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Technological Pedagogical Content Knowledge (TPCK): A Conceptual Framework with Examples for Integrating Technologies into Teacher Education

Bridging Digital and Cultural Divides: TPCK for Equity of Access to Technology

Mario Antonio Kelly

Hunter College
City University of New York

Abstract: This paper has three major objectives: 1) to elaborate on the TPCK framework (Mishra & Koehler, 2006; Koehler & Mishra, 2008) by discussing the interaction of the teaching-learning context with technology, pedagogy and content; 2) to describe, based on an extensive review of the literature, the multidimensional nature of the digital divide; and 3) to apply the TPCK framework to bridging digital and cultural divides.

Introduction

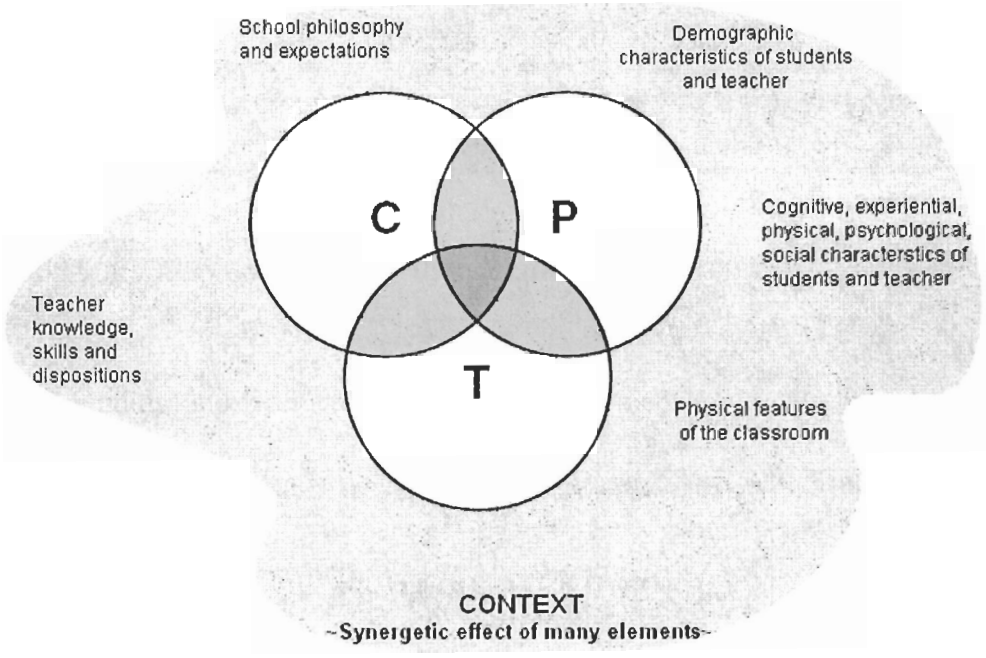
Cultural, socioeconomic, ethnic and linguistic characteristics of students play an important role in achievement, interacting with instruction, the curriculum and other factors, often to the benefit of some students and the disadvantage of others. The use of technology in teaching does not automatically neutralize these differences, and in fact has the potential to exacerbate them. This is particularly true when students have different levels of access to technology outside of the classroom, and different levels of prior experience using technology. An important goal of the TPCK (a.k.a. TPACK) framework (Mishra & Koehler, 2006; Koehler & Mishra, 2008) is that teachers use it to design instruction that is effective with all children. This paper discusses the component of the TPCK framework designed to achieve this goal and illustrates the application of this component to the issue of equity of access to information and communication technology.

The Context

The teaching-learning context (hereafter referred to as *the context*) is the component of the TPCK framework that addresses the role of factors beyond technology, pedagogy and content in the teaching learning process. The context is depicted as the

area surrounding and interacting with technology, pedagogy and content (see Figure 1 below).

Figure 1: TPCK Context
Kelly (2008, p. 51).



The context includes physical elements, such as the size and learning-conduciveness of the room, the quantity and quality of technology and other resources available in the classroom, and the arrangement of furniture. See Kelly (2008b) for a discussion of these factors.

Perhaps most important for the discussion of equity of access to technology, the context also includes demographic characteristics and other individual differences of students, including their ethnic, socio-economic, cultural and linguistic backgrounds, as well as their physical, cognitive, social and psychological characteristics. All of these play an important role in instruction. The prior experiential characteristics of students,

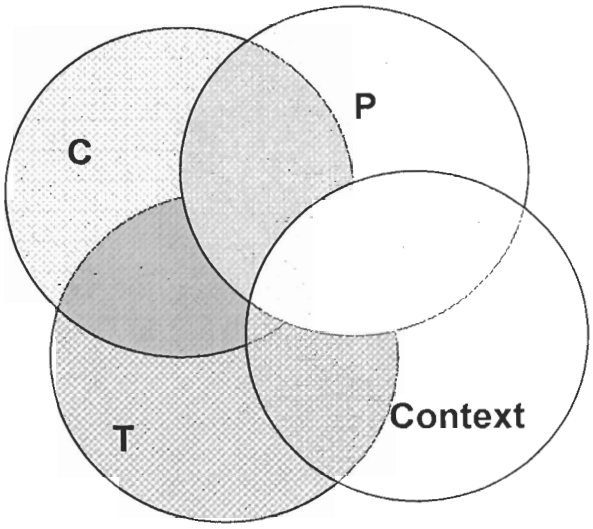
especially their technology experiences, constitute another set of context factors that are particularly relevant to the present discussion of equity of access to technology.

Teacher demographic characteristics, as well as teacher knowledge, skills and dispositions are also major context elements. So are the characteristics of the school, such as its philosophy, and its explicit and tacit expectations of parents, teachers, students and administrators.

Each TMI situation has its own context, and that context is much more than a mere setting for the unfolding of teaching and learning with technology, and more than the sum of the above stated factors. It is the *synergetic effect* of the combination of those factors in a unique class of students and teacher. All of these factors interact with one another and with technology, pedagogy and content in a complex way, affecting the psycho-social perceptions, motivation and learning behavior of individual students in a class. The synergetic effect is unique to each TMI situation; so unique that even the presence or absence of individual members of the class on a given day can alter the context and thereby the learning that occurs (Kelly, 2008a). The synergetic effect of the elements in the context is of central concern in the discussion of equity of access to technology, especially the effect on psycho-social perceptions, motivation and learning behavior.

Since the context is not merely added to the other components of the TPCK framework, but rather interacts with them, another way to think of the context is as a fourth body of knowledge—in addition to technology, pedagogy and content—that teachers should master. Moreover, teachers should be able to effectively incorporate this knowledge into instructional design (see Figure 2 below).

Figure 2: TPCK & Context Knowledge
Kelly (2008a, p. 54).



When the context works in students' favor it enhances their self-esteem, their sense of self-efficacy and their motivation to achieve. The result is likely to be high levels of student engagement, as well as leaning behavior that includes risk-taking, an important element in active, constructivist learning. The opposite can result when the context does not work in students' favor.

Given that the vast majority of American classrooms are made up of students from different backgrounds there is always the potential for the context to give some students an advantage, while placing other students at a disadvantage. The latter are usually the students from ethnic, cultural, and/or linguistic minority groups and those from low-income families. It is up to the teacher to level the learning field through good TPCK instructional design that manages the context well. That includes mining the context for its affordances while overcoming its constraints. Multiple issues can be salient in the context and require a teacher's attention. For example, differences among students in the

quantity and quality of their prior experiences with technology may be a salient context issue in some college classes. Such differences are often an age related cohort effect—students born after 1982 have had greater exposure to technology than students born earlier (Prensky, 2001; Kelly, 2008b). Similarly, in some elementary school classrooms with limited technology a salient context issue is the physical placement of computers in the classrooms (Kelly, 2008b). The focus of the present discussion is within class student differences in access to computers and other technology as well as student differences in cultural, ethnic, economic and linguistic background.

The Context Applied to Equity of Access

There is much that teachers should know about equity of access to technology if they are to design TPCK-based lessons that are effective with all students. This knowledge starts with the term "the digital divide", which has become synonymous with inequity of access in both the academic and lay literature. The term "digital divide" reduces the issue of equity to a simple binary problem: some people have access and others do not. However, teachers need to know that this is an oversimplification of a more complex reality, as discussed below. They need to know that the meaning of the term "digital divide" continues to evolve; that there are multiple digital divides (Attewell, 2001; Technology Counts, 2001; Gunkel, 2003); and that as teachers they need to be knowledgeable about, and have strategies for effectively responding to at least three of these divides (Kelly, 2008a). These are discussed below.

The First Digital Divide: The first digital divide refers to an actual physical divide between those who have information and communication technology (ICT), such as

computers, scanners, camcorders and access to the Internet, and those who do not. It is what most people think of as *the* "digital divide." The meaning of that term has evolved from its initial use to distinguish those who have access to computers from those who do not, to its present use to distinguish those who have the highest level of technology from those who have the lowest level and those who have broadband or high speed access to the Internet from those who do not (U.S. Department of Commerce, 2002, 2004). The first digital divide is about the fact that some families have greater, better, faster access than other families at home, at work, and at school. Despite the occasional rumors about its demise there is ample evidence of the continued existence of the first digital divide (e.g. U.S. Department of Commerce, 2004).

From an instructional perspective there are at least three reasons why the first digital divide matters:

- Children need physical access to complete homework assignments requiring ICT. Such assignments are becoming increasingly common, and even when assignments do not specifically require ICT access, students who have such access have an advantage over students who do not.
- Physical access has been associated with higher ICT literacy. In the 21st century this is rapidly becoming as important as reading-writing literacy.
- Broadband access to the Internet at home has been associated with higher Internet engagement, more frequent Internet use and decreased television watching; all potentially beneficial for ICT literacy, reading-writing literacy, and success in today's economy.

There are some basic facts that teachers should know about the first digital divide and should factor into their design of instruction that incorporates technology. In other words, teachers should know these facts and develop instructional strategies for responding to them. Perhaps the most critical of this knowledge for teachers is that the digital divide is not a simple binary issue of some students having access and some not. Such a simplification of the issue can lead to complacency in the sense that short of government intervention, there is nothing to be done about the inequality.

The reality is more complex. Children who lack physical access to technology at home often can gain out of school access in other ways, such as at local libraries and community centers. Teachers can and should identify such facilities and work with them to secure access for disadvantaged students. Many such facilities welcome the collaboration with teachers. Furthermore, teachers should enlist the assistance of the children's parents, who are often knowledgeable about such facilities in their communities (Wilson, Wallin, & Reiser, 2003).

The Second Digital Divide: It involves students having access to technology mediated instruction (TMI) that actually enhances their achievement. Unfortunately children from minority groups often attend schools that do not provide access to such instruction. Even within schools and classrooms that provide such instruction children from minority groups often experience a different reality. A variety of factors—including the students' often limited access and limited prior experience with technology, lower academic achievement and teacher perception of their abilities—conspire to result in minority students having a different learning experience with technology than their majority peers. This is an experience in which drill and practice exercises on the

computer are more prevalent—and a lot less motivating—than the challenging, multipart, constructivist, technology based projects assigned to peers.

The critical second digital divide issue that should be salient for teachers is that it is not unusual for children within the same classrooms to have quite different experiences with technology—some using it for boring drill and practice, others for exciting, engaging projects. Often this difference is the result of the best intentions of teachers gone awry. Trying to help academically struggling children, teachers give them a lot of drill and practice computer exercises. In contrast academically successful students are given multi-part projects that are challenging and engaging. The likely result is increased motivation for the latter group, decreased motivation for the former group.

The Third Digital Divide: It involves students having access to technology mediated instruction that is culturally sensitive. This can be conceptualized as multicultural education updated for the digital age. The basic issue is whether instruction mediated by technology is culturally compatible, or at least culturally sensitive to the backgrounds of individual students. For many middle-class and White students instruction, including technology mediated instruction, is more consistently culturally compatible than is the case for many minority and low-income students.

Like "the digital divide," the variable *culture* has often been oversimplified when applied to teaching-learning situations. While culture has been defined in numerous ways--see for example Geertz (1973) and LeVine (1972)—most definitions include at least three components (Bodley, 1994): 1) the material products or artifacts that people produce, including foods and dress; 2) how people behave (for example, whether or not it is normative in the culture for individuals of different status to maintain eye contact; and

3) how people think, their mental processes, including learning styles, and what people believe, their values and belief systems. In the classroom each of these three components corresponds to an aspect of cultural sensitivity that has to be addressed if students are to be treated equitably. One of the shortcomings of the implementation of the multicultural education movement, in this author's opinion, is that teachers focused most of their attention on the first aspect, sometimes referred to as the surface level of culture (Kinsler, Romero, Kelly, Graves, Mercado, 1991), and decreasing amounts of attention and energy to the increasingly deeper and more difficult to manage second (behavioral level) and third (deep values level) of culture. We run similar risks with instructional technology.

It is easy to assume that technology, and by extension teaching with technology, is culture-free, because at the surface level they appear to be. Neither is inherently so. Technology hardware and especially software choices involve cultural choices. Moreover, the mere presence of technology as part of a lesson does not neutralize the many other behavioral level and deep values level cultural elements present in the lesson. Indeed, if a teacher is not careful, technology has the potential to exacerbate these elements. Therefore it is important that teachers explicitly incorporate strategies for addressing this issue into their design of instruction.

Among the relevant third digital divide issues teachers need to consider is whether software systematically excludes some demographic groups, or portrays others in a negative way. Teachers also need to consider whether consistently, across the semester or the academic year, the software is more compatible with the behavioral level and/or deep values level cultural characteristics of majority students, but not of other students. These issues are addressed more specifically below.

Designing Instruction for Equity of Access

At least three assumptions/guidelines for designing instruction that incorporates technology can be derived from the TPCK framework:

Teaching with technology is a wicked problem. Teaching, and even more so teaching with technology, is an example of what Rittel and Webber (1973) referred to as "wicked problems" (Koehler & Mishra, 2008). In general, wicked problems have several distinctive features. 1) They are unique and situation-specific, each wicked problem different from other similar problems. 2) They are ill-structured, comprising many elements interacting in idiosyncratic ways. 3) Because of their uniqueness, wicked problems, even apparently similar ones, defy solutions that consist of prefabricated strategies; requiring instead tailor-made solutions. In addition, wicked problems of teaching often arise while teachers are actively engaged in instruction, requiring an immediate solution. Given the complexity of the context described above, it seems quite appropriate to describe teaching, including teaching with technology, as a "wicked problem."

Teaching with technology—the problem for teachers of how to best use technology to help students learn a lesson — is a wicked problem. It is ill-structured; it is subject area and situation specific; it is unique in that even two teaching problems that appear identical are likely to be different in subtle ways. For example, the problem of how to best teach math with technology is in many ways different from the problem of how to best teach social studies with technology.

Much of the "wickedness" of the problem of teaching with technology can be attributed to the context. The synergetic mix of the lesson content, the technology and other resources for teaching the lessons, the teacher's characteristics, and the intellectual, social and psychological characteristics of the students in a math class makes the context of that class different from the context of even other math classes. Indeed, the mere presence or absence of individual students on any given day can make a difference. Therefore, the problem requires a solution custom-made for that context, and TPCK, if it is to be an effective solution, must accommodate to such context elements.

Solutions to context problems often have to be improvised. Because wicked problems can arise while teachers are actively engaged in the act of teaching, teachers are frequently challenged to *vividly construct solutions at the moment of enactment.* This concept, modified from speech theory, means that the teacher has to actively develop appropriate solutions at almost the very instance that they are required to respond to a problem, and the response has to be specific and appropriate to the synergetic effect of the of elements in that context. While the teacher may be able to select from a menu of prefabricated or "canned" strategies, at a minimum these have to be tweaked on the spot to fit the current context. It is not uncommon for teachers to have to construct original solutions from scratch on the spot. This requires engagement at the application, analysis, synthesis and evaluation levels of Bloom's taxonomy for the cognitive domain (Bloom, B.S., Engelhart, M.D., Frost, E.J., Hill, W.H., & Krathwohl, D.R., 1956), sometimes in a matter of seconds.

It is not inconsistent with the above assumptions that teachers need to think ahead about the contextual affordances and constraints of their specific classrooms and have

instructional strategies available to respond appropriately. Of course, teachers must also embrace a willingness to refine and tweak these strategies as necessary. Below are possible strategies for bridging digital and cultural divides and providing equity of access to technology. They constitute responses to the three digital divides described above.

Strategies for Bridging the First Digital Divide

1. Work with school administrators to secure after school access to school ICT. Where schools have up-to-date technology, especially a computer laboratory, it may be important to work with administrators to secure after school access with technical and academic support. Even well intentioned administrators may not spontaneously see the need.

2. Work with parents and others to identify public ICT facilities in the community. Develop a list of resources (e.g. after school programs) that are close to the school or student's homes that can provide access for those who lack it at home. Managed and/or supported by a community-based organization, a local civic group, or business, such facilities can be found in communities across the nation. Teachers can work collaboratively with parents and administrators to identify such facilities and make arrangements for students to use them for homework assignments. Teachers are likely to find in some parents a valuable resource in locating public facilities, given that Wilson, Wallin, & Reiser (2003) found that not only are African Americans less likely to have home computers or Internet access, even when SES is controlled, but they are also more likely to know of public facilities in their community.

The establishment of formal and informal relationships with such programs can sometimes make equipment and even tutors available for completing class assignments. Teachers, parents and staff at public facilities can collaborate to provide an ideal level of support for students. Such facilities often have on staff former teachers or others sufficiently familiar with K-12 education to be academic resource for students, especially if well informed by teachers about students' needs and homework goals.

3. Develop strategies to counter problems at public ICT facilities. There are potential drawbacks to the use of after-school computer programs at schools or other public facilities. These include the possibility that children may have to share computers, the limited hours of access which often require working immediately following school with no break for meals, and that parents are usually not present (Gorsky, 2001). However, there are silver linings to these clouds. With some attention to how children are grouped and the structure of the TMI task, children can derive important learning and social benefits from the sharing of computers. Since relatively high amounts of television watching (sometimes at the expense of homework) is a characteristic of many children in the group of interest, working immediately after school may not only be an effective alternative to television watching — previously cited data associates increased technology use with decreased television watching — but it is one that many parents have instituted. Regarding the meal issue and parental involvement, arrangements can be made for healthy snacks and many programs can accommodate (and some invite) the participation of parents.

4. Seek assistance from local colleges and universities. Gorski and Clark (2001) proposed a strategy similar to the one described above, but built around colleges and

universities and their technology resources. He suggested that teachers seek for their students and families, physical access to university computer labs, digital access to universities' libraries and the direct engagement of faculty, especially those whose expertise involves the intersection of multicultural education and technology. Unfortunately this strategy may not be as widely applicable as desired given that some institutions of higher education are finding their technology facilities insufficient to meet the needs of their own students.

5. *Take steps to learn about the ICT access and history of students in the classroom.* Survey the class early in the school year to determine out of school access to technology, history of ICT use and level of skill. Talk to not only students, but with whoever plays the most significant role in the student's life and education, be that person a parent, a legal guardian or extended family member. A student may have access to ICT and considerable prior experience even though these may be at a friend's or neighbor's home rather than in their own home or a community center. Many students have ICT skills that, while not acquired with a focus on academics, are a sound foundation on which to build. Therefore, the line of questioning must be sufficiently broad, non-threatening and confidential to elicit this information.

6. *Advocate for the fair and effective distribution of ICT resources.* If teachers lack technology skills, encourage school administrators to provide professional development before the large scale purchase of equipment that in the absence of training may be poorly used or not used at all. Suggest purchasing one or two carts of laptops that can be shared by many classrooms as opposed to equipping every classroom.

7. *Plan for equipment failure.* For schools that primarily serve low income students *workability* issues—that the equipment will not work is a common problem (Warschauer, Knobel, & Stone, 2004). If the school does not have resources and a plan in place for dealing with such problems, e.g. (ICT staff), then identify colleagues with technology skills and set up an informal network, or at least ask if it is OK to call on them in emergencies.

Strategies for Bridging the Second Digital Divide

1. *At the start of an academic term take steps to learn about the prior ICT knowledge and skills of students in the classroom.* (See strategy 5 under the first digital divide).

2. *Determine the required technological competencies for each activity and whether all students have them* (Chisholm, Carey, & Hernandez, 2002). Do not rely entirely on promotional statements from manufacturers.

3. *If there is wide variation in the prior technology or subject knowledge of students, then use this variation as a variable in pairing students or otherwise organizing some TMI activities.*

4. *Expose students to a variety of ICT*, including computers, the Internet, visualization software. This strategy is important for bridging the first digital divide by providing all children access to a full range of technology. It is also important for bridging the second digital divide in that effective TMI will incorporate a range of technology in pedagogically appropriate ways for each content area.

5. *Avoid educational technological performativity*—merely running students through a checklist of technology activities of skills for the sake of being able to state that they were exposed, but with little concern about whether they really understand and are able to apply the new knowledge in meaningful, purposeful ways (Lyotard, 1984; Lankasshear & Knobel, 2003, Warschauer, Knobel, & Stone, 2004).

6. *Use drill and practice when necessary, but not excessively, and not exclusively for any group.*

7. *Develop activities that encourage all students to use ICT to explore natural phenomena, experience scientific phenomena, extend their thinking, create multiple representations of their understanding, and communicate with teachers and peers* (Edelson, 1998; Hug, Krajcik, & Marx, 2005; Linn, 1998; Spitulnik, Stratford, Krajcik, & Soloway, 1998). In addition to increased understanding and higher achievement, another important result is likely to be increased motivation (Blumefield, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991).

8. *Assign to all students creative, problem-solving activities that require application, analysis, synthesis and evaluation*—e.g. multiple step projects that require searching the Internet, evaluating what is found and then applying it to the solution of a problem.

9. *Avoid using ICT to engage in defensive teaching (Garrison and Bromley, 2004), and especially avoid granting basic access to ICT as a reward.*

Strategies for Bridging the Third Digital Divide

1. *Analyze TMI before, during and after lessons.*

Identify specific culture components and attempt to determine whether and how they have affected teaching and learning with technology.

2. *Review software and multimedia programs for bias or insensitivity.* For example, are non-whites depicted in costumes, when these are not relevant to the main discussion (Warschauer, 2003).

3. *Provide a balance of individual assignments and group TMI activities so that the preferences of different cultural group—e.g. collective, initial work-- are alternatively addressed.*

4. *Make TMI activities consistent with "good teaching" (Haberman, 1991).* "Good teaching" engages students with major concepts and ideas; it has them applying ideals; it encourages them to question common sense; it engages students with important issues in their lives and encourages them to reflect upon these issues; it has them learn to perfect their work by redoing and polishing; and in terms of the third digital divide, it has them using technology in meaningful ways. Therefore, teachers should assign creative, problem-solving activities that require application, analysis, synthesis and evaluation—e.g. multiple step projects that require searching the Internet, evaluating what is found and then applying it to the solution of a problem.

5. *Use TMI activities to foster an "equitable classroom" (Cohen & Lotan, 2004), especially when group projects are involved.* In equitable classrooms teachers and students view all students as capable of acquiring basic skills and high-level concepts; all students have equal access to (and often share) challenging learning materials; all students are challenged by tasks that require higher-order thinking skills; teachers create opportunities that enable English language learners and students reading below grade

level to complete activities; and students have equal status in terms of participating in class and openly expressing opinions. When group work is involved teachers should assign different roles or tasks to group members and make sure that all students experience the full range of roles by revolving group membership and group roles throughout the semester. In particular, teachers should make sure minority and low-income students experience leadership roles with technology.

6. *Use information obtained at the start of the academic year (see first and second digital divide strategies above) to identify and meet the unique needs of students.*

For example, Chisholm, Carey, and Hernandez (2002) found that computer based self-efficacy was lower among low-income university students with limited prior computer ownership, information that could be useful in addressing the unique student needs.

7. *Employ Attribute-Treatment-Interaction Pedagogy (ATIP) (Kelly 2008a) when teaching with technology.* The term is a deliberate alteration of the concept of Aptitude-Treatment-Interaction, replacing the term *aptitude* with *attribute* to convey the equality of cultural characteristics. In ATIP students vary on a particular cultural attribute, such as preferred learning style (Hale-Benson, 1986), and it is the teacher's responsibility to figure out which instructional strategies will be the most compatible (interact best with the preferred learning style) to result in the highest achievement.

The "treatment" may be different for different students. In its strongest form, ATIP involves making instruction compatible with the cultural preferences of individual students. This is challenging and difficult to achieve. Far more practical is to vary modes of instruction so that the cultural preferences of different students are all covered at different times.

Another important aspect of ATIP is that pedagogical practices often interact with student cultural attributes in unique ways, resulting in unintended academic, social and psychological outcomes. Whether or not a teacher is aware of it, a student will have accumulated a history of experiences and knowledge about how others respond to their cultural background. Intended to or not, pedagogical practices are often interpreted by students (positively or negatively) through the filter of this prior experience. Teaching with technology is no exception. That interpretation matters because it is often the basis for student achievement related behaviors. Students who interpret an instructional strategy as high or at least neutral teacher expectation are likely to exhibit higher motivation to learn than students who interpret the strategy as low teacher expectations. This is one of the central factors that should guide technological pedagogical practice intended to bridge the third digital divide. Clearly no teacher can know each student's prior history or thought. However, there are practices that decrease the likelihood of negative interpretations (and increase positive ones) for all children. These include creating and maintaining "equitable classrooms", and engaging in "good teaching".

Conclusion

The TPCK framework is all about integrating technology into instruction as opposed to merely using technology to teach. It is about good instructional uses of technology as opposed to poor uses. Without careful attention to context issues even teachers very skilled in T, P, and C are likely to leave some students, often many students behind. The context component of the framework focuses teachers on important role

played by individual differences in the teaching-learning-with-technology process and the need to accommodate some of those differences.

When TPCK context issues of equity are not adequately addressed in the design of instruction the consequence can be poor uses of technology that fail to engage and motivate groups of students. Many of these are students who are already academically disadvantaged in many other ways. (Show video example 1).

When TPCK context issues of equity are addressed well the result can be just the opposite for such students. (Show video example 2).

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