ICT Kit in Mathematics

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Abstract

The role of ICT in the mathematics curriculum is much more than simply a passing trend and it is envisaged not simply as a technical skill or as a means of improving learning effectiveness but also as a way of transforming the goals and processes of education. It provides a real opportunity for teachers of all stages and subjects to rethink fundamental pedagogical issues alongside the approaches to learning that students need to apply in classrooms. Innovations that require teachers to change many aspects of their daily routines are very demanding for them. Complex innovations can only be successful if a number of interacting conditions are met. This paper describes a design for an ICT based tool which can be fitted in mathematics teachers' daily routine easily. Though every teacher has her own style, this paper provides a comprehensive technology exposure along with how to design digital content resources using open source mathematical software with the pedagogical approaches and an evaluation mechanism through ICT. This ICT Kit in mathematics describes a design of a source for teacher's professional development in mathematics as well as rubrics based continuous and comprehensive evaluation tool.

Background and need

We believe that use of ICT foregrounds the ways in which teachers can match in school the opportunities for learning provided in home and child's other surroundings. In fact, there is increasing evidence that young people who have always been surrounded by and interacted continuously with ICT develop a different approach to learning and knowledge management from students who have not had this opportunity. Therefore, the integration of ICT is believed to be very crucial for the welfare and well-being of our future generations.

In educational reforms the teacher is the last but most crucial chain. However, when considering ICT related innovations in education we cannot conceive teachers as isolated actors. Teachers follow routines that they have learnt during pre-service training and on the job, they are

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required to implement curricular objectives and contents that quite often are formally established, they work within the constraints of the school organisation having fixed timetables, etc. Innovations that require teachers to change many aspects of their daily routines are very demanding for them. Complex innovations can only be successful if a number of interacting conditions are met.

It is believed that when students learn with technology, they may use it as a cognitive tool that helps them to construct meaning based on their prior knowledge and conceptual framework. Also, the growth rate of Web users and developers has increased exponentially.

Publishers, curriculum specialists, mathematicians, teachers, and students have placed a great deal of mathematics and mathematics-related information and activities on the Web. There is a need to consolidate these applications so 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.

Keeping in view this visionary attitude, this article 'ICT Kit in Mathematics' focuses on following broad objectives:

i. How to design and develop e-content using different subject-specific open source software on various concepts of Mathematics as digital-interactive content

ii. How to develop rubric based Continuous and Comprehensive Evaluation system on process evaluation

Digital Technologies and Mathematics Education

The mathematics education community is engaged in a constant quest to find out how children best learn mathematics. Due to coherence property, mathematics is an enormous and constantly expanding network of interrelated facts and ideas like the fields of cognitive development and the psychology of learning. A large proportion of teachers these days try to base much of their teaching practice on constructivist ideas – that is, on the belief that the teacher's role is to create opportunities for children to build their own understanding of the 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. Many would say that this is an impossible dream. We can never achieve ultimate professional enlightenment, not only because every child and every teacher is different, but because the social and cultural contexts keep changing. The impact of advances in science and technology cannot be underestimated.

Even though technology can influence what is taught, teachers need to be mindful of designing instruction and environment that promote these 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 can be seen as catalysts for a paradigm shift. Since printed material and books became readily accessible, 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, greater emphasis has been placed on developing research and problem-solving skills. In recent years, with emerging information and communication technologies (ICTs), the pressure 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 ability to find and process new information using digital technologies. Many educators are now seeing digital technologies, with their interconnectedness, as environments, rather than 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.

Continuous Professional Development of Teachers

Towards the one of the major objectives, i.e. Teachers' professional Development programme, we need to come up with a very innovative and effective approach. This ICT Kit in Mathematics will provide a design of a utility tool for the professional development.

We know that teaching is closely connected to the affective aspect of human minds, and being a teacher means to be emotionally involved. Education is deeply rooted in personal attitudes and values. The fact that teaching is closely linked to emotions, means that teaching by its nature is impossible to dictate. Consequently the idea of teachers' professional development should be built on the acknowledgment that teachers' concern is their students.

Teachers' professional development is an elusive term. To some it may conjure images of short term courses and workshops. Others may associate it with ongoing and reflective practice. So, what does the term teachers' professional development actually mean? According to Darling-Hammond (1994) teachers' professional development is a process of enhancing teachers' status through increased awareness and an expanding knowledge base. Linda Evans (2002) defines Teachers' professional development as 'an ideologically-, attitudinally-, intellectually- and epistemologically- based stance on the part of an individual, in relation to the practice of the profession to which s/he belongs and which influences her/his professional practice'. She also mentions that teachers' professional development is an ongoing process. In fact, her definition implies that professionalism should be enhanced through a development process.

De Corte, 2000 has written that the teacher's task is to enable his or her students to develop their individually different processes of knowledge building and meaning construction as well as positive attitudes. It is a common belief that mathematics is a difficult subject. Therefore, in order to help learners succeed it is of the utmost importance that the teacher should examine and analyse possible barriers that might have a negative impact on learning. A good mathematics teacher should be able to suggest ways to minimise these and to use a variety of effective teaching strategies that help to overcome individual learning difficulties.

The general question is 'What professional skills, what attitudes are to be acquired for the teaching of mathematics?' Learning to teach requires a balance between teachers' theoretical and practical knowledge and skills including knowledge of mathematics, knowledge of teaching mathematics, and knowledge of psychology and pedagogy. These components are only general; they do not answer the basic question about the content and extent of the knowledge required.

It is, therefore, mentioned that evolving effective pedagogy with digital technology for teaching and learning mathematics content will enhance professional skills.

1. Continuous Professional Development through ICT Kit

The ICT Kit will be about supporting quality teaching in mathematics. Our intent with the ICT Kit is to provide design of a tool for teachers as they seek to improve their effectiveness in delivering high quality, productive learning experiences for all students.

We will define tools and techniques in the ICT Kit for practical and user-friendly support for effective teaching. Regardless of how effective any one of us might be in our teaching, we can continue to grow and improve. The ICT Kit will be aimed at continual improvement and sustaining quality teaching as well as for the beginners it will be designed to help identify areas for performance improvement, and to focus support for the important and ongoing process of development. With ICT Kit 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 of users along with implementing a rubric-based effective evaluation system. The most important point to make about the use of ICT is that it cannot and should not replace the teacher. Excellent teaching and effective learning can only occur when a good teacher is present. The key lies in how the technology is used and employed, not in the teaching of the technology itself.

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.
- Increase interest for learning and making it a fun for those who find

the concepts tough by providing innovative presentations of content.

Working of the ICT Kit

1. Pedagogical Enhancement

Teaching is being viewed as a process of facilitating students' learning by creating a learning environment conducive to enquiry. This necessitates the teachers to upgrade and reorient themselves. Though every teacher has her own style, here comprehensive technology exposures along with how to design digital content resources with pedagogical approaches and evaluation mechanism through ICT will be discussed. If ICT is to be successfully incorporated into any lesson then there are some fundamental issues that need to be tackled at a very early stage. The subsequent success of the lesson depends upon that. Employing ICT as part of a mathematics lesson is not difficult, but it adds another dimension and the place and purpose of it need careful consideration.

Planning the ICT Lesson

So what does mathematics lesson where ICT is to be used look like? Much of it will be familiar, containing as it does all of the key features that one would expect in a plan for a mathematics lesson. This is detailed below:

- Selecting an appropriate topic: Why has a particular mathematics topic been chosen?
- Key learning objectives: What are the intended learning outcomes as a result of the lesson?
- The content of the lesson: What exactly is to be taught?
- Details of any prior learning: The starting point may often be the children's previous experiences.
- Teaching methodology to be used: Particularly crucial, whenever ICT is involved.
- Key teaching points: What are you actually going to teach the students? What are you going to say to them? What are you going to ask them so as to ensure that they learn what you want them to learn?
- The foci for assessment: How are you going to assess what you hope the children have learned? What do you think they will 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 into an overall sequence of work?
- Resources: What hardware or software is to be used?

On the basis of above exhaustive features, following design for our template may be selected to develop a mathematics lesson:

(i) Learning objectives

(ii) Introduction of a topic

(iii) Some thought-provoking questions

(iv) Flow of chapter (Step by Step)

(v) Examples

(vi) Hands-on activities

(vii) Self exploratory experiments (if any)

(viii) Daily life application

(ix) Application (Problem solving)

(x) Interdisciplinary applications/ problems

(xi) HOTS questions

(xii) Extension activities

(xiii) External Web resources for the content

(xiv) Time management tricks for teachers

(xv) Suggestive reading

(xvi) Some thought provoking questions that lead students to do some kind of exploration.

2. Towards Technological Empowerment

Many ICT tools are available to support and enhance teaching and learning. Different software tools offer widely varied experiences and access to different aspects of a topic. Simply to consider the range of number of applications which users are learning to use is 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. The ICT use can be invoked in two distinct ways. Sometimes it is appropriate to give the users 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. Users give shape to their own ideas using technology in this latter 'expressive mode', as well as tasks in which users work with software in a more constrained, pre-planned 'exploratory mode'. Geogebra applets can be pre-built for users to explore or they can build their own reflecting their particular way of looking at a situation.

We may use following open source software to develop the kit:

(i) Latex and PStricks for presentation

(ii) Maxima

(iii) SVG or Canvas

(iv) Screen capturing - Jing, Camstudio

(v) Picture lessons - Microsoft Photostory 3

(vi) Geometry and Algebra Applets -GeoGebra

(vii) Small animations - UnFreez (See examples UnFREEz)

(viii) Complete lesson module - eXe

(ix) Snag it

(x) Eclipse crossword

(xi) Tarsia Formulator (creating puzzles (jigsaw type)

(xii) Graph 4.3 for graphing

(xiii) Open Office

(xiv) Scratch programming: useful to develop logical thinking

(xv) Geogebra : Geometry and Algebra

(xvi) Dr. Geo: Geometry, school level

(xvii) DIA Diagram Creation Program

(xviii) Freemind (Mind mapping)

(xix) Geonext

(xx) Picture Collage maker Pro

(xxi) WinPlot (ploting and animating), LOGO, etc.

LOGO (Logic Oriented Graphics Oriented.) is open-source software easy to use by teachers and students. It may be downloaded from softronics. Winplot is a general-purpose plotting utility, which can draw curves and surfaces in various formats and can be animated.

3. General Approaches

It is a common assumption that when using ICT in mathematics education meaningful interaction with the learning situation depends upon students individually constructing their own figures from a blank screen (the expressive option).

Here may be two further possibilities:

1. 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.
2. A second possibility is to provide the students with preconstructed files. In such files, students could manipulate the figures that appear before them; many of the initial access problems can be somewhat bypassed.

4. Thinking Geometrically Dynamics through Software (Pedagogical implications)

Geometry software is a powerful tool for facilitating mathematical learning, exploration and problem-solving. Arising from its richness and scope, there are, perhaps unsurprisingly, significant pedagogic issues to be addressed in order to use geometry software effectively in secondary classrooms. Through ICT Kit in Mathematics we may show the potential for interactive geometry to support teaching and learning of mathematics, as well as considering how learners can be introduced to the considerable possibilities afforded by the software.

In mathematical endeavour we know that 'Geometry' is a skill of the eyes and hands as well as of the mind. The word 'Theorem' has the Greek word meaning 'Vision' at its root, as well as linking to the word 'theatre': both are concerned with show, with display; both have a touch of revelatory magic about them. The Interactive Geometry Softwares' essence lies in the way users can interact directly with geometric figures they have constructed (or that have been preconstructed for them). This interaction occurs in a continuous and dynamic way, by means of the direct control of your 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 most striking and powerful impact comes when, in pursuit of a mathematical question or goal, students directly explore a geometric realm informed by hand and eye, focused by their minds.

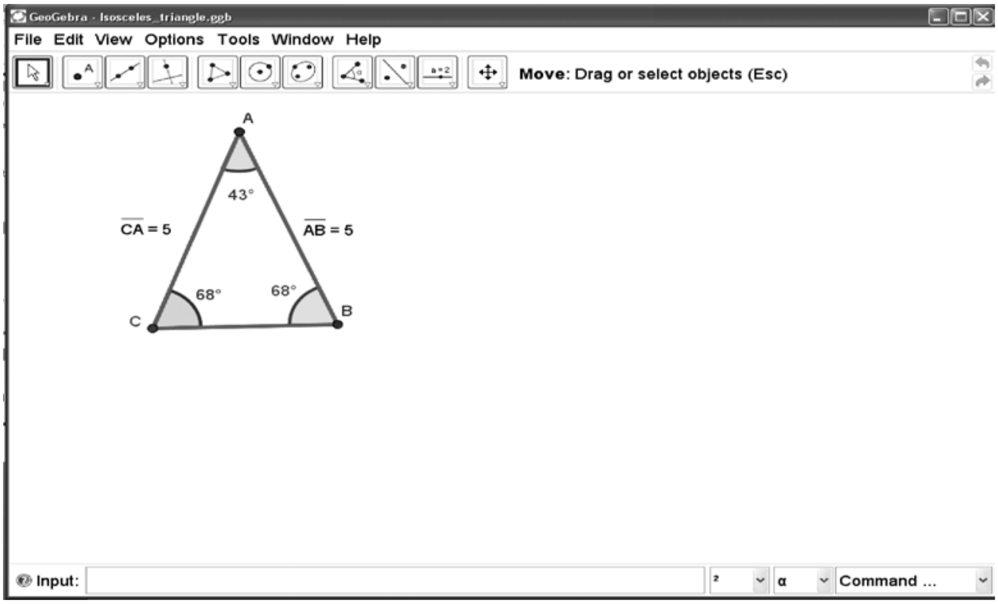
One of the issues in trying to describe motion and its effects in text is that one necessarily has to miss out on all of the essential ingredients. Not least among these is the sense of surprise and wonder that animating mathematical diagrams and images can bring, externalising and setting back in motion images that have been held static within the pages of textbooks.

We need to separate out of exploratory versus expressive approaches to using ICT. One place where this distinction arises in relation to interactive geometry is with the question of offering users pre-constructed files to explore, rather than having them construct figures of their own. And, as always, there is the general pedagogic question of what kinds of question 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.

At this place some questions arise, 'how to evoke the need for students to prove or otherwise explain and justify general claims or results that the software seems to show them directly.' A dynamic demonstration can be very compelling. How can a geometric diagram which is always and necessarily particular be used to argue convincingly about what must happen in general? With interactive geometry, most often seeing is believing, especially given the sense of generality evoked by the plurality of linked instances of a given configuration. In fact, when a new piece of software is used in a lesson for the first time, some things do not go quite as expected or hoped. We need to work on some of the issues involved in making effective use of the software.

With any software, there is a learning curve involved in acquiring a certain facility with it. A task that looks simple when demonstrated by an informed individual might involve steps that are not so easily discovered by a beginner. Interactive geometry software, geogebra, is very open, offering a wide variety of tools and facilities. 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 menu 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 of the 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 how to do things in the specific software: how to create points or lines or circles, how to operate with menu items (like 'rotate' or 'construct perpendicular bisector'), how to perform calculations (like measuring lengths, areas or angles). It reflects the decisions made by the software designer. For example, in order to be an effective user of the software, the student may need to find and use the tool to



construct a mid-point. Such learning is not intrinsically mathematical and can be developed in a context in which students are not deliberately extending their mathematical understanding. Tasks that develop instrumental understanding may involve the creation of images or the use of features such as reflection or animation. One striking thing about interactive geometry is that instrumental learning is also frequently conceptual. Mathematical language of the interface both provides and seeds the preferred 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 the software, both on and off the computer. It can be difficult at times for users to make sense of the visual complexity of a filled, changeable computer 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.

5. Working with Reconstructed Files

A major feature of such files is that it is possible to modify or add to them. The use of preconstructed files involves students working in 'exploratory mode', to explore within the constraints set by the creator of the files. This is in contrast to the students engaged in making constructions of their own, which can be seen as working in 'expressive mode'.

Advantages and Disadvantages of Preconstructed Files

Advantages	*Disadvantages*
Students (and teachers) only need to be able to manipulate: no initial knowledge of the software is needed.	Resources to either acquire (cost), find (time) or create (time).
Less time-consuming for students, as object does not need to be constructed.	
Can focus immediately on desired learning outcomes without the distraction of needing to construct the required figures.	May restrict student exploration.
Files can be modified or added to.	Files can be drastically messed up.
Such files may lead to questions such as 'how did they do that? Which may motivate students (and teachers) to begin to create their own files.	Some students (and teachers) need to know how a file works before they can be comfortable using it, and hence get little by using it.

Although learning to use a new tool takes time, there are advantages for students in making constructions of their own. Construction offers considerable scope for students to be creative, to be challenged and to engage in open-ended problem-posing and problem-solving. They can work at their own mathematics. The process can give the student ownership of what they create and can lead to a deeper understanding of the figure. Of course, it is possible that some tasks may be too challenging for certain students, leaving them frustrated and not knowing where to begin, but with support these issues can be overcome.

When to Use a Preconstructed File and When to Construct

When to use a preconstructed file	*When to construct*
In the early stages of learning to use the software (by either teacher or student).	When students have sufficient confidence with the software (or the geometry).
In the early stages of geometry learning when shapes can be identified visually, but the idea of properties of the shape is not understood.	When students have some idea of the relationship of the properties of a shape to the construction of a shape.
When the learning objectives are unrelated to the way in which the file was constructed.	When the process of construction is intrinsic to learning objectives, such as exploring ways to create a rhombus or constructing a figure in order to explain its properties.
When a situation seems to be bit complex for construction.	When the complexity of construction is an appropriate challenge to the student.
When instructions to create a figure are more complex than the resulting figure.	In open-ended tasks or when using the software to solve a particular problem or when looking for an explanation of why something is happening.

Focusing Attention when Exploring Geometry

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

What's Happening?

This is the fundamental question that all students must ask when confronted with an interactive geometry file. 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 —What stays the same and what changes? This question focuses attention on the hunt for invariance, a fundamental issue in geometrical thinking. Interactive geometry software is particularly useful for exploring this question in various contexts.

What If ?

'What if . . .?' questions provide a variation on the theme of looking for 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 a single screen. At every stage, students can be asked to predict what will happen if the teacher changes something. It is also an important question in independent exploration, where the question can lead to changing initial aspects of the situation to extend a task. It is always questions that drive exploration and investigation.

Can I Make ... Happen?

The question might be quite simple (Can I create a triangle of a certain area?) or it might involve complex problem-solving (Can I create a file to depict a rotating icosahedron?). The answer to the question may turn out to be 'no', but the process of exploration still may well 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.

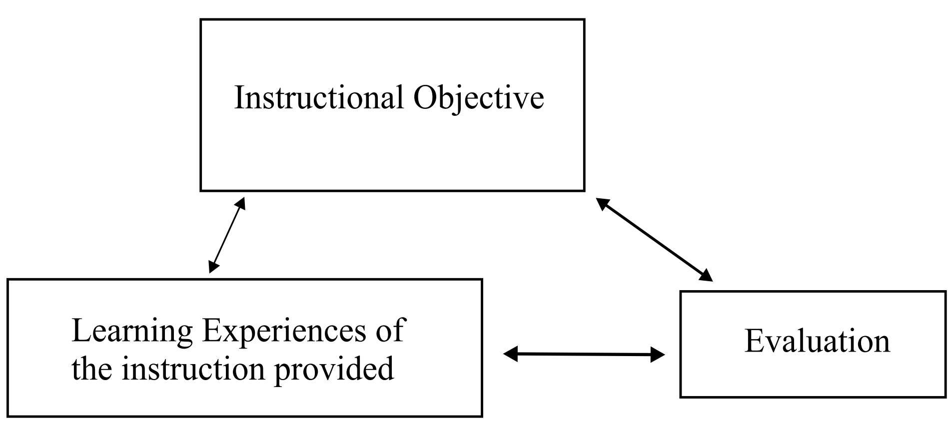
Thus, we have looked at some of the issues involved in using interactive geometry software in the classroom and some of the ways of dealing with them. Although interactive geometry can be used anywhere in the mathematics curriculum where a visual approach is appropriate, it is geometry and geometric thinking that underlie all such models. Preconstructed files can be created for students to manipulate but if the geometry is neglected, students will not be able to represent mathematical situations expressively for themselves. The ultimate aim should be to equip students so that they are able to choose to use such software in support of their mathematical thinking, whenever and wherever it is useful.

In fact, digital- interactive content materials based on the software will form a resource pool and motivate users from exploratory mode towards expressive mode. To make the process simple and effective, several video tutorials focusing on above mentioned attention may also be added for its effectiveness at maximum extent.

Continuous and Comprehensive Evaluation (CCE)

Evaluation is an integral part of any teaching and learning programme. Whenever a question is asked in a class and answered by a student and the answer is judged by the teacher, evaluation takes place. Thus, both teaching and evaluation go hand in hand with each other. In fact, it is not possible to have teaching and learning without evaluation.

Both teaching and evaluation are based on the instructional objectives which provide direction to them. Instructional objectives are those desirable behaviour which are to be developed in students through the learning experiences. These are reflected in the form of syllabus, instructional material and information given by the teacher. Instructions are given for achieving the objectives and evaluation is done to see whether the instructional objectives have been achieved and to what extent. The interrelationship of objectives, instructional process or the learning experiences and evaluation in a programme of teaching can be expressed more clearly through the following diagram:



The above diagram illustrates that the three components—teaching, learning and evaluation constitute an integrated network in which each component depends on the other. Thus, through evaluation, the teacher not only assesses as to how far the student has achieved the objectives but also examines the effectiveness of the teaching strategy such as methodologies, means and the materials used for achieving those objectives.

Introducing Rubrics

At its most basic, a rubric is a scoring tool that lays out the specific expectations for an assignment. Rubrics divide an assignment into its component parts and provide a detailed description of what constitutes acceptable or unacceptable levels of performance for each of those parts. Rubrics can be used for grading a large variety of assignments and tasks: Project evaluation, discussion, participation, laboratory reports, portfolios, group work, oral presentations, and more.

(i) Do We Need a Rubric?

How do we know that we need a rubric? One sure sign is if we check off more than three items from the following list:

- We are getting pain from writing the same comments on almost every student's paper.
- We're far behind in our grading.
- Students often complain that they cannot read the notes we worked so long to produce.
- We have graded all our papers and worry that the last ones were graded slightly differently from the first ones.
- We want students to complete a complex assignment that integrates all the work over the term and are not sure how to communicate all the varied expectations easily and clearly.
- We want students to develop the ability to reflect on ill-structured problems but we aren't sure how to clearly communicate that to them.
- We give a carefully planned assignment that we never used before and to our surprise, it takes the whole class period to explain it to the students.
- We give a long narrative description of the assignment in the syllabus, but the students continually ask two to three questions per class about our expectations.
- We work with our colleagues and collaborate on designing the same assignments for programme courses, yet we wonder if our grading scales are different.
- We've sometimes been disappointed by whole assignments because all or most of the class turned out to be unaware of academic expectations.
- We have worked very hard to explain the complex paper; yet students are starting to regard then as incomprehensible assignments. Rubrics set us on the path to addressing these concerns.

(ii) What Are the Parts of a Rubric?

Rubrics are composed of four basic parts in which the teacher sets out the parameters of the assignment. The parties and processes involved in making a rubric can and should vary tremendously, but the basic format remains the same. In its simplest form, the rubric includes a task description (the assignment), a scale of some sort (levels of achievement, possibly in the form of grades), the dimensions of the assignment (a breakdown of the skills/knowledge involved in the assignment), and descriptions of what constitutes each level of performance (specific feedback) all set out on a grid, as shown in Table 1.

Table 1 : Basic Rubric Grid Format

Task Description	*Scale level 1*	*Scale level 2*	*Scale level 3*
Dimension 1			
Dimension 2			
Dimension 3			
Dimension 4			

This is the most common, but sometimes we may use more. Rarely, however, we may go over our maximum of five scale levels and six to seven dimensions. We look at the four component parts of the rubric and, using an assignment as an example, provide the above grid part-by-part until it is a useful grading tool (a usable rubric) for the teacher and a clear indication of expectations and actual performance for the student.

(iii) Part-by-Part Development of a Rubric

Part 1: Task Description

The task description is almost always originally framed by the teacher and involves a performance of some sort by the student. The task can take the form of a specific assignment, such as a project, an activity, or a presentation.

Part 2: Scale

The scale describes how well or poorly any given task has been performed and occupies yet another side of the grid to complete the rubric's evaluative goal. Terms used to describe the level of performance should be tactful but clear. Here are compiled some commonly used labels:

- Sophisticated, competent, partly competent, not yet competent
- Exemplary, proficient, marginal, unacceptable
- Advanced, intermediate high, intermediate, novice
- Distinguished, proficient, intermediate, novice
- Accomplished, average, developing, beginning

There is no set formula for the number of levels a rubric scale should have. We should prefer to clearly describe the performances at three levels using a scale. The more levels there are, the more difficult it becomes to differentiate between them and to articulate precisely why one student's wzzork falls into the scale level it does. On the other hand, more specific levels make the task clearer for the student and they reduce the Teacher's time needed to furnish detailed grading notes. We may have the following grid for scaling in the ICT Kit in Mathematics:

Table 2 : Parts of Scales

Dimensions	Exemplary	Competent	Developing
Knowledge/ Understanding			
Geometrical Skills			
Analytical skills			
Applications			

Part 3: Dimensions

The dimensions of a rubric lay out the parts of the task simply and completely. A rubric can also clarify for students how their task can be broken down into components and which of those components are most important. Is it calculation? The analysis? The factual content? The process techniques? And how much weight is given to each of these aspects of the assignment? Adding points or percentages to each dimension emphasises the relative importance of each aspect of the task. Dimensions should actually represent the type of component skills students must combine in a successful work, such as the need for a firm grasp of content, technique, citation, examples, analysis, etc. When well done, the dimensions of a rubric (usually listed along one side of the rubric- Table 2) will not only outline these component skills, but after the work is graded, should provide a quick overview of the student's strengths and weaknesses in each dimension.

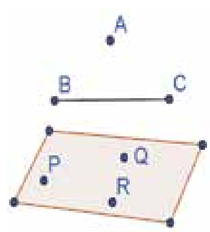
Breaking up the assignment into its distinct dimensions leads to a kind of task analysis with the components of the task clearly identified. Both students and teachers find this useful. It tells the student much more than a mere task assignment or a grade reflecting only the finished product. Together with good descriptions, the dimensions of a rubric provide detailed feedback on specific parts of the assignment and how well or poorly those were carried out.

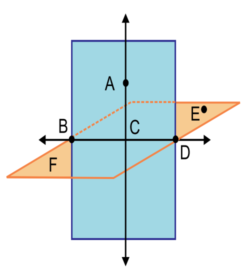
Part 4: Description of the Dimensions

Dimensions alone are all-encompassing categories, so for each of the dimensions, a rubric should also contain at the very least a description of the highest level of performance in that dimension. A rubric that contains only the description of the highest level of performance is called a scoring guide rubric. Scoring guide rubrics allow for greater flexibility and the personal touch, but the need to explain in writing where the student has failed to meet the highest levels of performance does increase the time it takes to grade using scoring guide rubrics.

On the basis of learning objective of modules several task may be identified. For each task towards the dimensions Knowledge/understanding, geometrical skill, analytical skill and application— performance anchors have been described in the form of rubric related to the task. Sufficient number of mathematical illustration would also be provided for the effective utilisation of these various task-based rubrics.

Task: To check whether the student has understood the basic terminology (Point, Line, Plane, etc.) of Geometry

Dimensions	*Exemplary*	*Competent*	*Developing*
Knowledge/ Understanding	• The student understands the meaning of the word Geometry. He is able to recognise and draw the basic building blocks of geometry viz point, line and plane and knows that they are undefined terms.  	• The student understands the meaning of the word Geometry. He does not know that the basic building blocks of Geometry viz point, line and plane are undefined. He is able to draw basic building blocks.	• The student understands the meaning of the word Geometry.
	• The student understands the meaning of the word Geometry. • He is able to recognise and draw the basic building blocks of geometry viz point, line and plane and knows that they are undefined terms.concurrent lines, etc. • He is able to solve the following question successfully.	• He is able to recognise the geometrical shapes in his surroundings. • He is not able to define terms like collinear points, coplanar points, line segment, ray, intersecting lines, parallel lines, concurrent lines, etc. But he is able to draw them. • He is able to solve the question	• He is not able to recognise the geometrical shapes in his surroundings. • He is able to draw points, lines, etc. but not able to draw intersecting lines, parallel lines, concurrent lines, etc. • He is able to solve the question but not able to label the figures correctly.

Qu.1. Draw and label each of the following: a) a segment with endpoints U and V opposite rays with a common end pointQ			
Analytical Skills	• The student applies his problem-solving skills to solve the following question successfully: Qu. Use the figure to name each of the following  a Three points b Two lines c Two planes d One ray e Intersecting lines The student understands the meaning of the following statement : • If two rays share a common end point, then they form a line.	• The student is able to recognise and name points and lines but unable to recognise plane, ray and intersecting lines.	• The student is able to recognise points and line but not able to name them.

Applications	• The student is able to recognise a sheet of paper as a plane. • He is able to draw a line segment by paper folding. • He is also able to locate a point as the intersection of two line segments by paper folding.	• The student is able to recognise a sheet of paper as a plane. He is not able to draw line segment and point using paper folding.	• The student is not able to understand paper folding activities.

For most tasks, we prefer to use a rubric that contains at least three scales and a description of the most common ways in which students fail to meet the highest level of expectations.

Note how the next level down on the scale indicates the difference between that level of performance and the ideal, whereas the last level places the emphasis on what might have been accomplished but was not. This puts the emphasis not on the failure alone, but also on the possibilities.

In this sample rubric, the descriptions are limited enough that when a student does not fit neatly into one column or the other, we can convey that fact by circling elements of two or more columns.

When we first began constructing and using rubrics, we quickly found that they not only cut down on grading time and provided fuller feedback to our students, but they affected our classroom preparation and instruction as well.

Rubrics not only save time in the long run, but they are also a valuable pedagogical tool because they make us more aware of our individual teaching styles and methods, allow us to impart more clearly our intentions and expectations, and provide timely, informative feedback to our students.

In fact, rubrics will make grading easier and faster in several ways:

- Establishing performance anchors
- Providing detailed, formative feedback
- Supporting individualised, flexible, formative feedback (scoring guide rubrics)
- Conveying summative feedback (grade)

These four ways are generally chronological in nature. Establishing performance anchors will help us get started more quickly and also more fairly. Three-to-five-level rubrics allow us to provide detailed, informative feedback very rapidly by simply checking and circling prewritten criteria, whereas scoring guide rubrics allow us to do the same thing more flexibly and in a more individualised fashion, at the cost of speed. Finally, by conveying summative feedback in an easy to read, almost graphic fashion, rubrics will enable us to assign grades more rapidly and defend them more easily.

Conclusion

The characteristics of digital technology provide potentially powerful learning and assessment tools, but in schools it's the teacher who creates the learning environment that either unleashes this potential or inhibits it. Teacher can create learning environments likely to maximise the educational benefits of using digital technologies. These learning environments exist, at least partially, within the technologies themselves.

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