MODULE 2: CognitiveDevelopmentandMathematics Learning

UNIT 1:Gagne’s HierarchyofConceptandMeaningand Mathematics Learning

UNIT 2:PiagetTheoryofIntellectualDevelopmentand Mathematics

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UNIT 1:Gagne’s HierarchyofConceptandMeaningand Mathematics Learning

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1.0 Introduction

Cognitivedevelopmentisafieldofstudyinneuroscienceandpsychologyfocusingonachild's developmentin termsofinformationprocessing,conceptual resources,perceptual skill,languagele

arning,andotheraspectsofbraindevelopmentandcognitivepsychology comparedtoanadult's pointofview.Alargeportionofresearchhasgoneintounderstandinghowachildimaginesthe world.Amajorcontroversy incognitivedevelopmenthasbeen“natureversusnurture”ornativism versusempiricism.However,itisnowrecognizedbymostexpertsthatthisisafalsedichotomy: thereisoverwhelmingevidencefrombiologicalandbehavioralsciencesthatfromtheearliestpoints indevelopment,geneactivityinteractswitheventsandexperiencesintheenvironment.Another issueishowcultureandsocialexperiencerelatetodevelopmentalchangesinthinking.Another questionisphylogenyconvergenceorhomology withnon-humananimals.Mostaspectsoflearning andcognitionaresimilarinhumans andnon-human animals.Theseissuespropagate tonearlyevery aspectofcognitivedevelopment.

2.0Objectives

Attheendofthe unityoushouldbeable to:

- IdentifyGagne's HierarchyofConceptandMeaning
- ExplainHowthe Present-dayMathematics TeachingViolates Gagne's Principle
- DiscusstheimplicationofGagne's Hierarchytotheteachingandlearningofmathematics

3.0Main content

3.1Gagne'sHierarchyofConceptandMeaning

RobertGagneinhisbook'OntheConditionsofLearning',hasgivenataxonomyoflearningtypes (Gagne,1970Chap.4). thathehas arrangedhierarchically.

1. *Signallearning.*Thisisatypeof associativelearningthathasbeeninitiallystudiedbyPavlovwho has calleditconditionedreflex.Asubjectthatrespondsinacertain way(R)toastimulusS1is giventwostimuli(S1andS2)simultaneously.Aftersufficientnumberof repetitionshelearns togivethe response (R)toS2evenintheabsence ofS1.Muchofthelearningthatwedowithoutgivingconsciousthoughtisofthistype.Muchofthe initiallearningofearlychildhoodis signallearning.

2. *Stimulus-responselearning.*Thisisanothertypeofassociativelearningthathasbeencalledtrial anderrorlearningby Thorndike.Skinnerhasused theterm operantlearningforit.Itinvolvessome goal orobjectivethatthesubjectattemptstoachieve.Theprocessisessentially asuccessive approximationprocess.Theinitial effortsarealmostrandom.Thesubjectmodifieshisapproachin everyattempt.Eachsuccessfulattemptisrememberedwhilefailed attemptsareforgotten. The successrateimproveswithmoreattempts.Agoodexampleisachildlearningtowalk.Initiallyhe falls downoften.Butwithmoreattempts heis abletomastertheskill.

3. *Chaining.*Chainingistheprocessofestablishingasequential connection ofaset ofstimulus-responsepairsforthepurposeof attainingaparticulargoal.Forexample,theopeningof alock involvesanumberofsimplerstepsconnectedinasequence(locatethekey-hole-insertthekey-turn thekey clockwise-watchforleverunlocking-takeoffthelock).Successful chainingrequires priorlearningofeachcomponentresponse.Algorithmsaregenerally suchchainingsequences.

4. *VerbalAssociation.*Humanbeingshavetheabilitytoencodeandexpressknowledgethrough soundpatterns. Verbal associationhererefersto themostelementary kindofverbalbehaviour-learningofverbal associations (object«name)andverbal sequences(chainsofverbalassociations).

5. *MultipleDiscriminationLearning.*discriminationis theabilitytodistinguishbetweentwoormore stimulus objects or events. Therearetwodifferentkinds ofcapabilities involved.Thefirstiswherethelearnerisableto makedifferentresponsestodifferentmembersofa collectionof

stimuluseventsandobjects.Thesecondtypeinvolvesthecapabilityof thelearnerto respondinasinglewaytoacollectionofstimulibelongingtoasingleset. (Thisinvolves recognitionofthedefiningrulefortheset andrespondingaccordingly.)

6. *Conceptlearning.*Conceptlearninginvolves discriminationandclassificationof objects**.**Wewill distinguishbetweentwotypes ofconceptlearning:concreteandabstract. Concreteconceptsare thosethatareformedthroughdirectobservation.Forexample,considerthe edgeofatable,theedgeofarazorbladeandtheedgeofacliff.Itispossibletoformulatearulethat definesanedge.Buttheconceptof edgeisformedmoreeasilythroughdirectobservationof several examples.Alearnercanrespondtoasetof stimulusobjectsintwoways–onebydistinguishing amongthemandtheotherbyputtingthemintoaclassandrespondingtoanyinstanceofthatclassin thesameway.Boththesetypesareexamplesofconcept learning.Thesignificanceofconcept learningis thatitfrees thelearnerfromthecontrolbyspecific stimuli.

7.*Principle(or rule)learning.*Someconcepts are notconcrete. They arebased on rulesthatinvolveotherconcepts.So they havetobelearntthrough definition. Definitions arestatements thatexpress rulesforclassifying,i.e.rules thatareapplicabletoany instanceofaparticular class.Definitions areusedforobjects as wellasforrelations.Asalientfeatureofprinciplelearningis thatthelearnercannotacquiretheconceptthroughmemorizing itsstatementsverbatimunlessheknows thereferentialmeaningsof thecomponentconcepts.For example, $ax^2+bx+c=0$ismeaningless unlessyouunderstandwhat*a, b,c*, and*x*represented.

8.*Problemsolving.*Problemsolving,here,referstosomethingmorethan classroommathematical drills.Alsoreferredtoasheuristics(Polya,1957),theprocess ofproblemsolvingis oneinwhichthe learnerdiscovers acombinationofpreviouslylearntrules thatcanbeappliedtoachieveasolutionfor anovelsituation.Thefollowingsequenceofeventsis typicallyinvolvedinproblem solving.
(a)presentationof theproblem,
(b)definitionof theproblem,
(c)formulationof hypothesis,
(d) verificationofhypothesis.

Thelearningoutcomeofproblemsolving isahigherorderrulethat becomes apartofthestudent's repertory. AccordingtoGagne,cognition andconceptformationisamulti-layeredphenomenon,eachlayer consisting of a particular learning type. Signal learning, Stimulus-response learning, Chaining, VerbalAssociationandMultipleDiscriminationLearningareall pre-requisitesfortheformationof conceptsandtheability tosolveproblems.Theprocessofconceptformationinvolvesall theseeight processes.

Averyimportantpointhereisthatifthelearninghasnotbeensufficientlyaccomplished atanylevel,thenthereis perceptibledeteriorationatallhigherlevels(GagneandWigand, 1970).

3.2RoteLearningintheContextofGagne's Hierarchy

Letusexaminethedifferenthierarchy levelsofGagne andseewherethetraditionalmethodsof teachingfit.Signallearning,Stimulus-responselearning,Chaining,VerbalAssociation andMultiple DiscriminationLearningconstitute thebasicformsoflearning.Theyarethebasicbuildingtoolsthat enablethemindtoacquireaworkingset-upforconceptformation.Itisthisareawhererotelearning ismost effectiveand insufficient learning atthislevelimpairs thestudent'sabilitiesfor higher learning.

Signal learningreferstolearning through unconditional association.When smallchildrenmemorize alphabetsanddigitsymbols,they areunconditionallyassociatingthesymbolsoundswith theirform. Sincethechilddoesnotasyetpossessany relatedpre-formedassociations,thisistheonlylearning alternativeavailableatthisstage.Rotelearning isthemost effectivelearningtoolatthisstage becauseitdirectly doeswhatisrequired.Stimulus-responselearningorOperandConditioningisa processbasedonsuccessiveapproximation.Oncethebasicnodalassociationshavebeenformedin themind,asuccessiveapproximationprocessorshapingtakesplaceonthebasisof positiveand negativereinforcements.In thetraditionalelementary education,thisstepisaccomplishedthrougha lotoforalexercises.

Thenextstep,chaining,istheprocessofcombiningasetofindividualS-R'sinsequence.Infact, theconceptof*Sutra*developedinancientIndia(Namita,1996),isaformalisationof thisstep.*Sutra* has beenidentifiedwithalgorithmbyVernekar.Theterm'algorithm'refers toastepby-stepmethod forsolvingany problem (Rajaraman,1980,p.3).AccordingtoVernekar(1994),thebasicideaofthe algorithmicmethodis thatthevarious steps inanoperation arearrangedlikebeadsinathread(sutra). Thussutraaswellasalgorithmsrefers tothesameprocess as chainingorformingmentallinks.

Thenextstepisverbalassociation.Mostofthebeginners'verbalassociationsaredefinitionsand fact-snippetstobememorized.Hereagain,therotemethodsareapplicable.Althoughmemorizingthevoca bularyisaveryboringjob,onceastudentacquiresgoodvocabulary throughwhatsoever means,its roleinunderstandingverbalandwritten materialcannotbedenied.

SELF ASSESSMENT EXERCISE

Under which of Rober Gagne's learning types does early childhood learning fall? Give a brief illustration

3.3HowthePresent-dayMathematics TeachingViolates Gagne's Principle

Present daycurriculastresstheroleandnecessityofconceptformation ineducation(National CurriculumFramework2000,2005). This cognitiveapproachappearstobe quitereasonable.Acognitiveapproachcanbevery usefulin thiscontext(Redish,1994).Atpresent, theheuristicconstructivistapproachisbeingimplementedin themodern schoolsforteaching mathematics as wellas othersciencesubjects. Amajorityofstudents whogotohigher classes arefoundtobeextremelypoorinconcepts

(Agnihotrietal.,1994).Arons(1997)haspointedoutseveraldeepconceptualflawsinthethinking of averagePhysics students. Why doconceptual flaws occur? Assuming Gagne'smodel, the followinglearningtypesheavily rely on previouslylearnedmaterials.(1)Chaining,(2)Multiple discriminationlearning,(3)Conceptlearning,(4)Principlelearning, and(5)Problem solving.Andas wehaveseen,thekindoflearningmaterialthattheselearningtypes arebasedonismosteffectivelydonethroughmemorization.

Inmathematics,onewhohasmemorizedthemultiplication tablesandrigorously practicedbasic mathematical operations through oral methods is much more confident in higher mathematics becausehehasless stumblingblocks toovercome.

Modern schooleducation has graduallydone awaywith basic mathematicaldrills. So the pre-requisitesforformation ofhigherconceptsaspointedoutby Gagnearenotbeingfulfilled. Mathematicalknowledgeiscumulativeinnature.Sowithaweakfoundation themajority of students areboundtodisplay an overallweaknessin theirconcepts.This,according tomy view,isthemain reasonwhymanyoftoday's students areweakinconcepts.

4.0 Conclusion

Gagne'sinformationprocessingmodelas shownabove, thattheroteandalgorithmicmethods could beusedintraditionalschoolsforeffective buildingastrongbaseforformationofhigher concepts.Weshoulddevelopteachingmethodologyformathematics andothersubjects that incorporatesrotelearninginaneffectivewaysothatknowledgeisbetterconveyedandrepresented inthemindofstudents.Therotelearningofbasicmathematicalfacts and word-meaninginprimary schoolswillinparticularbeavery useful preparationforhigherconcepts. Forbetter resultsabalancebetween heuristicapproach andalgorithmicapproach willhavetobe established.Weshouldalsodevelopeffectiveuses ofsutrainmathematics teaching.

5.0 Summary

In this unit Gagne'sHierarchyofConceptandMeaning was identified. Howthe present-daymathematics teachingviolates Gagne's principle as well as theimplicationstotheteachingandlearningofmathematics were discussed.

6.0Tutor-MarkedAssignment

1ListGagne's HierarchyofConceptandMeaning
2WhataretheimplicationsofGagne'sHierarchyofConceptandMeaningtothe teachingand learningofmathematics.

7.0REFERENCES/FURTHERREADINGS

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UNIT 2: PiagetTheoryofIntellectualDevelopmentandMathematics

CONTENTS

1.0Introduction

JeanPiaget(1896-1980)was abiologistwhooriginallystudiedmolluscs(publishingtwenty scientificpapers onthembythetimehewas 21)butmovedintothestudyofthedevelopmentof children's understanding,throughobservingthemandtalkingandlisteningtothemwhilethey workedonexercisesheset. His viewofhowchildren'sminds workanddevelophasbeenenormouslyinfluential,particularlyin educationaltheory. His particularinsightwasthe roleofmaturation(simplygrowingup)inchildren's increasingcapacitytounderstandtheirworld:theycannotundertakecertaintasks untiltheyare psychologicallymatureenoughtodoso. His researchhas spawnedagreatdealmore,muchofwhich has underminedthedetailofhis own,butlikemanyotheroriginalinvestigators, hisimportance comesfromhis overallvision. Heproposedthatchildren's thinkingdoes notdevelopentirely smoothly:instead, therearecertainpoints atwhichit"takesoff" andmovesintocompletelynew areas andcapabilities.Hesawthesetransitions as takingplaceatabout18months,7years and11or 12years.This has beentakentomeanthatbeforetheseages childrenarenotcapable(nomatterhow bright)ofunderstandingthingsincertainways,andhasbeenusedas thebasisforschedulingthe schoolcurriculum.Whetherornotshouldbethecaseis adifferentmatter.

2.0Objectives

At the end of the unit you should be able to:

- IdentifyPiaget's stages ofintellectualdevelopment
- Distinguish betweenassimilationandaccommodation
- DiscusstheimplicationofPiaget'sstagesofintellectualdevelopmenttotheteachingandlear ningofmathematics

3.0Main content

3.1TheNatureofIntelligence:OperativeandFigurativeIntelligence

Piagetbelievedthatrealityisadynamicsystemof continuouschange,andassuchisdefinedin referencetothe twoconditionsthatdefine dynamicsystems.Specifically,hearguedthatreality involvestransformationsandstates.Transformationsrefertoallmannersofchangesthata thingorpersoncanundergo.Statesrefertotheconditionsortheappearancesinwhichthingsorpersons canbe foundbetweentransformations. Forexample,theremight bechanges inshapeorform(forinstance,liquidsarereshapedastheyaretransferredfrom onevesseltoanother,humanschangein theircharacteristicsastheygrowolder),insize(e.g.,aseriesofcoinsonatablemightbeplaced closetoeach otherorfarapart)in placementorlocationinspaceandtime(e.g.,variousobjectsor personsmightbefoundatoneplaceatonetimeandatadifferentplaceatanothertime).Thus,Piaget argued,thatifhumanintelligenceistobeadaptive,itmusthavefunctionstorepresentboth the transformational andthe static aspects of reality. He proposed that operative intelligence is responsiblefortherepresentationandmanipulationof thedynamicortransformationalaspectsof realityandthatfigurativeintelligenceisresponsiblefortherepresentationof thestaticaspectsof reality.

Operativeintelligenceistheactiveaspectofintelligence.Itinvolvesall actions,overt orcovert, undertakeninordertofollow,recover,oranticipatethetransformationsof theobjects orpersons of interest.Figurativeintelligenceis themoreorlessstaticaspectofintelligence,involvingallmeans of representationusedtoretaininmindthestates (i.e.,successiveforms,shapes,orlocations)that intervene betweentransformations. That is, it involves perception, imitation, mental imagery, drawing,andlanguage.Therefore,thefigurativeaspects ofintelligencederivetheirmeaningfromthe operativeaspectsofintelligence,becausestatescannotexistindependentlyofthetransformations that interconnectthem. Piaget believed that the figurative or the representational aspects of intelligencearesubservienttoits operativeanddynamicaspects,andtherefore,thatunderstanding essentiallyderivesfromtheoperativeaspectofintelligence.

At any time, operative intelligence frames how the world is understood and it changes if understanding is not successful. Piaget believedthat this process ofunderstanding and change involves twobasicfunctions:Assimilationandaccommodation.

3.2AssimilationandAccommodation

Throughstudyingthefieldof educationPiagetfocusedonaccommodationandassimilation. Assimilation,oneoftwoprocessescoinedbyJeanPiaget,describeshowhumansperceiveandadapt tonewinformation.Itis theprocess of takingone’senvironmentandnewinformationandfittingit intopre-existingcognitiveschemas.Assimilation occurswhenhumansarefaced withnewor unfamiliarinformation andrefertopreviously learnedinformationin ordertomakesenseofit. Accommodation,unlikeassimilationis theprocess oftakingone'senvironmentandnewinformation, andalteringone's pre-existingschemasinordertofitinthenewinformation.

Throughaseries ofstages,Piagetexplains thewaysinwhichcharacteristicsareconstructedthatlead tospecifictypesof thinking;thischartiscalledCognitiveDevelopment.ToPiaget,assimilationis integratingexternalelementsintostructures oflives orenvironments orthosewecouldhavethrough experience.Itisthrough assimilation thataccommodationisderived.Accommodationisimperative becauseitishowpeoplewill continuetointerpretnewconcepts,schemas,frameworks,etc. Assimilationisdifferentfrom accommodationbecauseofhowitrelatestotheinnerorganism dueto theenvironment.Piagetbelievesthat thehuman brainhasbeen programmed through evolution to bringequilibrium,andtomoveupwardsin aprocesstoequilibriatewhatisnot. Theequilibriumis whatPiagetbelievesultimatelyinfluencesstructuresbecauseof theinternal andexternalprocesses throughassimilationandaccommodation.

Piaget'sunderstandingisthatthese twofunctionscannotexistwithoutthe other.Toassimilatean objectintoanexistingmental schema,onefirstneedsto takeintoaccountoraccommodateto the particularities of this objecttoacertainextent;forinstance,torecognize(assimilate)anappleasan appleoneneedsfirsttofocus(accommodate)on thecontourofthisobject.Todo thisoneneedsto roughlyrecognizethesizeoftheobject.Developmentincreases thebalanceorequilibrationbetween thesetwofunctions.Wheninbalancewitheachother,assimilationandaccommodationgeneratemen tal schemasoftheoperativeintelligence.When onefunctiondominatesovertheother,they generate representations whichbelongtofigurativeintelligence.

FollowingfromthisconceptionPiagettheorizedthatintelligenceisactiveandconstructive.Itis activein theliteralsenseofthetermasitdependson theactions(overtorcovert,assimilatory or accommodatory),whichthethinkerexecutesinordertobuildandrebuildhismodelsoftheworld.It isalsoconstructivebecauseactions,particularlymental actions,arecoordinatedintomoreinclusive andcohesivesystems,thus theyare raisedtomorestableandeffectivelevels offunctioning.

3.3Piagets’Stages ofIntellectualDevelopment

Sensorimotorstage

The**sensorimotorstage**isthefirstof thefourstagesincognitivedevelopmentwhich"extendsfrom birthtotheacquisitionoflanguage".Inthisstage,infantsconstructanunderstandingoftheworld by coordinatingexperiences(such asseeingandhearing)with physical,motoricactions.Infantsgain knowledge oftheworldfrom thephysicalactionstheyperform onit.Aninfantprogressesfrom reflexive,instinctualactionatbirthtothebeginningofsymbolicthoughttowardtheendofthestage. Piagetdivided thesensorimotorstageintosix sub-stages”:0–2years,Infantsjusthavesenses- vision, hearing,andmotorskills,suchasgrasping,sucking,andstepping.--- fromPsychologyStudyGuide byBernstein,Penner,Clarke-Stewart,Roy

Sub-Stage	**Age**	**Description**
1*Simple Reflexes*	Birth-6weeks	"Coordination ofsensation and action through reflexive behaviors". Three primary reflexes are described by Piaget: suckingof objectsinthemouth,followingmovingorinteresting objectswiththeeyes,andclosingofthehandwhenanobject makescontactwith thepalm (palmargrasp).Overthefirstsix weeksoflife,thesereflexesbegintobecomevoluntaryactions ; forexample,thepalmarreflexbecomesintentionalgrasping.
2*Firsthabits and primary circular reactions phase*	6weeks- 4months	"Coordinationofsensationandtwotypesof schemes:habits (reflex)andprimarycircularreactions(reproductionof anevent thatinitiallyoccurredbychance).Mainfocusis stillontheinfant's body." Asanexampleofthistypeofreaction,aninfantmight repeatthemotionof passingtheirhandbeforetheirface.Alsoat thisphase,passivereactions,causedby classical oroperant conditioning,canbegin.
3*Secondarycircular reactions phase*	4–8 months	Developmentof habits."Infantsbecomemoreobject-oriented, movingbeyondself-preoccupation; repeatactionsthatbring interesting or pleasurable results." This stage is associated primarilywiththedevelopment ofcoordinationbetweenvision andprehension.Threenewabilitiesoccur atthisstage:intentional grasping foradesiredobject,secondarycircularreactions,and differentiationsbetweenends andmeans.Atthis stage,infants will intentionallygraspdtheairinthedirectionofadesiredobject, often totheamusementoffriendsandfamily.Secondary circular reactions, or the repetition of an action involving an external object begin; for example, moving aswitchtoturnonalight repeatedly. The differentiationbetween means and ends also occurs.This

		child's growthas itsignifies thedawnoflogic.
4 *Coordination of secondary circular reactions stages*	8–12months	"Coordination ofvisionandtouch--hand-eyecoordination; coordination of schemes and intentionality." This stage is associatedprimarily with thedevelopmentoflogicandthe coordination betweenmeansand ends.Thisisan extremely important stageofdevelopment, holding what Piaget calls the "firstproperintelligence."Also, thisstagemarksthebeginningof goal orientation,thedeliberateplanning ofstepstomeetan
5*Tertiary circular reactions, novelty, andcuriosity*	12–18months	"Infantsbecomeintriguedbythemanypropertiesofobjectsand by themany thingsthey canmakehappen toobjects; they experimentwithnewbehavior." Thisstageis associatedprimarily withthediscoveryofnewmeanstomeetgoals.Piagetdescribes thechildatthisjunctureas the"youngscientist," conducting pseudo-experimentstodiscovernewmethodsof meeting challenges.
6 *Internalization of Schemes*	18–24months	"Infantsdeveloptheabilityto useprimitivesymbolsand form enduring mental representations." This stage is associated primarily with thebeginningsofinsight,ortruecreativity.This marks

Bytheendofthesensorimotorperiod,objectsarebothseparatefromtheself andpermanent.

Objectpermanenceis theunderstandingthatobjectscontinuetoexistevenwhentheycannotbeseen,heard,or touched.Acquiringthesenseof objectpermanenceisoneof theinfant'smostimportant accomplishments,accordingtoPiaget.

Preoperational stage

The preoperative stage is the second of four stages of cognitive development. Cognitive DevelopmentApproaches.By observingsequencesofplay,JeanPiagetwasabletodemonstratethat towardstheendofthesecondyear,aqualitativelynewkindofpsychologicalfunctioningoccurs.

(Pre)Operatory Thoughtisanyprocedureformentallyactingonobjects.Thehallmarkofthe preoperationalstageissparseandlogicallyinadequatementaloperations.Duringthisstage,thechild learnstouseandtorepresentobjectsbyimages,words,anddrawings.Thechildisabletoform stableconceptsaswellasmentalreasoningandmagicalbeliefs.Thechildhoweverisstillnotableto perform operations; tasksthat thechildcandomentally ratherthanphysically.Thinkingisstill egocentric.Thechildhasdifficultytakingtheviewpointofothers.Twosubstagescanbeformed frompreoperativethought.

- **The SymbolicFunctionSubstage**

Occursbetweenabouttheagesof2and7.During2-4yearsold,kidscannotyetmanipulate andtransforminformationinlogicalways,buttheynowcanthinkinimagesandsymbols. Thechildisabletoformulatedesignsofobjectsthatarenotpresent.

Otherexamplesof mentalabilitiesarelanguageandpretendplay.Althoughthereisanadvancementinprogress, therearestilllimitationssuchasegocentrismandanimism.Egocentrismoccurswhenachild is unabletodistinguishbetweentheirownperspectiveandthatof anotherperson's.Children tendtopicktheirownviewof whattheyseeratherthantheactualviewshowntoothers. An example isan experiment performed by Piaget and BarbelInhelder. Three viewsof a mountainareshownandthechildisaskedwhatatravelingdollwouldseeatthevarious angles;thechildpicks theirownviewcomparedtotheactualviewofthedoll.Animismis the beliefthatinanimateobjectsarecapableof actionsandhavelifelikequalities.Anexampleis achildbelievingthatthesidewalkwasmadandmadethemfalldown.

- **TheIntuitiveThoughtSubstage**

Occursbetweenabouttheagesof4and7.Childrentendtobecomeverycuriousandask manyquestions;begintheuseofprimitivereasoning.Thereisanemergenceintheinterestof reasoningandwantingtoknowwhy thingsaretheway theyare.Piagetcalledittheintuitive substagebecausechildrenrealizetheyhaveavastamountofknowledgebuttheyareunaware ofhowtheyknowit.

'Centration'and'conservation'arebothinvolvedinpreoperativethought.

Centrationistheactoffocusingallattention on onecharacteristiccomparedto theothers. Centrationisnoticedinconservation;theawarenessthatalteringasubstance'sappearance doesnotchangeitsbasicproperties.Childrenatthisstageareunawareof conservation. Example,In Piaget'smostfamoustask,achildispresentedwith twoidenticalbeakers containingthesameamountofliquid.Thechildusuallynotes thatthebeakershavethesame amountofliquid.When oneofthebeakersispouredintoa tallerandthinnercontainer, childrenwhoaretypicallyyoungerthan7or8years oldsaythatthetwobeakersnowcontain a differentamount of liquid. The childsimply focuses on the height and width ofthecontainercomparedtothegeneralconcept.

Concreteoperational stage

The**concreteoperational stage is**thethirdoffourstagesofcognitivedevelopment in Piaget'stheory.Thisstage,whichfollowsthepreoperationalstage,occursbetweentheages of7and11 yearsandischaracterizedbytheappropriateuseoflogic.Importantprocesses duringthis stageare:

Seriation—theability tosortobjectsinan orderaccordingtosize,shape,orany other characteristic.Forexample,ifgivendifferent-shadedobjects theymaymakeacolorgradient.

Transitivity-Theabilitytorecognizelogical relationshipsamongelementsinaserialorder, andperform 'transitiveinferences' (forexample,IfAistallerthan B,andBistallerthan C, thenAmustbetallerthanC).

Classification—theabilitytonameandidentifysets ofobjectsaccordingtoappearance,size orothercharacteristic,includingtheideathatonesetofobjects canincludeanother.

Decentering—wherethechildtakesintoaccountmultipleaspectsofaproblemtosolveit.Forexample,thechildwilln olongerperceive anexceptionallywidebutshortcup tocontain less thananormally-wide,tallercup.

Reversibility—thechildunderstandsthatnumbersorobjectscanbechanged,thenreturned to theiroriginalstate.Forthisreason,achildwillbeabletorapidly determinethatif4+4 equals t,t−4willequal4,theoriginalquantity.

Conservation—understandingthatquantity,length ornumberofitemsis unrelatedtothearrangementorappearanceoftheobjectoritems.

EliminationofEgocentrism—theability toviewthingsfrom another'sperspective(evenif they thinkincorrectly).Forinstance,showachildacomicinwhichJaneputsadoll undera box,leavestheroom,andthenMelissamovesthedoll toadrawer,andJanecomesback.A childin theconcreteoperationsstage willsay thatJane willstillthinkit'sunderthebox even thoughthechildknowsitisinthedrawer.

Childreninthisstagecan,however,onlysolveproblemsthatapplytoactual(concrete)objects or events,andnotabstractconceptsorhypotheticaltasks.

Formaloperational stage

Theformal operational periodisthefourthandfinal oftheperiodsofcognitivedevelopment inPiaget'stheory.Thisstage,whichfollowstheConcreteOperationalstage,commencesat around11 yearsofage(puberty)andcontinuesintoadulthood. Inthisstage,individuals movebeyondconcreteexperiencesandbegintothinkabstractly,reasonlogically anddraw conclusions from the information available, as well as apply all these processes to hypothetical situations.The abstractquality oftheadolescent'sthoughtat theformal operationallevelisevidentin theadolescent'sverbal problem solvingability.Thelogical qualityoftheadolescent'sthoughtiswhen childrenaremorelikely tosolveproblemsina trial-and-errorfashion.Adolescentsbegintothinkmoreasascientistthinks,devisingplans tosolveproblemsandsystematically testingsolutions.They usehypothetical-deductive reasoning,whichmeansthatthey develophypothesesorbestguesses,andsystematically deduce,orconclude,whichisthebestpathtofollowinsolvingtheproblem.Duringthis stagetheadolescentis abletounderstandsuchthings aslove,"shades ofgray",logicalproofs andvalues.During thisstagetheyoungpersonbeginstoentertain possibilitiesforthefuture andisfascinatedwithwhattheycanbe.Adolescentsarechangingcognitivelyalsobythe waythat theythinkabout socialmatters.Adolescent Egocentrismgovernsthewaythat adolescentsthinkaboutsocialmattersandistheheightenedself-consciousnessinthemas theyarewhichisreflectedintheirsenseofpersonaluniquenessandinvincibility.Adolescent egocentrismcanbedissectedintotwotypesofsocialthinking, imaginaryaudiencethat involvesattention gettingbehaviour,andpersonalfable whichinvolvesan adolescent'ssense ofpersonaluniqueness andinvincibility.

The Stages and Causation

Piagetseeschildren'sconceptionofcausationasamarchfrom"primitive"conceptionsof causetothoseofamorescientific,rigorous,andmechanicalnature. Theseprimitiveconcepts arecharacterizedasmagical,withadecidedlynon-natural ornon-mechanicaltone.Piaget attributesthistohismostbasicassumption:that babiesarephenomenists.Thatis,their knowledge"consistsofassimilatingthingstoschemas"from theirownactionsuchthatthey appear, fromthechild'spoint ofview, "to havequalitieswhich in fact stemfromthe organism." Consequently,these"subjectiveconceptions,"soprevalentduringPiaget'sfirst stageofdevelopment,aredashedupon discoveringdeeperempirical truths.Piagetgivesthe exampleofachildbelievingthemoonandstarsfollowhimonanightwalk;uponlearning thatsuchisthecaseforhisfriends,hemustseparatehisselffrom theobject,resultingina theorythatthemoonisimmobile,ormovesindependentlyofotheragents.Thesecondstage, fromaroundthreetoeightyearsofage,ischaracterizedbyamixofthistypeofmagical, animistic,or"non-natural"conceptionsofcausation andmechanical or"naturalistic" causation.Thisconjunction ofnatural andnon-natural causal explanationssupposedly stems fromexperienceitself,thoughPiagetdoesnotmakemuchofanattempttodescribethe natureof thedifferencesinconception;inhisinterviewswithchildren,heaskedspecifically aboutnatural phenomena:whatmakescloudsmove?Whatmakesthestarsmove?Whydo riversflow?Thenaturesofalltheanswersgiven,Piagetsays,aresuchthattheseobjects mustperform theiractionsto"fulfill theirobligationstowardsmen."Hecallsthis"moral explanation

SELF ASSESSMENT EXERCISE

Distinguish between assimilation and accommodation

3.4Challenges toPiagetianstage theory

Piagetians'accountsofdevelopment havebeen challenged onseveralgrounds. First, asPiagethimselfnoted,developmentdoesnotalwaysprogressinthesmoothmannerhis theoryseemstopredict.'Decalage',orunpredictedgapsinthedevelopmental progression,suggest thatthestagemodelisatbest ausefulapproximation.Morebroadly,Piaget'stheoryis'domaingeneral',predictingthatcognitivem aturation occursconcurrently acrossdifferent domainsof knowledge(suchasmathematics,logic,understandingof physics,oflanguage, etc.).Duringthe1980sand1990s,cognitivedevelopmentalistswereinfluencedby "neo-nativist"and evolutionarypsychologyideas. These ideasde-emphasized domaingeneral theoriesandemphasizeddomainspecificity ormodularity ofmind.Modularityimpliesthat differentcognitivefacultiesmaybelargelyindependentof oneanotherandthusdevelop according toquite different time-tables. In this vein, some cognitive developmentalistsargued thatratherthanbeingdomaingenerallearners,childrencomeequippedwith domain specifictheories,sometimesreferredtoas'coreknowledge',whichallowsthemtobreakinto learningwithinthatdomain.Forexample,evenyounginfants appeartobesensitivetosome predictableregularitiesinthemovementandinteractionsofobjects(e.g.thatoneobject cannotpassthroughanother),orinhumanbehavior(e.g.thatahandrepeatedlyreachingfor an objecthasthat object,notjustaparticularpath ofmotion),asis thebuildingblock out ofwhichmoreelaborateknowledgeis constructed. Morerecentworkhas stronglychallenged someof thebasicpresumptions of the'coreknowledge'school,andrevisedideas of domain generality—but froma newer dynamic systems approach, not froma revised Piagetian perspective. Dynamicsystems approaches harkentomodernneuroscientific researchthatwas notavailabletoPiagetwhen hewasconstructinghistheory.Oneimportantfindingisthat domain-specificknowledgeisconstructedaschildrendevelopandintegrate knowledge.This suggestsmoreofa"smoothintegration"oflearninganddevelopmentthaneitherPiaget,or hisneo-nativistcritics,had envisioned.Additionally,somepsychologists,such asVygotskyandJeromeBruner, thoughtdifferentlyfromPiaget,suggestingthatlanguagewasmore.

3.5 Post Piagetian and Neo-Piagetian stages

Intherecentyears,severalscholarsattemptedtoamelioratetheproblemsofPiaget'stheory by developing new theories and models that can accommodate evidence that violates Piagetianpredictions andpostulates.Thesemodelsaresummarizedbelow.

Theneo-Piagetiantheories ofcognitivedevelopment,advancedbyCase,Demetriou,Halford, Fischer,andPascual-Leone,attemptedtointegratePiaget'stheory withcognitiveand differentialtheories ofcognitive organization and development. Their aimwas to better accountforthecognitivefactors ofdevelopmentandforintra-individualandinter-individual differencesincognitivedevelopment.TheysuggestedthatdevelopmentalongPiaget'sstages isduetoincreasingworkingmemory capacity andprocessingefficiency.Moreover, Demetriou'stheory ascribesanimportantroletohype-cognitiveprocessesofself-recording, self-monitoring,andself-regulationanditrecognizestheoperation ofseveral relatively autonomous domains ofthought(Demetriou,1998;Demetriou,Mouyi,Spanoudis,2010).

- Postformalstageshavebeenproposed.KurtFischersuggestedtwo,MichaelCommons presents evidence for four postformalstages: the systematic, metasystematic, paradigmaticandcross paradigmatic.(Commons &Richards,2003;Oliver,2004).
- A"sentential"stagehasbeenproposed,saidtooccurbeforetheearlypreoperational stage.ProposedbyFischer,Biggs andBiggs,Commons, andRichards.
- Searching for a micro-physiological basis for human mental capacity, Traill (1978, proposedthattheremaybe"pre-sensorimotor" stagesdevelopedinthewomband/or transmittedgenetically.

Postulatedphysicalmechanisms underlying"schemes"andstages

Piagethimself(1967)consideredthepossibility ofRNA*molecules*aslikelyembodimentsof hisstill-abstract"schemes" (whichhepromotedas units ofaction)—thoughhedidnotcome toanyfirm conclusion.Atthat time,duetoworksuchasthatofHolgerHydén,RNA concentrationshad indeedbeenshowntocorrelatewithlearning,so theideawasquite plausible.

However,bythetimeofPiaget'sdeathin1980,thisnotionhad lostfavour.Onemain problemwasovertheproteinwhich(itwasassumed)suchRNAwouldnecessarily produce, andthatdidnotfitinwithobservation.Itthenturnedout,surprisingly,thatonlyabout3%of RNAdoescodeforprotein(Mattick,2001,2003,2004).Hencemostof theremaining97% (the"ncRNA")couldnowtheoreticallybeavailabletoserveasPiagetianschemes(or other regulatory roles now under investigation). The issue has not yet been resolved experimentally,butits theoreticalaspects havebeenreviewed;(Traill2005/2008).

4.0Conclusion

Piagetbelievedthatallchildrentrytostrikeabalancebetweenassimilationandaccommodation, whichisachievedthroughamechanismPiagetcalledequilibration.As childrenprogressthroughthe stages ofcognitivedevelopment,itisimportanttomaintainabalancebetweenapplyingprevious knowledge (assimilation)andchangingbehaviortoaccountfornewknowledge (accommodation). Equilibrationhelps explainhowchildrenareabletomovefromonestageofthoughtintothenext.

5.0Summary

Piaget's theory,howevervitalinunderstandingchildpsychology,didnotgowithoutscrutiny.Amain figurewhoseideascontradictedPiaget'sideas was theRussianpsychologistLevVygotsky.Vygotskystressedtheimportanceofachild'sculturalbackg roundasaneffecttothestagesofdevelopment.
Becausedifferentculturesstressdifferentsocialinteractions,thischallengedPiaget'stheory thatthe hierarchy oflearningdevelopmenthadtodevelopinsuccession.Vygotskyintroduced thetermZone ofproximaldevelopmentasanoveralltaskachildwouldhavetodevelopthatwouldbetoodifficult todevelopalone

6.0Tutor-MarkedAssignment

1 IdentifyPiaget's stages ofintellectualdevelopment
2 Describeindetails allthestages ofPiagetstagesofintellectualdevelopment.
3 What arethe implicationsofPiaget'sstages ofintellectualdevelopment totheteaching andlearningofmathematics.

7.0References/FurtherReadings

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UNIT 3:WritingObjectives UsingBloom's Taxonomy

CONTENTS

1.0 Introduction

Behaviouralobjectives aremeans ofconceivinginstructional strategyinaformthatrequires a specificationofwhattasksthestudents areexpectedtobeabletoperform,underwhatconditions and howsuchtasks willbeevaluated.Theprocessoflearningis anindividualexperienceforeachstudent. Accordingtobehaviouristschoolofpsychology,learningtakes placewheneveran individual'sbehaviourismodified,thatis whenhethinks oracts differently;orwhenhehas acquired newknowledgeoranewskillandsoforth. Thus theconceptofbehaviouralobjectives as a significanteducational strategyis similartotheconceptofoperationaldefinitionofterms developed insciencesomeyears ago"toeliminatehypotheticalconcepts bydefiningaconceptinterms ofthe stepsoroperations wherebythephysicalrealityoftheconceptcouldbeobserveormeasured" (Dressel,1977).

2.0Objectives

Attheendofthe unityoushouldbeable to:

- stateBloom's Taxonomyofeducation objectives
- identifytheattributes ofeachlevelofthetaxonomy
- writebehaviouralobjectives

3.0Main content

WritingObjectives UsingBloom's Taxonomy

Various researchers have summarized how to use Bloom's Taxonomy. Followingarefour interpretations thatyoucanuseas guidesinhelpingtowriteobjectives usingBloom's TaxonomyBloom'sTaxonomydividesthewaypeoplelearnintothreedomains.Oneoftheseisthec ognitive domain,which emphasizesintellectual outcomes.Thisdomainisfurtherdividedintocategoriesor levels. Thekeywordsused andthetypeofquestionsasked mayaidintheestablishment and encouragementofcriticalthinking,especiallyinthehigherlevels.

Level	LevelAttributes	Keywords	Questions

1 Knowledge	Exhibits previously learned material byrecalling facts,terms, basic concepts and answers.	who,what,why,when, omit, where,which,choose,find, how, define, label, show, spell, list, match, name, relate, tell,recall,select	Whatis…?Howis.?Where is...? When did --- happen? How did - happen? How would youexplain…?Whydid…?How wouldyoudescribe…?When did …? Can you recall …? How would you show …? Who were the main...?Canyoulistthree...?How wouldyouclassifythe type of. . . ?Howwouldyoucompare…?Contrast...?Will youstateorinterpretinyour ownwords ...?How would you rephrase themeaning...? Whatfactsor ideasshow...?
2 Comprehension	Demonstrating understandingof facts andideas by organizing comparing, translating, Interpreting, giving descriptionsand stating main idea.	compare, contrast demonstrate, interpret explain, extend,illustrate, infer, outline, relate rephrase, translate summarize, show, classify	Which statementssupport...? Canyouexplain whatis happening...whatismeant. ..?Whatcanyousayabout ...?Whichisthebestanswer...? How wouldyou summarize...?
3 Application	Solving problemsby applying acquired knowledge, facts, techniques and rules inadifferentway.	apply, build, choose construct, develop interview,make use of organize, experimentwith plan,select, solve, utilize model,identify	How wouldyouuse...? What examples canyoufindto...? How would you solve usingwhatyouhave learned...? Howwouldyou organize toshow…? How wouldyoushowyour understandingof...?What approachwouldyouuseto...? Howwouldyouapply what youlearned to develop...? Whatotherway wouldyou planto…?Whatwouldresult if...?Canyoumakeuseofthe factsto...? Whatelements wouldyouchoosetochange...? What facts would you selecttoshow...? What questionswouldyouaskinan interview with what…?

4:Analysis	Examining and breaking information intoparts identifyingmotives or causes; making inferences andfinding evidence to support generalizations.	analyze,categorize,classify, compare,contrast,discover, dissect, divide, examine inspect, simplify, survey take part in, test for distinguish, list, distinction, theme, relationships, function, motive, inference, assumption,conclusion	Whatarethepartsorfeaturesof...?How is related to. . . ?Whydoyouthink. . . ?What isthetheme. . . ?Whatmotive isthere...?Canyou listthe parts...? What inferencecanyou make...? Whatconclusionscanyou draw...?Howwouldyouclassify...?How would you categorize...? What evidence can youfind...? Whatisthe relationshipbetween...? Can youmake adistinctionbetween...? Whatisthe functionof...? Whatideasjustify...?
5 Synthesis	Compiling information together inadifferentway by combining elementsin anew pattern or proposing alternative solutions.	build,choose, combine, compile, compose, construct, create,design, develop,estimate, formulate imagine, invent, make up, originate, plan, predict, propose, solve, solution, suppose, discuss, modify, change, original, improve, adapt, minimize,maximize, delete, theorize,elaborate, test, improve, happen, change	What changes would you make tosolve...? Howwould youimprove...? Whatwould happenif ...?Canyouelaborate onthereason...? Can you propose analternative...?Canyouinvent...? How wouldyou adapt tocreateadifferent tocreateadifferent ...? How couldyou change (modify) the plot (plan) ...? Whatcouldbe done to minimize (maximize) ...? Whatwaywouldyoudesign...?Whatcouldbecombined to improve (change) …?Suppose youcould whatwouldyoudo...? How would youtest ...?Can you formulatea theoryfor ...? Can youpredicttheoutcomeif ...? Howwouldyouestimate the resultsfor...?Whatfactscan youcompile...?Canyou constructamodel thatwouldchange...?Canyouthinkof an original way for the …?
6 Evaluation	Presenting and defendingopinionsby making judgments about information,validity ofideas qualityofworkbased, on a set of	award, choose, conclude, criticize, decide, defend, determine,dispute,evaluate, judge, justify, measure, compare, mark, rate, recommend,ruleon,s	Doyouagreewiththeactions...? with theoutcomes ...?What isyour opinion of...? How wouldyou prove ...?disprove …? Can you assess thevalueorimportanceof...? Woulditbebetterif...?Why did they (the character)choose ...?What wouldyou,recommend ...? How would youratethe...?Whatwould

	criteria.	elect, agree, interpret, explain, appraise,prioritize,opinion, support, importance, criteria, prove, disprove, assess, influence, perceive, value, estimate, influence, deduct	youcitetodefendtheactions...?Howwouldyouevaluate...?Howcouldyoudetermine...? Whatchoicewouldyouhave made...? What would youselect...? Howwouldyou prioritize...?What judgment wouldyoumake about...?Based onwhat you know, how wouldyouexplain...?What informationwouldyou use tosupportthe view...? Howwouldyoujustify ...? Whatdatawas usedtomake theconclusion...?Whywasit betterthat...?Howwouldyou prioritize thefacts...? How wouldyoucomparetheideas …? People …?

3.2 Bloom's Ranking of Thinking Skills

Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
List, name, identify, show, define, recognize, recall, state, visualize	Sumarize, explain, Interpret, describe, compare, paraphrase, differentiate, demonstrate, classify	Solve, illustrate, calculate, use, interprete, relate, manipulate, apply modify	Analyse, organize, deduse, contrast, compare, distinguish, discuss, plan, devise	Design, hypothesis, support, schematize, write, justify	Evaluate, choose, estimate. judge, report, defend, critisize

AccordingtoBenjaminBloom,andhis colleagues, therearesixlevels ofcognition:

1. Knowledge:rotememorization,recognition,orrecalloffacts
2. Comprehension:understandingwhatthefactsmean
3. Application:correctuseofthefacts,rules,orideas
4. Analysis:breakingdowninformationintocomponentparts
5. Synthesis:combinationoffacts,ideas,orinformationtomakeanewwhole
6. Evaluation:judgingorforminganopinionabouttheinformationorsituation

Ideally,eachoftheselevelsshouldbecoveredineachcourseand,thus,atleastoneobjectiveshould bewrittenforeachlevel.Dependingonthenatureofthecourse,afewoftheselevelsmayneedtobe givenmoreemphasis thantheothers.

3.3Examplesofobjectiveswrittenforeachlevelof Bloom’sTaxonomy andactivitiesand assessmenttools based onthoseobjectives.

Commonkeyverbs usedindraftingobjectives arealsolistedforeachlevel.

Level	**Level Attributes**	**Keywords**	**Example Objective**	**Example Activity**	**Example Assessment**
1 Knowledge	Rote memorization, recognition, recall of facts.	List, recite, define, name, or match, recall, label, recognize	“By the end of this course, student will be able to recite Newton’s laws of motion.”	Have students group up and perform simple experiments to the class showing how one of the laws of motion works.	Use the following question on an exam or home work. “Recite Newton’s three laws of motion.”
2 Comprehension	Understanding what the facts mean.	Describe, explain, paraphrase, restate, give original examples of, summarize, interpret, discuss	“By the end of this course, the student will be able to explain Newton’s three laws of motion in his/her own words.”	Group students in to p[airs and have each pair think of words that describe motion. After a few minutes, ask pairs to volunteer some of their descriptions and write these words on the board.	Assign the student to write a simple essay that explains what Newton’s laws of motion means in his/her words.
3 Application	Correct use of the facts, rules, or ideas.	Calculate, predict, apply solve, illustrate, use, demonstrat e, determine, model	By the end of this course, the student will be able to calculate the kinetic energy of projectile.	After presenting the kinetic energy equation in class, have the students pair up for just a few minutes and practice using it so that they feel comfortable with it before been assessed.	On a test, define a projectile and ask the students to “Calculate the kinetic energy of the projectile.”

4 Analysis	Breaking down information in to component parts.	Classify, outline, breakdown, categorize, analyze, diagram, illustrate	"By the end of this course, the student will be able to differentiate between potential and kinetic energy."	Present the student with different situations involving energy and ask the students to categorize the energy as either kinetic or potential then have them explain in detail why they categorized it the way they did, thus breaking down what exactly makes up kinetic and potential energy	Give the student an assignment that asks them outline the basic principles of kinetic and potential energy. Ask them to point out the differences between the two as well as how they are related.
5 Synthesis	Combining parts to make a new whole	Design, formulate, build, invent, create, compose, generate, derive, modify, develop	By the end of this section of the course, the student will be able to "Design an original homework problem dealing with the principle of conservation of energy."	Tie each lecture or discussion to the previous lecture or discussion before it, thus helping the student assemble all the discrete classroom sessions in to a unified topic or theory.	Give the student a project in which they must design an original homework problem dealing with the principle of conversation of energy.
6 Synthesis	Judging the value or worth of information or ideas.	Choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, convince, select, evaluate	"By the end of the course, the student will be able to determine whether using conservation of energy or conservation of momentum would be more appropriate following a	Have different groups of students solve the same problem using different methods, then have each groups present pros and cons of the method they choose.	On a test, describe a dynamic system and ask the students which method they will use to solve the problem and why.

			dynamic problem."		

4.0 Conclusion

Behaviouralobjectiveshavebeendefinedas desiredoutcomeoflearningwhichis expressedinterms ofobservableand/ormeasurablebehaviourorperformance.Incontrasttoaneducationalaimwhich onlystipulates changes thatcannotbeobservedormeasured,behaviouralobjectives spelloutwhatthelearnershouldbeabletodoas aconsequenceofthelearningexperiences associatedwiththe objectives.Ithas beenfoundthatBloom's taxonomyoncognitivedomainlendsitselftoanumberof adaptations suitableforformulatingbehaviouralobjectivesinscienceinstruction.

5.0Summary

Thesixlevels ofcognitionas proposedbyBloomare:

1. Knowledge:rotememorization,recognition,orrecalloffacts
2. Comprehension:understandingwhatthefactsmean
3. Application:correctuseofthefacts,rules,orideas
4. Analysis:breakingdowninformationintocomponentparts
5. Synthesis:combinationoffacts,ideas,orinformationtomakeanewwhole
6. Evaluation:judgingorforminganopinionabouttheinformationorsituation

6.0Tutor-MarkedAssignment

1. ListBloom's taxonomyofeducationalobjectives
2. Pickamathematics topicwritebehaviouralobjectivesforeachoftheBlooms' levels ofcognition.

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UNIT 4:INNOVATIONSINTEACHINGOF MATHEMATICS

CONTENTS

1.0Introduction

It is a common saying that a business man who does today's work with yesterday's tools should not expect to remain in business tomorrow. Life is dynamics, so is education and teaching techniques. There are lots of innovations in the teaching of mathematics. This unit shall explore these innovations.

2.0Objectives

Attheendoftheunityoushouldbeableto:

Listanddiscuss atleastfourinnovativemethods ofteachingmathematics

3.0Main content

3.1NeedforInnovations inTeachingMathematics

ThoughMathematicsbeingsoimportantsubjectandoccupyingacentral positionsincetheAncient period, stillithasnotbeen theinterest ofmany students.Thegapsarefoundbetween aspiration and achievement.Mathematicsis highlyabstract. Itisconcernedwithideas ratherthanobjects;withthemanipulationof symbolsratherthanthemanipulationof object.Itisaclosely-knit structurein whichideasareinterrelated.Mathematical conceptsarehierarchical andinterconnected, muchlikeahouseofcards.Unlesslower-levelconceptsaremastered,higher-levelconceptscannot beunderstood.Studentswhodiscoversomeof thestructuresofmathematics,areoftenimpressedby itsbeauty.Theynotethelackofcontradiction,andtheyseehowanewtechniquecanbederived fromonethathas alreadybeenlearned.

Teachingofmathematicsis notonlyconcernedwiththecomputationalknowhowofthesubjectbutis alsoconcernedwiththeselectionofthemathematical contentandcommunicationleadingtoits understandingandapplication.Sowhileteachingmathematics oneshouldusetheteachingmethods, strategiesandpedagogicresourcesthataremuchmorefruitfulingainingadequateresponsesfrom thestudentsthanwehaveeverhadinthepast.Theteachingandlearningofmathematicsisa complexactivity andmanyfactorsdeterminethesuccessof thisactivity.Thenatureandqualityof instructionalmaterial,thepresentationof content,thepedagogicskillsof theteacher, thelearning environment,themotivationofthestudentsareallimportantandmustbekeptinviewinanyeffort toensurequalityin teaching-learningofmathematics.

Innovationsandinnovativepracticesin teachingmathematics,isdiscussedunderteachingmethods, strategiesandpedagogicresources.Theprocessofinnovationisgenerally describedasconsistingof threeessentialsteps,startingwiththeconceptionof anidea,whichisthenproposedandisfinally adopted.Though manyideashavebeen conceivedtobringaboutchangein theteaching of mathematics,itisyettobeproposedandadopted.So,theinnovationsdiscussedmaynotbenewin terms oftheideabutis newinterms ofpractice.

Lookingtotheaimsofteachingmathematicsitcanbeseenthatmorefocusislaidtothehigherlevel ofobjectivesunderlyingthemathematicssubject,likecriticalthinking,analyticalthinking,logical reasoning,decision-making,problem-solving.Such objectivesaredifficulttobeachievedonly throughverbalandmechanicalmethods thatareusuallyusedintheclass ofmathematics.Theverbal methodsofinstructiongiveallimportancetospeechandtexts,tothebookandtotheteacher.From anhistoricalpointofviewthismethodwasmajorlyuseduntiltheendofthenineteenthcentury.

Inoneoftheseverbalmethodsteachersaresimplysatisfiedwithgivingthemathematical rulesto pupilsandhavingthemmemorizeit.Theyjustifythismethodbysayingpupilswouldnotunderstand explanations.Theirtaskisto transmitto theirpupilstheknowledge whichhasaccumulated overthe centuries,tostufftheirmemorywhileaskingthemtoworkexercises,e.g. theruleof signsandformulasin algebra;studentsmemorizethisandrememberit!Anotherverbal methodinvolvesexplanation.Teacherswhousethismethodassumethatthementalstructure ofthe childissameastheadult's.ButadevelopmentalstageaccordingtoPiagetisaperiodof yearsor monthsduringwhichcertaindevelopments takeplace.Teachers thinkteachingmustimplylogic,and logicbeing linkedto language,oratleasttoverbalthought,verbalteaching issupposedtobe sufficienttoconstitutethislogic.Thismethodleadstoseriesofexplanationsandstudentsatthe initial stepsoflogical explanationstryingtounderstandandgraspbutslowly thegapiscreated betweentheexplanations transmittedbyteacher andreceived bystudentswhichleadto thepoorunderstandingonpart ofstudentsand they developafearofthe subject:Math phobia.TheEducation Commission (1964-66)pointsout that"In theteachingof Mathematicsemphasisshouldbemoreon theunderstandingofbasicprinciplesthan on the mechanicalteaching ofmathematicalcomputations".Commenting on theprevailingsituationin schools,itisobservedthatin theaverageschool todayinstructionstillconfirmstoamechanical routine,continuestobedominatedby theoldbesettingevilofverbalismandthereforeremainsdull anduninspiring.

SELF ASSESSMENT EXERCISE

Write a brief note on the need for innovations in the teaching of mathematics

3.2Innovations inTeachingMathematics

Innovationsinteachingofmathematicscanbediversifiedinterms ofMethods,PedagogicResources andMastery LearningStrategyusedinteaching-learningprocess.

1.MasteryLearningStrategy

TeachingStrategyis ageneralizedplanforalessonandincludes aspecific structuretobefollowed.B.S.BloomhasdevelopedMasteryLearningStrategy.Itisanewinstructionalstrategythatisused fordevelopingmasterylearningandobjectivesof curriculumcanberealized.Itconsistsof different steps:divisionofcontentintounits,formulationofobjectives relatedtoeachunit,teachingandinstructionareorganizedforrealizingobjectivesof eachunit,administeringunittestto evaluatethemastery leveland diagnosethelearning difficulties,remedialinstructionsaregiven to removethedifficultiesandattainmasterylevelbyeverystudent.Thisstrategyplaysanimportant roleforlearningof basicsandfundamentalse.g. operationsindifferentnumbersystems–Natural numbers,Integers,Rationalnumbers,Realnumbers.

2.Methods

Methodisastyleof thepresentationof contentinclassroom.Thefollowingaretheinnovative methods thatcanbeusedtomaketeaching-learningprocess ofMathematics effective.

Inducto-DeductiveMethod

Itisacombinationofinductiveanddeductivemethod.Inductivemethodistomovefrom specific examples to generalization and deductive method is to move from generalization to specific examples.Inclassroomusuallytheinstructions directlystartwiththeabstractconceptsandarebeing taughtinawaythatdoes notbringunderstandingonthepartofmajorityofthestudents.Formulas,theorems,examples,results arederived,provedandused.But teacherneedsto startwithspecificexamples andconcretethings andthenmovetogeneralizationsandabstractthings. Thenteacheragainneedstoshowhowgeneralizationcanbederivedand itholdstruethrough specificexamples.Thismethodwillhelpstudentsforbetterunderstanding,students don'thaveto cramthethings andwillhavelonglastingeffect.

Example:PythagorasTheorem-Inaright- angle □□ABC right angled at B, $AB2+2BC= 2AC$ (Consideringrightangletrianglesof differentmeasurementleadingtogeneralization andthen establishingitthroughthetheoreticalproof).

Analytico-SyntheticMethod

ItisacombinationofAnalytic andSyntheticmethod.Analyticisbreakingdown andmovingfrom unknowntoknownandSyntheticisputtingtogetherknownbitsof informationandmovingfrom known tounknown.Thesemethodsarebasicallyusedin provingtheresultsandsolvingsums.In textbooksmostlysyntheticmethodisused,toprovesomethingunknownwestartwithacertain

knownthing,butthatleavesdoubtinmindof studentswhywehavestartedwiththatstepandusing this particularknownthing.Soteacherhas tousecombinationinordertoexplainandrelateeachstep logically.
Example:If*ba*=*dc*thenprovethatd(a-ab)=b(c-2ad).

SyntheticMethodAnalyticMethod
ba=dc □*ba- 2a=dc-2a**(Why??)** *d(a□2ab)=b(c-2ad)*

*thedoubtraisedinstudents mindisbeingsolvedwiththehelpofanalyticmethod *d(a-2ab)=b(c-2ad) ba 2ab=dc 2ad ba-2a=dc-2a ba=dc*
□ −□ −□ □ □

Problem-SolvingMethod

Thismethodaimsatpresentingtheknowledgetobelearntintheform ofaproblem.Itbeginswitha problematicsituation andconsistsof continuousmeaningfulwell-integratedactivity.Choosea problemthatusestheknowledgethatstudentsalreadyhavei.e.youasateachershouldbeableto givethemtheproblemandengagethemwithoutspendingtimeingoingoverthethingsthatyou thinkthey shouldknow.Afterstudentshavestruggledwiththeproblem togetsolution,havethem sharetheirsolutions.Thismethodwillhelpthemindevelopingdivergentthinking.

Example:Putaproblemoffindingtheamountof waterinagivencontainerinsteadof derivingthe formulaofvolume (cylinderfilledwithwater).

Play-WayMethod

Thismethodconsists of theactivities thatincludeasortoffunorplayandgivejoytothestudents. Studentsdon't realizethattheyarelearning but inawaytheyaregaining knowledgethrough participatingindifferentactivities.

Thismethodhelpstodevelopinterestinmathematics,motivatesstudentstolearnmoreandreduces theabstractnatureofthesubjecttosomeextent.
Example:Mathematicalgames andpuzzles.

LaboratoryMethod

Laboratorymethodisbasedon theprinciplesof"learningby doing"and"learningby observation" andproceedingfromconcretetoabstract.Studentsdonotjustlistentotheinformationgivenbutdo somethingpracticallyalso.

Principleshavetobediscovered,generalizedandestablishedbythestudentsinthismethod.Students learnthroughhandsonexperience.Thismethodleadsthestudenttodiscovermathematicalfacts. Afterdiscoveringsomethingbyhis ownefforts,thestudentstarts takingprideinhisachievement,it gives himhappiness,mentalsatisfactionandencourages him towards furtherachievement.

Example: Making and observing models, paper folding, paper cutting, construction work in geometry.

3. Pedagogic Resources

Pedagogic resources arethe resources thatateachermayintegrateinamethodforthetransactionofaparticularcontentanddrawupontoadvancethestudents'learning.

TeachingAids

Teachingaidsarethematerialsusedforeffectiveteachingandenhancingthelearningof students.It canbeanythingready-madeormadebytheteacherormadebystudents.Differentteachingaidsshouldbeusedinteachingmathematicslike Charts,Manipulatives,ProgrammedLearningMaterial (PLM),computers andtelevision.

Charts–Itcanbeusedtodisplayformulae,symbols,mathematicalandgeometricalfigures. Charts canbeusedformakingstudentsfamiliartothesymbolsandformemorizationofbasicformulae. Evenitcanbeusedtobringtothestudentstwo-dimensiongeometryandthe graphicalrepresentationinabetterway.

Manipulatives–Theyareobjectsormaterialsthatinvolvemathematicsconcepts,appealingto several senses,whichcanbetouchedandmovedaroundby thestudents (notdemonstrations of materialsbytheteacher).Eachstudentneedsmaterialtomanipulateindependently.Withstudents activelyinvolvedinmanipulatingmaterials,interestinmathematicswillbearoused.Canny(1984) has shownthat mathematics instruction and students' mathematics understanding will be more effectiveifmanipulativematerialsareused.Modelscanbeusedtomakethingsconcretelikethree dimensionfiguresingeometry.

ProgrammedLearningMaterial(PLM)–Itisaself-learningmaterialinwhichlearnercanproceed athisownpace.Ithasthecharacteristicsof allsequentialsteps,learner'sresponse,self-pacing, immediatefeedback,reinforcementandself-evaluation.Itishelpfulinacquisition of conceptslikefractions,numbersystems,etc.andcanbeusedasaremedyforslowlearnersfora specificcontent.

ComputersandTelevision–Computercanbeusedformultimediapresentationfortheconcepts thatrequiresvisualizationand imagination.Computercanalso beused forprovidingComputer AssistedInstruction (CAI),itissimilartoPLMi.e.itisacomputerizedPLM.Television can beused toshowsomegoodmathematics educationshow.

Activities

Activitieshereincludeallsuchworkwhereinstudentsplayanactiverole,hastointeractwith differentresourcesandgenerateknowledge.It includesQuizcompetition,Projects,Roleplay, Seminars, Discussion,Mathematics club,Assignment,Fieldtrips,etc.

NameoftheActivityExamples/Situations whereActivity canbeused

QuizCompetition

Logic,Properties ofNumbers,Mathematical RulesandResults

Projects ContributionbyDifferentMathematicians

RolePlay

Arithmeticalconcepts like Profit&Loss,Simple& CompoundInterest

Seminars

ShortcutsthroughVedicMathematics,

ApplicationofMathematicsinotherDisciplines

Discussion

Properties of'Zero', Difference between Rational and Irrational Numbers, Relating Different Concepts inMathematics

Mathematics Clubs

Applicationoftheconceptstudied,PreparingModels,Paper Folding(Origami) AssignmentSelf-Study,ExtensionofKnowledge

Field Trips

ExperiencingtheFunctionaluseofMathematicsinBank, InsuranceCompany

Inanycurriculum,contentandpresentationof contentarethetwomostimportantandinseparable components.Itisdifficulttosay anythingdefinitelyaboutwhichmethodandpedagogicresourceis goingtobemosteffectiveforpresentationof aparticulartypeof content.Selectionofmethodand pedagogicresourcedependsonmanyfactorsliketypeofcontent,objectivestobeachieved,levelof thestudents,entry behaviour,availabilityof resources.Alsoacceptanceofinnovativemethodsand positiveattitudeofteacherstowardsit,isan important factorfortheselectionofmethod and pedagogicresource.Thethingsincludedunderinnovationsareexisting inbooks,alsothereare researcheswhichshowthatsomeinnovationsarecarriedoutintheclassroom andhasshownthe positiveeffectonteachinglearningprocess buttheirpracticalusageandimplementationinclassroom isnotseentotheexpectedlevel.

3.3Guidelines foraTeacherinIncorporating Innovations inTeachingMathematics

Foreffectivetransactionofthecurriculumand achievementofcurricularobjectivesappropriate methodandpedagogic resources shouldbeusedinprovidinglearningexperiences tothestudents.

Anumberof factorsneedtobeconsideredwhilemakinguseof aparticularmethodandpedagogic resource:learners'capabilities,availabilityof resources,entry behavior,school environment, objectives tobeachieved,thenatureofcontentandtheteacher's ownpreparation andmastery.

Decideonandplaninadvancetheinnovativeideathattheteacherwouldbeincorporatingto transactaparticularconceptsothatloss ofinstructionaltimeis preventedorminimized.

Theimmediateenvironmentofthelearnerbothnaturalandhuman shouldbeusedwhenandwhere possibleformakinglearningconcreteandmeaningful.

Involvethestudentsintheprocessoflearningbytakingthembeyondtheprocessoflisteningto thatofthinking,reasoninganddoing.

Inordertopromoteself-studyskills useoflibraryandresourcecenterneeds tobeencouraged.

Receivingregularfeedbackforteachingandlearningshouldbeaninbuiltcomponentof teaching-learning process. Continuous and comprehensive evaluation has to be ensured as it plays an importantroleforthe requiredmodificationinteaching-learningprocess. Mathematics-teachers'organizationsatdifferentlevelsshouldbeformedwheresharingofideas andexperiences,developingresourcesin acollaborativemannerand themechanismsthatenable teachers tocarryoutinnovationsisbeingdiscussed.Mathematics-teachers'organizations canbeinstrumentalinestablishingaclimateof confidenceincarryingoutinnovationsandapositive attitudetonewapproachesinteachingmathematics.
Properly instructandguidethestudentsforcarrying outdifferentactivitiesandprecautionary measures shouldbetakensothatstudents arenotmisguided. Study mathematical journals and modern books of professional interest. Anyfacilities ofin-servicetraining shouldbeavailedofforimprovingteachingofmathematics.

Theteachercanalwaysaskhimselftwoquestions:1.'IsthereSomenewwayinwhichIcanpresent thismaterialin ordertomakeitmoremeaningful andmoreinteresting?'2.'Whatactivities, demonstrations,teachingaids,etc.wouldenrichtheclassroom presentation anddirectattentionof studentstotheimportantelements?'Oncetheteacherdiscoversinnovativeways to arouseinterestandenthusiasmintheclass,hewillbeabletousetheseideasagainthefollowing year,since those willbenewandfascinatingtoa differentclass.Butteachershouldkeepinmindthat as timepasses,theworldundergoes achange,theenvironmentsurroundingstudents' changes andtheirneedsalsochanges,soonehastocontinuouslygoonmodifyinganddiscoveringnewways ofteachingwhichproves himabetterteacher.

4.0 Conclusion

Itisimportantforteacherstohavearepertoireknowledgeof severalinnovativewaysof presenting mathematics totheirstudents**.**

5.0 Summary

In this unit some innovative methods were discussed namely, inducto-deductive, analytico-synthetic, problem-solvin, play-way, laboratory methods. Some teaching resources were also discussed such as: charts,manipulatives,programmedlearningmaterial(PLM),computers andtelevision. Some guidelinesforateacherinincorporating innovations inteachingmathematics were provided

6.0 Tutor-Marked Assignment

(a) Whyisinnovativeteachingnecessaryinmathematics classroom?

(b)Discuss asmuchas possiblefourinnovativeways ofteaching mathematics.

7.0 References / Further Readings

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