USING INFORMATION AND COMMUNICATION TECHNOLOGY FOR QUALITY MATHEMATICS TEACHING

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The technological pedagogical content knowledge framework in Mathematics (originally TPCK, now known as TPACK, or technology, pedagogy, and content Knowledge in Mathematics) for teacher knowledge is described in detail, as a quality interaction among Content, pedagogy, and technology, the three components of knowledge. To successfully integrate technology use into quality teaching-learning, we require the types of flexible knowledge which could emerge by theoretical as well as practical interaction of these components of knowledge. This article explores from a theoretical perspective the importance of ICTs in education. Furthermore, it describes the concept of key competences and ICT competences that learners should achieve in order to enable them to successfully participate in quality learning.

Key words: *ICT in Education, Education, TPCK, Mathematics Education, ICT Integration in Mathematics, Professional Development in Mathematics*

Introduction

ICT, Digital Media and especially Web 2.0 tools are important levels to support quality learning and improve the learning outcomes of the participants. We observe that in a normal classroom situation there are several ways for applying ICT. In a substitution method an educator replaces a number of the old technologies with ICT. For example: the teacher may use PowerPoint, may allow students to send their homework via e-mail, even could present the tests electronically. Such ICT-scenario wouldn't require much change or training. This may be called a cosmetic change. There is a need to have a paradigm shift in teaching-learning situations through a transformational approach through which the following recommendations of broad process perspectives of *National Curriculum Framework 2005*, for teaching and learning of Mathematics could be met

- Student Activity
- Multiple Representations
- Experimental and Guided Discovery Learning

In the transformational scenario, digital media like Mathematics specific software for example, GeoGebra, Cabri, winplot, etc., can provide these opportunities to enhance learning by

- visualising—learners can see abstract concepts
- representations—learners can make connections
- experiments—learners can discover mathematics

Background and Need

We believe that the use of ICT foregrounds the ways in which teachers can match in school the opportunities for learning with child friendly environment. In fact, there is enough evidence that young people who have been surrounded by and interacted with ICT on continuous basis develop a different approach to learning and knowledge management from those who have not had such opportunity. Therefore, the integration of ICT is believed to be crucial for the welfare and well being of our future generations.

In educational reforms the teacher is the last but crucial chain in the process of educational change. However, when considering ICT related innovations in education we cannot consider teachers as isolated performers. In their schedule, Teachers follow routines, according to their pre-service training and on the work , they're required to implement curricular objectives and contents that very often are formally established, they work within the constraints of the school organisation having fixed time tables, etc. Innovations that need teachers to vary many aspects of their daily routines are very demanding for them. Complex innovations can only achieve success if variety of interacting conditions are met.

It is believed that when students learn with technology, they'll use it as a cognitive tool that helps them to construct meaning supported their prior knowledge and conceptual framework. The growth rate of Web users and developers has increased at large. Publishers, curriculum specialists, mathematicians, teachers, and students have placed an excellent deal of mathematics and mathematics-related information and activities online. There is a requirement to consolidate these applications in order that students can access a greater range of learning opportunities and teachers can have a stronger sense of the technology's utility and connection to learning outcomes. Also technology enhances learning opportunities because it can efficiently support graphing, visualising, and computing. Moreover, the technology is used as a medium to provide resources and learning situations that would otherwise be unrealistic or impossible to create.

Digital Technologies and Mathematics Education

The mathematics education community is engaged with the question to find out how children best learn mathematics. Due to coherence property, Mathematics is a huge and constantly expanding network of interrelated facts and concepts just like the fields of cognitive development as well as the psychology of learning. A large proportion of teachers lately attempt to base much of their teaching practice on constructivist ideas— i.e., on the assumption that the teacher's role is to create opportunities for children to build their own understandings of concepts. However, if only we could discover precisely how the child best learns mathematics then we could work out exactly how to teach the child the subject in the most effective way.

Even though technology can influence what is taught, teachers need to be mindful of designing instruction and environments that promote content and learning framework. In fact, technology supports learning requirements when it is used "as a tool for processing the concepts with investigations and problem solving". Digital technologies are often seen as catalysts for a paradigm shift. Keeping in view of readily availability of printed material and books, education has experienced a gradual shift away from the idea that its success relies on the student's capacity to memorise and accurately recall large amounts of information. Instead, developing research and problem-solving skills are on the wider targets. With emerging information and communication technologies (ICTs), in recent times, the main objective has rapidly mounted to shift our views on effective teaching and learning even further. Emphasis is now placed on equipping students with effective inquiry skills, including the power to seek out and process new information using digital technologies. Many educators are now seeing digital technologies, with their interconnectedness, as environments, instead of just tools, for learning and teaching. The difference between these two perspectives is significant, the former requiring a fundamental change in teaching practice for many teachers.

Challenges of Teaching with Technology

Considering the challenges with newer technologies present to teachers, for many teaching with basic technology may be complicated itself. Computers, handheld devices, and software applications like digital technologies, by contrast, are protean (usable in many different ways; Papert, 1980); unstable (rapidly changing); and opaque (the background workings are hidden from users; Turkle, 1995). Newer digital technologies, which are usable in many different ways, updating regularly, and opaque, present a great deal of challenges to teachers who are struggling for technology integrated teaching. Also facing complications while teaching with technology gives an impact that technologies are neither neutral nor unbiased. Rather, particular technologies have their own propensities, potentials, affordances, and constraints that make them more suitable surely tasks than others. Understanding, how these affordances and constraints of available technologies are impacting teachers' classroom activities, is not straightforward and may require restructuring teacher education and teacher professional development by giving new thoughts.

Social and contextual factors also impacting the connections between teaching and technology. Teachers may not be getting adequate supports to integrate technology use into their work under social and institutional contexts. They often have inappropriate experience with using digital technologies for teaching and learning activities. Many teachers earned degrees at a time when educational technology was at a really different stage of development than it's today. It is, thus, not surprising that they are not consider themselves sufficiently prepared to use technology within the classroom and sometimes don't appreciate its value or relevance to teaching and learning. Acquiring a replacement knowledge domain and skill set are often challenging, particularly if it's a time-intensive activity that has got to fit into a busy schedule. Moreover, this data is unlikely to be used unless teachers can imagine technology uses that are according to their existing pedagogical beliefs (Ertmer, 2005). Furthermore, teachers have often been given inadequate training for this task. This is another dilemma, that even teachers operate in diverse contexts of teaching and learning, while technology integration many approaches to teachers' professional development offer a one size-fits-all.

An Approach to Thinking About Technology Integration

Faced with these challenges, how can Mathematics teachers integrate technology into their teaching? An approach is required that treats teaching as an interaction between what teachers know and the way they apply what they know within the unique circumstances or contexts within their classrooms. To integrate technology into curriculum, the "one best way" is still unavailable. Rather, integration efforts should be creatively designed or structured for particular material ideas in specific classroom contexts. At the guts of excellent teaching with technology, there are three core components: content, pedagogy, and technology, plus the relationships among and between them. Since, these three components playing out differently across diverse contexts, the interactions between and among these components, account for the wide variations seen within the extent and quality of educational technology integration. Thus, these three knowledge components (content, pedagogy, and technology) form the core of the technology, pedagogy, and content knowledge (TPACK) framework.

Continuous Professional Development—Digital Integration

The TPCK framework in Mathematics through digital integration will be about supporting quality teaching in Mathematics. Our intent with the TPCK framework in Mathematics is to provide designing a way for teachers as they seek to improve their effectiveness in delivering high-quality, productive mathematics learning experiences for all students.

We define tools and techniques in the TPCK framework in Mathematics for practical and user-friendly support for effective teaching. Regardless of how effective anybody could be in their teaching, we may still grow and improve. The TPCK framework in Mathematics will be aimed at continual improvement and sustaining quality teaching as well as for the beginners it will be designed to help identify areas to improve the performance, and to focus support for the important and continuous development. With TPCK framework in Mathematics, our ultimate goal is to improve the educational experiences and achievement of the students we serve in our schools by focusing directly on teacher effectiveness. The focus is for Pedagogical enhancement, Technological empowerment and effective content delivery.

In Order to enhance the quality resources and its availability to a Teacher of Mathematics, following points should be met by effective use of ICT.

– It should integrate easily into the teacher's daily work.

– By providing innovative presentations of content, increase interest for learning and making it a fun for those who find the concepts tough.

Designing TPCK Framework

(i) Towards Pedagogical enhancement NCF-2005 recommends that Teachers are now facilitators for students' learning by creating a learning environment intertwined with inquiry approach. Accordingly the teachers need to upgrade and reorient themselves. Though every teacher has her own style, here comprehensive technology exposures side by side, the way to design digital content resources with pedagogical approaches are going to be discussed. If ICT is to be successfully incorporated into any lesson then there are some fundamental issues that require to be tackled at a really early stage. The next success of the lesson depends upon that. Employing ICT tools as a part of a mathematics lesson isn't difficult, but it adds another dimension and therefore the place and purpose of it needs careful consideration.

Planning the ICT lesson

So what does ICT based mathematics lesson appear with in TPCK Framework? Much of it will be familiar, containing because it does all of the key features that one would expect during a plan for a mathematics lesson. These features consider the following

- Selecting an appropriate topic: Why this, i.e., the particular topic been chosen?
- Key learning objectives: What are the intended learning outcomes as a results of the lesson?
- The content of the lesson: Teaching points.
- Details of any prior learning: The start line may often be the children's previous experiences.
- Teaching methodology to be used: Focusing on ICT integration.
- Key teaching points: What exactly you are going to transact? What will you communicate? What will be your query to make sure that they learn what you would like them to learn?
- The foci for assessment: How to assess to ensure that students have learned? What are the intended learning outcomes?
- Cross-curricular links: Are there any clear and relevant connections to other areas of the curriculum?
- Follow-up work: Where does this lesson fit during entire teaching-learning episodes?

Based on above exhaustive features, the subsequent design for our template has been selected to develop a mathematics lesson:

1. Learning Objectives
2. Introduction of the subject
3. Flow of chapter (Step by Step containing GeoGebra and other Applets, etc.)
4. Examples
5. Hands on activities
   (a) Self exploratory experiments (if any)
   (b) Day to day application
   (c) Application (Problem Solving)
   (d) Interdisciplinary Applications / Problems
   (e) HOTS questions

6. Extension activities

   (a) External Web resources for the content

   (b) Suggested Readings

   (c) Thought-provoking questions that lead students to do more exploration

(ii) Towards Technological Empowerment

Many ICT tools are available to support and enhance teaching and learning with digital media. Different software tools offer widely varied experiences and access to different aspects of a subject. Simply to consider the range of number of applications which users are learning to use in generally not a good way to monitor the value of new technologies. One user who only uses a single application may achieve far more in the same time than another user who uses several. Software applications are resources and it is more important to think about the nature of the user's experiences. Use of software can be invoked in two distinct ways. Sometimes it's appropriate to offer the user a ready-made document or file which has been already created and invite them to explore it. At other times, it may be better for users to create their own from scratch, as they express themselves with contentment by means of a more open application or resource. While using tools like Geo-Gebra, etc., users give shape to their own ideas in "expressive mode," as well as in pre-planned "exploratory mode." Geogebra or other applets can be pre-built for users to explore or they can build their own reflecting their particular way of looking at a situation.

One may use these open source software to develop a module based with TPCK framework in mathematics:

1. GeoGebra Applets (www.geogebratube.org): For dynamic and interactive representations of mathematics content.
2. LA TEX (http://www.latex-project.org/): A document preparation system
3. PS tricks (http://tug.org/PSTricks/): A set of macros that allow the inclusion of PostScript drawings directly inside LA TEX code
4. Camstudio (http://camstudio.org): Software that can record all screen and audio activity on your computer and create video files (i.e., screencasts)
5. Wink (http://www.debugmode.com/wink/): Screencasting software
6. Screencast-o-matic (http://www.screencast-o-matic.com): Screencasting software
7. UnFreez (http://www.whitsoftdev.com/unfreez/): An application that will take any number of images, saved as separate GIF files, and create a single animated GIF from those images.
8. eXe (http://exelearning.org/wiki): Application for snapping (capturing) images from selected parts of one's computer screen (i.e., screen capture)
9. MWSnap (http://www.mirekw.com/winfreeware/): Screen capture software
10. Eclipse (http://www.eclipsecrossword.com): Software that generates crossword puzzles from lists of words and clues

11. Tarsia Formulator (http://www.mmlsoft.com): Software to create, print out, save and exchange customised jigsaws, domino activities and a variety of rectangular card sort activities
12. Graph (http://www.padowan.dk/graph/): Graph is an open source application used to draw mathematical graphs in a coordinate system
13. Libre Office (http://www.libreoffice.org/): LibreOffice is an open source personal productivity suite for Windows, Macintosh and GNU/Linux, that includes 6 document production applications (e.g., spreadsheet, word processor, presentation software)
14. Scratch (http://scratch.mit.edu/): It is a programming language to create user's own interactive stories, animations, games, music, and art- and share their creations on the Webpage.
15. DIA (http://live.gnome.org/dia/): Dia is a GTK+ based diagram creation program for GNU/Linux, MacOS X, Unix, and Windows
16. Freemind (http://freemind.sourceforge.net): It is a free mind-mapping software written in Java. Basically, Mind maps are tools to visualise, generate, structure, and classify ideas. This is also very useful in studying and organising information, solving problems, making decisions, and writing.
17. Geonext (http://www.tdmaths.com/en/geonext.htm): Geonext is an interactive and dynamical geometry program for making geometric constructions.
18. WinPlot (http://math.exeter.edu/rparris/winplot.html): Winplot is a general-purpose interactive plotting utility use to draw (and animate) curves and surfaces presented in a several formats.

General Approaches

During learning, meaningful interaction depends upon students individually constructing their own figures from a blank screen (the expressive option). One way to develop meaningful interaction is to run a teacher centred lesson using a single laptop with a data projector and an interactive whiteboard. A second possibility is to supply students with pre-constructed sketches. With such files, students can manipulate the figures that appear before them: many of the initial access problems are bypassed.

Thinking Geometrically — Dynamics through Software (Pedagogical Implications)

As teachers, we know that "Geometry" is a skill of the eyes and hands as well as of the mind. The word "Theorem" comes from a Greek words meaning "vision" and 'theatre': both are concerned with display; both have a touch of revelatory magic about them. The power of software like GeoGebra lies within the way its users interact directly with geometric figures they need constructed (or that are pre-constructed for them). This interaction occurs in a continuous and dynamic way, by means of the direct control of one's hand on the mouse. It is also possible to 'animate' a construction, so that the screen images move 'on their own.' But, for us, the foremost striking and powerful impact comes when, in pursuit of a mathematical question or goal, students directly explore a geometrical realm informed by hand and eye, focused by their minds. One of the problems in trying to explain motion and its effects in text is that one necessarily has got to miss out on all of the essential ingredients. In fact, animating mathematical diagrams and illustrations can bring, externalising and setting back in motion images that are held static within the pages of textbooks provide a sense of surprise and wonder. Towards this pedagogical requirement we need to separate out exploratory versus expressive approaches to using GeoGebra. In other words, we must confront the decision of offering users preconstructed files to explore versus providing students with tasks that require the construction of their own figures. And, as always, there's the overall pedagogic question of what sorts of questions and tasks can help students to focus their attention on the mathematically important aspects of the situations presented to them by others or generated by them. There's a learning curve involved in acquiring a particular function within software itself. (Murdock, Kamischke, and Kamischke, 2002). A task that appears simple when demonstrated by an informed individual might involve steps that aren't so easily discovered by a beginner. Interactive geometry software, like GeoGebra, etc., offers teachers and their students a wide variety of tools and facilities to explore mathematics. Some users thrive in such an open-search setting, exploring at length and at will. Others can become somewhat overwhelmed initially by the variety of options in the menus and by the fact that each tool does something mathematical to the image on the screen and is related to a geometrical concept. However, with a structured introduction to certain available tools, and with perhaps some introduction to the experience of dragging dynamic constructions, users can acquire confidence and build valuable insights. There are two different but related kinds of learning involved in using software, which we call instrumental and conceptual. Instrumental learning is about the way to do things within the specific software: the way to create points or lines or circles, the way to operate with menu items (like 'rotate' or 'construct perpendicular bisector'), the way to perform calculations (like measuring lengths, areas or angles). Instrumental learning reflects decisions made by the software designer. For example, so as to be an efficient user of the software, the scholar may have to seek out and use the tool to construct a midpoint. Such learning isn't intrinsically mathematical and may be developed during a context during which students aren't deliberately extending their mathematical understanding. Tasks that develop instrumental understanding may involve the creation of images or the utilisation of features like reflection or animation. One striking thing about interactive geometry software is that instrumental learning is also frequently conceptual. Mathematical language of the interface both provides and seeds the well-liked vocabulary for subsequent mathematical discussion. An understanding of some or many of these terms is gained in the software environment and the words act as both labels for that experience as well as the commands to make that action occur. Thus, the words can serve as both verbs and nouns. This is a common process in mathematics, where verbs are turned into nouns. However, effective use of the software also requires conceptual learning. Conceptual learning develops gradually, through deepening experience with both geometry and thereforethe software, both on and off the PC. It is often difficult for users to form a sense of the visual complexity of a filled, changeable display screen. A more experienced user learns to 'hide' objects used in a construction and to construct visible line segments where they need to be visible. The pedagogy regarding working with pre-constructed sketches or students constructing their own sketches may be refereed in 16.

Focusing Attention when Exploring Geometry

Whether constructing from a blank screen (expressing) or exploring a pre-constructed file (exploring), many users will benefit from having some fundamental questions to ask themselves as they investigate. Some fundamental questions need to address while working geometrically, both with and without pre-constructed files. It might be involved in helping users deal meaningfully with these questions.

What's happening ...? – It is not always a straightforward question to answer, as it is not always easy to make sense of a confusion of changing geometric figures. One way of beginning to make sense of what's happening is to start with the question of what stays the same and what changes? This question focuses attention on the hunt for invariance, a fundamental issue in geometrical thinking.

What if?– What if? questions provide a variation on the theme of trying to find invariance. The process is now one of asking 'if I change this, what else changes?' and, by implication, 'what stays the same?' 'What if . . .?' questions are particularly important in whole-class discussion around one screen? At every stage, students can be asked to predict what will happen if the teacher changes something. It is also a crucial question in independent exploration, where the question can cause changing initial aspects of things to increase a task.

Can I make . . . happen? – The question could be quite simple ('can I create a triangle of a particular area?') or it might involve complex problem-solving ('can I create a file to prove the Pythagoras theorem?'). The solution to the question may end up to be 'no,' but the method of exploration still could be valuable. For example, an attempt to create a triangle with two right angles may lead to an understanding of why this is not possible.

Summary

Thus, we've looked at ICT integrated pedagogical approaches in quality mathematics learning for sustainable development. Although interactive geometry is often used anywhere within the mathematics curriculum where a visible approach is acceptable, it's geometry and geometric thinking that underlie all such models. GeoGebra and other software-based interactive content materials will form a resource pool and motivate users from exploratory mode towards expressive mode.

Thus a primary goal is to know the relationships between two key domains: (a) teacher thought processes and knowledge and (b) teachers' actions and their observable effects. The TPACK framework seeks to increase tradition of research and scholarship by bringing technology integration into the sorts of knowledge that teachers got to consider when teaching towards ESD. The TPACK framework enforces development of better techniques for discovering andand describing how technology-related professional knowledge is implemented and instantiated in practice and ultimately influence ESD. By better describing the kinds of data teachers need (in the shape of content, pedagogy, technology, contexts and their interactions), educators are during a better position to know the variance in levels of technology integration occurring. Additionally, the TPACK framework offers several possibilities for promoting research in teacher education, teacher professional development, and teachers' use of technology. It offers options for watching a posh phenomenon like technology integration in ways in which are now amenable to analysis and development. In summary, TPACK allows teachers, researchers, and teacher educators to think beyond oversimplified approaches that treat technology as an "add-on" instead to focus and redesign entire teaching-learning scenario, and during a more ecological way, upon the connections among technology, content, and pedagogy towards Education for Sustainable Development.

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