PIs were recruited through email requests. PIs from all 65 ITEST teacher-education projects funded between 2003 and 2008 were contacted. Fifty PIs completed the online survey for 51 projects (one PI led two distinct projects). Thirty of these PIs participated in the phone interview, describing 31 projects. The online survey asked PIs about the design and delivery of their professional development project, and it consisted of Likert-scale items, multiple-choice items, and open-response items. To address validity and reliability, we developed the survey from a pilot study, had an expert panel review the instrument, and had six ITEST PIs complete a draft of the survey and provide feedback. From the survey results, we identified several common elements of these IT-immersion projects. We used these elements to develop our interview protocol, which asked PIs to reflect more deeply on these elements. We synthesized the survey by identifying the most frequent responses and recurring themes. To examine characteristics of the two teacher roles, we performed correlation and stepwise discriminant function analyses using responses from the Likert-scale items. For the interviews, we tallied positive responses to questions regarding whether a particular PD element was critical or relevant. For the survey's open-response items and the transcribed interviews, we applied grounded theory by first creating preliminary codes based on responses. To establish and maintain reliability, our team independently coded the same interview transcript, compared and discussed differences, and modified the preliminary codes as needed. We then coded the rest of the data for these two themes and synthesized the results to determine the most frequent responses.

RESULTS

While they use a wide range of IT applications, many ITEST teacher-education projects center on communications, field-data-collection, modeling/simulation, spatial data analysis, and numerical analysis, and almost all use more than one of these applications (Figure 1). Not surprisingly, projects tend to emphasize technology skills more than STEM content knowledge or pedagogical strategies (Figure 2); many also incorporate technological pedagogical strategies and promote in-depth understanding of the targeted technologies in the context of professional applications (Figure 3). Project materials typically supplement rather than replace existing curricula, emphasize "how-to" guidance and alignment with education standards, and integrate educative and assessment elements (Figure 4). Most ITEST professional development projects were required to include an opportunity for teachers to work with youth in an out-of-school context, as the teachers learned new technologies and practiced or developed in-class materials; 79% of interviewed PIs said these out-of-school experiences were a critical part of their professional development design.

Teacher Role with Regard to Curricular Materials

When asked to select a dominant role that teachers were placed in during the professional development (limited to two choices), about half surveyed PIs said they had teachers use/adapt provided curriculum materials (53%) and half said they had teachers develop their own curricular materials (47%). However, we found no significant correlation between these two roles and Likert-scale items that focused on collaboration, curricular materials, STEM career pathway, technology integration and interactions with youth participants (Table 1). We attempted to tease apart differences between the two teacher roles using stepwise discriminant function analysis but found no significant grouping of surveyed items that distinguished these roles. This may have occurred in part because our sample size was somewhat small for this multivariate analysis.

Because the survey results did not describe the differences between projects based on the teacher role with regard to curricular materials, interviewed PIs were asked if this role was a critical part of their professional development design; 86% agreed. When asked if given the choice of a third option that was a combination of the two listed teacher roles (i.e., teachers *both* developing materials and using/adapting provided materials), 52% of interviewed PIs said they would switch their choice to this third option with 22% and 26% maintaining the original selected role (teachers developing materials and teachers using/adapting materials, respectively).

Other important themes

From the interview data, we also identified several important themes of these IT-immersion professional development projects including authenticity, collaboration, cultural connections, intensive support, and interactions with youth outside of school. For this paper, we explored two themes in more depth—*authenticity* and *collaboration*. We defined *authenticity* as interactions, activities and resources in the professional development that link to real-world content, contexts, or processes. We identified four subthemes related to *authenticity* in teacher education— (1) alignment with the process and nature of STEM, (2) involvement of STEM professionals, (3) emphasis on STEM careers, and (4) placement in actual geographic locations. We defined *collaboration* as two or more individuals in the professional development working in significant ways towards a common goal. We identified five subthemes related to *collaboration* in teacher education—(1) supporting structure and functioning of collaborative interactions, (2) taking advantage of team members' expertise, (3) supporting collaborative learning and working collaboratively on curricular materials, (4) helping maintain long-term collaborations, and (5) using technology to support collaborations. These subthemes are described in more detail below.

Authenticity

(1) Alignment with the process and nature of STEM

Ninety percent of interviewed PIs reported their professional development activities aligned with the process and nature of STEM. These activities included providing first-hand experiences with STEM research and design practices including collaborating and sharing findings with peers and public audiences; emphasizing inquiry and problem/project-based learning; and using technology in ways that parallel professional uses. For example, one PI explained, "We would have discussions and debates with the teachers…, which is a…different way of teaching rather than the classroom setting," while another said, "We emphasized that the nature of science is collaborative…you can't be the expert in everything." Several projects underscored this alignment with real-world practices by having teachers work in professional STEM settings such as research laboratories.

By aligning professional development to the STEM process, projects promoted a deeper understanding of STEM culture, concepts and process and created opportunities to make novel discoveries. As one PI described, "[Teachers] had culture shock...the way you interact with one another, what you think about, how you decide on anything is completely different in so many ways…there isn't always an easy answer, everything is up for debate and discussion at any one time." A PI explained, "Teachers have to see how it's done or how it can be done, and then understand some of the theories behind it before they can actually move it in to their own use in the classroom…[they need to] spend time with the content [and] make sense of the content." An added advantage of this immersion in the STEM process was establishment of teachers' creditability as experienced researchers, programmers or designers. For example, the PI of an ITEST project focused on gaming described the importance of teachers gaining 'gaming credibility' with their students; "Whenever you have a forty-plus-year-old teacher teaching game making to kids, they are instantly going to question what credibility that person has, and game knowledge, and let alone game creation knowledge."

(2) Involvement of STEM professionals
Seventy-four percent of interviewed PIs reported that they involved STEM professionals in their teacher projects in significant ways. These professionals included scientists, programmers, engineers, harbormasters, fishery specialists, community leaders, and company CEOs. These professionals hosted field trips; supervised teacher science research; mentored teachers as they worked on curricular materials; and assisted with classroom implementation. These STEM professionals personalized the STEM process and STEM career pathways and helped sustain collaboration and implementation beyond the professional development.

(3) Emphasis on STEM careers
Seventy-four percent of interviewed PIs reported that they emphasized STEM careers and related pathways during the teacher professional development. They did this through college and career fairs, guest speakers, tours, career materials, and role-playing. Benefits included making technology and the STEM process relevant to teachers, students, parents and administrators; making links to STEM careers in the local community; and helping teachers understand unfamiliar STEM fields.

(4) Placement in actual geographic locations
Sixty-five percent of interviewed PIs situated professional development activities or materials in actual geographic places. These places typically were the local community or surrounding region. Benefits included engaging teachers and students by connecting to their interests and allowing exploration of relevant environmental and social topics or issues (e.g., local fossil beds, schoolyard ecological features, community lobster hatcheries). In one place-based project, teams of teachers, students and community members worked together on a local project—"We asked the kids…what are the major research stewardship issues in your community and had them…drive that conversation, which…helped the teachers see where the interest really lay [sic] for the students."

<u>Collaboration</u>
(1) Supporting the structure and functioning of collaborative interactions
Ninety percent of interviewed PIs said they used strategies to support the structure and functioning of collaborative interactions. These included allotting time for collaboration and social interactions; assigning teachers to groups or letting teachers drive group formation and dynamics; organizing team meetings; and enhancing teamwork and leadership skills. As a PI noted, "We had teachers work as 'critical friends'…[and discover] it's not always necessarily just sitting there giving your suggestions; it's more like asking your questions, and then it makes you think." One project had teachers complete a ropes course together to promote teamwork, while another gave select teachers additional training on curriculum development so they could function as more effective team leaders. These supports led to more productive partnerships, but many projects faced significant challenges in supporting these collaborations including addressing team conflict and dissension (especially in school-based groups). As one PI reported,

"Sometimes groups…have difficulty collaborating because they have different leadership styles. [W]e…do an activity on leadership styles and the kinds of… things to be mindful of when you are working in a team. [W]e provide…telescope time on the Green Bank Telescope, which tends to really galvanize the group…and make them forget their…anxiety-induced group dynamic problems."

(2) Taking advantage of team members' expertise

Ninety percent of interviewed PIs said they used strategies that took advantage of the expertise of different team members. These included having teams work as equals; using mentors (e.g., more experienced teachers) to guide teams; building on teachers' expertise in pedagogy, content and local context; and drawing on the expertise of administrators, guidance counselors, STEM professionals, past teacher participants, and community members (including a minor league baseball team to explore math in sports). As noted earlier, teachers also worked collaboratively with youth as part of the professional development experience, and this was regularly cited as a particularly valuable relationship. As described by one PI, "The nonhierarchical learning [in our project] was extremely important...the [summer] students and the teachers were learning in a peer-to-peer format. So, there weren't teachers teaching kids…trying out things on the kids. It was everybody was learning the same thing at the same time on the same exact level." Often, the project staff also worked as equal partners with the teachers, as another PI reported, "We are interested in developing a … true partnership where… we are [not] the [only holders] of information or knowledge; [where] we can learn from [the teachers]."

Benefits of this emphasis on team members' expertise included teachers learning from each other and becoming more engaged and more comfortable with technology applications and their classroom integration. As one PI noted, "[Teachers] really got together and started working in a very unique and good way…creating their own activities … and tracking throughout the school year [across districts]." Teachers also developed a better understanding of and appreciation for students' technological expertise. One PI reported that, "We got the teachers to recognize much more the expertise the students had and that they were able to learn something from the students and not feel so threatened by that idea." Another explained, "Students of this generation are wired to understand the technology and how it can be used, the teachers are not. So, we really had to actually train the teachers in how to become facilitators of knowledge rather than imparters of knowledge." In some cases, this approach aligned with the culture of the local community; for example, one PI said, "In [our] community, elder is not a concept that linked necessarily to age, so that a teenager who has clearly exhibited a talent is in some ways an elder…we consciously built on that concept that the youth are really the experts in technology and if teachers can …figure out how to tap into that then they have these tremendous resources in their classrooms."

(3) Supporting collaborative learning and working collaboratively with curricular materials

Eighty-one percent of interviewed PIs used collaborative learning and working collaboratively with curricular materials. These included working together on science research and game design; discussing ideas and sharing information; writing and revising materials; peer-reviewing and trouble-shooting materials and teaching; managing shared resources such as equipment; and co-teaching with other teachers, project staff, STEM professionals, and K-12 students. As one PI explained, "[Our teachers] self-aggregate into teams based on common interests and then collaboratively develop materials and then peer-review them in their, in larger groups."

Through these collaborative learning and working opportunities, teachers gained important advice from colleagues and developed a deeper understanding of STEM content and process and of the curricular materials. A PI noted that, "As they are learning about the new content [such as nanotechnology] or the new educational technology like simulation software tools,…they are listening,….[and] talking…to each other about what they just heard and saw." This collaborative work also provided an opportunity to reverse the typical role of students, who shifted to providing technical support and feedback to the teacher, as well as an extra set of hands back in the classroom. As one PI explained, "In most cases the students [in this out-of-school context] actually ended up teaching the teachers, and that really helped to provide actually a support mechanism...So, [during the classroom implementation], the teachers could actually go to the kids to say 'hey, how did that code work, or what button am I supposed to press when I am trying to do this map?' "

(4) Helping maintain long-term collaboration

Fifty-eight percent of interviewed PIs used strategies that help maintain long-term collaboration. These included promoting communities of practice, where teachers depend on each other for support. As one PI explained, "We try to get [teachers] to reveal what they know, and then have other teachers go to them as opposed to coming to us for that kind of expertise." These communities developed within individual schools, as well as across schools and districts via online interactions; PIs used various approaches to support them. For example, one PI said, "[We used the] 'Sustainable Learning Community,' [in which] teachers had a [support network] within their own building, within their own community that they could go to [when they trying to implement] who had similar trainings and a similar summer intensive experience." Another used the Cascading Leadership Model, where each group of past teacher participants mentored new participants; the PI felt that by having this approach, "[These] communities of practice will…organically evolve."

These long-term collaborations were critical to maintaining project-based knowledge and practices at a school even with teacher attrition (especially in urban school districts). One PI explained, "[Teachers in our project] support other teachers within the school, and they build a body of knowledge within that school about how to use these portable [lending IT] labs… if one teacher leaves, that doesn't take away that intellectual knowledge and connection to the institution*."* However, many projects faced the significant challenge of the lack of time for collaborations outside of the professional development. "It's very hard for teachers to make huge strides without having [time for collaboration]…built into their daily lives…as part of teaching," said one PI.

(5) Using technology to support collaboration

Forty-five percent of interviewed PIs used technological strategies to support collaboration among team members. These included using social networking sites, blogs, wikis, podcast, videos, and online courses. One project used 3-D immersive environments, which provide opportunities for planned and unplanned interactions across space and time. Supporting distance collaborative learning and working on curricular materials was a key benefit. One PI explained how remote statewide videoconferencing led to spontaneous sharing of technology. Another noted that, "Having someone in close proximity [who] is using the same tools and sharing [through social networking provided an opportunity to ask question such as,] 'what were the challenges, what were the aha moments, is this worth better doing it in teams of three students or five students?' "

CONCLUSION

The practice of providing curricular materials versus helping teachers develop their own materials is commonly used in many professional development efforts, and the use of these two roles may help us better understand how to effectively support the integration of innovative applications of technology into K-12 classrooms. The results of our study indicate that these roles were relevant, as PIs of IT-immersion teacher experiences did identify with one or the other of the roles or a mix of the two, and most agreed this was a critical part of their professional development. However, our analysis indicates that this two-pronged teacher role model may not be the defining feature of these IT-immersion projects. Instead, the roles should be considered as a continuum and together with other emerging project themes.

Our findings point to several additional themes that PIs also identified as being critical parts of teacher professional development focused on innovative applications of technology. Some of these parallel best practices regularly cited in the literature, such as promoting communities of practice and collaborations among teacher participants. For example, Collins (2010) emphasizes the value of sustained collaborative interactions with other teachers and with experts, although he agrees there is often little time allocated for sustained professional learning and collaboration beyond the professional development experience. However, at least two other key practices of the ITEST projects are either not commonly cited in the literature or not emphasized in more traditional efforts: (1) promoting authenticity by immersing teachers in professional STEM practices, tools and contexts and making connections to environmental/social topics and careers in the local community and (2) expanding collaborative efforts to include STEM professionals, local citizens, and students as team members and using technology to support and sustain collaboration. In these IT-immersion teacher education projects, it was particularly valuable to involve students directly in the professional development—that is, outside of the school environment and as valued partners. These atypical teacher-student relationships helped teachers develop skills in student-centered inquiry-based teaching and acquired a better understanding of youth's relationship with technology; sometimes, teachers even gained additional technical support in the classroom.

While promoting collaborations in teacher professional development has been described (e.g., Butler et al. 2004, Dooner et al. 2008, Collins 2010), strategies and benefits of authenticity in teacher education is not well developed. Much research has focused on involving STEM university faculty and other professionals in teacher education in order to improve gains in content knowledge and skills and to promote teacher recruitment and retention (e.g., Hora and Miller 2007, Baker and Keller 2010). Additional research has examined the immersion of teachers in science fellowships and has demonstrated positive impacts on teachers' identify, self-efficacy, confidence, knowledge, interest, and motivation to be science and math teachers (e.g., Baker and Keller 2010, Varelas et al. 2005), as well as improvements in student science achievement of participating teachers (Silverstein et al. 2009). However, much more information is needed on authenticity as an effective design element for teacher professional development focused on innovative applications of technology such as those used in the NSF ITEST program.

We are continuing to analyze the PI interview data for additional themes. We will then explore whether ITEST projects cluster around these themes or if each is unique in its design. In our next phase, we will conduct an online survey with teacher participants of the ITEST projects to understand their perspectives on the professional development designs and impacts on their teaching strategies. Finally, we will conduct a comparative study to see how these teachers' practices differ from those of teachers who have not participated in technology-intensive professional development.

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FIGURES

Figure 1: Percentage of technology applications used in NSF ITEST projects (n=51)

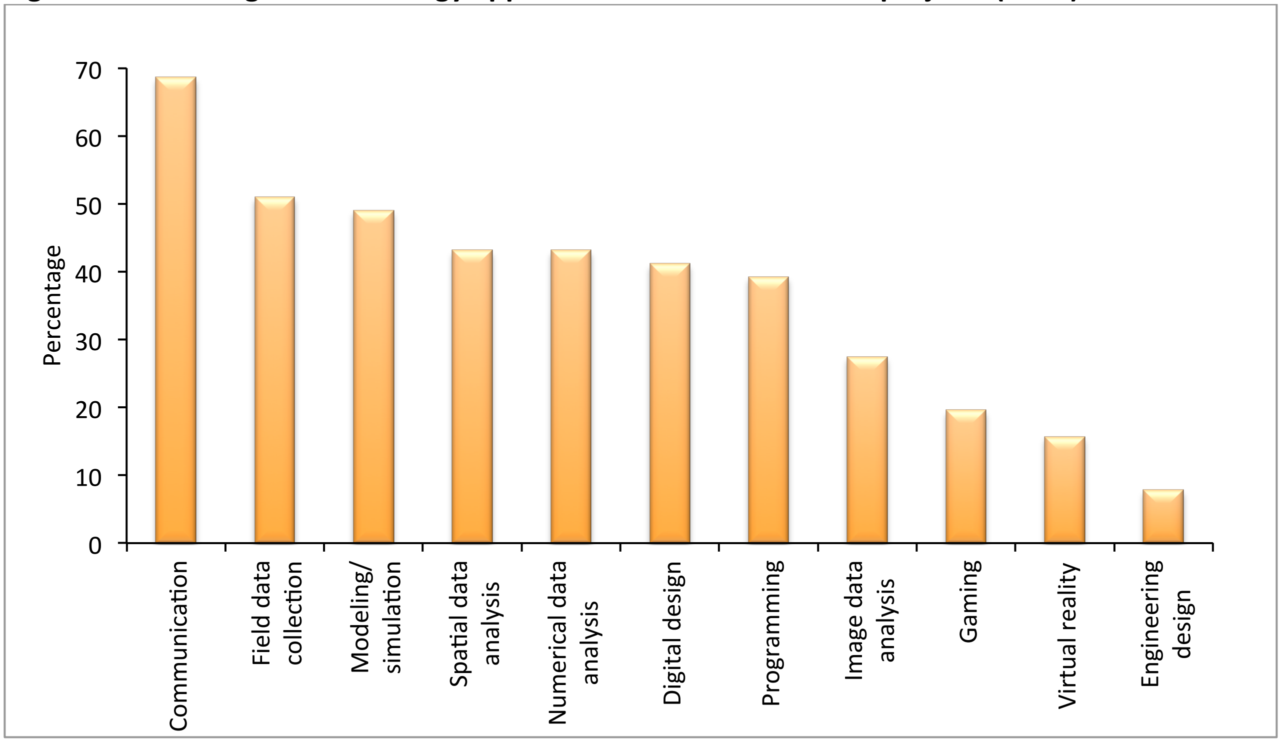

Figure 2: Percentage of ITEST PIs (n=51) who emphasized the following in their teacher profession development projects

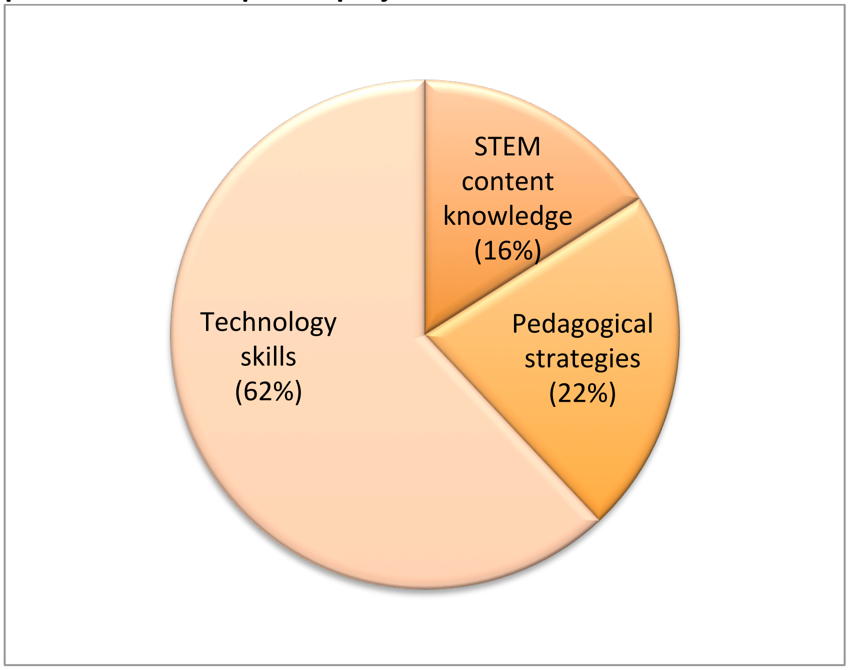

Figure 3: Percentage of ITEST PIs (n=51) who strongly agreed or agreed that their project was most effective in promoting changes in teacher practice when their professional development…

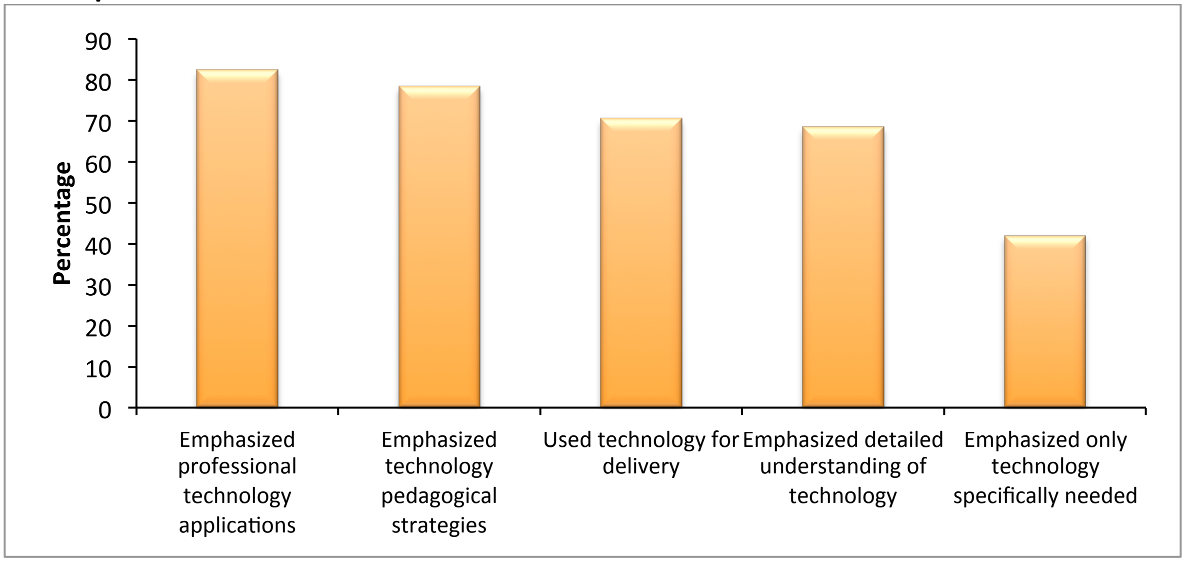

Figure 4: Percentage of ITEST PIs (n=51) who strongly agreed or agreed that their project was most effective when their curricular materials

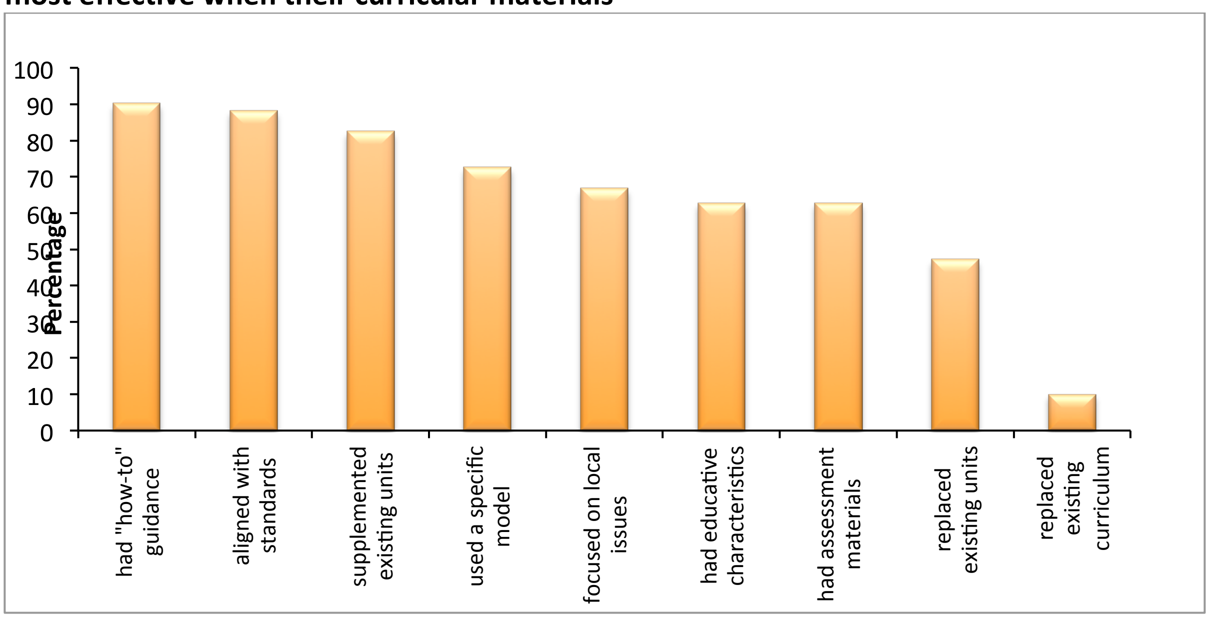

Table 1: Correlations between the original two PI-identified teacher roles (from survey) and other project elements (Likert-scale items in the survey)

Items organized by thematic groups	Pearson correlation (point bi-serial)
Collaborative practices (6 items)	-0.08 to 0.13
Curricular materials (9 items)	-0.22 to 0.13
STEM careers focus (8 items)	-0.35 to 0.06
Technology integration (6 items)	-0.33 to -0.12
Youth interactions with teachers (9 items)	-0.29 to 0.15