Transforming Teaching through Implementing Inquiry (T2I2): Professional Development That Meets the Needs of Technology and Engineering Teachers

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Introduction

There is limited pre-service and in-service professional development opportunity for technology and engineering teachers and the professional development that is provided is far less comprehensive than that of other disciplines (NAE, 2009; NRC, 2011). The lack of Technology National Board certified teachers identifies a need for an enhanced pipeline for these educators (NBPTS, 2011). This need and limited professional development opportunity were the impetus behind the development and implementation of the *Transforming Teaching through Implementing Inquiry* (T2I2) project.

T2I2 delivers a research-informed, interactive, object-oriented and networked cyber infrastructure that supports professional development for technology and engineering teachers. This four-year research and development project (2011- 2015) was built upon professional learning frameworks, developed and refined within prior studies such as

Visualization in Technology Education (VisTE) and the Tech-Know Project, that used state of the art course/content management and collaboration software to provide clear, challenging, connected, and coherent professional development for educators that encourages critical reflection on practice and self-evaluation (Ernst & Clark, 2007; Ernst, Taylor & Peterson, 2005; Mundry, 2007; NRC, 2011).

T2I2's flexible and practical professional development curricular units transform teacher practice through topics that parallel many of the National Board for Professional Teaching Standards (NBPTS). This inquiry-based coursework was developed by a team that included National Board Certified teachers, teacher educators, and K-12 educators who specialize in technology and engineering education. Participating teachers are introduced and prepared for work toward National Board Certification through the partial completion of required written and video artifacts as tasks within the modules. These five research questions framed this study to explore the applicability in the advancement of teacher knowledge and practice:

> RQ#1: To what extent is teacher ability to *manage learning environments* supported by using T2I2 professional development materials?
>
> RQ#2: To what extent is teacher ability to *monitor learning environments* supported by using T2I2 professional development materials?

RQ#3: To what extent is teacher ability to *adjust learning environments* to improve instruction supported by using T2I2 professional development materials?

RQ#4: To what extent is teacher ability to *contribute to the learning community* supported by using T2I2 professional development materials?

RQ#5: To what extent is teacher ability to *increase teacher self-assessment* supported by using T2I2 professional development materials?

Methodology

This four-year project began with the development of resources and a web-based cyberinfrastructure. Work was informed by teacher-identified and research-based areas for improvement, resulting in the design of eighteen learning objects organized within four units. This coursework, paralleling many themes and requirements of National Board Certification in Career and Technical Education, addresses best practices in teaching within a technology and engineering context. The T2I2 team also developed enhanced *Engineering by Design* (EbD) middle and high school units for teacher implementation.

Pilot testing of the learning objects was conducted in years 2 and 3 with in-service teachers from the project's five-state region (Illinois, Kentucky, Ohio, North Carolina, and Virginia). Upon the completion of each unit, teachers completed required written and video artifacts as evidence of their learning and practice. The artifacts, similar in design to National

Board Certification artifacts, but scaled down in proportion, align to the five research questions and are identified within Table 1.

Table 1
Artifacts Aligned with Research Questions

Research Question	Module	Artifacts
RQ#1: To what extent is teacher ability to *manage learning environments* supported by using T2I2 professional development materials?	Demonstration Lesson	Entry 2.1 --Video Capture #1
RQ#2: To what extent is teacher ability to *monitor learning environments* supported by using T2I2 professional development materials?	Fostering Teamwork	Entry 3.1 – Video Capture #2 Entry 3.3 – Written Commentary #2
RQ#3: To what extent is teacher ability to *adjust learning environments* to improve instruction supported by using T2I2 professional development materials?	Assessment of Student Learning	Entry 1.4 – Written Commentary #3
RQ#4: To what extent is teacher ability to *contribute to the learning community* supported by using T2I2 professional development materials?	Demonstration Lesson	Entry 2.3 – Written Commentary #1
RQ#5: To what extent is teacher ability to *increase teacher self-assessment* supported by using T2I2 professional development materials?	Documented Accomplishments	Entry 4.1 – Description and Analysis

A National Board Certified teacher-assessor scored all artifacts using a four-point criterion-referenced rubric to measure teacher ability in

managing a learning environment, monitoring a learning environment, adjusting a learning environment to improve instruction, conducting self-assessment, and contributing to a learning community.

Data Analysis and Findings

Data from the pilot studies was collected and analyzed as a test of hypothetical value conducted using the non-parametric Wilcoxon-signed-ranks Test to determine the teachers' abilities to monitor, manage, and adjust learning environments, contribute to learning communities, and increase self-assessment. A median ≥ 3 with 3 indicating a proficiency level, as described and determined by NBPTS, was set as the specified parameter for this study. The results of the data analysis for each of the five research questions are displayed in Table 2.

Table 2
Wilcoxon-signed-rank test of hypotheses

Research Question	n	n for test	Median Est.	Wilcoxon Stat.	*p-value*	Method
RQ1	33	18	3.5	126	0.9476	Norm. Approx.
RQ2	33	24	3	88	0.9444	Norm. Approx.
RQ3	39	32	3	279	0.2377	Norm. Approx.
RQ4	37	26	3	67.5	0.9982	Norm. Approx.
RQ5	33	21	3	77	0.8684	Norm. Approx.

The Wilcoxon-signed-rank tests were employed for ordinal data with a sample size less than 50. The number of instances for each test varied according to the number of constructs within each variable. Directional hypotheses of H1: $\Theta \geq 3$ were tested. The researchers failed to reject each hypothesis at p=0.05 and concluded that teacher ability to monitor, manage, and, adjust the learning environment, to contribute to the learning community, and to increase self-assessment were supported by using T2I2 professional development materials.

Learning Objects within the four units were modified and improved following the collection and analysis of teacher user and access data. Participants' time-on-task, pretest and post test scores, as well as the teachers' access data focusing on total unit view, average unique unit views per day, and average time spent on the unit provided valuable formative assessment for curriculum refinement.

Many aspects of the study, from the number of pilot teachers to the Learning Objects' content, were revised the summer between Year 2 and 3. Two of the four units, *Assessment of Student Learning* and *Documented Accomplishments*, received major revisions and are the basis of the Year 4 field study. Iterative design propelled by teacher reflection and feedback, resulted in ongoing improvements and modifications for each phase of this study.

Conclusions

There is evidence, based upon this study's data analysis, that the sample population of teachers who completed the T2I2 professional development were supported in their ability to manage, monitor, and adjust learning environments. Data also supports that this sample group increased their ability for self-assessment and their contributions to the learning community.

The design and delivery of T2I2 offers technology and engineering teachers' flexible and practical professional learning experiences that transforms teacher practice and can be applied immediately and directly into classroom instruction. The coursework and technology provides succinct and focused self-paced, job-embedded learning that can be immediately applied to improve teacher practice. T2I2 responds to more demanding professional standards and evaluations placed upon teachers; increased political pressure to improve student learning outcomes; and the comparison and ranking of schools, school systems, programs, and teachers. The learning modules were framed by National Board for Professional Teaching Standards, but were more fully developed through collaborative work of STEM education professionals to incorporate science, technology, engineering and mathematics content and practice learning

experiences for both teachers and students, increasing the focus on integrated STEM Education.

Completion of the T2I2 modules broadens technology and engineering teachers' understanding of the integration of STEM content and practice, preparing the teachers to deliver more integrated STEM instruction. This is an area for future studies, not only for the field of technology and engineering education, but for all related STEM fields.

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