The Promotion of a Revised TPACK Model (TSPACK): Lessons Learned from the Foundry Inspired Steelcase Active Learning Space Project

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Abstract

The purpose of this contribution is to introduce an even more inclusive version of the Technological, Pedagogical, Content Knowledge (TPACK) Framework[1,2] that integrates Space as a fourth component necessary for the promotion of innovation-driven learning. This version evolved from the lessons learned during a project by the Renaissance Foundry Research Group (RFRG) at Tennessee Technological University (TTU) with support from Steelcase, Inc. Through funding in the form of a Steelcase Active Learning Center grant designed to support development of active learning spaces, the RFRG developed a learning environment representative of the Renaissance Foundry Model (herein the Foundry).[1] The outcomes of the efforts provide insights regarding the importance of integrating space along with technological resources and novel pedagogical approaches to improve student acquisition of content knowledge. Conception and implementation of the approach are discussed and illustrated.

Keywords

Renaissance Foundry, TPACK Framework, Space, Innovation-Driven Learning

Introduction

The original Technological, Pedagogical, Content Knowledge (TPACK) framework was proposed as a model that integrates socio-techno-pedagogical-content knowledge for the development of effective learning environments.[2,19] The purpose of this contribution is to introduce an even more inclusive version of the TPACK Framework[1,2] that integrates Space as a fourth component necessary for the promotion of innovation-driven learning. This version evolved from the lessons learned via the implementation of a Steelcase Active Learning Center (ALC) grant by the Renaissance Foundry Research Group (RFRG) at Tennessee Technological University (TTU). The grant awarded to the university was selected during a highly competitive funding cycle in 2016. A goal of such funding is to support academic institutions at the k16 level in efforts to transform physical learning spaces into active learning environments.[4] Through these efforts, the RFRG sought to advance the implementation of innovation-driven pedagogy by integrating novel strategies that leverage integration of knowledge domains. As part of this challenge, the RFRG had the opportunity to develop a space (now referred to as the Foundry Steelcase Active Learning Studio, SALS] designed to facilitate the implementation of the innovation-driven learning platform, the Renaissance Foundry (herein the Foundry), that it has been working to develop.[3] In the following, we detail the process that led to the reconceptualization of the TPACK framework as delineated by our experiences in the creation, development, and use of the Foundry SALS. We refer to this reconceptualization as TSPACK with the Space (S) component designating the role of the space as an equal factor within the framework. The outcomes of these efforts provide insights regarding the importance of integrating space along with technological resources and novel pedagogical approaches to improve student acquisition and transfer of content knowledge. Conception and implementation of the approach, including the benefits of use via faculty, student, and interdisciplinary research perspectives, is discussed and illustrated.

Background

Innovative Learning Spaces

As the culture of postsecondary education shifts more towards active learning, discovery processes, and collaboration across disciplines, a space that fosters discussion and the exchange of ideas is invaluable to creating an active learning environment centered on the facilitation of such interaction.[5,6,7,8] This argument is not new – rather, it has been the focus of discussion of various scholars focused on enhancing curricula and learning processes via the utilization of space as an essential component of innovative learning environments.[5,6,9-11,12] Within academia content re-design that integrates active learning compels a shift from the traditional classroom space to one more readily embraced by Scott-Weber's[6] aforenoted description. In two recent studies - one at the postsecondary level[5] and another at the high school level[13] - scholars utilized a Post-occupancy methodology to research student, teacher, and faculty perceptions of the impacts of physical space on overall engagement and learning outcomes. The results were similar and indicate that physical environment does indeed matter with respect to student, teacher, and faculty engagement[13,14] Further, Neill and Etheridge[15] make the claim that in order to effectively support pedagogical innovation, the reevaluation of the physical space that is utilized as part of the curricular redesign is warranted to foster student engagement, collaboration, flexibility and overall learning.

The Foundry Model

Set within the current postsecondary push for the incorporation of active and inquiry based, student-centered learning approaches, the Foundry is a pedagogical platform that addresses these needs via the re-design of curricula founded on a powerful dynamic that fosters students critical and creative thinking skills.[8,16] The Foundry was created by the RFRG - an interdisciplinary research team that incorporates the expertise of faculty members from various disciplines including Chemical Engineering, Education, Nursing, Business, and Interdisciplinary Studies.[3,16] It is an innovation-driven pedagogical platform that incorporates two student-centered learning paradigms (i.e., Knowledge Acquisition and Knowledge Transfer) in an iterative process that takes students through six-steps that culminate in the creation of a prototype of innovative technology.[3] The primary objective of the Foundry as applied to Chemical Engineering courses at TTU is to promote the development of a holistic type of engineering professional that encompasses both content specific training and cross-disciplinary skills (e.g., creative and critical thinking, problem solving, communication, etc.) that are reflective of inquiry- and active-based approaches to learning.[3,7,17,18] Due to the fluid and constant activity required by the Foundry as a pedagogical platform, we note that Space, and its effective utilization as a primary component of the learning process, is vital in assisting students to change the dynamic of their learning to a more student-centered, active learning environment.[3,5,6]

Revising the TPACK Model to TSPACK

The original TPACK Framework acknowledges that three major components for the promotion of effective learning (i.e., Technology, Pedagogy, and Content Knowledge) must work as a cohesive whole within the curricular design, building on one another and not simply working in parallel.[12] The model was initially proposed as a theoretical framework for knowledge used by teachers (or teacher trainers) to design a socio-techno-pedagogical-content centered learning environment.[2,19] Three types of knowledge comprise the TPACK framework: pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK).[1,20] These conceptualizations of new knowledge are reflective of the overlap between the three major constructs of this model.[2,20] The premise of the framework therein posits that the integration of technology as essential to the advancement of pedagogy and content knowledge and technological knowledge will generate new, enhanced socio-techno-pedagogical student learning environments.[2,19,21]

In subsequent versions of the framework, space has been identified as a fourth component; however, it is often depicted as an external element that never reaches the core intersections between technology, pedagogy, and content knowledge.[22,23] In such models, space is not necessarily envisioned as an interactive element of the framework (see Figure 1). In the revised four-dimensional model introduced in this work, we argue that the learning environment (i.e., the Space) is both enhanced and enhances the pedagogy, content, and use of technology via the Foundry platform to create an integrated innovative learning experience[3,6]. This places Space on par with the previous central three elements of the TPACK framework and reconfigures the catalytic center for learning within the intersection of all four elements, rather than the aforementioned three (see Figure 2). We thus argue that the use of Space in combination with the Foundry platform, collaborative learning content, and fully integrated technology provides a more in-depth learning experience than the traditional TPACK Framework. In short, we have added a fourth dimension of knowledge to the framework centered around the role played by Space in student learning within an innovation-driven platform; this component is denoted simply as Space Knowledge.

As noted, the Foundry provides a pedagogical framework that incorporates the three elements of the original TPACK Framework (i.e., Technology, Pedagogy, and Content Knowledge) by providing a strategy for delivering the content knowledge to students through innovative pedagogy and promotes technology not only through implementing technology in the classroom but also by tasking students with applying the Foundry to a course project to enhance their problem identification and problem-solving skills through the creation of a prototype of innovative technology. Previous studies[16,24,25] provide evidence that the Foundry effectively

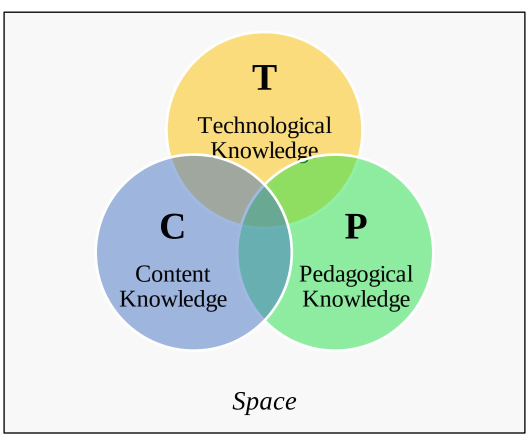

Figure 1. An Illustration of the Original TPACK Framework

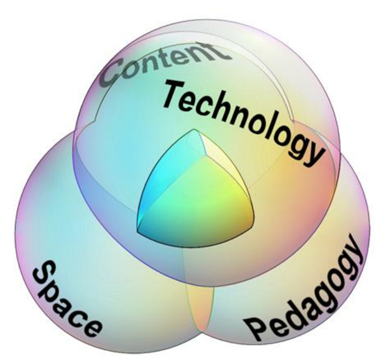

Figure 2. Revised TSPACK Framework

transforms content and pedagogy via a learning environment that leverages a strategy in which individuals, within groups, become primary problem identifiers and solvers in their quest to formulate a prototype of innovation as the proposed solution to the challenge initially identified.[3] Such a process not only requires active collaboration among individuals (*e.g.*, through the Linear Engineering Sequences of the Foundry), but also movement - both physically among individuals as members of teams and cognitively via the active exchange of ideas - to make new connections that lead to the creation of a prototype of innovative technology.[3]

The Foundry SALS

The Steelcase Active Learning Studio (SALS) in the Department of Chemical Engineering (CHE) at TTU integrates space, technology, and the Foundry pedagogical platform to maximize student learning.[3,4] With support from Steelcase and from TTU, the studio occupies a once-outdated space (780 ft^2) that has been remodeled with new paint, carpeting, ceiling tiles, window treatments, and electrical connections. It has also been resourced with mobile furniture and tools designed to facilitate active learning, including: six, flexible, half-oval tables intended to be moved to adjust to team-based activities; rotating chairs designed to actively transform to facilitate team-based movements (e.g., individual rotation, change in altitude, and movement across the room); various storage bin stations placed to house a multitude of implementation tools necessary to explore topics via other mediums (e.g., items for experimentation, simulation, prototype design); a computational work station with projection capabilities to help assist with the distribution of ideas via an electronic medium; a smartboard interface to maintain active interaction with this electronic medium; and fixed, as well-as portable, dry erase boards designed to capture the exchange of team-based ideas to facilitate the interpretation and integration of the distinct, similar, and dissimilar elements of these interactions (Figure 3). The studio comfortably accommodates 24 individuals with ample space and elemental tools to seamlessly shift between both individual and team-based activities. Due to its focus on collaboration and active learning, the Foundry SALS has been used extensively for educational activities, various meetings, and in outreach efforts.

Figure 3. Design Concept of the Foundry SALS

Illustrations of Use of the Room

For Faculty

From the faculty perspective, the Foundry SALS offers instructors the capability of transforming the learning environment into an essential part of the curricula by providing an avenue in which to engage in *praxis*-the incorporation of theory into practice.[26] For example, a vital part of the Foundry centers on collaboration as a form of knowledge construction where students are making connections from previous knowledge acquisition and transferring the knowledge for a given application.[3] In creating curricula for this purpose, student discussion is critical for such cognitive iteration to occur. Traditional classrooms, based on teacher-centered strategies,[5,6,15] limit student discussion and interaction as the typical layout physically silos students into individual spaces and creates barriers within the learning environment by not encouraging interaction. By eliminating the barriers to these student silos, the Foundry SALS places students in naturally-formed groups, which encourages the type of interaction fostered by the Foundry.[3] Due to this formation, students have been observed to eventually take charge of their own learning in discussion through their peers instead of focusing solely on the ideas and knowledge of the instructor. This is also evidenced by the student perspective, illustrated below.

For Students

As one example, the Foundry SALS was used in the Spring 2018 semester as part of efforts to test a *lateral thinking-focused pedagogy* within the Foundry for developing problem solving skills in students enrolled in a senior-level, biomolecular engineering course.[3,27] This pedagogical approach involved challenging student teams to identify a problem and to solve the problem using multiple techniques such as: 1) a thought exercises (*i.e.*, thinking about the problem and proposing a solution); 2) an analytical solution methodology; 3) experimentation, and 4) simulation. Students self-assembled into teams representing varying qualifications. Through their program of study, students were previously trained and familiar with the Foundry model. Preliminary observations from this semester reflect a highly effective integration and utilization of the space as reflected in the revised TSPACK framework.

Key data points that support our preliminary observations are as follows. The lateral thinking pedagogical approach was modeled in the class/lab through technical problems which ranged in difficulty presented by the instructor. Teams were then challenged to both propose/identify and solve these problems using a thought exercise and at least one other of the techniques described above. The network capabilities within the SALS allowed students to develop experience in the use of the COMSOL® Multiphysics software (for simulations). The Foundry SALS was also appropriate for thought exercises, development of analytical solutions, and completion of simple experiments. Problem statements that were identified/developed ranged from modeling mass transport in the kidneys to heating of fluid traveling through the heart. Three of eight teams used three of the problem-solving techniques that were emphasized by the instructor while the other five teams solved problems that they identified using two of the techniques mentioned. Upon further refinement, the goal is that teams will be able to use all four techniques as we continue to learn to use the Foundry SALS.

When asked to provide thoughts regarding which of the four problem solving approaches were most helpful, students in this course indicated that all four approaches were effective with thought exercises and simulation selected with a higher frequency (see Figure 4).
Both approaches can be explored extremely well in the Foundry SALS. For example, thought exercises can be more fully explored using the dry erase boards, prompts provided by the instructor, and reflections from students. The ability to access software remotely while in the Foundry SALS also provides a robust portal through which simulations can be explored. A significant amount of time was spent during the semester on this, and efforts will be pursued to further increase students' interaction with the software to solve problems and to explore the effects of changes in the problem statement on a solution. Finally, the analytical solution methodology can be completed effectively in the Foundry SALS, and experiments were

conducted there as well. The results as indicated above were highly favorable, with comments indicating utility in all four approaches and suggestions also being made for improving the approach. The ability to effectively leverage Space Knowledge as a new dimension of the framework is currently an ongoing area of exploration.

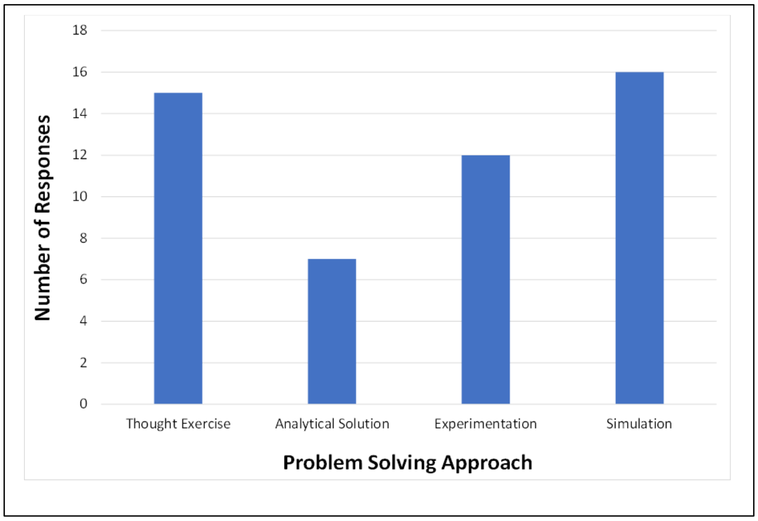

Figure 4. Frequency of responses regarding the most helpful problem-solving techniques

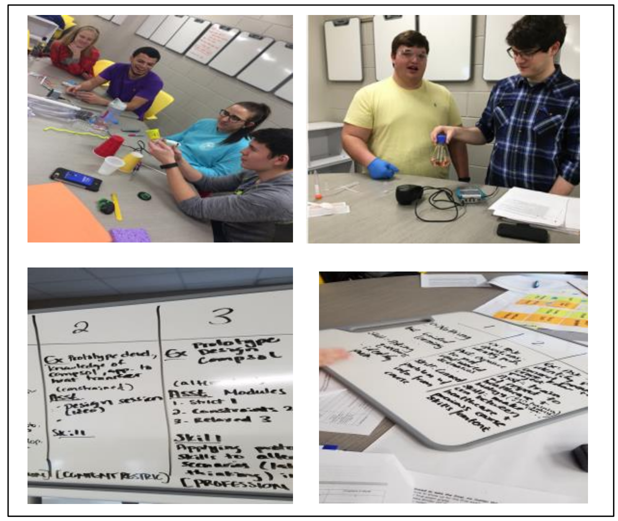

Figure 5. Student and Research use of the Foundry SALS

For Interdisciplinary Research

The Foundry SALS room has also been effectively utilized as the primary space for the development of various educational and research proposals to enhance innovation-driven learning strategies. Several interdisciplinary groups at TTU use this room as an environment conducive to brainstorming, exchanging ideas, and collaborating on these multi-faceted projects. As these groups are interdisciplinary in nature, it is necessary to transcend disciplinary boundaries through effective communication strategies for the development of new ideas[6,15]. The inflexibility of a traditional classroom layout would not easily facilitate the type of communication and active learning experiences necessary for a collaborative project of this nature to develop organically.[5,6] As the Foundry is based on team collaboration, the Foundry SALS is an ideal space for such implementation.[3] For example, the room is a catalyst for fostering the identification and exchange of ideas at the nascent stages of these projects, through the use the technology that is available in this space including: the portable, individual whiteboards, the smartboard, and the round tables that facilitate the conversation with different members of the groups.

Implications and Future Work

The purpose of this work was to provide background and detail the process of our reconceptualization of the TPACK framework from lessons learned from the design, creation, and utilization of the Foundry SALS. Based on our experiences and observations, we posit that wherein the Foundry platform provides a framework in which to develop the curriculum and activities around this type of interaction, the Foundry SALS provides for the effective delivery of this interactive content.[3] In future uses of the space, we will continue to explore additional ways to enhance the use of space as part of the TSPACK framework.

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