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Research Paper

The Investigation on the Reasoning and Motivation: An Assessment of the Case of the Students

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Abstract: *Reasoning is a skill that is demonstrated during the advanced stages of thought (Umay, 2003), in other words, during problem-solving processes, and which represents high-order mathematical thinking (Kenney & Lindquist, 2000). Webster (1982) also defines reasoning as "the ability to think coherently and logically and draw inferences or conclusions from facts known or assumed". Reasoning skills are an important component of education, and reasoning skills are necessary for understanding mathematics in particular, and they present an important means of developing ideas (National Council of Teachers of Mathematics [NCTM], 2000). Mathematical reasoning refers to the ability to formulate and represent a given mathematics problem, and to explain and justify the solution or argument (Kilpatrick, Swafford & Findell, 2001).*
Key Words: *Reasoning, Motivation, Reasoning Skills, Generalisability Skills,*

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I. INTRODUCTION: REASONING AND MOTIVATION

According to the NCTM (2000), mathematical reasoning can be gained at the elementary school level. In order to acheive this, during elementary education students should be placed in situations in which they are able to make, refine, and test their own conjectures (Mansi, 2003). Secondary school students must be able to evaluate conjectures and assertions, to reason deductively and inductively by formulating mathematical assertions, and to develop and maintain their reasoning skills. If their reasoning skills remain underdeveloped, students will come to view mathematics as an aggregate of specific rules, and an ensemble of thoughtlessly executed calculations and drawings (Ross, 1998). In addition, studies indicate that good mathematical reasoning skills are imperative to proof-writing performance (Battista & Clements, 1995; Edwards, 1999; Fischbein & Kedem, 1982; Izen, 1998; Jones & Swafford, 1997; Mistretta, 2000). Toole (2001) and Kramarski, Mevarech and Lieberman (2001), have emphasised that a direct relation exists between reasoning skills and success in mathematics, where individuals who demonstrate better reasoning skills display good problem-solving profiles with the interrelations they are able to identify, while also having better communication skills.

Malloy (1999) described that individuals may use more than one reasoning approach in problem-solving situations. Moreover, their ability to use these approaches and reasoning skills is closely related to the depth of their conceptual knowledge and to their corresponding associative skills (Briscoe & Stout, 2001 ; Gerald, 2002 ; Lithner, 2000). In addition, reasoning is a process that provides depth to the existing body of knowledge (Duval, 1998). Battista (2007) described that educators need to understand students' thought processes in order to provide them with a meaningful education. In addition, Makina and Wessels (2009) stated that understanding students' minds during problem solving improves a teacher's understanding of his pupils. In this process, students can be encouraged to explain why they made certain errors and exhibited certain misconceptions (Molefe & Brodie, 2010). For example, students may sometimes choose the correct problem solving strategy; yet follow the wrong course of action when finding solutions by using information, by finishing reasoning processes before they have been finalized, or by becoming oriented towards familiar solution patterns due to conceptual shortcomings. These situations, commonly known as faulty reasoning, should be investigated closely, as they provide important clues for understanding students' thought processes (Umay & Kaf, 2005).

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In addition, students experience issues in problem solving due to poor reasoning. Poor reasoning involves unfounded and hasty reasoning processes resulting from insufficient understanding of the subject in question. Students who lack knowledge of what to do and how to solve the problem in these circumstances will add, subtract, multiply, or divide the numbers they see without giving much thought to their reasons for doing so (Russell, 1999 cited in Umay & Kaf, 2005). Işrksal, Koç and Osmanoğlu (2010) revealed that 8th Grade students showed difficulty in solving problems, in demanding a conceptual understanding of reasoning, and in measuring the surface area and volume of cylinders. Mukucha (2010) found in his study in South Africa that most students lacked conceptual understanding and reasoning skills.

Similarly, Arslan (2007) noted that students in 6th, 7th and 8th Grades exhibited low-level reasoning skills. These studies have suggested that different methods and techniques are necessary for students to develop reasoning skills. For example, Pilten (2008) has described metacognition-based education to have led to the development of mathematical reasoning, and Maqsud (1998) found that metacognitive strategies influenced low-achieving South African students. Additionally, cooperative learning should be used to improve students' mathematical reasoning (NCTM, 2000; Kramarski et al., 2001). As described by researchers, communication skills are important for the development of students' reasoning skills (Lithner, 2000; Briscoe & Stout, 2001; Aineamani, 2011).

For this reason, both teachers and students should be in the habit of asking 'why?', as this question is essential for students to develop their mathematical reasoning skills (Mansi, 2003). Information about a student's reasoning skills helps the teacher develop an opinion regarding the students' thoughts, based on which he or she can review the procedures and techniques used in learning processes, if necessary.

Geometry is an important branch of mathematics. It allows for people to understand the world by comparing shapes, objects and their connections. Goos, Stillman and Vale (2007) have indicated the processes of visualisation and reasoning to be part of in mathematical thinking. Moreover, Duval (1998) has stated that the geometric thinking involves the cognitive processes of visualization and reasoning. Visualization and reasoning are those essential mental skills required for mathematics (Battista, Wheatley & Talsma, 1989), and these cognitive processes are interconnected, promoting students' success in geometry (Duval, 1998). Visualization is a skill that helps students to recognise shapes, to create new shapes or objects, and to reveal relationships between them (Arcavi, 2003). Battista (2007:843) said that geometric reasoning refers to the act of "inventing and using formal conceptual systems to investigate shape and space". Many researchers claimed that visualization can be improved by training (Ben-Chaim, Lappan & Houang, 1988; Brinkmann, 1966) and by using materials (Werthessen,1999; Battista, Wheatley & Talsma, 1982; Ben-Chaim et al., 1988; Onyancha, Derov & Kinsey, 2009; Yıldız, 2009). In addition, visualization and reasoning skills can be improved through the instruction methods (Jones, 2000; Arıcı, 2012; Goos et al., 2007).

Furthermore, the NCTM (2000) also recommends the use of Dynamic Geometry Software (DGS) to promote reasoning skills and geometric understanding. The relationships between visualisation and mathematical problem solving (Moses, 1977; Van Garderen & Montague, 2003), as well as between visualization and mathematics achievement (Fennema & Sherman, 1977; Ünal, Jakubowski & Corey, 2009), have been shown in many studies.

Furthermore, Kospentaris, Spyrou and Lappas (2011) stated in their study that visualization is important factor that effects the choice of strategy when students undertake geometry tasks. Küchemann and Hoyles (2006) investigated students' mathematical reasoning in geometry and development in their reasoning, by an analyses of students' responses to three annual proof tests. They found that many students made little progress. Tierney, Boyd and Davis (1990) emphasised that three factors effected students' responses were "knowledge, visual perception, logical arguments".

Carroll (1998) identified that students who acquired an effective experience in geometry during elementary school were better able to use their reasoning skills to solve geometry problems in secondary education. For this reason, it is important to investigate 8th Grade students' reasoning skills in geometry. As described by Duval (1998), in order to determine the difficulties encountered by students in geometry, it is necessary to identify the cognitive processes that underlie geometric processes. The reasoning skills demonstrated by a student whilst problem solving will allow us to observe the way in which the student associates geometric concepts and by what means they reach a solution.

Trends in International Mathematics and Science Study (Acat, Şişman, Aypay & Karadağ, 2011) has stated that a student with reasoning skills must be able to perform the following: identify and use interrelations between variables in mathematical situations; dissociate geometric shapes in order to facilitate the resolution of a geometrical problem; draw the expansion of an object; visualise the transformation of three dimensional objects; and deduce valid results based on the provided information (Analyse); think mathematically and describe anew the results obtained through problem solving and expand on these solutions (Generalise); use mathematical operations in combination and combine the results in order to obtain more advanced solutions (Synthesise); use mathematical results or properties to provide evidence for the validity of an action or the truth of a mathematical expression (Justify); and solve non-routine problems by applying his/her geometrical knowledge and appropriate mathematical processes (Solve Non-routine Problems). In this context, when solving geometry problems, this study aims to investigate whether 8th Grade students display reasoning skills indicated by TIMSS.

The results of this study are important for assessing the way in which the students think when solving geometry problems as well as for observing the way in which they demonstrate reasoning skills. Additionally, the study will help teachers to assess whether the students' performance is reflected their reasoning skills. The results also provide for the teachers' self-assessment, and encourage them to reconsider the current techniques used in learning processes. In addition, it is expected that the results of this study will contribute to improving the quality of geometry education in those developing countries with low mathematical performance (e.g. Botswana, Colombia, Ghana, Iran, Saudi Arabia, South Africa, and Turkey) in international exams (e.g. TIMSS).

The present study is based on the importance of social approving reasons in the development of academic motivation. Motivation has also an important influence on a learner's attitude and learning behaviour and academic motivation is a key determinant of academic performance and deserves closer attention (Linnenbrink & Pintrich, 2002).

We took into consideration the contributions of Harre (in Hayes, Orrel, 2003) which argues that one of the fundamental reasons for social behaviour is social respect (which you can fall also within social reasons, affiliation), "none of us wants to appear stupidly in front of others".

Harre supports the idea that people want to be respected for what they are, obstinately avoiding the perception that they might be ridiculous in some aspects; according to the author that motivation is one developed from childhood (children on the playground, they "give air" posing in various hypostases), requiring more research of this field of action. For Watters and Ginns (2000) mood can be beneficial for involvement in pregnancy and the sadness or the happiness felt by individuals can continue to influence the cognitive functioning and Palmer (2005) says that "students may have a range of personal goals, including social goals (eg, gaining the approval of teachers or peers)".

Thus, approval motivation is a very important factor for developing academic motivation. The quality of interaction between teacher and their students and between the child and entire academic group (classroom's mates) is balanced by a lot of dimensions of extrinsic motivations. In this context, approval motivation is one with big impact (because of the teacher - a figure with authority at early age of pupil and, secondly, because of evaluation necessity through person's evaluation of adolescent or young adult/social evaluation. These can influence positively or, contrary, to destabilise academic motivation. In fact, Rook says that the damages produced by social stress are, in general, bigger that the stress produced by non-social stress. Also "negative social interactions have more potent effects on well-being than positive interactions" (Rook, 1984, p. 1106).

Social approval needs is well connected with affiliation needs, needs which a student have in school because he tries to adapt himself at educational space, but also at educational group. The first ones who investigated this motivational area are Crowne and Marlowe; they identified different behaviours between the subjects with different scores – extremely high or extremely low at social desirability scale (considered indicator for approval need according to authors). For example, the level of conformism was very high at those subjects which high need of approval and the results were opposite at those with low conformism (in Bourne, Ekstrand, Dunn, 1988).

There are other researchers (Herbert et all, 1997) who linked these two concepts „social desirability (the tendency to respond in such a way as to avoid criticism) and social approval (the tendency to seek praise) are two prominent response set biases evident in answers on structured questionnaires". (Herbert et all, 1997, p. 1046). So, „approval motivation refers to the desire to please others and to avoid disapproval". Naturally need of approval represents a positive factor stimulating social integration, sustaining social behaviour and being a possible predictor of the way of acting in different groups. The need of social approval is biased acceptance, which also brings in discussion the concept of conformism. Individuals are tempted to be conformist not only to general norms of a certain group, but also the secondary ones (how to be dressed, hair cut etc.). The approval needs can be developed in larger conceptual area – social support (support concept also for social approval).

An interesting hypothesis on social support is those that it has the role of buffer. A series of studies remarked that social support becomes important, especially in the situations in which persons are experiencing anxiety or it is influencing by a stressful factor. „People who are highly motivated to obtain social approval and avoid disapproval are predisposed to experience social anxiety, presumably because they are motivated to control how they are regarded by others" (Leary & Kowalski, 1995, 111-112). There are studies that named that even in absence of these factors, social support is important. There are other studies which affirm that social support is important even when these factors are missing.

The problem can exist in the type of social support and the benefits which are obtained by the receiver of them. Karen Rook (in Panisoara, Panisoara, 2005) argued that in the moment in which social contact takes perspective of group fun, humour, affection, the positive impact will be produce even in the non-stressful generated situations.

On the other perspective, the actions oriented towards problems such as advice's solicitation, material support, verbal assurance and showing empathy are more useful in the stress-related periods of time. As we mentioned before, approval motivation is included by specialty literature in category of extrinsic motivation (Sansone, Harackiewicz, 2000). „Extrinsic motivations are calculated more toward gaining attention, Georgeta Panisoara et al. / Procedia - Social and Behavioural Sciences recognition, approval and gratification for others" (Mortensen, 2008, 118). „Although not tangible, praise, recognition and approval are also considered to be extrinsic motivators" (Shaw, Gorely, Corban, 2005, 98). Much of the recent research indicates that academic motivation is an important component in learning and achievement. More than that, Deci and Ryan (in Kennedy-Moore & Lowenthal, 2011) are describing three types of extrinsic motivation: motivation based on situation, motivation based on approval and motivation based on values. One of them is valuable indeed for individual (said the authors), the third one. The approval needs lead the children to seeking all around the judgement of peers and adults for feedback about their actions. Their self-esteem depends in big percent by how another person's evaluate what they are doing.

In consequences they will quit rapidly the actions when decide that it is a big risk to be negative evaluated. Approval motivation – „also reported feeling anxious and coping poorly with failure. When they didn't perform well, they worried and put themselves down or denied the importance of the setback". Not only that, Kohn (in Lavoie, 2008, 120) observe that praise are growing dependence of the child in rapport with adults and approval's adult. There are opposite opinions. So, Atkinson and Raynor (in Flink et al., 1992, p. 189) observe that „extrinsic incentives, such as social approval or tangible rewards, would have a positive effect on motivation by increasing student`s willingness to pursue an academic activity".

Also Thomas (1989, 89) said "There can be no doubt that desire for the approval of others – parents in the case at hand – can be a powerful motivating factor". Panisoara & Panisoara (2010) highlight - the social approval acts very strongly, representing an im 1218 Georgeta Panisoara et al. / Procedia - Social and Behavioural Sciences motivation in their learning experience in each class. (Palmer, 2007; Debnath, 2005; D'Souza and Maheshwari, 2010, in Williams & Williams, p. 2).

1.1. A Case Study on the Investigation of Reasoning Skills in Geometry

The aim of this study is to evaluate the reasoning skills in geometry-related subjects of six 8th Grade students. The study data were obtained at the end of the 2009-2010 spring period in a public elementary school. The study uses a case study with qualitative research techniques to investigate how students use reasoning skills. In this study, six geometry problems were used to collect the study data. The students were asked to think aloud when solving the problems so as to be better able to explain their thoughts. From the data obtained, it was identified that the processes involved when demonstrating reasoning skills showed a number of differences.

Participants:

The study was conducted at the end of the 2009-2010 spring terms with six 8th Grade students (3 female and 3 male) receiving their education at a public elementary school that was randomly selected from among schools of a moderate socioeconomic level. The participants were selected from a class with a mathematics teacher capable of effectively implementing the mathematics curriculum, based on his 23 years of experience. The participants were selected according to their level of achievement (high, medium, low) in the mathematics class and their willingness to voluntarily participate in the study. In this respect, the sampling technique used for sampling purposes in this study is the "exception sampling technique". This sampling technique envisages the study of a low number of cases that can be subject to evaluation, but which, at the same time, hold a wealth of information (Şimşek, 2008). The actual names of the participants are provided in this study. The female participants, in decreasing order of academic performance (i.e. from the highest to lowest performer) were Ceren, Elif and Mine; the male students were Ege, Arda and Baha. They were 14 years old.

The information regarding the students was obtained from their mathematics teachers by talking about math achievement levels of students in the previous period (autumn term) and by looking at their mathematics exam score for the spring term.

Data Collection Tool

The questions used for data collection in this study were multiple-choice examination questions for 8th Grade students, prepared by experts at the Student Selection and Placement Center (ÖSYM) and the Ministry of Education (MNE) and used within the context of an examination ["Level Determination Examinations (SBS)"] performed during the transition to secondary education. This examination was developed in accordance with the elementary school curriculum in order to assess students' higher level thinking skills (Güzeller, 2006). The examination questions allow for an assessment of the adequacy of the student's interpretation, analysis, critical thinking, result prediction, and problem-solving skills, based on his/her educational achievements in class

(MNE, 2007). On the other hand, within the scope of the internationally conducted TIMSS examination, the TIMSS mathematics framework has two dimensions: Content Domain (numbers: 30%, algebra: 30%, geometry: 20%, and data and chance-probability: 20%) and Cognitive Domain (knowing: 35%, applying: 40%, and reasoning: 25%) (A cat et al., 2011).

Also, in the examination results (especially in the latest reports of TIMSS, in which Turkey is also a participant and is ranked 30th among 49 countries in the TIMSS of 2007), Turkey not only figures below average in all fields of learning, but it also has the lowest average in geometry. This situation necessitates a revision of geometry education (Acat et al., 2011). In Turkey, the distribution of SBS questions applied to 8th Grade students with respect to the learning areas in mathematics is approximately as follows: 20% numbers; 25% geometry; 20% measurement; 15% probability and statistics; and 20% algebra.

Within the context of this study, 2 mathematics educators and 1 mathematics teacher were asked to categorise, according to the cognitive processes described in A cat et al. (2011), 15 questions regarding geometry from SBS examination questions that were applied to 8th Grade students in 2009, 2010 and 2011. Prior to the categorisation, example questions were shown to the experts about how TIMSS categorises geometry questions, and about how information was provided regarding cognitive processes. Based on the categorisation they performed, the mathematics educators and mathematics teacher were asked to describe the reasoning skills reflected by the questions that were part of the reasoning cognitive processes. The working definition for reasoning skills provided by A cat et al. (2011), which includes "analysis, generalisation, synthesis, justification, and non-routine problem solving" was used. Table 1shows the reasoning skills that were assessed.

Table 1 Reasoning skills assessed by the test questions

Year	Analyse	Generalise	Synthesise	Justify	Solve Non-routine Problems
2009	8, 9*	11	-	-	-
2010	-	-	3	-	-
2011	13, 20	-	-	-	-

* Number of questions

As can be seen in the table, the test questions used in each of the three years did not make use of reasoning skills pertaining to the justification or solving of non-routine problems. As a result of this evaluation, it was observed that the consistency was approximately 91%. The test questions are listed in an Appendix.

Process and Data Analysis

A clinical interview was performed, while the six students were solving the geometry questions. The clinical interview is a technique structured according to Piaget's clinical method and Vygotsky's educational experience; it aims to study information structures and thought processes (Clement, 2000; Hunting, 1997). The participants were told that their answers to the questions would not be considered as grades, and that the interview notes would only be used to understand their thoughts during problem-solving. The students were then asked to think aloud when solving the problems so as to be better able to explain their thoughts. The researcher also asked them questions when necessary. In addition, questions such as "How did you think of this?" and "How did you draw this?" were asked in order to reveal the students' thought processes. The clinical interviews were performed in a silent environment in the school library and recorded on video. The problem-solving process for each student lasted approximately 30 minutes.

For the analysis of the study data, the video records were first transferred to the interview forms without any corrections being performed. An expert then evaluated the extent to which the transferred data and original data were consistent with one another. The data transferred to the interview forms were coded independently by two area experts. The codes that were created by each expert were converted into visual form and associated with one another by using a diagram. Converting the diagram into a visual form through the use of a diagram becomes important with regard to rendering the relations between the emerging concepts and themes more apparent and to reaching certain results based on these concepts, themes, and relations (Miles & Huberman, 1994; Yıldırım & Şimşek, 2008). To calculate the reliability of the data coded by the researcher and field experts, the Reliability = Agreement / (Agreement + Divergence) formula of Miles and Huberman (1994) was used, and the reliability coefficient was determined as 89%. Among the different qualitative data analysis methods, the content analysis method was used to analyse the data from the video recording. The results obtained from these types of analyses are presented in an organised and interpreted form (Yıldırım & Şimşek, 2008). In order to enrich the data analysis and interpretation, the students who were interviewed were directly quoted, and their statements were compared with the study results. When examining the students' responses, the reasoning skills which TIMSS indicated such as "analysis, generalisation, synthesis" were emphasised.

Results:
The questions the students were asked were to assess their skills in analysing, generalising, and synthesising among their different reasoning skills. Their answers are evaluated as follows within the context of these skills.

1.2. Analysis of the Results Among the different Reasoning Skills

The first question assessed the students' analytical skill from among the reasoning skills indicated by TIMSS. The students were expected to select, from among the given choices, the triangle that satisfied this condition, and which had the largest perimeter. The results of the student responses to this question are shown in Figure 1. Also provided are an analysis of the student's answers, with the resulting sub-themes and categories formed within the context of identifying the relation between the triangle's edges, and finding the triangle with the largest perimeter. These results also include information regarding the students.

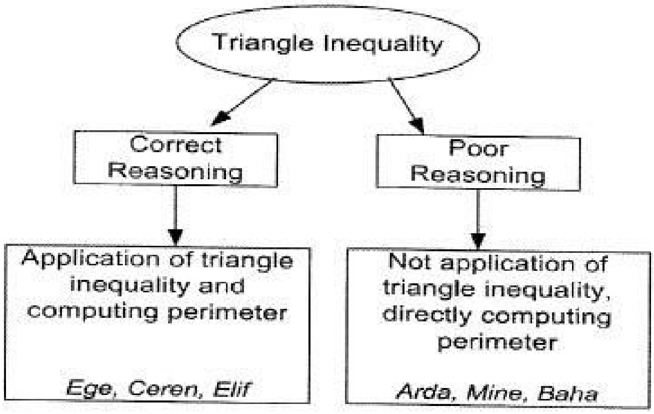


Figure 1 Triangle inequality

The students employed two different approaches when solving this question. Ege, Ceren, and Elif employed correct reasoning. These students found the triangle with the largest perimeter length by pointing out that the formation of a triangle is based on satisfying the triangle inequality theorem, and then identifying the triangles that satisfied this condition. Ege's interview statement is provided below as an example:

For there to be a triangle, one of the edges must be shorter than the total length of 2 edges and larger than their difference. Let's try this for all of the edges...if we think of L, it is larger than 2 and smaller than 10, so it satisfies this condition; M is bigger than 3 and smaller than 9, so it also satisfies it; N is bigger than 1 and smaller than 7; so it also satisfies it. [From amongst] L, M [and] N: The correct option is D. There is [the] option [of] B, but its perimeter is smaller.

However, Arda, Mine and Baha, demonstrated poor reasoning, by trying to determine the largest perimeter in a direct manner by adding the length of the strips that were given, without determining the relationship between the edges of the triangle. In this question then, these students were unable to associate the adding up the length of three strips with the triangle inequality theorem. They could not use interrelations between variables in mathematical situations. Below is an excerpt from Mine's interview:

Among the strips given in these options, the ones that are the longest will have the largest perimeter, and I will find the answer that way...[She reviews each option according to the length of the strips]...the longest one is option C.

The second test question also assessed the students' analytical skill. In this question, the students were asked to form a cube by using geometric objects. The students were expected to join three-dimensional geometric objects and visualise the transformation of three dimensional objects. Figure 2 shows the sub-themes and categories obtained from the analysis of the student responses.

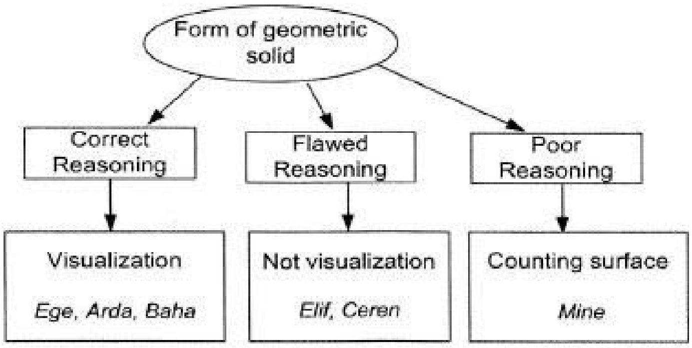


Figure 2 Form of a geometric solid

Students employed three different approaches when solving this question. Ege, Arda and Baha formed a cube by visualising the given structures using correct reasoning skills. Arda found the correct answer in a short period by visualising the structures in his mind, and then placing them on top of one another to form a cube. Ege and Baha formed a cube in a similar way. However, the other students did not. Being unable to fully visualise the structures when bringing them together, Elif and Ceren displayed inadequate, or in other words, flawed reasoning. Part of Ceren's clinical interview reads as follows:

If I look at option B...L, M, N... If I a place M here, it will close this location [shows that she is placing M vertically in a location suitable for the cube in the lower section of the N structure]. Empty spaces remain here and there [shows the empty spaces that are one cube in size in front of and behind the 2nd line of the N structure]. If I tip L sideways and place it here, I think it'll work. Yes, it might be the B option.

As can be seen from Ceren's interview, she was not able to perceive the excess in the structure she formed, which she assumed to be correct. Similar to Elif, she chose to place the structures on top of one another; however, she was not able to visualise the section that would form an excess. Mine, on the other hand, attempted to form the required cube by counting the surfaces. However, she was not able to find the right answer, due to poor reasoning. In her clinical interview, Mine stated the following:

I am trying to count the surfaces, but I can't because I am not good at imagining. I am having some difficulties with this question... Now let's try K, L, M...if we place K on top of L, and we place M in front...hmm...actually, the surface areas also match. In my opinion.I say that this option is correct.

The fifth question also assessed analytical skill. In this question, the students were asked to find the situation in which the surface areas did not change as a result of the separation of three dimensional geometric shapes. Figure 3 shows the sub-theme, along with categories obtained from the analysis of the student responses.

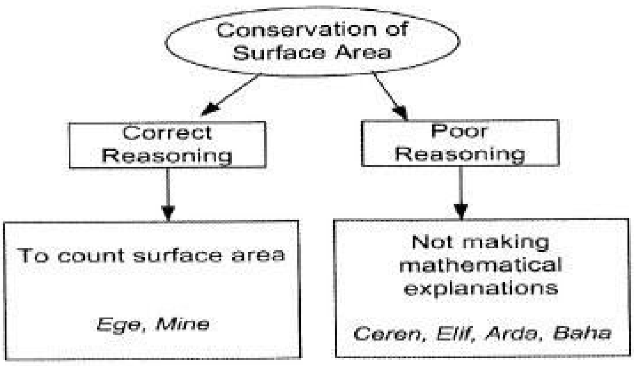


Figure 3 Conservation of surface area

The students employed two different approaches when solving this question. Ege and Mine solved the question through correct reasoning. Both students were able to find the correct answer by calculating whether the same amount of surface area remained on the structure after subtracting the surface area provided by the unit cubes. During the clinical interview, Mine stated that she did not have any difficulties when solving this question, and she mentioned that "When solving this question, my brother's cubes came to my mind. When we played together, we would join the smaller cubes to build larger cubes. That's why I did not have any difficulties in solving this problem." So, Mine's previous experience of concrete materials helped her to visualise during the task. The other students couldn't dissociate geometric shapes.

Among the other students, Ceren and Baha demonstrated poor reasoning by stating,"while unit cubes 1, 2 and 4 are located on the sides, unit cube 3 will not change the surface area because it is located in the center" and they did not indicate the correct answer. Elif also demonstrated poor reasoning by saying that "As unit cube 4 is under the large cube, nothing will change if it is removed." Although he provided the correct answer, Arda could not provide a mathematical argument for its validity. He said, "I cannot explain...teacher, I won't be able to [answer] this question" [sic]. For this reason, he was considered to have demonstrated poor reasoning.

The other question that assessed analytical skill was the sixth question, in which the students were asked to find which one of the edges would have the same length when the opened geometric shape is transformed into an enclosed form. Figure 4 shows the sub-theme along with categories obtained from the student interviews.

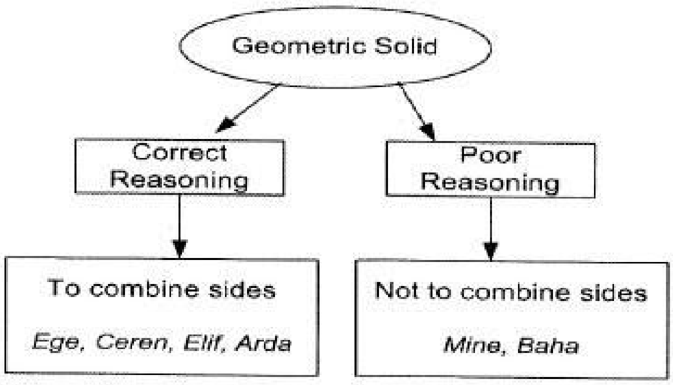


Figure 4 Geometric solid

The students employed two different approaches when solving this question. Ege, Ceren, Elif, and Arda were able to see the edges that would join when creating the enclosed form of the prism, and also the edges of similar length when the edges that formed the bases of the prism were compared. When assessing this situation, the students expressed that among the edges that formed the base of the prism, the edges oriented in the same direction were also of the same length. Based on this observation, it can be said that Ege, Ceren, Elif and Arda were able to visualise the enclosed form of the object. In contrast, Mine and Baha were not able to find edges that would join. As they only considered the edges on the same base in order to find the edges of equal length, they demonstrated poor reasoning and were not able to find the correct answer. Their performance indicates that Mine and Baha hadn't formed the enclosed form of the prism by visualising.

1.3. Results related to Generalisability skills

The third test question assessed generalisability skills. To solve this question, the students were expected to both identify the existing pattern using the rule of self-similarity and repetition of fractals, and to find a generalisation of the mathematical relation that existed within the pattern. Figure 5 shows the sub-themes and categories based on the analysis of the student interviews.

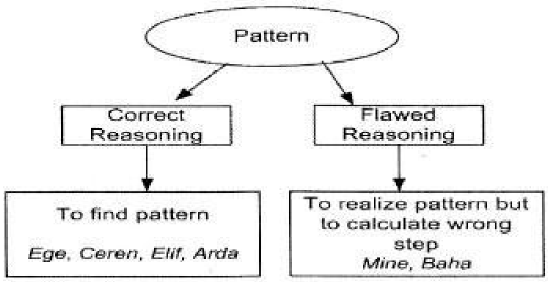


Figure 5 Pattern

The students used two different approaches when solving this problem. All of the students were able to see the relation between the processes. However, Ege, Ceren, Elif and Arda were able to identify the pattern in the question and saw that the length of the edges decreased by half. They were then able to determine the generalisation of the mathematical relation to be found in the pattern of the question. This reveals that these four students had thought mathematically and expand on these solutions. Then, by describing the length of the edge of the square they formed in the 10th step, they demonstrated a balance between conceptual and procedural knowledge. Mine and Baha noticed the pattern; however, following flawed reasoning, they did not notice that their answers represented the edge length of the square that was formed in the 11th step instead of the 10th step. This demonstrates that Mine and Baha had not shown the truth of a mathematical expression. In this context, it was flawed reasoning.

Results related to synthesising skills

The fourth test question assessed the students' skill in synthesis. To solve this question, the students were expected to determine and use the relation between the length of the given triangle's edges and the size of the angles facing these edges. Figure 6 shows the sub-themes and categories based on the analysis of the student interviews.

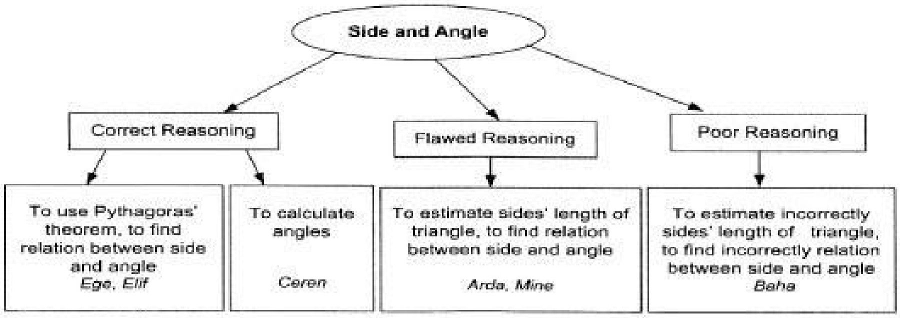


Figure 6 Relation of sides and angles in a triangle

The students used three different approaches when solving this problem. Prior to determining the relation between the length of the triangle's edges and the size of the angles that faced these edges, Ege and Elif attempt to find the length of the edges of the triangle using the Pythagorean theorem. Then, based on the relation that sets the largest angle in front of the longest edge, they followed correct reasoning by comparing the size of the angles. Ceren, on the other hand, followed different reasoning. She attempted to estimate the size of the angles and length of the edges in the given triangle, and she followed correct reasoning when she described her claim regarding the situation in mathematical terms. Her reasoning, which followed a different course, was as follows:

Now, the points on the geometry board have been placed at equal distances... Now [draws an isosceles right triangle such that AC becomes its hypotenuse], there will be an isosceles right triangle here. The angles will be 45 degrees [on the isosceles triangle, shows the base angles that consider AC edge as the base]. Here I can draw an isosceles right triangle [draws an isosceles right triangle such that the AB edge is the hypotenuse]. These angles will be 45 degree [on the isosceles triangle that she formed, shows the base angles that consider the AB edge as the base]. Here, angle A will be 90 degrees [shows angle A of the ABC triangle]. For B, I can say this...if this edge [shows the BC edge] passed over the upper points, angle B would have been 45 degrees , but instead it passes from below...and the angle is greater than 45 degree...as the total of internal angles of a triangle is 180 degrees , angle C must be smaller than 45 degree . If I compare the angles in that case...the correct option would be D.

Arda and Mine also found the correct answers. However, they followed flawed reasoning by estimating the edge lengths and comparing the respective angles, and they could not confirm their explanations in mathematical terms. The example below is from Arda's clinical interview.

Arda: One of the reasons the geometry table was provided is to show points that are equally distant from each other, so I also considered that the distance between these points is 1 unit. The BC edge is 6 units; the AB edge is 3 units; and the AC edge is 4 units.

Researcher: But while the AB and AC edges pass over the points, The BC edge does not pass over these points. Could they be equal?

Arda: .but we can consider it so. For this reason, angle A is larger than B, which is larger than C.

By attempting to determine the sizes of the triangle's inner angles depending on how large or small they appear, Baha made visual estimations, displayed poor reasoning, and gave the wrong answer.

1.4. Discussion and Recommendations

The aim of this study was to investigate 8th grade students' reasoning skills in solving geometry questions, and to determine when the students display reasoning skills which TIMSS indicated (analysis, generalization, synthesis). Various results were found. In this study. It was determined that the students' responses affected the geometrical knowledge, visual perception, personal logical arguments as Tierney et al. (1990) have said. Because the students sometimes have insufficient geometrical knowledge and visual perception, sometimes they are not able to provide a mathematical argument for its validity.

Based on the results of the question regarding triangle inequality, three of the students were observed to have followed correct reasoning and to have successfully used the triangle inequality theorem, whereas the other three students were not able to associate their operations with the triangle inequality theorem. This indicates that some students did not know the requirements for the formation of a triangle. Similarly, studies conducted with 8th Grade students and teachers regarding the triangle inequality also identified difficulties experienced with regard to this theorem, and it was deduced that inadequate learning of the triangle inequality might be the underlying cause of these difficulties. To solve this problem, exploratory activities on triangle inequality can be conducted during the education period.

In the cube formation, the question requiring visualisation of structures, where three of the students successfully formed a cube by following correct reasoning. However, the other three students could not do so, following flawed reasoning instead. This performance demonstrates that the students were not able to visualise the joining of the geometric object. Similarly, in the question where the students were expected to visualise a closed geometric shape based on the open geometric shape that was provided, two of the students followed poor reasoning. In order to solve this problem, and given that visualisation is a form of reasoning (Gutiérrez, 1996), learning environments ought to allow students to visualise the assembly or separation of geometric shapes. For this reason, the assembly or separation of geometric shapes ought to be in different positions.

The results obtained from the question regarding the preservation of surface area showed that the majority of the students followed poor reasoning. The underlying cause of their poor reasoning was their lack of conceptualisation regarding the instances in which surface area preservation was achieved, as well as their inability to visualise surface area preservation. If visual perception was considered an important component (Kospentaris et al., 2011), and if the visual perception of students had been supported during the educational process, then it may have been possible to obtain the desired results. For this reason, and as mentioned by Pitta-Pantazi and Christou (2009), the skills necessary for the development of student performance in area preservation ought to be further investigated and supported. In addition, it is said that visual tools can facilitate the learning of mathematical concepts. Furthermore, one student stated that her previous experience with tangible objects helped her solve the problem. Therefore, future studies should investigate the effect of tangible materials on a student's understanding of area preservation.

In the question regarding the skill of generalisation, all of the students easily identified the existing pattern as well as the mathematical relationship within the pattern by using the self-similarity and repetition rules of fractals. However, even though two low-achieving students noticed the pattern, they were unable to balance conceptual and procedural information, using flawed reasoning instead. Because patterns contribute to a better understanding of the structure of mathematics and assist in making generalisations (Olkun & Toluk, 2007; Tamşlı & Özdaş, 2009), it is necessary to ensure that students use proper reasoning when reaching generalisations from patterns. In order to achieve this and to consolidate geometrical knowledge, educational environments should assist students. Actually it is difficult for students to transition from a visual expression to an algebraic expression, where this balance can be expected to help students.

In the question where the skill of synthesis was tested, three of the students easily established the relation between the edge lengths of the given triangles and the size of the angles facing these edges by following correct reasoning. In addition, one of these students used a different reasoning for solving the questions, focusing on problem solving by associating conceptual knowledge in a different way. Although they provided the correct answer, two students followed flawed reasoning in solving the question, and were unable to substantiate their answer with a rational explanation. This leads to the conclusion that the students did not achieve conceptual learning. Besides, Baha made visual estimations. He followed poor reasoning by attempting to estimate the angles of the triangle according to their appearances. The expressions based only on visual estimations seem to be unreliable, as Kospentaris et al. (2011) noted.

In conclusion, it appears that school curriculum should place more emphasis on reasoning skills. When it comes to geometrical concepts, students ought to be presented problems that allow them to use different reasoning skills. For this, the results suggest that the number of studies should increase in order to reflect their geometrical knowledge, visual perception, and logical arguments. Besides this, the results of this study have implications for teachers and educators. Specifically, the results can help teachers better understand the way in which their students think when they are solving geometry problems, and can help them see their students' reasoning skills. The results also encourage teachers to reconsider the techniques used in learning processes. Studies that explore methods for teaching and learning in geometry-related subjects will serve to assist teachers and students in developing their reasoning skills. In addition, for students to acquire geometric reasoning skills, research should first and foremost be conducted in relation to whether teachers have these necessary skills, and it would be appropriate to emphasise those topics that are important for teacher training.

CHAPTER – II

2.1. Students' Motivations for Data Handling Choices and Behaviours: Their Explanations of Performance

With the national and international cries for accountability in education, student performances at all levels and in all school contexts are coming under ever-closer scrutiny. The outcomes of student performances are subjected to detailed analyses and published in newspapers, becoming a factor in school selection and funding. The consequences for various levels of performance range in effect from student promotion and graduation, to teacher pay scale, to school accreditation. However, in the midst of all the discussion about what students do, there remains little understanding of why they do it. Even less do the impacts of various student motivations on learning and the accuracy of performances in representing learning factor into the political debate. The current study explores these issues in the context of secondary school science.

In the United States, the United Kingdom, and other educational systems around the world, "practical work" has come to play an increasingly significant role in a variety of subjects, especially in science. Having begun with *Science—A Process Approach* (American Association for the Advancement of Science [AAAS], 1969) in the United States and carried on in projects such as the Nuffield Science projects (Wellington, 1998 ; Donnelly and Jenkins, 2001) and the Assessment of Performance Unit (APU) (Driver *et al*., 1982 ; Archenhold *et al*., 1988) in Britain, the procedural science movement continues to influence curriculum and assessment in science education worldwide.

Science in the National Curriculum (Department for Education, 1995) of England and Wales includes content goals and targets in biology, chemistry, and physics, but its first section at every level is *Experimental and Investigative Science*. In this primary section lie the procedural goals of handling data, including making decisions about what and how much data to collect, analyzing data through calculations and graphs, interpreting data by seeking patterns, and evaluating data for reliability. This section is assessed through the students' submission of course work and forms 25% of their final marks for their General Certificate of Secondary Education (GCSE). Through the assessment process teachers, Boards of Examiners, and interested others can ascertain how well students performed on data handling tasks in this particular assessment context. However, a detailed exploration of this system reveals that it does not begin to address the issues of determining the full extent of students' knowledge and skills in data handling or their reasons for implementing or failing to implement their complete range of competencies. The research described here, a naturalist study of 14- to 16-year-old students doing practical work in an English school, analyzes students' explanations for their data handling in an effort to understand their performances on these various tasks.

THEORETICAL BACKGROUND:

According to Head (1985 , p. 31), "Both the ability to perform a task and a willingness to do so are necessary for success, the latter often proves the more important." Motivation can be conceived of as a will they or won't they phenomenon (Cannon and Simpson, 1985) or "his/her willingness to engage in the relevant learning activities" (Hofstein and Kempa, 1985 , p. 222); however, it is the development of classifications of types of motivations that illuminates students' complex behaviours and performances. Hodson (1998b , p. 55) makes the point that various motives have different results for student learning and performance:

We should also bear in mind that when students are presented with a learning task they may perceive it in a way that is in marked contrast to the way in which the teacher saw it during the planning stage. Consequently, their actions may be somewhat different from those anticipated. Rather than attending to the rational appraisal of competing explanations in order to extend their understanding, for example, students may be actively engaged in any number of other pursuits, including: seeking teacher approval for compliant behaviour; trying to look busy, thereby avoiding unwelcome teacher attention; ascertaining the 'right answer' (that is, the one that gains marks in tests); trying to maintain feelings of self-worth; attending to their 'classroom image'. These other agendas may lead students to adopt behaviours and make responses that are not helpful in bringing about better scientific understanding.

It is evident that many aspects of student activity are quite logical and rational: strategies are consciously employed to deal with threat and anxiety; goal expectations are consciously calculated; logical decisions are reached; information is sought and processed; self-insight may be attained; and so on. Conversely, many aspects of student behaviour appear to be quite irrational: self-esteem is defended in unknown ways; expectations are biased; illogical decisions are reached; information is improperly utilized; and there is gross personal delusion.

Yet the seeming illogic of some student behaviour can be laid at the feet of the observer: "If we cannot specify an individual's goals, we cannot judge what behaviour will maximise the chances of achieving these goals and minimise the chances of avoiding undesirable outcomes" (Nicholls, 1984 , p. 40). Thus, examining why students engage in various classroom behaviours involves the dissecting of multiple overt and covert goals and agendas.

Maehr (1983) describes four goal types that he believes are associated with school achievement: task involvement, ego involvement, social solidarity, and extrinsic rewards. According to Maehr, when students are pursuing task goals they are absorbed in the activity and seek competence in the task for the sheer pleasure of doing well. Ego goals, however, involve "doing better than some socially defined standard, especially a standard inherent in the performance of others" (Maehr, 1983 , p 192); here doing better or best is the motivator. Maehr describes social solidarity goals as being directed toward pleasing others, while extrinsic reward involves motivation by acquisition of something such as a high mark or extra free time. Nicholls (1983) combines the latter two goals into a single extrinsic involvement motivation. These distinctions among motivations, their implications for interpreting classroom behaviours, and their interactions with concepts such as attribution have been explored and expanded in theory and research during the past two decades. Ames and Archer (1988 , p. 260) collapse the various classification systems, claiming that "the conceptual relations among task, learning, and mastery goals and among ego, performance, and ability goals are convergent," and thus in their work use only "mastery" and "performance goals", respectively. However, this composite leaves out much of the richness and complexity of students' motivations in classroom settings, especially with reference to performance goals. Deci *et al.* (2001a) analyze "intrinsic motivations" and "extrinsic rewards" but create many internal classifications depending on the type of reward and context. Maehr's framework of four goal types illuminates the subtle but important differences among motivations that are focused away from the task, yet even this set does not incorporate the goal of limiting effort that appears in research on mental models (Norman, 1983).

An additional possible explanation for student behavior falls outside the literature of motivation but, nevertheless, is worthy of consideration: rule following. White (1988 , p. 38) defines rules as "procedures, algorithms, which are applicable to classes of tasks." Scardamalia and Bereiter (1983 , p. 63) go as far as to say that "the normal processes of acquiring procedural knowledge or 'know-how' include observation, practice, and rule learning." However, while they acknowledge that rule development and following are normal parts of learning, they discuss the drawbacks to such rules with regard to reading and writing:

Here, too, there is much redundancy, so that with practice students can develop efficient strategies that allow them to meet the routine demands of school reading and writing tasks with a minimum of effort. The result, however, is comprehension strategies that are insensitive to the distinctiveness and complexity of text information (Scardamalia and Bereiter, in press c), and writing strategies that are insensitive to distinctive requirements of different writing goals (Scardamalia and Bereiter, in press a). Rising above these routine "cognitive coping strategies," as we call them, requires sustained effort directed towards one's own mental processes. (Scardamalia and Bereiter, 1983 , p. 65)

Thus, when rule following, students are not truly task involved because the rules may not actually be appropriate to the task. Scardamalia and Bereiter (1983 , p. 65) warn that there are some "skill areas in which 'practice makes perfect' is an untrustworthy slogan."

Davis (1988 , p. 97) discusses another concern within the area of rules:

Rule-following requires the existence of an established use or custom. Understanding a rule is to possess certain abilities. Wittgenstein distinguishes between following a rule, where an agent "knows that there is a rule, understands it, and intentionally moulds his actions to it" (1958, p. 155), and merely acting in accord with a rule, as a monkey might move chess pieces on a chess board in a way which happened to conform with the rules.

Thus, if this is correct, a crucial difference exists between students who understand rules and those who merely follow them. The danger to educators is that the two performances may appear identical, eliminating the possibility of easily discerning learning from conforming.

There is overlap among these various theories of motivation and explanations of student behaviour. Thus, a compiled literature framework for description of student goal types and behavioural explanations in classroom activity consists of

1) Task involvement,
2) Ego involvement,
3) Social solidarity,
4) Extrinsic reward,
5) Effort minimization, and
6) Rule following.

However, some significant areas of contradiction and variation in emphasis exist among these researchers and their findings. For example, current meta-analysis authors disagree about the negative effects of extrinsic rewards on intrinsic motivation (Cameron, 2001 ; Deci *et al.*, 2001b). Some researchers have found that motivations can coexist, while others claim that the appearance of one replaces another (Seifert, 1996). Additionally, whether rule following enables or inhibits student learning remains a contested issue (Scardamalia and Bereiter, 1983 ; Davis, 1998). Therefore, a thorough understanding of student performances from within the current environment requires further study and analysis of their motivations.

2.2. Research Methodology

This study employed qualitative research methods. In qualitative studies, the goal is to provide an accurate description of a real situation. To this end, such studies attempt to directly present the opinions of individual participants and to collect data through detailed and in-depth methods (Şimşek, 2008). As this study investigates the way in which students use reasoning skills, a case study with qualitative research techniques was produced.

The study employs two approaches:

1. Designing, piloting and implementing a questionnaire
2. Semi-structured interviews with students

Designing, piloting and implementing a questionnaire

In addition, the Self-Determination Scale, the Perceived Competency Scale and the Intrinsic Motivation Inventory have been interrogated to identify any sections or questions not otherwise included. These scales and inventories are available on the website of Deci and Ryan. The questionnaire originally consisted of a set of 53 questions employing the Likert scale. The 53 questions were grouped into twelve sub categories: standards, goals, tasks, effort, values, ability, interest, learning from others, responsibility for learning, extrinsic rewards, intrinsic rewards and social rewards.

A pilot study of the questionnaire was given to nine male first and second year engineering students. The resulting feedback lead to the rewording of some questions and the removal of those that were considered confusing and/or correlated very strongly with other similar questions. This resulted in the final questionnaire consisting of 22 questions (Appendix A).

1,930 undergraduate HE students were selected to receive the questionnaire. This was all of the full-time undergraduate students in the Faculty of Technology, the majority of whom (approximately 80%) were male students. Approximately half of the students invited to complete the questionnaire were studying engineering courses. Other courses included were mathematics, computer science and property development. A cash prize was offered to increase incentives for returns. A link to the online version of the questionnaire was emailed to each student, along with clarification on how to complete it. A reminder was sent out a week later to those who had not responded.

Semi-structured Interviews

After the questionnaire results had been collated 24 students were invited to attend a semi-structured interview. The aim of the interview was to allow each student to elaborate on their university experience and how that experience affects their motivation. All interviews followed the same structure: firstly, questions were asked to identify attributes of motivating lecturers and motivating pedagogical interventions. The students were then asked to reflect on their confidence in working with the subject material at the end of a unit and how competition with other students affected their studies. The interviews were recorded and then transcribed. No leading questions or suggestions of any pedagogic techniques were made to the students at any time. The list of questions used is given in Appendix B.

The purpose of the research:

This research intends to investigate the effect that reasoning of social approving on academic motivation at students. For this the study aims to observe the differences that appear in the ability to retain a list of words by students and general motivation that they have in the presence of social approval (provided by the teacher and peers) in the absence of social approval.

METHODS:

This motivation study is part of a larger project exploring the data handling choices and behaviours of 14- to 16-year-old students engaged in science activities in an English comprehensive school (Keiler, 2000). The study relies on qualitative case study methods of observations and interviews, with the motivation findings coming from interviews with student participants. A single school was selected so that an in-depth description of the students' experiences could be developed (Schofield, 1990 ; Wolcott, 1994), considering that "selection on the basis of typicality provides the potential for a good 'fit' with many other situations. Thick description provides the information necessary to make informed judgments about the degree and extent of that fit in particular cases of interest" (Schofield, 1990 , p. 211). The study school was selected based on certain criteria that maximized its "typicality." According to its own literature, it "is a medium sized fully comprehensive school for pupils between the ages of 11 to 16 serving [a town] and the surrounding area. It is the only Secondary School in [the town]." Being the only secondary school in town diminished the effects that school choice and parent selection might have on the student sampling frame. The school had students from a wide range of economic backgrounds, but very little ethnic or language diversity. According to the school's information on the Science department, "At Key Stage 4 all pupils follow the NEAB Modular Science Course. This allows pupils to gain a double award in Science. Pupils study modules which cover aspects of Biology, Chemistry and Physics." These modules, taught by teachers qualified in the subject area, spread the three subject areas over the 2 years comprising Key Stage 4.

Key Stage 4 students are 14–16 years old or in Years 10 and 11 of school. Key Stage 4 *Science in the National Curriculum* (Department for Education, 1995) includes sections on Experimental and Investigative Science, Life Processes and Living Things, Materials and Their Properties, and Physical Processes. These areas can be roughly translated into experimental procedures, Biology, Chemistry, and Physics, respectively, with a little Earth Science mixed in. Key Stage 4 comprises the final 2 years of school when all students are required to take science, which culminates in the General Certificate of Secondary Education (GCSE) exam. The final GCSE mark combines course work, called assessed practicals, with the examination score. By investigating Key Stage 4 students, the study allows for the maximum possible learning while avoiding the self-selection of the next level of education. The classes observed were preparing for the higher tier of their Science GCSE exam.

According to School Curriculum and Assessment Authority (SCAA) (1995 , p. 74) regulations, the lower tier includes only selected parts of each of the numbered areas of the Key Stage 4 program of study, while the higher tier "must address all aspects of these sections of the programme of study." Thus, sampling the students preparing for the lower tier would have restricted the range of knowledge and skills the students were expected to display in Science. Limiting the range of tasks in Science lessons might have artificially reduced the use of data handling by the students, of which this study sought the maximum. This sampling of higher tier curriculum demarcated the range of students participating in the study, and claims developed from the work might be confined in application to this population. However, approximately 90% of the students at the school were preparing for the upper tier examination and, thus, included in the sampling frame. Students were tracked into classes based on past performance in Science, and classes from high, medium, and low levels were included in the study.

Twelve units of work, selected by the teachers at the school as involving data handling, were observed and both impromptu in-class interviews and semistructured out-of-class interviews were conducted (Merriam, 1988 ; Millar *et al.*, 1994 ; Kvale, 1996). Impromptu interviews occurred while students were engaged in data handling during lessons, usually following up a comment made by a student to his/her classmates. These interviews consisted of a question or two. According to Kvale (1996 , p. 27), "Technically, the qualitative research interview is semistructured: It is neither an open conversation nor a highly structured questionnaire." This method was chosen because information was being gathered about a specific topic, data handling, but the researcher wanted to remain responsive to relevant issues raised by the interviewees. According to Merriam (1988 , p. 74),

In the semistructured interview, certain information is desired from all the respondents. These interviews are guided by a list of questions or issues to be explored, but neither the exact wording nor the order of the questions is determined ahead of time. This format allows the researcher to respond to the situation at hand, to the emerging worldview of the respondent, and to new idea topics.

However, while the semistructured interview was used for all events that the researcher labeled "interviews" to the participants, the in-class impromptu interviews and out-of-class discussions with teachers more closely followed Wolcott's (1995 , p. 106) "casual or conversational interviewing." These events were much less directed by the researcher and, in many cases, provided context and topics for the semistructured interviews. In providing so much control to the research subjects, semistructured interviews access information that the interviewer may not have known was available. However, this structure limits the effectiveness of quantifying responses and making cross-interview comparisons, as the subjects may not choose to address identical topics. This type of qualitative research generates a broad description of phenomena, not necessarily an accurate estimate of frequency.

Three groups of two to five students who worked together in each class were asked to participate in semistructured interviews outside of class time. The students were interviewed as soon after observed class periods as could be scheduled without interfering with their other responsibilities, usually during their break or lunch the following day. The purpose of the student interviews was to ascertain the students' thinking and decision-making during the data handling portion of the unit of work. The same groups of students were interviewed at two or three points during the unit of work, to check their progress with the work, confirm their explanations, and compare their plans to their accomplishments. The timing and number of interviews were determined by the instructional events in the unit. The students were treated as experts on their own actions and learning and asked to explain their choices and behaviours since "interviews are a useful means of gaining partial access to the child's knowledge and attitudes" (Palincsar and Brown, 1989 , p. 23). Interview questions were designed to ascertain the sources of information and skills demonstrated by the students, the students' thought processes as they handled data, and their affective responses to these activities. Shulman (1986 , p. 17) suggests, "To understand why learners respond (or fail to respond) as they do, ask not what they were taught, but what sense they rendered of what they were taught." It was this sense of their own learning experiences about which the students were questioned. Finally, the students were asked to evaluate their performances during the classes and provide suggestions for improving their work; this served to demonstrate some of the differences between what students can and what they do accomplish, as the students pointed out discrepancies between what they knew and what they produced. Samples of the students' work were reviewed during classes and interviews. These interviews lasted between 20 and 40 min, with interviews later in the unit lasting longer than those following data collection. Additionally, lessons reviewing for GCSE examinations were observed and students were interviewed immediately following these examinations for approximately 0.5 h. The units of work observed were as follows:

- 1 Year 11 Biology class—assessed practical: enzyme catalysis
(3 lessons, 6 student interviews, 2 teacher interviews)
- 1 Year 11 Physics class—assessed practical: springs
(4 lessons, 10 student interviews, 1 teacher interview)
- 1 Year 11 Chemistry class—investigation: rates of reaction
(2 lessons, 2 student interviews, 1 teacher interview)
(This unit was cut short due to the death of the teacher.)
- 3 Year 11 Chemistry classes—assessed practical: rate of reaction
(9 lessons, 11 student interviews, 1 teacher interview)
- 2 Year 11 Biology classes—inheritance problems
(4 lessons, 4 student interviews, 1 teacher interview)
- 2 Year 10 Physics classes—assessed practical: electrical resistance
(10 lessons, 6 student interviews, 2 teacher interviews)
- 2 Year 10 Biology classes—assessed practical: osmosis
(5 lessons, 5 student interviews, 1 teacher interview)
- 2 Biology, 3 Chemistry, 2 Physics classes—GCSE review sessions
(10 classes, 4 student interviews)

In two cases a class of students appeared in more than one unit. Thus, excluding the review sessions, the study included 10 classes of students, with 60 students being directly involved through interviews and/or work samples.

Student sampling decisions were made based on detailed information from the study site. For example, the physical arrangement of the room and the number of students in work groups partially determined how many students could usefully be observed in one lesson. As Cooper and McIntyre (1996 , pp. 28–29) find, the ideal of interviewing all students about the lessons was impractical and impossible. They explain their alternative:

In order to minimize the potentially negative effects of failing to interview all pupils a sampling procedure was operated. This involved gathering data from the teachers about their perceptions of individual differences among members of the teaching group, through interviews and brief written comments. On the basis of these data it was possible to ensure that the pupils interviewed were broadly representative in terms of the salient differences among them as perceived by teachers.

Stake (1994 , p. 244) suggests for within case sampling that the: "researcher notes attributes of interest…. discusses these characteristics with informants, gets recommendations,…. The choice is made, assuring variety but not necessarily representativeness, without strong arguments for typicality" (Stake 1994 , p. 244) thus, prioritizing the opportunity to learn. As the study's focus was the students' data handling, the most important student feature for which some sort of representative sample was desirable was data handling performance. During student selection, science teachers were consulted in order to ensure the inclusion of highly skilled, middle range, and low performing students in the groups interviewed, with consideration for gender balance influencing the selection.

The data analyzed by developing, testing, and modifying assertions about the students' explanations through multiple readings of the student interview transcripts (Tobin and Fraser, 1987 ; Tobin and Gallagher, 1987 ; Anderson and Burns, 1989 ; Maykut and Morehouse, 1994 ; Millar *et al*., 1994 ; Cooper and McIntyre, 1996). The percentage of students who provided explanation in each category was calculated for each class and the entire sample.

The conclusion discusses the outcomes for student learning and performance associated with the explanation categories. Marked papers and student examination marks were unavailable due to student and teacher confidentiality issues, the honouring of which was a condition of school access. However, even if the school had provided students' examination scores, no question-by-question analysis is conducted by the Examination Boards. Thus, it would be impossible to ascertain whether a high or low score in Science was due to data handling proficiency or the other 75% of the examination material. In this study judgments of learning were based on students' claims of understanding, demonstrations of understanding in interviews, and samples of work reviewed during interviews and classes. Claims are not made about student scores, but about the quality and quantity of learning that appeared to occur in these circumstances.

FINDINGS:

Both spontaneously and in response to questions students provided explanations for their choices and behaviours with regard to handling data. These student explanations fall within six categories, labelled 1) implementing correct procedures, 2) following instructions, 3) earning marks, 4) doing what is easy, 5) acting automatically, and 6) working within limits. These categories emerged from the data and use student language as closely as possible. The categories and their combination form the bases for the seven assertions about student motivations while handling data in science activities.

2.3. Objection of Some Students to Base Their Data Handling on "Implementing Correct Procedures"

The "implementing correct procedures" category consists of explanations students gave when they provided what they believed to be accepted criteria for their decisions about data handling. Seventy-seven percent of the students interviewed made at least one statement that fell into this category, including 100% of the students whose work was not currently being assessed. While none of the students explicitly said that they were "implementing correct procedures," the explanations supporting this assertion demonstrated the students' beliefs that there are right and wrong ways to handle data and they were doing it the right way. In some cases, these explanations were based in accepted scientific practice; however, even when the students' scientific facts were erroneous, the motivation behind the explanation was a desire to follow what they believed were "correct procedures." These explanations appeared especially frequently in their discussions about how much and what type of data to collect.

Researcher: Why did you choose six different concentrations (of chemical solutions)?

Winston: Because we wanted to get enough so that we could see a pattern developing in our results, and we thought that would be the right number.

Winston knew that patterns would be important for later data interpretation and was seeking the correct number to allow him to proceed accurately. Students also gave "correct procedures" explanations when they described how to analyze and interpret data. For example, in this group, John spoke as his two partners nodded in accord.

John: We're recording the voltage across the wire and the amps. And we do it five times and we average out the results.

Researcher: Why do you do it five times?

John: So we get an average of all the results, because one might be a freak result and where you got everything wrong or something. So you do it to see if you get all the same numbers.

John and his group wanted reliable data and believed that multiple trials and averaging would allow them to avoid a "freak result" or the effects of their getting "everything wrong." This represented a widely held belief among these students that averaging was done to reduce the impact of "freak," "stray," or "anomalous" results. While this is not the statistical rationale for averaging data in experiments, the students in this study claimed that they were conducting multiple trials and averages for this reason. The fact that their justifications were unscientific does not lessen their legitimacy for the students, who expressed their belief in these procedures with deep conviction.

As part of their data analysis, student had to select the type of graph to include in their write-ups, sometimes attributing the decision to following a "correct procedure":

Norman: It's not discrete data that you have. The gas syringe could have any quantity of gas in it, so rather than drawing a bar chart, it doesn't jump from thirty-six to thirty-seven in less than an instant, but it will go through thirty-six point one two three four. Because I think it's a line graph for continuous data.

Norman, unlike all others interviewed, correctly attributed his decision to the type of data he collected; he knew that line graphs were used for "continuous data" and that is what he believed he had. Therefore Norman followed a "correct procedure" and constructed a line graph. While Norman's reasoning stood alone in its scientific validity, other students did give explanations that demonstrated a concern for good practice, with the most common being the claim that line graphs showed patterns more clearly than other types of graphs.

On What They Have Been Told to Do

The "following instructions" category consists of explanations in which students claimed that the basis of their choice or behaviour was doing what they were taught or told to do. Seventy-four percent of the students provided this justification at some point in their interviews. Comments such as "We aren't going to play dot-to-dot because that's what [the teacher] doesn't like" (George) typified this form of motivation. Students' attempting to follow rules passed on by their teachers also falls into this category.

Ruth: I think that's how it—there is a kind of rule that you have to use. I think that's how it is. I think time goes up the side and the variables come along the bottom, but it might be the other way around. I have to ask about that before I do it. We have been taught that but I've forgotten which way it goes [laughing].

Thus, the rule takes the form of instructions by the teacher, allowing the student to avoid making the decision for herself by asking the teacher to repeat the rule. Some students appeared to be heavily reliant on teacher instructions, even when doing supposedly independent work.

Researcher: At what point did you decide that you were going to do averages?

Jane: She [the teacher] kind of told us.

Cathy: She wasn't supposed to and everyone kept saying "should we do the average" and then I don't know

Charlotte: I think people just figured it out.

In her interview the teacher claimed that the students had asked her whether they should average their results and that she asked them the question back, a claim that was supported by tape recordings from the lessons. However, at least Jane remembered the interaction as having been told to do the averaging; she considered herself to be doing what she was told. While the students knew that their teachers were restricted by assessment conditions, they still tried to ascertain what the teachers expected; Had the teachers been allowed, what instructions would they have been provided?

Sometimes the practices that the students claimed to have been taught were correct scientific procedures, e.g., using lines of best fit; sometimes the practices were erroneous, e.g., always putting time on the *Y*-axis. The identifying factor for this category is that the students believed that they were doing what the teacher wanted and expected. The critical difference between this and the previous category is the location the of the authority for the choice. In the "implementing correct procedures" category, the authority was in the method itself. Students claimed to be doing what was right because it was right; they indicated that they had made the choice themselves because it was, in some absolute way, the right choice to make. In the "following instructions" category the authority was with the teacher. In a sense, the fact that the teacher had told them to engage in a certain behavior absolved them of the responsibility of making the decision themselves.

On Earning Marks

The "earning marks" category consists of explanations in which students' descriptions indicated that their behaviour was directed by what they must do to earn good marks on their assessed practical or exams. Seventy percent of students made claims related to earning marks at least once in their interviews. Some student conversations revealed this as the main reasons for all work in the 2 years of preparation for GCSE examinations.

Veronica: So basically everything you write down is just trying to gain you extra marks. That's the general reason for the investigations.

Rosie: That's the only reason we're doing it [laughing] is for the mark.

Researcher: Do you ever do experiments in class that aren't written up as assessed practicals?

Veronica: We used to in the first and third year, but now it's just either learning things for the final exam or doing assessed practicals. I think the teachers used the experiments when we were younger just to interest us and make us learn, but now they don't have time to do that.

Rosie: They have to count.

Veronica: If you're not doing theory, then you're doing an assessed practical.

Rosie: The last two years are just aimed at GCSEs mainly. Everything goes to a GCSE.

The marking system seemed so prevalent for these students that they perceived that all their work was directed toward earning marks: "Basically everything you write down is just trying to gain you extra marks." When they mentioned learning, it was for examination purposes; they saw that the days when their interest in the material mattered were long past—"now they don't have time to do that." These students' perceptions may have been reinforced by teacher comments similar to one during a Physics lesson, when the teacher admonished, "This is important. This is your GCSE practical."

For some students, marks served as a motivation to do high-quality work. One student discussed the extra care she was putting into her write-up for her osmosis practical because it was being marked.

Valerie: With my write-up, I was trying to get everything in from diagrams and trying to explain what I was doing, because I'm trying to, I can't remember what my other grades were with my other investigations. But I'm trying to get better every time, trying to fit more in, so I can get a good grade, get a better grade for it.

Valerie was motivated to do good work because of the marks she could earn. She wanted to "get better every time" in order to "get a good grade"; she wanted her performance to improve.

Although motivations for earning marks appear to increase efforts by some students, for others the marking scheme acted as an upper limit on performance. The latter groups explained that they knew much more than they demonstrated on their assessed practicals because "You don't really need to, to get good marks" (Frank). Other students claimed that the desire to earn marks was so great that they would deliberately do work that they thought was erroneous if it was higher in the marking scheme: "Even if there's something that might be better, you still have to do the stuff on the syllabus, because otherwise you don't get the marks" (Jane). Thus, for some students, the "earning marks" motivation took priority over the "following correct procedures" option.

To Base Their Behaviours on "Doing What Is Easy".

Just over half the students in the study explained their decisions about data handling using the words "easy," "easier," and/or "easiest." For some students, these reasons indicated a desire to minimize effort on their part; i.e., "easy" meant that they had to do less work or work that, for them, was at a lower level.

Researcher: Why did you choose to do a line graph for this one?

Joe: It was easiest [laughing].

Researcher: Okay.

Joe: A bar graph's really practically unlikely; I like line graphs.

This student and others like him consistently made choices that allowed them to put the least effort possible into their work. However, when some students used these terms to justify their choices, their explanations revealed a desire for elegance in the process of handling data. Although another group made the same decision, claiming that what they did was "easiest," their explanation was very different from Joe's.

Harriet: Because you can see, because the shape of the line can show you easily the patterns.

Karen: It's the simplest to understand really. You just look at it and you can see exactly what happens.

Although they used the same terms as Joe, Harriet and Karen communicated a desire to understand their data using their graphs: "You just look at it and you can see exactly what happens." They did not convey the impression that personal preference was an acceptable justification. They did indicate an awareness of the next step in their investigations, keeping in mind the overall purpose of graphing: "The shape of the line can show you easily the patterns."

Similarly, a student claimed to be using lines of best fit and line graphs for the subsequent ease of interpretation.

Researcher: Why are smooth lines better?

Frank: It gives a clearer indication. It's easier to draw comparisons between two lines that are smooth than two lines that perhaps intersect and bubble.

And later,

Frank: With a line graph it tends to be easier to see, with the steepness; if it's a steep curve then the reaction is happening quickly and if it shallows out then the reaction will begin to slow down. It's harder to see that with a bar chart or whatever. It tends to be an easy type of graph to interpret.

While using the term "easier," Frank described a "correct procedures" concern with identifying patterns as he justified his use of line graphs with lines of best fit, suggesting that he planned to "draw comparisons between two lines" and relate the rate of reaction to relative gradients. Karen, Harriet, and Frank used language that allowed their explanations to fall within the "easy" category, yet both groups indicated that, in this case, they were more concerned with gaining a quality product from their work than with reducing their efforts.

To Follow Data Handling Procedures "Automatically".

According to approximately one-fifth of the students in the study, various data handling procedures had become automatic; when they did an investigation they did not have to think about what to do with their collected data.

Julie: In Maths, in Science, we've just been encouraged to do graphs for years, and now it just comes naturally whenever you do an investigation.

Laura: Yeah, you don't think, "Oh we have to do."

Geri: You have to do a graph.

Julie: You just do and so you do stuff like predictions hypothesis naturally, as well. So it's just a way of showing the results that you've got.

They had been trained to do procedures that they had repeated so often that, these students claimed, the implementation of the procedures had become subconscious. Julie believed of graphing that "now it just sort of comes naturally," while Laura's "you don't think…you just do" clearly communicated the removal of the conscious aspects of the process.

Another group, discussing their resistance investigation, made claims of automatic practice.

Jane: People just do it naturally now.

Researcher: What do you mean "do it naturally"?

Jane: It's just something you have to do [laughing]. That's about it, with a graph or anything.

Charlotte: Yeah, usually you find the average of any results you have.

Jane: Make graphs with averages. You can't make a graph with every single result, because you'd have ten million graphs.

Cathy: And we've been told, when we do an experiment or something, we always have to do it five times, so we always have five results on one thing but less actual at the end results. So you just do it just automatically.

According to Jane, averaging is automatic for students doing investigations, "People just do it naturally now," with Cathy supporting this claim, "You just do it just automatically." While "naturally" and "automatically' may not technically mean the same thing, these students used them interchangeably. Both of these groups claimed not to think consciously about what procedures to include in their investigations. While the initial impetus for averaging and graphing may have been following teacher instructions, these students indicated that teachers no longer had to tell them to do graphs and other parts of their investigations.

Their Behaviours Were Limited by Contextual Factors

Almost two-fifths of the students in the study discussed contextual factors, such as time and equipment, in their explanations of their data handling. According to these students, they would have behaved differently if they had not been working under particular conditions, especially time limitations.

Frank: The time limit that we get, two lessons, and it's not enough to really do four to six experiments. We have fifteen to do, which is.

Norman: We're supposed to do it on our own, as well, which is stupid because there's only fifteen gas syringes between a class of thirty.

Frank: We're meant to share, and it doesn't work.
Norman: There's always some people larking around [laughing].
Frank: If we're given the time, then we do it properly but, it's too much pressure. There's not enough equipment. There's always never enough acid or anything.

In addition to their discussion of "larking around," some students did indicate that certain time constraints were of the students' own making. The same group who complained that they were not given enough time and equipment to collect their data later explained their poor performance as their own responsibility.

Frank: I probably could have done a lot better if I had really had the time. Because we tend to do it the night before it is due really [laughing]. They give you six weeks but the longer they give you…
Norman: It doesn't matter. We're going to do it the night before anyway.
Frank: They might as well give it to you tomorrow. It would be a better experiment that way; you'd actually remember it.

Nevertheless, students used these factors to account partially for their data handling choices and behaviours. These choices included fabricating data for their practicals, about which they were embarrassed but justified their behaviour by describing what they considered to be unreasonable working conditions.

2.4. Multiple Motivations for Their Data Handling

While students occasionally gave a single explanation for their behaviours and choices, they frequently provided more than one reason in consecutive interviews, the same interview, or even the same response to a single question. Only two students provided a single explanation for all their decisions, which was earning high marks. In some cases one of the multiple motivations the students discussed seemed to take precedence, while in others no clear supremacy emerged. Some students appeared to include both the "right" reason and the "real" reason, parroting the "correct" explanations they had been given but mentioning their own underlying motivations. For example, while explaining their decisions about how many data to collect for their resistance investigation, one group included both "correct procedures" and "earning marks" reasons

Jane: Accuracy. Make sure you get it right. It can be just really fluky or something like that.
Charlotte: Just in case.
Cathy: It could be the wrong power or something, for some stupid reason.
Jane: And you wouldn't know, unless you…
Charlotte: And you have to do it three times. You have to repeat it three times.
Jane: To get the accuracy and points and stuff.
Charlotte: Averages.
Researcher: You just talked about a whole bunch of things, so can you tell me more about the points?
Jane: Oh yeah. It's just like for marking. If you've just done it once then you don't have a very reliable source. So you don't get as many marks as if you did it a whole load of times, got an average, and said why you think they weren't all the same and why they were the same and what you think about it.

Jane's initial response was that they made their decisions based on what would be the most accurate. Her group's "correct procedures" explanations included incorrect rationales of avoiding "fluky" results and experimenter error, but they were about accuracy nonetheless. Later, Jane elaborated on the marking scheme, but she indicated a belief that the higher marks depended on more accurate procedures. It was unclear whether her primary motivation was being accurate or earning marks by being accurate. These multilayered motives exhibit the complexity of the problem of understanding students' choices and behaviours.

Table1 lists the percentages of students who provided at least one motivation in each of the categories by unit of work and overall.

Table 1

Percentage of students who provided at least one motivation in each category by unit of work and overall:

	Implementing correct procedures	Following instructions	Earning marks	Doing what is easy	Acting automatically	Working within limits
Enzyme catalysis	67	67	83	83	17	100
Springs	80	100	60	40	80	60
Investigation	100	75	75	75	25	0
Rates of reaction	86	43	71	36	0	57
Inheritance	100	100	0	0	0	0

Resistance	67	100	67	67	33	0
Osmosis	67	50	100	50	0	17
Exam sessions	0	0	100	0	0	0
Overall	77	74	70	51	19	38

Discussion of Outcomes:

The various explanations that students gave were associated with specific choices and behaviours, resulting in identifiable outcomes for both learning and performance. These outcomes were revealed through student explanations of their performances, including discussions of work samples. These outcomes are summarized below and related to findings in the literature.

When students claimed to be "implementing correct procedures," they attempted to produce the highest-quality work they could. They focused on the task, rather than external factors. Thus, their performances could be expected to reflect their knowledge and skills of data handling accurately. When students provided "correct procedures" explanations, teachers could accurately assess what the students' understood and could correct their misperceptions. This was one of the two most common categories of student explanations. This "implementing correct procedures" set of explanations most closely matches Maehr's (1983) task orientation motivation and the positive outcomes associated with intrinsic motivation described by Deci *et al*. (2001a) .

When students claimed to be "following instructions," they did not make choices for themselves but depended on what they believed a past or present teacher had told them. Thus, they were able to avoid responsibility for their work. Further, they relied upon recollections of teachings rather than true understandings of procedures, making them vulnerable to memory failures. Additionally, these students sometimes were able to produce work that they did not understand, simply by following a set of rules. Student work associated with this explanation provides no real insight into student understanding of science, merely memory for instruction. This category composed the overwhelming motivation for a minority of students and appeared sporadically in other interviews. For some students, this category corresponds to aspects of Maehr's (1983) social solidarity motivation, as seeking teacher approval appeared to be part of the explanation. For others, it corresponds more closely to the literature regarding the negative aspects of rule following (Scardamalia and Bereiter, 1983 ; Larson, 1995) involving limited mental activity and lack of effort.

When "earning marks" motivated students, they considered learning to be secondary to performance. Several students explained that they saw the marking scheme standards as the upper limit of performance. They were not willing to expend time and energy that were not rewarded by marks, so they did not demonstrate their full range of knowledge and skills.

Students also admitted that the emphasis of the school system on earning high marks justified their fabricating experimental data. Thus, when students were motivated by "earning marks," their performances frequently misrepresented their scientific understandings. This explanation competed with "implementing correct procedures" for being the most prevalent in interviews and most powerful for the students. Many characteristics of the "earning marks" motivation coincide with Maehr's (1983) description of extrinsic rewards orientations and support Deci and co-workers' (2001b) conclusions about the negative effects of rewards on intrinsic motivation.

When students claimed to be "doing what is easy," they acted in one of two ways. For one set of students "easy" meant that they avoided challenges, resulting in poor performances unrelated to actual knowledge and skill levels (Norman, 1983 ; Loughran and Derry, 1997). Other students used words such as "easy" when they sought elegant and useful procedures, producing work at their highest levels, matching characteristics of task-oriented students (Maehr, 1983). This category demonstrates that not only must educators listen to students' explanations of their work, but they must listen carefully if they want to appreciate true levels of understanding.

When students claimed to be "acting automatically," they did not make conscious decisions about their choices and behaviours. Sometimes this led to their efficiently using tacit knowledge to perform data handling tasks. In other cases, students applied "automatic" behaviours inappropriately. In both instances, the choices, behaviours, and their products were unmonitored by the students. These students' explanations of their performances seem to fall outside Maehr's framework, even with the addition of an effort minimization motivation. Rather, they appear to relate to the literature of tacit knowledge (e.g., Polanyi, 1962 ; Woolnough, 1989 ; Claxton, 1997).

When students claimed to be "working within limits," they did not perform at their full potential. They used contextual limitations as an excuse to avoid accountability for the quality and quantity of their work. Additionally, they created limitations for themselves, which could further protect them from exposing their actual levels of knowledge and skills.

These explanations may belong to Maehr's ego orientation, in that blaming contextual factors allowed students to preserve their egos, or to effort minimization, as focusing on external constraints permitted them to reduce their efforts.

Thus, it seems that only students who were motivated by “implementing correct procedures,” and some of those who were “doing what is easy” and “acting automatically,” produced work for their assessed practicals that accurately reflected their data handling knowledge and skills. In some cases, such as when they were “following instructions,” students' final products exceeded their understandings. More commonly, however, the students' level of performance on their assessed practicals was far inferior to their potential, either because the marking scheme did not included relevant mastered techniques or because the students were able to shield themselves from responsibility for their choices and behaviours. These findings have strong implications for the reliability of conclusions drawn about levels of individual, school, and program performances when students' motivations are not fully understood. Further, this research suggests that, to maximize learning and accurately assess students' understanding, educators must resist the temptation to motivate students through extrinsic rewards, be judicious in their provision of specific instructions and standards for success, and foster a desire in students to perform their tasks completely and accurately.

CHAPTER – III

3.1. The Importance of Social Approving Reasons in the Development of Academic Motivation.

There is widespread concern that assessments which have no direct consequences for students, teachers or schools underestimate student ability, and that the extent of this underestimation increases as the students become ever more familiar with such tests. This issue is particularly relevant for international comparative studies such as the IEA's Third International Mathematics and Science Study (TIMSS) and the OECD's Programme for International Student Assessment (PISA). In the present experimental study, a short form of the PISA mathematical literacy test is used to explore whether the levels of test motivation and test performance observed in the context of the standard PISA assessment situation can be improved by raising the stakes of testing. The impact of (1) informational feedback, (2) grading, and (3) performance-contingent financial rewards on the personal value of performing well, perceived utility of participating in the test, intended and invested effort, task-irrelevant cognitions, and test performance are investigated. The central finding of the study is that the different treatment conditions make the various value components of test motivation equally salient. Consequently, no differences were found either with respect to intended and invested effort or to test performance.

The present study is based on the importance of social approving reasons in the development of academic motivation. This research intends to investigate the effect that they have reasons for social approving on academic motivation of students. For this the study aims to observe the differences that appear in the ability to retain a list of words by students and general motivation that they have in the presence of social approval (provided by the teacher and peers) in the absence of social approval. It is a descriptive case research based on our teaching experience in higher education. Was analyzed the population of students, aged between 18 and 28 years in university in Romania. The results of analysis of available data, students consider as fundamental the need for approval in the development of academic motivation. The need for approval is a positive factor in point of view of social integration, it supports social behaviour as one possible predictor of how a person will relate to others, depending on the axis between the existence of maximal and minimal existence of this needs at a certain person. © 2015 The Authors. Published by Elsevier Ltd. Peer-review under responsibility of Academic World Education and Research Center.

Participants:

There were analyzed subjects - students, aged between 18 and 28 years, in university education. The participants were selected by purposive sampling, a method known in qualitative research (Patton, 1990). The sample group for this research includes 90 students from various faculties at University of Bucharest. Georgeta Panisoara et al. / Procedia - Social and Behavioural Sciences.

The results of the study were obtained by applying a written questionnaire to subjects. For the analysis of the questionnaire data were transcribed the responses.

The results of analysis of available data, students consider as fundamental the need for approval in the development of academic motivation. The need for approval is a positive factor in point of view of social integration, it supports social behaviour as one possible predictor of how a person will relate to others, depending on the axis between the existence of maximal and minimal existence of this needs at a certain person. Wishing to find out whether significant difference that appear in the ability to retain a list of words by students and general motivation that they have in the presence of social approval (provided by the teacher and peers) and in the absence of social approval, have obtained the following indicators.

According to the recent studies, it becomes obvious out that if the social support is formed in the bulk of the its criticism and condescension (and think about how frequent are such manifestations of social support in current practice), instead of increasing self-esteem and sense control of the situation in which the individual is sent to feelings of guilt, sees himself as incompetent, weak and dependent on others and - not the least - the situation. In this way, we emphasize the importance of strategies aimed at providing a positive social support / approving, strategies that can be pursued on a wide range of options. The need for approval is a positive factor in point of view of social integration, it supports social behaviour as one possible predictor of how a person will relate to others, depending on the axis between the existence of maximal and minimal existence of this needs at a certain person.

Student motivation for learning lies in its desire to find the most appropriate cognitive strategies, which they believe will assist in learning. Whether it's about organizing, repetition the information, monitoring comprehensive level or making connections between new and previously acquired knowledge, each student, in part, establishes their order of priority. clearly highlights the importance of communication between teachers and students, "verbal teacher–student interactions and student characteristics are meaningful for student learning and motivation". In this study, authors investigated how teacher questions and feedback in relation to individual student characteristics and gender predict cognitive learning activity and intrinsic learning motivation. Another study examines the relationship among students' and teachers' thinking styles, student psychological needs (autonomy, competence and relatedness), and their reports of intrinsic motivation in the Psychology Degree context.

They concluded that psychological need satisfaction has a significant and positive impact on student intrinsic motivation. The sources of motivation however are complex.

3.2. Secondary School Students' Motivation and Achievement in Combined Science

This study investigated students' motivation and achievement in combined science. A sample of 324 Year 11 students from eight government secondary schools in Brunei Darussalam participated in the study. Of the sample, 141 were boys and 183 were girls and their average age was 16.4 years. The motivation instrument used was adapted from the science motivation questionnaire (Glynn, Taasoobshirazi, & Brickman, 2009) and consisted of 24 items. Results show that this group of students displayed a moderate level of intrinsic motivation, personal relevance, self-determination and self-efficacy and a high level of extrinsic motivation and assessment anxiety in learning-combined science. Results also demonstrate significant differences in motivational orientations towards learning-combined science between boys and girls and between high ability and low ability students. Furthermore, correlation analyses show that there were significant positive associations between students' motivational orientations and science achievement.

The prominent place given to science in the school curriculum means that every Bruneian child has the opportunity to study science right from the primary to the secondary level of education. Concomitantly, much effort has been expended to enhance the quality of science education in schools. Despite the attention, as many as 75% of students fail to make the grade after completing 8-year-old of schooling to enter into the science stream. Instead, they are placed in the art stream and study combined science as one of the core subjects. A disturbing trend witnessed in recent years is the low percentage of less than 20% of these students who manage to obtain Grades A-C in combined science in the GCE (general certificate of education) ordinary level examination, a public examination for 16+ years old. Recently in 2011, only 0.58% of students obtained Grade A, 5.42% obtained Grade B, and 11.8% obtained Grade C in combined science. This is a cause for concern, since this will not augur well with Brunei's vision of becoming a fully developed nation by 2035. Future progress requires citizens who are scientifically and technologically literate. In recognition of science as the fundamental force behind social and economic development as well as a major contributor to citizenship and public understanding of scientific issues, the country responded by giving more emphasis to science education.

The importance of scientific literacy is evident and highlighted in the learning outcome for science which, among others, to enable students, to reason, think creatively, make logical and responsible decisions and solve problems; and to understand the impact of science on the phenomenal technological changes that have accompanied it and its effects on medicine and to improve the quality of life, on industry and business and on the environment. (The National Education System for the 21st Century, 2008, p. 37) As one of the researchers has been teaching combined science for more than 10 years, her observations and interactions with this group of students have made her aware of lack of motivation to study combined science as a possible reason for low attainment.

This observation underscores the urgent need for such a study to be conducted to find out if indeed students' motivation is the main contributing factor for low achievement in combined science. In addition, compelling evidence of the importance of motivation and its association with achievement (Reynolds & Walberg, 1991; Skaalvik & Rankin, 1995; Volet & Jarvela, 2001; Wong & Csiksezentmihalyi, 1991) also adds impetus for such a study to be conducted. The present study used the SMQ (science motivation questionnaire) adapted from Glynn, Taasoobshirazi, and Brickman (2009) as an instrument to measure students' motivation. The original questionnaire was first developed by Glynn and Koballa (2006). This instrument was chosen, because it has been widely used by researchers in over 70 countries illustrating its adaptability across cultural contexts.

The first aim of the present study was to investigate students' motivational orientations towards learning combined science. The second aim of the study was to compare boys' and girls' motivation to find out if the two groups of students respond differently to different motivational orientations. The third aim of the study was to find out if students who achieve at a low and high level have different motivation. Lastly, the fourth aim was to establish the relationship between motivation and achievement in combined science. The study is, therefore, significant as it provides useful information to teachers and educators in their efforts to improve achievement by fostering students' motivation to learn combined science. Literature Review Evidence documents motivation as an important determinant predicting students' achievement (Beal & Stevens, 2007; Broussard & Garrsion, 2004; Johnson, 1996; Sandra, 2002; E. M. Skaalvik & S. Skaalvik, 2006; Zhu & Leung, 2011). Motivation, like other attitudinal behaviours, encompasses many aspects and one such aspect is motivational orientations.

According to Steward, Bachman, and Johnson (2010), motivational orientations act as a driving force that encourages a person to engage in a task. Motivational orientations consist of several constructs and among these are intrinsic motivation, extrinsic motivation, personal relevance, self-efficacy, self-determination, and assessment anxiety. Intrinsic motivation is an inner force that motivates students to engage in academic activities, because they are interested in learning and they enjoy the learning process as well (Schiefele, 1991). Harter (1978) explained that intrinsic motivation is the true drive in human nature, which drives individuals to search for and to face new challenges. Their abilities are put to the test and they are eager to learn even when there are no external rewards to be won. Students with learning goals of seeking understanding for mastery of science content and skills are said to be intrinsically motivated (Cavallo, Rozman, Blinkenstaff, & Walker, 2003). Csiksezentmihalyi and Nakamura (1989) stated that intrinsically motivated individuals possess the following characteristics:

They engage in both mental and physical activities holistically, they remain highly focused throughout these activities with clearly defined goals, they are self-critical, they self-reflect on their own actions realistically, and they are usually relaxed and not afraid to fail during learning. A research study done by Stipek (1988) concluded that intrinsically motivated students learn independently and always choose to do challenging tasks. They persevere to complete the tasks they have undertaken. They integrate their knowledge acquired in school with their experiences gained from outside school. They often ask questions to broaden their knowledge and learn regardless of any external push factors or help from teachers, and they take pride in their work and express positive emotions during the learning process.

Highly intrinsically motivated students are able to learn new concepts successfully and show better understanding of the subject matter (Stipek, 1988). Unlike intrinsic motivation, extrinsic motivation drives students to engage in academic tasks for external reasons. Extrinsic motivators include parental expectations, expectations of other trusted role models, earning potential to enrol in a course later and good grades. According to Benabou and Tirole (2003), extrinsic motivation promotes effort and performance with rewards serving as positive reinforcers for the desired behaviour. Extrinsic motivation typically produces immediate results and requires less effort in comparison to intrinsic motivation (Ryan & Deci, 2000). The down side of it is that extrinsic motivators can often distract students from true independent learning.

Another problem with extrinsic motivators is that they typically do not work over the long term. Once, the rewards are removed, students lose their motivation (DeLong & Winter, 2002). As extrinsically motivated, students tend to focus on earning higher grades and obtaining rewards, Biehler and Snowman (1990) believed that extrinsic motivational factors can diminish students' intrinsic motivation. Such observation has also been reported by Bain (2004) who concluded that extrinsic rewards have negative impacts on intrinsic motivation. In the case of relevance, it has been commonly equated with students' interest in a task that they do (Hanrahan, 1998; Matthews, 2004; Osborne & Collins, 2001). Levitt (2001) interpreted relevance as importance, usefulness, or meaningfulness to the needs of the students. Keller (1983) defined relevance as a more personal interpretation, i.e., a student's perception of whether the content or instruction satisfied his/her personal needs, personal goals, and/or career goals. When students themselves decide on the topics of interest in school science, relevance takes on a personal meaning when students' hearts and minds are captured (Gardner, 1985; Osborne & Collins, 2001; Reiss, 2000). Thus, school science will only engage students in meaningful learning, if the curriculum has personal value and enriches students' cultural self-identities.

According to Holbrook, Rannikmae, Yager, and De Vreese (2003), students perceive science education as relevant to them through three areas: Firstly, usefulness of science in the society which means they are more interested to learn if the content is related to societal issues; Secondly, students' interest towards science learning which means that students are motivated to learn and do the tasks and activities in science; and Lastly, importance of science in the course they are taking which means the science content learnt is meaningful and useful to them. According to Bandura's social cognitive theory, self-efficacy is defined as individuals' beliefs about their own capabilities in learning and performing tasks at specific levels. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave (Bandura, 1997). Baldwin, Ebert-May, and Burns (1999) observed that self-efficacy is especially important in learning difficult subjects (such as biology and other sciences) given that students enter courses with varying levels of fear and anxiety. They also stated that self-efficacy becomes more important over the duration of the science course as the content becomes more complex.

As the students' self-efficacy may affect the learning process, choice of science, the amount of effort put into accomplishing science task, and persistence in learning science are some factors that are important in this respect (Kennedy, 1996). Self-efficacy beliefs influence on the choices individuals make and the courses of action they pursue (Pajares, 2001). Students with high self-efficacy are often confident enough to accept challenging tasks. They put in more effort and persist through difficult stages in learning. Goals are set in order to accomplish the tasks given. On the other hand, students of low self-efficacy may avoid the learning task and opportunities to seek for help. It is not surprising that many struggling learners have low self-efficacy in their studies, because they believe that they lack the ability to succeed. Low self-efficacy students tend to avoid challenging courses and give up quickly when difficulties arise (Margolis & McCabe, 2006). Many studies have reported that there is a relationship between self-efficacy and academic achievement (Andrew, 1998; Kan & Akbas, 2006; Graham & Weiner, 1996; Pintrich & De Groot, 1990; Zushou, Pintrich, & Coppola, 2003). Self-determination is the ability of students to choose and control over what and how they want to learn (Reeve, Hamm, & Nix, 2003).

An advantage of this approach is that when students are given the freedom to determine their academic tasks, they are more likely to benefit from them (Glynn & Koballa, 2006). Garcia and Pintrich (1996) found that the intrinsic motivation of college biology students increased when the students could select the course readings and term paper topics as well as the due dates for class assignments. Reeve et al. (2003) also concluded that when students believe that they have some degree of control over their learning, such as selecting some of their lab topics, overall motivation is increased. In a study conducted by Black and Deci (2000), results obtained supported the idea that self-determination leads to improvements in student learning. They found that students with a high desire to enroll in the course were significantly correlated with perceived competence, interest/enjoyment of the course, low anxiety, and were more focused on learning whilst those who enrolled due to course requirements were significantly correlated with dropping out of the course. Lavigne, Vallerand, and Miquelon (2007) posited that teachers who support self-determination in students' result in a positive impact on students learning toward science and pursuing a career in science.

Assessment anxiety and test anxiety are common terms used in educational studies and both terms share the same meaning and are used interchangeably. According to Olatoye and Afuwape (2003) and Hurlock (1972), test anxiety is a psychological state of mind where a student expresses levels of worry, fear, uncertainty, concern, and helplessness before, during, or after a test. These behavioural responses are commonly related to possible negative consequences on a test or some other similar evaluative situations (Zeidner, 1998). Consequences of failing test, unable to finish test or being embarrassed due to low grades are some similar thoughts that run through highly test anxious students' minds (Schunk, Pintrich, & Meece, 2008). Many studies had found assessment anxiety to be an important predictor of academic achievement (Olatoye, 2009). For example, Thomas and Gadbois (2007) reported that assessment anxiety was a significant predictor of mid-term examination grades. Sgoutas-Emch, Nagel, and Flynn (2007) also reported in their study that the level of perceived preparedness, self-efficacy, previous exposure to course materials and test anxiety significantly predicted students' achievement in science. In another aspect, assessment anxiety can also negatively affect achievement and performance (Cassady & Johnson, 2002).

As Cowden (2009) observed, students with high anxiety often show low confidence on their ability to cope with academic situations because they do not have the skills to cope, thus, they do not have control or are losing control of what they are doing. On the other hand, a moderate level of anxiety is in fact good as it helps motivate learning as observed by Cassady and Johnson (2002).

They further explained that when students are motivated to learn, it may increase their anxiety as they have high expectations and thoughts of the consequences of not meeting the expectations. Similarly, it has been reported in another study that the thoughts of failure disappointing the person who motivates them may also increase test anxiety (Olatoye, 2009). Students with high expectations and thoughts of perfection face assessment anxiety as well. They see the first position as so significant that coming in second place is considered as a failure (Oliver, 2006). Gender differences in the motivation to learn science has attracted much attention during the last decade (Eccles & Blumenfield, 1985; Greene & DeBacker, 2004; Greenfield, 1998; Morrell & Lederman, 1998).

Evidence accumulated thus far on gender differences in motivation is inconclusive. While many studies (L. H. Anderman & E. M. Anderman, 1999; Ayub, 2010; Lai, Chan, & Wong, 2006; Meece & Holt, 1993) reported that there are gender differences in extrinsic and intrinsic motivation between male and female students, studies by Rusillo and Arias (2004) and Glynn et al. (2009) reported otherwise. In terms of self-efficacy, Britner and Pajeras (2006) found that middle school boys have higher self-efficacy than girls in learning science. This was found to be the case in studies by Cavallo, Potter, and Rozman (2004) and Taasoobshirazi (2007) in which they concluded that college male students had significantly higher self-efficacy compared to female students. In the case of self-determination, Meece and Jones (1996) found boys are more likely than girls to assume control for their own learning and to evaluate different problem solutions while girls tend to show greater avoidance of problem-solving situation, take fewer risks, and request more assistance than boys. While female students believed they had more control over their learning than male students, there were no gender differences in personal relevance in learning science between the two sexes (Glynn et al., 2009).

Studies have also found that male students have more confidence and less anxiety than female students in learning science (Glynn et al., 2009). In chemistry, Jegede (2007) and McCarthy and Widanski (2009) observed that female students have more anxiety toward learning chemistry than male students. In physics, Taasoobshirazi (2007) conducted a survey on college students from an introductory level physics course and reported that women had higher assessment anxiety than their male counterparts. Moreover, studies have also shown that motivational orientations are discipline-based depending on the subjects that the students have opted for their studies. Steinkamp and Maehr (1984) found that girls' motivational orientations toward biology and chemistry were more positive than boys, whereas boys have more positive orientations toward physical and general science. Girls' higher motivational orientations toward biological sciences were also reported by DeBacker and Nelson (2000).

Studies which specifically investigated students' ability have yielded interesting findings in relation to their motivation. Talib, Wong, Azhar, and Abdullah (2009) conducted an in-depth study on motivation of students with outstanding performance in academics and revealed that good science learning outcomes do not rely on the way teaching is carried out but on many factors which include students' ability. Feldhusen and Hoover (1986) identified self-concept and motivation as the most important factors for high ability students' academic achievement. Other studies report that high ability students have higher scores than low ability students on academic goals, valuing science, and perceived ability (Debacker & Nelson, 2000) and they have more positive attitudes toward science in terms of interest and career in science than low ability students (Adams, 1996). According to Busato, Prins, Elshout, and Hamaker (2000), intellectual ability and achievement motivation were positively associated with academic success.

Other reasons for the high academic success of high ability students are their high level of motivation to continue their education (Kozochkina, 2009), their high intellectual ability, verbal ability, attribution of failure to stable factors and mood, academic self-concepts, attainment value, rehearsal, time management, and effort management than low ability students (Lau & Chan, 2001). Also, their high proficiency in English language, more time spent on studying, better test skills, and better skills in selecting the main ideas from spoken and written discourse than low ability students (Stoynoff, 1997). The Present Study The main aim of the present study was to investigate students' motivation to learn combined science using the science motivation questionnaire adapted from Glynn et al. (2009). This is to find out how motivated students in the art stream are to learn combined science in terms of intrinsic motivation, extrinsic motivation, personal relevance, self-efficacy, self-determination, and assessment anxiety.

Another aim of the study is to compare student's motivation between boys and girls, and between high ability and low ability students in order to gain additional insight into student's motivation to learn combined science. The present study also attempts to establish if there is a causal link between student's motivation and achievement. This study will answer the following specific research questions:

(1) What are the motivational orientations of Year 11 art stream students towards learning-combined science?

(2) Are there any significant differences in motivational orientations between boys and girl in learning-combined science?

(3) Are there any significant differences in motivational orientations between high and low ability students in learning-combined science?

(4) What are the relationships between Year 11 art stream students' motivational orientations and achievement in combined science?

LEARNING SCIENCE THROUGH INQUIRY

Teachers have very different levels of knowledge and skills in science. Prospective teachers in colleges and universities may have only high school science courses behind them. Experienced teachers who are certified in other fields may find themselves teaching science. Veteran science teachers or scientists who aspire to teach may have a strong but traditional science background or may be teaching a science different from their background. All may find themselves challenged by the need to learn more or a different kind of science.

To teach their students science through inquiry, teachers need to understand the important content ideas in science — as outlined, for example, in the *Standards.* They need to know how the facts, principles, laws, and formulas that they have learned in their own science courses are subsumed by and linked to those important ideas. They also need to know the evidence for the content they teach — how we know what we know. In addition, they need to learn the "process" of science: what scientific inquiry is and how to do it.

But *how* can teachers learn the major ideas in the scientific disciplines? There are many possibilities, from formal pre-service or in-service classes, to independent programs of study, to serious reflection on their interactions with students in their inquiry-based classrooms. The next three vignettes in this chapter describe a range of science courses and professional development experiences that give teachers an opportunity to learn the major ideas of science disciplines through inquiry. The first vignette tells the story of a university-based physicist who teaches teachers within the structure of a university course. The second describes the experiences of a teacher taking part in that same course. And the third tells of a kindergarten teacher who is immersed in science at a program in a science museum.

Besides, changing the traditional lecture approach in a science course, some college professors have developed special science courses for K-12 teachers. The Physics Education Group in the Department of Physics at the University of Washington offers special courses for both preservice and inservice teachers. The curriculum is based on *Physics by Inquiry*(McDermott et al., 1996), a set of laboratory-based modules that have been developed on the basis of research on the learning and teaching of physics. (References to relevant research can be found in McDermott and Redish, 1999.) The courses help teachers develop a functional understanding of important physical concepts.

BECOMING LIFE-LONG "INQUIRERS"

This chapter uses the term "professional development" to refer to opportunities those teachers have to learn at all stages of their careers. It thus encompasses learning experiences for prospective, beginning, and experienced teachers through preservice, induction, and in-service programs, respectively. This chapter also emphasizes the importance of thinking about professional development as a continuum. Teachers at any level may know an enormous amount about some things but not others, and the stage of their careers should not dictate what they will learn and in what depth they will learn it.

The *Standards* emphasize the importance of lifelong learning by making it one of four professional development standards. Professional development must satisfy the ongoing need of all prospective and practicing teachers to continue to grow, to increase their knowledge and skills, and to improve their value to their students. A commitment to inquiry — as something that all humans must do to improve their lives and those of others — is an important theme for professional development, in addition to its other goals.

The most effective professional development not only stimulates the need to continue to learn. It also provides knowledge about where to look for information, it provides opportunities to improve teaching and learning, and it introduces teachers to tools for continuous improvement. These tools include strategies to analyze classroom experiences; to observe and provide useful feedback to others; to record and document observations and important information from other sources; and to search databases for useful guidance and material.

The vignettes in this chapter show several of these tools in action. Several of these stories were drawn from the journals of teachers. Some journal writing was required by the teacher's professional development experience. Other teachers simply keep journals as a tool for self-reflection and as a way to take time to understand their activities and experiments.

Several of the vignettes also illustrate ongoing learning through inquiry. Steve describes a component of his program in which he was asked to define a research question about his teaching, design and use a data collection and analysis scheme to address the question, and then report the results to his colleagues. Such action research projects are important sources of information for teachers. They organize what might otherwise be random impressions, unsystematic observations, and unconscious behaviors into a frame that can inform teachers' practice. They give teachers a tool that they can use to pursue questions about teaching throughout their careers.

In Joanna's case, a teacher who had not previously experienced inquiry had her eyes opened to its possibilities as a source of ongoing learning. Through professional development, she acquired the confidence to continue to inquire into science concepts. Joanna's motivation to think deeply about how her students were learning and what abilities they needed to keep learning produced continual refinements in her teaching and the learning environment she established for her students.

3.3. Method Sample

The target population in this study were Year 11 students who were about to sit for their GCE "O" level examinations in October 2011. Altogether, 324 students were selected from eight government secondary schools in the Brunei-Muara district. Of the sample, there were 141 boys and 183 girls and their average age was 16.44 years. Instrument The first section of the instrument was designed to obtain the demographic profiles of students, such as participants' age and gender. The second section contained a questionnaire adapted from Glynn et al. (2009) and it consisted of 30 self-assessment items measured on a 5-point Likert type scale ranging from five for always, four for usually, three for sometimes, and two for rarely to one for never. The 30 items were not grouped into six separate variables but were randomly arranged. The items were categorized into six motivational scales, namely, intrinsic motivation, extrinsic motivation, personal relevance, self-efficacy, self-determination, and assessment anxiety. The description of each scale and an example of the test item are given in.

The survey instrument was first pilot tested on 11 students studying combined science in a government secondary school in April 2011. This was necessary to establish the suitability of the instrument before it was used for the main study. The Cronbach's coefficient alpha for the 30 items was 0.86. When each scale was analyzed, assessment anxiety was found to be low at 0.41. It was decided to remove the item "I hate taking science tests” to improve the alpha to 0.61. Other motivational scales have one item removed as well to make them consistent with four items each. An example of an item that was removed is “I am confident, I will do well on the science labs and projects”.

As students are seldom given the opportunity to do science labs and project, such an item is considered inappropriate to be included in the study. The reliability (internal consistency) obtained for the 24 items was 0.89 (see Table 1). Table 1 Scales, Descriptions, and Sample Test Items Scale Description Sample item Intrinsic motivation Extent to which students learn science for its own sake. I enjoy learning the science. Extrinsic motivation Extent to which students learn science to meet ends. I like to do better than the other students on the science tests. Personal relevance Extent to which students learn science for its relevance to their goals. The science I learn relates to my personal goals. Self-efficacy Extent to which students are confident that they can achieve well in science. I am confident, I will do well on the science tests. Self-determination Extent to which students believe they have some control over learning science. If I am having trouble learning the science, I try to figure out why. Assessment anxiety Extent to which students feel tensed over their grading in science. I am nervous about how I will do on the science tests. In the main study, the 24-item SMQ was administered to the participants, before they sat for the mock examination in August-September of that year. The Cronbach’s coefficient alpha was 0.92 which is similar to 0.93 obtained by Glynn et al. (2009). The alpha values obtained for the different scales ranged from 0.58 to 0.81 when the individual student was used as the unit of analysis. The 24-item SMQ was, therefore, found to be valid and reliable, and suitable for use in Year 11 combined science classes in Brunei.

In this study, the level of students’ motivation in each scale was calculated by summing the scores of all the four items in each scale. Since there are four items in each scale, the minimum score is 4 and the maximum score is 20. In interpreting the data, students who score from 4 to 9.3 are classified as having a low level of motivation, those who score from 9.4 to 14.7 are classified as having a moderate level of motivation and those who score from 14.8 to 20 are classified as having a high level of motivation for that particular orientation. Students’ Achievement in Combined Science Students’ achievement in combined science was determined by the marks obtained in the mock examination in August/September 2011.

The marks obtained range from 10% to 84% with a mean of 40%. As many as 72% of the students failed the examination and obtained less than 50%. In terms of gender, girls’ mean score was 40.89% (SD (standard deviations) = 16.35) and boys’ score was 38.36% (SD = 16.91). There was, however, no significant gender difference in achievement between the two groups (t-value = -1.33, p = 0.183).

The analyses of data were carried out using SPSS (Statistical Package for the Social Sciences) for Windows version 11.0. Both descriptive and inferential statistics were used to analyze the data collected. The descriptive statistics used were means, whereas, the inferential statistics used were t-tests for independent samples and Person product moment correlation. All research questions were answered at 0.05 level of confidence using a two-tailed test.

Results show high ability students have high levels of motivational orientations in all the six scales except for personal relevance which is at the moderate level. Low ability students, on the other hand, have moderate levels in all the six scales except assessment anxiety which is at the high level. Significant differences were found between these two groups of students in all the six motivational orientations. It seems that high ability students were more motivated intrinsically and extrinsically to learn combined science and were more willing to learn combined science for its own sake than low ability students. High ability students also seem to have more control and responsibility over their own learning and a strong belief of having the confidence to do well.

In terms of assessment anxiety, the means indicate that both high ability and low ability students were very anxious about their performance in combined science. The ES for the scales ranged from 0.30 to 0.91 which indicate that these differences are of educational importance which teachers should take notice of when they teach combined science. Correlations Between Motivational Orientations and Science Achievement Partial correlation coefficients were calculated to find out the relationships between motivational orientations and achievement in combined science. Results in Table 5 show positive and significant correlations between all the six motivational orientations with achievement and the values obtained ranged from 0.14 (assessment anxiety) to 0.37 (self-efficacy). These are below 0.50 which are considered low (Oosterhof, 1999). The positive and significant relationships, to a certain extent, can be considered meaningful and taken as evidence for possible causal relationships between these variables. This information is useful to teachers in fostering their students’ motivation in order to impact better teaching and learning of combined science.

The present study also reveals that students have a high level of assessment anxiety and extrinsic motivation and a moderate level of intrinsic motivation, personal relevance, self-determination, and self-efficacy. The reason for students’ high level of assessment anxiety is because they were anxious and nervous at the thought of not being able to get good grades in science tests. Anxiety of this magnitude has been reported to negatively affect students’ achievement (Cassady & Johnson, 2002), because it undermines their confidence to cope with their tasks (Cowden, 2009). One way teachers can help alleviate students’ assessment anxiety is by providing them with relevant materials for revision and teaching them the right techniques of tackling science examination questions.

The high level of extrinsic motivation displayed by the students indicates that earning a good grade is important in helping them to get a good job in their career. This observation suggests that it is not the relevance of combined science to their careers per se that is important to them but getting a good grade will increase their chance of meeting the entry requirements to advance to Year 12 or pre-university education, hence, the possibility of better job prospects in the future. Similarly, non-science majors were observed to have the same preoccupation (Glynn et al., 2009) who desired good grades for the purpose of getting a scholarship to enter a graduate school.

There are several strategies to enhance achievement among students who are extrinsically oriented. Davis (1993) suggested teachers should give frequent, positive feedback and praises to support students' beliefs that they can do well. Another strategy is to assign tasks that are slightly above the students' current ability level. As Adams (1998) observed, when the tasks are too difficult and students see them as unattainable, they become anxious and lose interest. When students are able to perform tasks successfully and get good grades, they will be motivated and willing to put more effort into their work (Bainbridge, 2011). There is also the need to raise students' intrinsic motivation, personal relevance, self-determination, and self-efficacy to enhance better learning outcomes in combined science. Perhaps, the most important of all, teachers should teach combined science in such a way that it is interesting and enjoyable for students.

This is a powerful pedagogical tool that enhances students' self-efficacy (Raelin, Reisberg, Whitman, & Hamann, 2007), motivation (D. W. Johnson & R. T. Johnson, 1999), and achievement (Kose, Sahin, Ergun, & Gezer, 2010). Teachers should explore and use this strategy to make students more determined and efficacious to learn combined science instead of using the teacher-centered expository approach that is so prevalent among science teachers. Teachers should also attempt to link science concepts to students' experiences, so that they can realize the relevance of what they learn to their everyday lives, thus making learning more meaningful and relevant.

In terms of gender, a significant difference was found between boys and girls in assessment anxiety while other motivational orientations were comparable between the two groups. Girls were more anxious than boys on assessment and this finding concurred with those studies carried out elsewhere (Ergene, 2011; Glynn et al., 2009; Jegede, 2007; McCarthy & Widanski, 2009). In this study, both boys and girls performed equally poorly in the mock examination and it seems that this affects girls more than the boys. Another important finding discerned from this study is that students' motivational orientations seem to vary with ability. High ability students unlike their low ability counterparts exhibited significantly higher level of motivation in all the six dimensions. The findings are significant as they provide insight into the importance of each dimension in impacting students' motivation to learn combined science. Teachers should pay attention to these motivational orientations as they are found to have positive relationships with achievement. When teachers are able to foster and increase students' motivation to learn combined science, it is likely that many more students will be able to successfully complete their secondary education and advance to higher education. They will form a significant proportion of the future workforce who will help propel the country forward to becoming a fully developed nation by 2035.

The present study is the first of its kind being conducted in Brunei, hence, more research studies need to be conducted in order to gain a better understanding of the relationships between the motivational orientations and students' achievement in combined science. It is recommended that a larger sample of students from all the four districts in Brunei should be used to generate more credible results that will provide a clearer picture of the relationships between students' motivation and achievement in combined science. The use of triangulation approach, for example, interviews, may yield further information on students' motivation to learn combined science. Interviewees should be carefully selected using stratified random sampling to represent a wide range of students' ability so that their motivation could be carefully scrutinized. It is also recommended that a longitudinal study should be conducted to measure students' motivational orientations over time. The scope of the study should also be widened to include other subject areas, such as mathematics, biology, chemistry, physics, and English language.

Another direction for future research is to compare art stream students with science stream students' motivation to learn science. Future studies should also consider other assessments as a measure of students' achievements. Besides, mock examinations marks, public examination grades, and school-based assessment should be included to present a more accurate record of students' ability and achievement. Researchers should also consider employing structural equation modelling to determine the relationships between students' motivational orientations and their performance in combined science. This would provide vital information on the variance of the different motivational orientations on students' achievement which may be influenced by factors, such as grade level, gender, ethnicity, and subject area.

The present study provides teachers and educators valuable information on students' motivation to learn combined science. Understanding of how each of the motivational dimensions influences learning will place teachers and educators in a better position to help and support this group of students who have long been struggling with combined science.

CHAPTER-IV

4.1 Motivation of Engineering Students in Higher Education

This paper examines motivational factors affecting higher education (HE) students in the Faculty of Technology at the University of Portsmouth. A reliable identification of motivational factors would usefully inform pedagogical interventions. Students who are more intrinsically motivated may benefit from less prescriptive assignments which offer more freedom to choose from "formative" assessment topics in which they have a greater personal interest. Those who are more extrinsically motivated, where the final "summative" grade is thought of as the most important, may be less influenced by pedagogical styles. The investigatory approaches employed in this study to assess motivation discover different results. While questionnaire responses indicate that students operate both intrinsically and extrinsically, semi-structured interviews found little evidence of the former, with most students indicating that they operate extrinsically.

The purpose of this study is to investigate factors which influence how students studying technology subjects are motivated and the extent, if any, to which motivation can be nurtured. If motivational influences change then pedagogical interventions may be adjusted to enhance learning experiences, thereby improving student satisfaction and reducing rates of attrition. A longer term goal of this study is to continue an examination of how to promote greater "efficiency" in educating technology students. With increased funding pressures on HE institutions, attention must be directed towards how our students learn.

Turner J.C. and PatrickH. (2004) Motivational influences on students' participation in classroom learning activities. Teachers College Record, 106 (9), 1759–1785.) have highlighted the importance of increasing a student's intrinsic motivation as they study at university. Intrinsically motivated students develop a "deep" approach to learning; emphasising intellectual rigour over a "surface" approach (Rowe, 2001RoweJ.W.K. (2001)

Approaches to study by first year engineering students. Progress 1 It is argued that the greatest influences on intrinsic motivation are the way that the teacher frames the work and the assessments that the student must complete (Vansteenkiste et al., 2004Vansteenkiste M., SimonsJ., LensW., SheldonK.M. and DeciE.L. (2004) Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts.

The importance of student motivation is highlighted elsewhere, significantly in a Treasury report (2003)HM Treasury.

Investigation Rationale

"Motivation" as an influence on the student body has thus far never been assessed within the University of Portsmouth. Data from this study may be useful in developing a strategy to support students by helping to manage expectations and to ensure that the transition from school or college to university is facilitated.

Motivation as a Concept

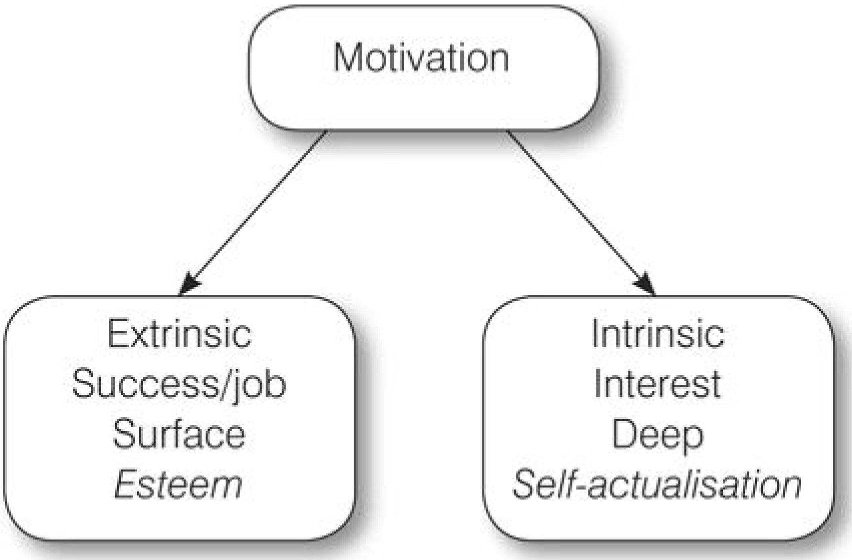
Motivation is variably conceptualised by different theorists and its definition is contested. Means of measurement include quantifying time spent on a task, assessment of personality traits and capture of various cognitive-based processes.

In this analysis, higher education may serve to address a student's self-actualisation needs as they seek to acquire purposeful knowledge within their subject area. Higher education may also fulfil the student's need for a reciprocally higher level of esteem as they progress and do well.

"Self-determination theory" addresses the underpinning of this desire by positing that people wish to develop themselves and to master challenges that confront them. It identifies two causes of desire to study: the need for recognition, praise and/or reward (extrinsic motivation) and the need to fulfil an interest (intrinsic motivation).

On qualitative differences in learning - 1: outcome and process. British Journal of Educational Psychology, 46 (1), 4–11.[Crossref], [Google Scholar]. Intrinsically motivated students can be thought of as taking on a "deep learning" style; that is they try to understand the reasoning behind the academic work that they are doing and experience their development as self actualisation. Extrinsically motivated students are referred to as "surface" learners, identifying only those features that they think they will be tested on in order to fulfil their esteem needs. This proposed framework of motivation is shown in Figure 1.

Figure 1. A Framework of Motivation



Other studies of the way that motivation is nurtured have found a positive correlation between actively developing a motivating environment and student performance. Motivational influences on students' participation in classroom learning activities. The synergistic effects of intrinsic goal contents and autonomy-supportive contexts. Journal of Personality and Social Psychology, 87 (2), 246–260.). A technology faculty may therefore wish to consider how to increase student motivation by adjusting pedagogical interventions and enhancing student learning experiences.

Measuring Motivation

Measurement of student motivation has often been conducted in primary and secondary school environments. The measurement of motivation has been conducted either through an assessment of the amount of time that students freely spent on an activity.

This is attempted by Waugh (2001) in his study of the motivation of 239 first year university students. He employs a 12 aspect model of motivation, assessing the students on each aspect: standards, goals, tasks, effort, values, ability, interest, learning from others, responsibility for learning, extrinsic rewards, intrinsic rewards and social rewards. Waugh uses a questionnaire with a five point Likert scale to attempt to assess the motivation of the students.

Other methods for testing motivation have been promoted by Ryan and Deci in a paper which discusses definitions of intrinsic and extrinsic motivation (Ryan and Deci, 2000DeciE. L. and RyanR. M. (2000) The "what" and "why" of goal pursuits: human needs and the self-determination of behaviour. They suggest a test for intrinsic motivation which involves letting students start a task and leaving them to see if they complete it unsupervised. Whilst this investigative method may assess levels of intrinsic motivation, it is less plausible as a measure of extrinsic motivation since the nature of the task will greatly affect a student's need or desire to do it and the preamble could greatly affect the outcomes of the investigation.

Measuring Motivation in Engineering

Although most of the work on motivation has been conducted in secondary schools or social science faculties, there has been some study within engineering disciplines. Much of this work has focused on student attrition and mainly attempts to identify ways to prevent high drop-out rates. A widely referenced study concerns students who prematurely quit Imperial College engineering degrees.

The students found the mathematics challenge too great, engineering dull and they did not feel adequately prepared for university learning styles. Baillie and Fitzgerald comment that the students had been inappropriately motivated (by the attraction of living in London and Imperial's reputation) rather than by the desire to study engineering. Also of interest to this investigation is a study conducted at Sheffield Hallam University.

Rowe looked at the learning techniques used by first year students and suggested that those with a "reproducing" learning style succeeded more reliably.

4.2 Pedagogical Interventions to Enhance Motivation

Other investigations suggest that the context within which work is presented, as well as the learning environment, has an effect on a student's learning and performance. Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts.

Learning material was set in either an extrinsic or intrinsic context, the latter resulting in improved student performance. However, Elton (1988) commented that as long as university students are presented with assessment-based goals they will focus on achieving those goals. Only when a goal has been achieved do they begin to become intrinsically motivated.

An attempt was made by Breen to assess the effect of the atmosphere of the department on student motivation (Breen and Lindsay, 1999). The study was qualitative rather than quantitative and involved interviewing two students from each of four disciplines to elicit accounts of experiences and perceptions of the influence of the learning environment on them. They sought to explore students' feelings about these episodes, discover what behaviours resulted and encourage students to identify those attributes contributing to their response to the situation. Not only social, but disciplinary and institutional cultures affect the learner.

Context and practice

If the learning culture of a university department is designed to ensure that students' self determination is increased (i.e. that all students develop a constructivist approach to knowledge of their subject area) it follows that students should be rewarded for adopting a constructivist approach, rather than for their ability to learn by rote and/or the effectiveness of their exam technique.

That conflicts sometimes arise in applying this approach is exemplified by a recent group discussion with a cohort of six direct entry third year students. The discussion was held in a laboratory and aimed to find out what difficulties the students had in their transition from a Ministry of Defence training establishment to university. During the discussion the students were free to make comments. Some commented, with all agreeing, that they were looking forward to coming to university because all their learning to date had employed a surface approach ("learning for exams"). They expected that HE would demand that they adopt a deep learning style. However, they reported that the quantum of content to be completed forced them to revert to a surface approach or risk falling behind the rest of the class. In this instance, the learning environment thwarted, rather than supported, students' proclivity for active engagement and growth.

Findings:

A total of 422 students completed the whole questionnaire. There were five partial submissions where no more than two questions were left incomplete. Of the 24 students invited to attend the interviews, 11 attended.

Questionnaire results:

All results were tabulated and coded, with 1 as "strongly agree", 2 as "agree", 3 as "neither agree nor disagree", 4 as "disagree" and 5 as "strongly disagree".

Questions of significance

Many questions were either rated as "strongly agree" or "agree". A mean of all student responses to each question was calculated and the highest scoring and lowest scoring questions were identified.

Students demonstrated a strong agreement that it was important to do well on the programme they are studying; that is to say that they value (tending towards "strong agreement") achievement in academic work. However, a previous study reported that students' interest in their subject area decreased in proportion to increased length of time at university. This finding is also supported here: the mean scored response to the question *'I do what I do because it interests me'* decreases in line with the year of study, from 1.7 in the first year to 2.03 in the third year. If students' interest in the subject declines as they spend more time at university it may indicate that their intrinsic motivation is often not being maintained or developed.

Whilst students understand that they are responsible for their own learning, they frequently value having a facilitator to guide them and give them advice. The extent to which this is the case may represent an individual's position on the continuum which runs from "being taught" to "constructing one's own understanding".

Of interest is that the question *'I have positive feedback from my lecturers on my ability in academic work'* features as a low scoring response. Nor did students typically show great inclination to read outside of their course area. This may be indicative of a lack of time or a lack of understanding of what other academic areas can contribute to wider study.

Interview findings

Motivating lecturers

Lecturer characteristics and the techniques that they employ will both be reported here. For example, it is interesting to note that all 11 interviewees, unprompted by the interviewer, referred to the use of PowerPoint and reading from PowerPoint slides as 'not very motivating', although the use of PowerPoint was not universally seen as a bad thing. It was suggested by two students that it should be used to prefigure what the class would do, as long as the presentation did not go on for too long (no more than 20-30 minutes).

All of the students except one were of the opinion that practical work was one of the best ways to learn and that lecturers should always give practical examples - preferably giving an indication of when they have used this particular technique in the past (i.e. putting the theory into the context of the real world or discussing how the students may use it in their future work).

All students commented that non-motivating lecturers are characterised as lacking engagement with the students. The personal characteristics of a good and motivating lecturer frequently include enthusiasm and commitment:

For the motivating one, commitment is definitely the key. Because when you feel that they are interested and committed it makes you want to be interested and the more committed they are the more they can get out of you because they can help you more.

It seems that many students directly derive their motivation from the lecturer's engagement and self-presentation and emphasise the importance of being treated correctly: *'treated like you are an adult who is there to do the work.'* One commented that *'He doesn't make you feel overwhelmed which other ones do, he doesn't make you feel inferior to him.'* This reflects the view that some students could have of lecturers being their intellectual superiors. Two students commented on lecturers going beyond expectation:

Whenever you need help he is always there - you can knock on his door whenever you want he is always there and you can send him emails and he will answer you even at the weekend. Whenever you want help he is always willing to help you.

Eight students commented on the difference between college and university, with particular respect to the apparent freedom that students are given. One commented that *'university is more on the students for what they are doing so in that aspect college was better because they said what you needed to do'*. This perhaps indicates a need for more effective transition management.

Motivating academic tasks

All except one student commented on the need for academic tasks to be "practical" and relevant to the real world:

I think I get motivated by something more if I think that it is going to be meaningful and used in real life rather than something that is just there and you are just going to learn it for the sake of it and you are never going to use it in real life.

Five of the students also commented on the requirement for a clear idea of what they need to do to achieve. This is not always obvious, as many units at university do not employ criteria referencing (where the student is assessed against a clearly defined and articulated benchmark). One commented that a lecturer would only give over 70% if the student thought of something that the lecturer did not expect, a daunting task if the lecturer is viewed as "intellectually superior". In such cases students cannot have their need for esteem met and they may be unable to progress further to self-actualisation if they are not helped to construct their own models of understanding.

All students commented on the need to get good grades, indicating that, in this instance, they are dominantly extrinsically motivated:

I think it is in every student's blood that they want to know how the mark is made up and what they should be getting into. I think it is bad because you are not thinking about doing the work because you want to; you are doing the work because you want to pass.

4.3. Discussion

If educators in the Faculty of Technology agree in wanting their students to take a constructivist approach to learning, there is clearly some disparity between the goals of educators and those of students evident from these findings. Interview data indicate that students are extrinsically motivated. Should the goal of educators therefore be to encourage success in summative assessments in order to fulfil the student's need for self-esteem? At the same time, the questionnaire responses indicate that students are also motivated by a desire to learn and for self-actualisation. Such evidence questions the extent to which we should seek to develop intrinsic motivation in undergraduate study.

A liberal, enlightened view of why students come to university will facilitate fulfilment of their self-actualising needs. However, with mass expansion of HE and its embracing of market forces, students today may feel that they must focus on meeting their needs for tangible, material achievement, worldly success and esteem.

The semi-structured interviews all highlighted the importance of the role of lecturers in motivating students. It is also apparent that radically innovative pedagogies seeking deep learning from students require patient, incremental implementation - undergraduate students may not immediately be confident in realising their own learning goals and acting as deep learners. Those interviewed demonstrated a greater proclivity towards extrinsic motivation, where surface learning brings about reward. Moving students away from surface learning and towards deep learning may require careful and thoughtful teaching design and full engagement of teacher and students.

The most important pedagogical question arising from this study concerns the advisability of structuring teaching to assist students to develop as "deep" learners. A significant body of educational thought indicates that this should be the case.

Another principal finding has been the potential of the lecturer to inspire and motivate students and influence their perception of education. This is evidenced by all interviewees bringing lecturer attributes up in response to almost every question asked (whether about the lecturers themselves, academic tasks, academic assessments or teaching techniques). This suggests that any improvement in practice must be predicated upon all lecturers constantly reflecting on how they engage, motivate and inspire students. Their performance in the classroom is at the centre of this engagement.

An interesting feature to emerge from this work is the possibility of tension between teacher expectation and student experience. This arises through issues such as the form and purpose of feedback and desired outcomes for undergraduate study within the market place for higher education. In turn they have implications on factors like contact time and class sizes and, crucially, the distinction between formative and summative models of assessment. Finally, there are important questions to address concerning the transitional arrangements needed to facilitate students' entry into the university sector.

This study anticipates another: what might be done to promote active learning whilst ensuring that necessary academic standards are maintained? The challenge is to stimulate our students' intrinsic motivation by providing them with opportunities for independent, self-developmental learning. This ambition must, of course, respect a context where undergraduate studies are recognised as appropriate within the public domain: that is a degree, organised as units or modules, in which the student has to satisfy objective-assessed standards.

Appendix A:

The questionnaire was presented where the student had to respond based on a 5 point Likert scale between strongly agree and strongly disagree.

1. I try my best to reach the academic standards that I set.
2. It is important to me to do well at this degree.
3. I try different strategies to achieve my academic goals when I have difficulties.
4. I set myself realistic but challenging academic goals.
5. When I have difficulties in reaching my goals, I make a renewed effort to ensure I achieve my goals.
6. I write and re-write my academic assignments in order to achieve.
7. When I have conflicts about the time I spend on achieving I re-think my priorities.
8. I value achievement in academic work.
9. I have positive feedback from my lecturers on my ability in academic work.
10. I feel able to meet the challenge of performing well in this course.
11. I read widely on a number of academic topics outside of my degree area.
12. I always feel like I choose the things I do.
13. I do what I do because it interests me.
14. I enjoy doing this course very much.
15. I participate in class discussions to improve my understanding in academic matters.
16. I try to pay attention to my teachers in order to learn as much as I can.
17. I take personal responsibility for my academic learning.
18. I plan to seek out information when necessary and take steps to master it.
19. I try to achieve academically because I like the rewards it brings to me.
20. I try to achieve academically because I like the challenges it brings.
21. After finishing each module, I felt pretty competent.
22. I like the social relationships involved in academic work.

Appendix B

Examples of questions asked of the students during the interview.

- Can you think about a lecturer that you felt was motivating and one you felt wasn't motivating and tell me the characteristics of each of them?
- Can you think about an academic assessment that you felt was motivating and one you felt wasn't motivating and tell me the characteristics of each of them?
- Can you think about an academic task that you felt was motivating and one you felt wasn't motivating and tell me the characteristics of each of them?
- Can you think about a teaching technique that you felt was motivating and one you felt wasn't motivating and tell me the characteristics of each of them?
- Can you give an example of when you had finished a unit and you felt confident using the material from that unit? Why did you feel confident

CHAPTER-V

5.1. An Evaluation of the Pattern between Students' Motivation, Learning Strategies and Their Epistemological Beliefs: The Mediator Role of Motivation.

This study aims at analysing the relations between students' achievement motivation, learning strategies and their epistemological beliefs in learning through structural equation modelling, and at exploring the mediation role of motivation in the relations between learning strategies and epistemological beliefs. The study group was composed of 446 undergraduate students attending the Faculty of Education. The Motivated Strategies for Learning Questionnaire (MSLQ) in addition to the Epistemological Belief Scale was employed as the instrument of data collection in the research. The data obtained were then analysed via confirmatory factor analysis and the path analysis. In consequence, it was found that the model consisting of such variables as learning strategies, motivation and the belief that learning depends on effort yielded the acceptable fit indices, and it was also found that motivation variable mediated between the relations holding between the belief that learning depends on effort and the learning strategies.

An effective process of learning is a process, which is accountable with the traits of the learner, the quality of the teaching process, the learning environment and the design of teaching. As is commonly known, teaching design and the learning environment are constructed by taking the properties of the learner into consideration. Psycho-educational structures are frequently considered in educational research as the properties intrinsic to the learner. However, on considering the inter-relations existing within those psycho-educational structures, a nomological network is established (Cronbach & Meehl, 1955). While the psycho educational structures consist of high-level mutual relations, the mediator variables sometimes play important roles in this pattern. Determining those mediator variables gives significant clues in constructing the learning process and the design of teaching. Motivation, epistemological belief and learning strategies-which are among the important properties of the learner-, are within the scope of this current research.

Besides, these are also the variables, which play important roles in learner-centred approaches. Students with high levels of epistemological belief concept will be more successful in using the learning strategies capable of influencing the learning process and in motivating themselves into learning. In addition to the direct effects of epistemological beliefs on learning strategies, these epistemological beliefs will also result in the positive development of learning strategies which are indeed the behaviours and thoughts arising in learning and facilitating learning with the increase of motivation due to students' sophisticated epistemological beliefs. In this case, describing the variable that motivation mediates in addition to describing the main effects of motivation on achievement is also important.

This study examines the ties between students' epistemological belief, their motivation and their learning strategies; and additionally, it also investigates whether or not the effects of motivation on learning strategies are mediator or not. Epistemological Beliefs Epistemological beliefs, which are personal traits, are the beliefs that individuals have in relation to the nature of knowledge and to acquiring the knowledge (Schommer, 1990; 1994). According to Hofer (2001), epistemological beliefs involve beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs. Epistemological beliefs, which might be considered to be altogether, also form a five-dimensional system of beliefs containing such dimensions as the source of knowledge, organisation or structure of knowledge, stability of knowledge, speed of learning and control of learning; which might be considered independent of one another (Shommer, 1990). Schommer suggests that epistemological beliefs held by individuals may be at differing levels. If individuals' belief trends are sophisticated, the individuals believe that knowledge is not certain and or absolute, that a great part of it is in development, that a part of it has not yet been explored, and that only a small part of it is stable.

Those individuals are knowledgeable and experienced, and they adopt a critical approach towards what they read. Yet those with naive epistemological beliefs are simple and inexperienced, and they believe that a great part of knowledge is certain and stable, that some knowledge will be newly explored, and that only a small portion of knowledge will change. They do not display a critical approach towards what they read, and they are likely to be influenced by what they read (Aypay, 2011a; 2011b; Deryakulu, 2002; Schommer, 1990; 1994). Science Education International 314 Individuals with sophisticated epistemological beliefs are often more successful in their academic life, they employ learning and study strategies more effectively, and are more successful in controlling the extent to which they have comprehended the new knowledge (Schommer, 1990).

According to a number of researchers, epistemological beliefs have impacts on such variables as individuals' ways of processing and interpreting the new knowledge, their levels of comprehension, the criteria to control their levels of comprehension, their choice of study strategies, their higher order thinking forms and problem-solving approaches, and efforts they make and time they spend for learning (Brownlee, Purdie, & Boulton-Lewis, 2001; Hofer & Pintrich, 1997; Tolhurst, 2007). Epistemological beliefs were found to be related to achievement motivation (Brâten& Olaussen, 2005; Brâten& Stromso, 2004; Buehl & Alexander, 2005; Chen & Pajares, 2010; DeBacker & Crowson, 2006; Muis, 2004; Muis & Franco, 2009) and to motivation and learning (Buehl & Alexander, 2005; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Hofer & Pintrich, 1997; Paulsen & Feldman, 1999).

Motivation On examining research studies conducted in relation to motivation, it was found that the concept of motivation was defined in different ways. Keller (1983) defines motivation as the direction of effort making a student willing to learn and as an intrinsic power while Schunk (1990) defines it as inclining towards a process of behaviour oriented to a certain goal and sustaining it; Kelecioğlu (1992) as the process enabling any activity to start and being influential in the direction, intensity and continuation of it; Dilts (1998) as a general power directing individuals or organisms to trigger them, as a stimulant or an influence; and Lindner (1998) as the power impelling individuals to attain individual or organisational objectives.

Related research in literature has revealed that there is a connection between students' motivation and their epistemological beliefs (Buehl & Alexander, 2005; Hofer, 1994, quoted by, Paulsen & Feldman, 1999; Paulsen & Feldman, 1999; Schutz, Pintrich, & Young, 1993, quoted by Paulsen & Feldman, 1999. Bandura (1997) and Dweck and Leggett (1988) point out that the beliefs held by individuals are the factors affecting their thoughts, motivation and behaviours (quoted by Buehl & Alexander, 2005). Buehl and Alexander (2005), on the other hand, found that students with sophisticated epistemological beliefs had higher levels of motivation. In a research study, Buehl (2003) developed a model showing that students' epistemological beliefs had direct effects on their achievement, motivation and cognitive processes (that is to say, their use of strategies).

On examining the results, it was found that epistemological beliefs affected students' motivation, their cognitive processes and learning strategies, and that their epistemological beliefs also indirectly influenced their achievement and their academic performance. It was pointed out by the researcher that, according to the findings, further research was needed in order to explore the relations between epistemological beliefs and motivation. Learning Strategies Learning strategies are the behaviours and thoughts expected of learners during learning and influential in their process of encoding, and facilitating their learning. They are the cognitive plans designed so as to fulfil a duty (Weinstein & Mayer, 1986). They range from such simple analysis abilities as stating the main idea and underlining it to more complicated processes of thought such as using analogies to enable someone to set up associations between prior knowledge and new knowledge (Gözütok, 1990). According to Wittrock (1986), learning strategies are students' behaviours and thoughts arising in learning and affecting motivation, encoding of knowledge and permanence and transfer of it. Mayer (1988) suggests that learning strategies are the various thoughts and behaviours which are to be influential in individuals' processing the new knowledge to be acquired in their mind (quoted by Deryakulu, 2004).

Learning strategies could be defined as learners' displaying the efforts needed for their putting the new knowledge presented to them into mental processes and making sense of it, and thus constructing it in the learning-teaching process or in their individual activities (Tay, 2004, 2005). Such factors as the nature of the task, the orientation made by the teacher or the teaching materials, students' prior knowledge, their knowledge of learning strategies, their aims, their attitudes towards and beliefs in learning, the type and level of motivation are the factors influential in students' determining which learning strategy to use, in their using the selected strategy effectively and in their evaluating the results of strategy use (Deryakulu, 2004). In research conducted by Pintrich and De Groot (1990) the relations between students' academic achievement, their motivation and learning strategies were investigated.

Consequently, it was found that there was a positive relation between self-efficacy and intrinsic goal orientation, which were the sub-dimensions of motivation, and learners' cognitive behaviours and their performance; and it was also found that self regulation, self-efficacy and test anxiety- the sub-dimensions of motivation- were the variables best predictive of academic performance. In their research, Zusho, Pintrich and Coppola (2003) investigated whether or not learners' motivation, their cognitive and meta cognitive Science Education International 316 learning strategies were predictive of their performance in the chemistry course. On evaluating the results of the study, it was concluded that the learners with higher self-efficacy and task value levels were better at the courses than those employing other learning strategies. Another conclusion reached by the researchers was that the students using the rehearsal strategy- a strategy of learning- displayed better performances than those using other strategies. In research performed by Yumuşak, Sungur and Çakıroğlu (2007), the effects of students' motivational beliefs and their use of cognitive and metacognitive learning strategies on their achievement in biology were examined.

In consequence, it was found that extrinsic goal orientation and task value- the sub-dimensions of motivation- and rehearsal learning strategy, regulation learning strategy, time/study environmental management, and peer learning- the sub-dimensions of learning strategies were significantly correlated with students' achievement in biology. Besides, it was also found that the use of extrinsic goal orientation, rehearsal learning strategy and peer learning were in reverse correlation with students' achievement in biology. In literature, it was pointed out that learners' epistemological beliefs influenced the teaching strategies chosen (Cotterall, 1999; Deryakulu, 2002, 2004, 2006; Horwitz, 1999; Mauren, 2010; Kardash & Howell, 2000; Schommer, Crouse, & Rhodes, 1992; Schreiber & Shinn, 2003; Tsai, 1997). Epistemological beliefs affect the type and level of learners' cognitive and meta cognitive learning strategies, and they also affect students' looking at the knowledge in a critical way and their ways of thinking. Students with sophisticated epistemological beliefs are capable of employing cognitive and meta cognitive learning strategies in a more effective and efficient way (Deryakulu, 2006).

According to Richter and Schmid (2009), students with sophisticated epistemological beliefs use the simple learning strategies (such as rehearsal) less while they use deep strategies (learning approaches) more often. Köller, Baumert and Neubrand (2000) found positive correlations between high school students' simple learning strategies (rehearsal) and their beliefs in the truth and accuracy of knowledge whereas Köller (2001), Schiefe, Emgassen and Moschner (2003) found no significant correlations between high school and university students' simple learning strategies (rehearsal) and their beliefs in the truth and accuracy of knowledge.

5.2. The Purpose and Significance of the Study

Facilitating meaningful learning efficiently depends on conducting learning rather than teaching, students' acquiring the knowledge through taking active roles in learning rather than transferring the knowledge directly into the students, on the belief that each learner's individual differences are influential in learning, and on students' constructing the Science Education International new knowledge on their own. In pieces of research performed in literature such cognitive and motivational variables, as prior knowledge, attitudes, logical thinking, learning approaches, self-efficacy, goal orientation, and epistemological beliefs were studied (Buehl, 2003; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 1999; Murphy, Buehl, Monoi, & Long, 2002; Paulsen & Feldman, 1999, 2005; Schommer, 1998; Sungur & Tekkaya, 2006). Of these variables affecting students' learning, motivation, epistemological beliefs and learning strategies are within the scope of this research.

The intrinsic goal orientation, extrinsic goal orientation, task value, self-efficacy and belief in learning control sub-dimensions of the Motivated Strategies for Learning Questionnaire (MSLQ) were used in determining students' achievement motivation- as was the case in the research conducted by McKenzie and Gow (2004) and by McKenzie, Gow and Schweitzer (2004). And for the learning strategies, the factors of organisation, elaboration, metacognitive self-regulation, effort management and time/study environmental management of the MSLQ were used; because those factors account for the self-regulation definition offered by Zimmerman (1990) and reflect the deep learning approach (McKenzie & Gow, 2004; McKenzie et al., 2004). The factor of the belief that there is only one truth measures the beliefs in knowledge while the factors of the belief that learning depends on effort and the belief that learning depends on ability measure beliefs in learning. Due to the fact that this research is in search of studying students 'epistemological beliefs in learning, the factors of "the belief that learning depends on effort" and "the belief that learning depends on ability" were used in this research; and the hypothesis model in Figure 1 was developed accordingly.

Thus, the purpose of this research is to analyse the correlations between educational faculty students' epistemological beliefs in learning, their achievement motivation, and learning strategies. In addition to that, another aim of the research is to examine whether students' epistemological beliefs influence their learning strategies directly or through the motivation variable.

RESEARCH QUESTIONS

Answers were sought to the following questions in this research:

1. What is the structural equation model explaining the relations between educational faculty students' epistemological beliefs in learning, their learning strategies and achievement motivation? 2. Do the students' epistemological beliefs in learning influence their learning strategies directly or through the motivation variable?

RESEARCH METHODOLOGY

The Study Group A total of 446 educational faculty students, 308 of whom were girls and 138 of whom were boys, took part in the research. 78 of the students were in biology teaching department, whereas 66 were in physics teaching, 117 were in chemistry teaching, and 185 were in science teaching departments.

Data Collection Tools:

The Motivated Strategies for Learning Questionnaire (MSLQ) was developed by Pintrich, Smith, Garcia and McKeachie (1991) so as to evaluate university students' motivational adjustment and their use of different learning strategies for their courses at university. The questionnaire was adapted into Turkish by Büyüköztürk, Akgün, Özkahveci and Demirel (2004). It is a 7-pointed Likert type questionnaire. The MSLQ is composed of two main parts; namely motivation and learning strategies. The motivation part includes 31 items and 6 subdimensions.

The sub-dimensions are: intrinsic goal orientation (IGO) (or learning goals), extrinsic goal orientation (EGO) (or performance goals), task value (TV), control of learning beliefs (COLB), self-efficacy for learning and performance (SFLAP), and test anxiety (TA). The learning strategies part, on the other hand, is related to differing cognitive and metacognitive strategies employed by students, and consists of 31 items. Besides, in addition to the 31 items, there are also 19 items related to the management of different sources. The learning strategies part contains 9 sub-dimensions; namely: rehearsal, organization, elaboration, critical thinking, metacognitive self-regulation, time/study environmental management, effort regulation, peer learning, and help seeking (Pintrich, et al., 1991; Büyüköztürk et al., 2004). High scores received from a factor in the Motivated Strategies for Learning Questionnaire shows that the student has the property related to the factor at high levels (Pintrich, et al., 1991; Büyüköztürk et al., 2000).

This study employs the intrinsic goal orientation, extrinsic goal orientation, task value, self-efficacy for learning and control of learning beliefs sub-dimensions in order to determine students' achievement motivation (McKenzie & Gow, 2004; McKenzie et al., 2004). On the other hand, the factors of organization, elaboration, metacognitive self-regulation, effort management, and time/study environmental management were used for the learning strategies. These factors account for the definition of self-regulation offered by Zimmerman (1990), and are reflective of deep learning approach (McKenzie & Gow, 2004; McKenzie et al., 2004). Epistemological

Belief Scale was developed by Schommer (1990), and having performed the validity and reliability studies of the scale, it was adapted into Turkish by Deryakulu and Büyüköztürk (2002, 2005).

The motivation score, however, accounts for 54% of the variance in learning strategies scores. In relation to the second sub-problem of the research, the mediator role of motivation was examined in the relations between the belief that learning depends on effort and motivation and learning strategies in the alternative model that was established as different from the hypothesis model. In order to determine the mediation relation, the variable of the belief that learning depends on effort should predict the motivation and the learning strategies variables separately; and motivation should satisfy the prediction conditions for predicting the learning strategies on checking the variable of the belief that learning depends on effort. Besides, on checking the motivation variable, a reduction in the amount of the relations between the belief that learning depends on effort and the learning strategies (i.e. partial mediation effect) or the statistical insignificance of the relation (full mediation) is an indicator of the mediation effect.

5.3 Assessments

The primary audiences for this chapter are classroom teachers and teacher educators. The chapter offers a guiding framework to use when considering everyday assessments and then discusses the roles and responsibilities of teachers and students in improving assessment. Administrators also may be interested in the material presented in this chapter.

Assessment usually conjures up images of an end-of-unit test, a quarterly report card, a state-level examination on basic skills, or the letter grade for a final laboratory report. However, these familiar aspects of assessment do not capture the full extent or subtlety of how assessment operates every day in the classroom. The type of classroom assessment discussed in this chapter focuses upon the daily opportunities and interactions afforded to teachers and students for collecting information about student work and understandings, then uses that information to improve both teaching and learning. It is a natural part of classroom life that is a world away from formal examinations—both in spirit and in purpose.

During the school day, opportunities often arise for producing useful assessment information for teachers and students. In a class discussion, for example, remarks by some of the students may lead the teacher to believe that they do not understand the concept of energy conservation. The teacher decides that the class will revisit an earlier completed laboratory activity and, in the process, examine the connections between that activity and the discussion at hand. As groups of students conduct experiments, the teacher circulates around the room and questions individuals about the conclusions drawn from their data.

The students have an opportunity to reflect on and demonstrate their thinking. By trying to identify their sources of evidence, the teacher better understands where their difficulties arise and can alter their teaching accordingly and lead the students toward better understanding of the concept.

As another example, a planning session about future science projects in which the students work in small groups on different topic issues leads to a discussion about the criteria for judging the work quality. This type of assessment discussion, which occurs before an activity even starts, has a powerful influence on how the students conduct themselves throughout the activity and what they learn. During a kindergarten class discussion to plan a terrarium, the teacher recognizes that one of the students confuses rocks for living organisms and yet another seems unclear about the basic needs of plants. So the conversation is turned toward these topics to clarify these points. In this case, classroom teaching is reshaped immediately as a result of assessments made of the students' understanding.

Abundant assessment opportunities exist in each of these examples. Indeed, Hein and Price (1994) assert that anything a student does can be used for assessment purposes. This means there is no shortage of opportunities, assessment can occur at any time. One responsibility of the teacher is to use meaningful learning experiences as meaningful assessment experiences. Another is to select those occasions particularly rich in potential to teach something of importance about standards for high-quality work. To be effective as assessment that improves teaching and learning, the information generated from the activity must be used to inform the teacher and/or students in helping to decide what to do next. In such a view, assessment becomes virtually a continuous classroom focus, quite indistinguishable from teaching and curriculum.

The *Standards* convey a view of assessment and learning as two sides of the same coin and essential for all students to achieve a high level of understanding in science. To best support their students' learning, teachers are continuously engaged in ongoing assessments of the learning and teaching in their classroom. An emphasis on formative assessment—assessment that informs teaching and learning and occurs throughout an activity or unit—is incorporated into regular practice. Furthermore, teachers cultivate this integrated view of teaching, learning, and continuous assessment among their students. When formative assessment becomes an integral part of classroom practice, student achievement is enhanced (Black & Wiliam, 1998a; Crooks, 1988; Fuchs & Fuchs, 1986). However, as discussed in the previous chapter, research also indicates that this type of assessment often is not recognized as significant by teachers, principals, parents, or the general public, and is seldom articulated or featured as a priority.

Formative assessment refers to assessments that provide information to students and teachers that is used to improve teaching and learning. These are often informal and ongoing, though they need not be. Data from summative assessments can be used in a formative way.

Summative assessment refers to the cumulative assessments, usually occurring at the end of a unit or topic coverage, that intend to capture what a student has learned, or the quality of the learning, and judge performance against some standards. Although we often think of summative assessments as traditional objective tests, this need not be the case. For example, summative assessments could follow from an accumulation of evidence collected over time, as in a collection of student work.

The centrality of inquiry in the vision of science education advanced in the *Standards* provides a particularly compelling reason to take a closer look at classroom assessment, and formative assessment, in particular. If students are to do science, not solely verbalize major facts and principles, they should engage in activity that extends over several days or weeks. Their work should be less episodic and fractured than lesson-based science teaching. A different kind of assessment is necessary, one that is designed to help students get better at inquiring into the world of science (NRC, 2000). The best way to support inquiry is to obtain information about students while they are actually engaged in science investigations with a view toward helping them develop their understandings of both subject matter and procedure. The information collected by teachers and students while the students are at work can be used to guide their progress. A teacher asks questions that may help spur thinking about science concepts that are part of the investigation and may help students understand what it takes to do work that comports with high standards. At the end, the information may be collected and reviewed to form a basis for summative evaluations.

Following general template for designing and integrating formative assessment into regular classroom practice.

Where are you trying to go?
Where are you now?
How can you get there?

Having posed these questions as a guide, it is important to note that no one blueprint or single best model exists for using assessment as a tool that, first and foremost, supports and facilitates student learning. Each teacher needs to develop a system that works for him or her. By making explicit desirable features of assessment, these three critical questions provide a framework for achieving powerful classroom assessment. The questions and the obtained responses are tightly interconnected and interdependent and they are not new. Based on experience, many teachers both intuitively and purposefully consider these questions every day. Attention to them is part of good teaching.

Through the vignettes and discussion that follow, we hope to make features of formative assessment more explicit and, in doing so, highlight how intimately they are connected to teaching.

A Look Inside Two Classrooms

The seventh-grade students in Ms. K's science class are working on long-term research projects investigating their local watershed. In addition to class discussions, laboratory activities, and field trips, small groups of students are exploring various areas of particular interest and importance. One group is surveying local industrial, agricultural, and residential areas to locate general and point sources of pollutants. Another group is examining water quality. A third group is focusing on how the local ecosystem influences water quality. During project work-time, Ms. K conducts conferences with groups of students about their projects. In these small groups, the students share the details of their project; from content to process, Ms. K keeps herself informed on the working status of the different groups. Information she gathers from these conferences feeds into her decisions about allotment of work time, possible resource suggestions, and areas where she can identify additional learning opportunities. She also is able to note progress that occurs throughout the project, as well as from the last time she engaged in a similar activity with students. For example, after one of the discussions, she realized that the students in one group were not connecting algal blooms to possible sources of pollutants. She asked questions that encouraged them to explore possible causes of the burst in algal blooms, and together they devised an experiment that had the potential of providing them with some useful, additional information.

Journals kept by the students become the stimulus for regular reflections on learning and the connections between their topic to the bigger picture of the local watershed. Ms. K collects the journals weekly. The journal reflections inform her about the progress of the groups and the difficulties they are having, and so serve as a springboard for class discussion. From reading student responses and listening to discussion, Ms. K knows that some of her students are making deeper connections, and many are making different connections. Painting the broad landscape for the entire class will give those who are struggling to find a broader context for their work and sustain their inquiries, so she decides to create an opportunity to do so. When she is not in discussions with students, she mills around the areas where her students work, moving from group to group, sometimes asking questions, sometimes just listening and observing before she joins the next group. She carries a clipboard on which she jots down notes, quotes, and questions that she will want to come back to with a particular student or the entire group. At the very beginning of the project, Ms. K and her students started conversations about how their projects would be assessed. As a class, they cycle back through the criteria that were established, deepening understanding by highlighting exemplars from past projects and just talking through what constitutes quality work.

They share examples of visual display boards, written reports, and models from other projects. Ms. K wants to make sure that each student understands the standards that they are expected to meet. Students chose many of the criteria by which they wish their peers to evaluate them, and, with Ms. K's help, they developed an evaluation rubric that will be ready on presentation day—now just 2 weeks away. At that time, they will be making public reports to peers, parents, and community members.

The King School was reforming its science curriculum. After considerable research into existing curriculum materials and much discussion, the team decided to build a technology piece into some of the current science studies. The third-grade teacher on the team, Ms. R., said that she would like to work with two or three of her colleagues on the third-grade science curriculum. They selected three topics that they knew they would be teaching the following year: life cycles, sound, and water.

Ms. R. chose to introduce technology as part of the study of sound. That winter, when the end of the sound study neared, Ms. K., was ready with a new culminating activity—making musical instruments. She posed a question to the entire class: Having studied sound for almost 6 weeks, could they design and make musical instruments that would produce sounds for entertainment? Ms. R had collected a variety of materials, which she now displayed on a table, including boxes, tubes, string, wire, hooks, scrap wood, dowels, plastic, rubber, fabric and more. The students had been working in groups of four during the sound study, and Ms. R asked them to gather into those groups to think about the kinds of instruments they would like to make. Ms. R asked the students to think particularly about what they knew about sound, what kind of sound they would like their instruments to make, and what kind of instrument it would be. How would the sound be produced? What would make the sound? She suggested they might want to look at the materials she had brought in, but they could think about other materials too.

Ms. R sent the students to work in their groups. Collaborative work had been the basis of most of the science inquiry the student had done; for this phase, Ms. R felt that the students should work together to discuss and share ideas, but she suggested that each student might want to have an instrument at the end to play and to take home. As the students began to talk in their groups, Ms. R added elements to the activity. They would have only the following 2 weeks to make their instruments. Furthermore, any materials they needed beyond what was in the boxes had to be materials that were readily available and inexpensive.

Ms. R. knew that planning was a challenge for these third graders. She moved among groups, listening and adding comments. When she felt that discussions had gone as far as they could go, she asked each group to draw a picture of the instruments the children thought they would like to make, write a short piece on how they thought they would make them, and make a list of the materials that they would need. Ms. R made a list of what was needed, noted which children and which groups might profit from discussing their ideas with one another, and suggested that the children think about their task, collect materials if they could, and come to school in the next week prepared to build their instruments.

Ms. R. invited several sixth graders to join the class during science time the following week, knowing that the third-grade students might need their help in working with the materials. Some designs were simple and easy to implement, for example, one group was making a rubber-band player by stretching different widths and lengths of rubber bands around a plastic gallon milk container with the top cut off. Another group was making drums of various sizes using some thick cardboard tubes and pieces of thin rubber roofing material. For many, the designs could not be translated into reality, and much change and trial and error ensued. One group planned to build a guitar and designed a special shape for the sound box, but after the glued sides of their original box collapsed twice, the group decided to use the wooden box that someone had added to the supply table. In a few cases, the original design was abandoned, and a new design emerged as the instrument took shape.

At the end of the second week, Ms. R set aside 2 days for the students to reflect on what they had done individually and as a class. On Friday, they were once again to draw and write about their instruments. Where groups had worked together on an instrument, one report was to be prepared. On the next Monday, each group was to make a brief presentation of the instrument, what it could do, how the design came to be, and what challenges had been faced. As a final effort, the class could prepare a concert for other third grades.

In making the musical instruments, students relied on knowledge and understanding developed while studying sound, as well as the principles of design, to make an instrument that produced sound. The assessment task for the musical instruments follows. The titles emphasize some important components of the assessment process.

Science Content: The K-4 science content standard on science and technology is supported by the idea that students should be able to communicate the purpose of a design. The K-4 physical science standard is supported by the fundamental understanding of the characteristics of sound, a form of energy.

Assessment Activity: Students demonstrate the products of their design work to their peers and reflect on what the project taught them about the nature of sound and the process of design.
Assessment Type: This can be public, group, or individual, embedded in teaching.
Assessment Purpose: This activity assesses student progress toward understanding the purpose and processes of design. The information will be used to plan the next design activity. The activity also permits the teacher to gather data about understanding of sound.
Data: Observations of the student performance.
Context: Third-grade students have not completed a design project. Their task is to present the product of their work to their peers and talk about what they learned about sound and design as a result of doing the project. This is a challenging task for third-grade students, and the teacher will have to provide considerable guidance to the groups of students as they plan their presentations.
As described in the science standards, the teacher provided the following directions that served as a framework that students could use to plan their presentations:

1. Play your instrument for the class.
2. Show the class the part of the instrument that makes the sound.
3. Describe to the class the purpose (function) that the other parts of the instrument have.
4. Show the class how you can make the sound louder.
5. Show the class how you can change the pitch (how high or how low the sound is) of the sound.
6. Tell the class about how you made the instrument, including

- What kind of instrument did you want to make?
- How like the instrument you wanted to make is the one you actually made?
- Why did you change your design?
- What tools and materials did you use to make your instrument?

7. Explain why people make musical instruments.

In order to evaluate the student performance, the teacher used the following Guidelines:

Student understanding of sound will be revealed by understanding that the sound is produced in the instrument by the part of the instrument that vibrates (moves rapidly back and forth), that the pitch (how high or how low) can be changed by changing how rapidly the vibrating part moves, and the loudness can be changed by the force (how hard you pluck, tap, or blow the vibrating part) with which the vibrating part is set into motion. An average student perfor- mance would include the ability to identify the source of the vibration and ways to change either pitch or loudness in two directions (raise and lower the pitch of the instrument or make the instrument louder and softer) or change the pitch and loudness in one direction (make the pitch higher and the sound louder). An exemplary performance by a student would include not only the ability to identify the source of the vibration but also to change pitch and loudness in both directions.

Student understanding of the nature of technology will be revealed by the student's ability to reflect on why people make musical instruments —to improve the quality of life—as well as by their explanations of how they managed to make the instrument despite the constraints faced—that is, the ability to articulate why the conceptualization and design turned out to be different from the instrument actually made. (p. 49)

There is no one best assessment system for the classroom. What works for Ms. K or Ms. R in their classrooms may not work in another. What is important is that assessment is an ongoing activity, one that relies on multiple strategies and sources for collecting information that bears on the quality of student work and that then can be used to help both the students and the teacher thinks more pointedly about how the quality might be improved.

In the first vignette, Ms. K is helping her students by painting the broad landscape so that they can see how their work fits into a wider context. She also reminds them of the criteria for quality work. Thus, she is helping them to develop a clear view of what they are to achieve and where they are going. At this stage, the view is usually clearer to the teacher than to the students. One of her responsibilities is to help the students understand and share the goals, which will become progressively clearer to them as the inquiry progresses.

To chart student progress, Ms. K relies on several strategies and sources: observations, conversations, journal assignments, student work, and a final presentation. These opportunities are part of the natural flow of classroom life, indistinguishable for her and for the students from collecting data, discussing findings, planning next steps, drawing conclusions, and communicating findings about the main concepts they are expected to learn. In helping her students to reach their goal, she bases her actions on multiple pieces of evidence that she gleans from activities embedded in her teaching and curriculum. She uses this information to make decisions about work time, about support she needs to provide, and about resource suggestions.

Ms. R also uses assessment in strategic and productive ways. She frames an assessment task in a way that will engage students to learn as they prepare for the final presentation and concert. Peer-design reviews, conversations, and other assessments were built into the activity of designing and building instruments so that students could draw from these to inform their design and construction of instruments. She provides the students with prompts and elements that should be included in their presentations so that the students will be clear on what is required. She has clear guidelines about the quality and depth of responses in terms of how students will demonstrate their understandings and skills.

The usefulness of assessment does not stop at teachers collecting information in the course of their teaching and providing feedback. Like Ms. K and Ms. R, they plan and structure specific assessment events, such as individual conferences with students, occasions for the students to write about a topic, design reviews, observations of students at work, presentations of work, and initiating whole-class discussion of what they have learned so far. These are just some of the many assessment activities and methods available to teachers and students. In these same scenarios, teachers could also have integrated the use of additional written assessments—including selected response, short answer, essay, lab reports, homework problems, among others —into their teaching in ways that would generate rich assessment opportunities.

Throughout this text, we have attempted to avoid technical terms whenever possible. When we do use them, we try to offer a definition or use it in a context where its meaning makes sense. Box 3-2 provides operational definitions of several terms you will find in the assessment literature.

Alternative assessment:

Assessments those are different in form than traditional paper-and-pencil assessments.

Performance assessment:

Assessments that allow students to demonstrate their understandings and skills (to a teacher or an outsider) as they perform a certain activity. They are evaluated by a teacher or an outsider on the quality of their ability to perform specific tasks and the products they create in the process.

Portfolio assessment:

A purposeful and representative collection of student work that conveys a story of progress, achievement and/or effort. The student is involved in selecting pieces of work and includes self-reflections of what understandings the piece of work demonstrates. Thus, criteria for selection and evaluation need to be made clear prior to selection.

Embedded assessment:

Assessments that occur as part of regular teaching and curricular activities.

Authentic assessment:

Assessments that require students to perform complex tasks representative of activities actually done in out-of-school settings.

Now, consider the assessment in the two vignettes in light of the following three guiding questions:

Where are you trying to go?

Where are you now?

How can you get there?

WHERE ARE YOU TRYING TO GO?

The goals articulated in the *Standards* arise from their emphasis on the active nature of science and their stress on the range of activities that encompass what it means to do science and to understand both specific concepts and the subject area as a whole. Thus, the *Standards* advocate going beyond the coverage of basic facts to include skills and thought processes, such as the ability to ask questions, to construct and test explanations of phenomena, to communicate ideas, to work with data and use evidence to support arguments, to apply knowledge to new situations and new questions, to problem solve and make decisions, and to understand history and nature of scientific knowledge (NRC, 1996). To best assist students in their science learning, assessment should attend to these many facets of learning, including content understanding, application, processes, and reasoning.

In his book on classroom assessment for teachers, Stiggins (2001) writes,

The quality of any assessment depends first and foremost on the clarity and appropriateness of our definitions of the achievement target to be assessed...We cannot assess academic achievement effectively if we do not know and understand what that valued target is. (p. 19)

As Stiggins states, it is important that teachers have clear performance criteria in mind before they assess student work and responses. Ms. R's guidelines included attention to both: she expected her students to demonstrate an understanding of concepts of sound, such as causes of pitch, as well as the nature of technology. Before the students engaged in the assessment, Ms. R had outlined how she would evaluate the student responses in each area.

Clarity about the overall goals is only a first step. Given that goals are clear, the teacher has to help the students achieve greater clarity. This usually entails identification of somewhat discrete stages that will help the students to understand what is required to move toward the goal. These intermediate steps often emerge as the study progresses, often in lesson design and planning but also on the spot in the classroom as information about the students' levels of understanding become clearer, new special interests become apparent, or unexpected learning difficulties arise. This complex, pedagogical challenge is heightened because the goals that embody the standards and the related criteria need to be understood by all students.

One of the goals of the *Standards* is for all students to become independent lifelong learners. The standards emphasize the integral role that regular self-assessment plays in achieving this goal. The document states:

Students need the opportunity to evaluate and reflect on their own scientific understanding and ability. Before students can do this, they need to understand the goals for learning science. The ability to self-assess understanding is an essential tool for self-directed learning. (p. 88)

Sadler (1989) emphasizes the importance of student understanding of what constitutes quality work, "The indispensable condition for improvement is that the student comes to hold a concept of quality roughly equivalent to that held by the teacher..." (p. 121). Yet, conveying to students the standards and criteria for good work is one of the most difficult aspects of involving them in their own assessment. Again, teachers can use various ways to help students develop and cultivate these insights. Following the example of Ms. K's class in the first vignette, students and teachers can become engaged in a substantive, assessment conversation about what is a good presentation, such as a good lab investigation or a good reading summary while engaging students in the development process of assessment rubrics. Another starting point for these conversations could be a discussion about exemplary pieces of work, where students need to think about and share the characteristics of the piece of work that makes it "good."

In the first vignette, Ms. K facilitates frequent conversations with her class about what constitutes good work. Although these discussions occur at the beginning of the project period, she regularly and deliberately cycles back to issues of expectations and quality to increase their depth of understanding as they get more involved in their projects. In discussions of an exemplary piece of work, she encourages the students to become as specific as possible. Over time, the students begin to help refine some of the criteria by which they will be evaluated. Such a process not only helps to make the criteria more useful; it increases their ownership of the standards by which judgments will be made about their work. For her third graders, Ms. R provides guidelines for planning and presenting their instruments and introduces questions for the students to address as they engage in their work.

WHERE ARE YOU NOW?

Once they have clearly determined where they want to go, teachers and students need to find out where students currently stand in relation to the goals. Of course, the process is not quite so linear. It is not unusual for the goals to change somewhat as the students and teachers get more involved in the study.

Variety Is Essential

Ms. K's and Ms R's classrooms demonstrate the many ways assessment information can be obtained. In the first scenario, conferences with students allow Ms. K to ask questions, hear specifics of project activity, and probe student reasoning and thought processes. She can get a sense of how and where the individuals are making contributions to their group 's work and help to ensure that they share the work at hand, including development of an understanding of the underlying processes and content addressed by the activity. The information she learns as a result of these conferences will guide decisions on time allocation, pace, resources, and learning activities that she can help provide. After observations and listening to students discuss instruments, Ms. R made the judgment that her students were ready to continue with the activity. The journals prepared by Ms. K's students and the individual reflections of Ms. R's provided the teachers with an indication of their understanding of the scientific concepts they were working with, and thereby allowed them to gain new and different insights into their respective students' work. The entries also provided the teachers with a mechanism, though not the only one, to gain some insight into the individual student's thinking, understanding, and ability to apply knowledge. In Ms. K's class, the journal writing was regular enough that the teacher's comments and questions posed in response to the entries could guide the students as they revisit previous work and move on to related activities and reflections.

Through such varied activities, the teachers in the vignettes are able to see how the students make sense of the data, the context into which they place the data, as well as the opportunity to evaluate and then assist the students on the ability to articulate their understandings and opinions in a written format or by incorporating understandings into a design. As they walk around the room, listening, observing, and interacting with students, both teachers take advantage of the data they collect.

Any single assessment is not likely to be comprehensive enough to provide high-quality information in all the important areas so that a student or teacher can make use of the data. Ms. K, for example, would not use the student conferences to obtain all the information she needs about student comprehension and involvement. She gets different information from reading student journals. In the individual reflections, Ms. R can get additional data to complement or reinforce the information obtained by observing students as they engage in the activity or by talking with them.

Questioning

The occasions to sit with, converse with, question, and listen to the students gave Ms. K and Ms. R the opportunities to employ powerful questioning strategies as an assessment tool. When teachers ask salient open-ended questions and allow for an appropriate window or wait time (Rowe, 1974)—they can spur student thinking and be privy to valuable information gained from the response. Questions do not need to occur solely in whole-group discussion. The strategy can occur one-on-one as the teacher circulates around the room. Effective questioning that elicits quality responses is not easy. In addition to optimal wait-time, it requires a solid understanding of the subject matter, attentive consideration of each student's remarks, as well as skillful crafting of further leading questions. In the vignette, Ms. K needed to be aware of the existence and causes of algal blooms in order to ask questions that may lead her students down productive paths in exploring them.

Examination of Student Work

The close examination of student work also is invaluable, and teachers do it all the time. When looking at work, it is important to ask critical questions, such as “For what does this provide evidence? ” “What do they mean by this response?” “What other opportunities did the child have to demonstrate knowledge or skills?” “What future experience may help to promote further development? ” “What response am I expecting?” “What are the criteria for good work?” “What are the criteria for gauging competency?” These are just a few of the questions that can spur useful analysis. Continued and careful consideration of student work can enlighten both teacher and student.

Form to Match Purpose

Like Ms. K and Ms. R in the vignettes, teachers are not concerned with just one dimension of learning. To plan teaching and to meet their students' needs, they need to recognize if a student understands a particular concept but demonstrates difficulty in applying it in a personal investigation or if a student does not comprehend fundamental ideas underlying the concept. Specific information regarding the sources of confusions can be useful in planning activities or in initiating a conversation between students and the teacher. An array of strategies and forms of assessment to address the goals that the student and teacher have established allows students multiple opportunities to demonstrate their understandings.

This is important if we hope to support all students. Darling-Hammond (1994) comments, “if assessment is to be used to open up as many opportunities as possible to as many students as possible, it must address a wide range of talents, a variety of life experiences, and multiple ways of knowing” (p. 17).

A comprehensive understanding of science requires more than knowledge of scientific information and skills. The *Standards* articulate the breadth and depth of what it means to know and be able to do in science at different grade levels. To help ensure that assessment addresses and supports a broader view of science understanding, it can be helpful to consider the different dimensions that comprise knowledge in science. Some aspects of science knowledge are highlighted in Box 3-3.

With knowledge of the student's strengths, a teacher can help ensure that any particular assessment allows the student to demonstrate understanding and can assess whether information would be better gathered in a different format to allow for that opportunity to express thinking in different ways. For instance, Ms. K collects her assessment data from a variety of places, including discussions, conversations, conferences, observations, journals and written work, in addition to providing useful information, relying on a variety of sources and using a variety of formats so as not to privilege any one way of knowing. The conferences she sets up and the conversations that ensue give her opportunities to probe understandings and confusions and reach students that may not be as articulate when it comes to written work.

What Is “Understanding”?

Stiggins encourages teachers to devise classroom assessments of five different, but related, kinds of expectations:

1. mastery of content knowledge, where mastery includes both knowing and understanding;
2. the use of that knowledge to reason and solve problems;
3. the development of performance skills;
4. development of the ability to create products that meet certain standards of quality; and
5. the development of important dispositions.

In their work in science assessment, Shavelson and Ruiz-Primo attend to the following aspects of knowledge:

- propositional or declarative knowledge—knowledge about facts, concepts and principles;
- procedural knowledge—knowing how to do something; and
- strategic knowledge—knowing which, when, and why a specific knowledge would be applicable.

They, too, stress that different forms of assessment are better suited for different aspects of knowledge.

This complexity is important to consider when developing a rich and comprehensive assessment system. Any classroom assessment system should assess and support growth in all areas. A single type or form of assessment will not be able to capture all of the dimensions of scientific knowing and doing.

Thus the form that assessment takes is significant. The form and content of assessment should be consistent with the intended purpose. Underlying this guideline is the technical notion of validity. Technical features are discussed later in this chapter. Validity centers on whether the assessment is measuring or capturing what it is intended to measure or capture. If content understanding is the goal, it is necessary to design an appropriate assessment that would tap into that dimension of their understanding. If the ability to design an investigation is the goal, it is necessary to provide the opportunity for a student to demonstrate her ability to do such an activity. Validity is not, then, an inherent property of an individual assessment; rather, the interpretations drawn from the data and the subsequent actions that ensue are either valid or invalid. Choices for the form of the assessments are extensive and should be guided by the goals set for student learning. To find the direction for best use of the assessment data, a teacher or student gathers data in the course classroom activity by asking questions, such as "What does this information tell me?" and "How can I use it to further learning and improve teaching? " and "What other types of data should I be looking for to help me make sense of this information?"

From Stiggins' (2001) book, *Student-Involved Classroom Assessment,* Figure 3-1 offers questions to consider when designing, selecting, or implementing an assessment. After first advising teachers to set clear and appropriate targets—or learning and performance goals—and convey these targets to their students, he stresses the importance of selecting appropriate methods and of taking care to avoid invalidity and bias.

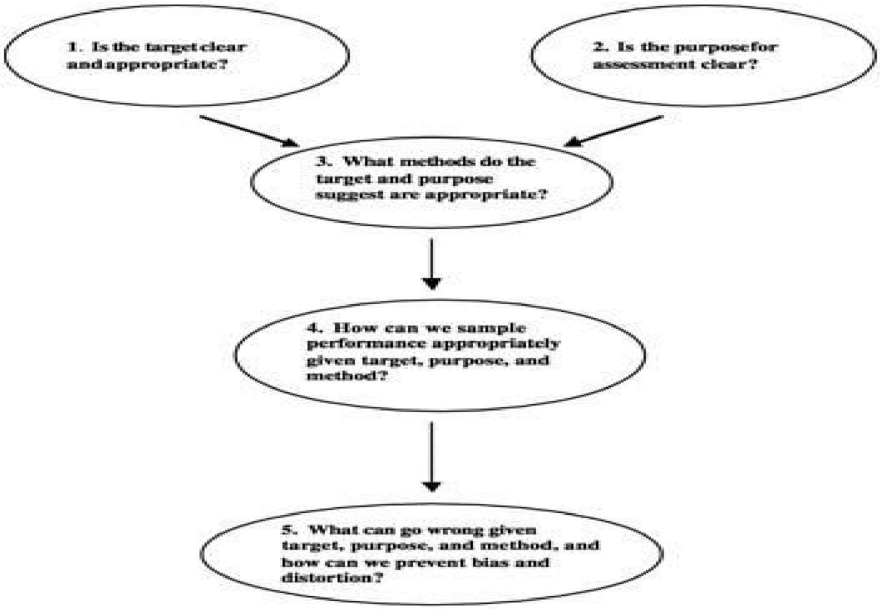


FIGURE 3-1 Considerations for designing, selecting, implementing assessment.

Subject-Matter Goals

Effective formative assessment must be informed by theories to ensure that it elicits the important goals of science, including a student 's current understanding and procedural capability. The elements of curriculum goals and methods of instruction come together, for part of the instructor's task is to frame subgoals that are effective in guiding progress towards curriculum goals. However, this can only be done in light of the teacher's beliefs about how best to help students to learn. This introduces learning theory in addition to assessment, but in formative assessment these are very closely intertwined. Thus there has to be a conceptual analysis of the subject goals, which also is complemented by analysis of the cognitive capacities of the learners. Examples of issues that might arise are the choice between concrete but limited instances of an idea and abstract but universal presentations, the decision about whether to use daily experience or second-hand evidence, the complexity of the patterns of reasoning required in any particular approach, and research evidence about common misconceptions that hinder the progress of students in understanding particular concepts. (For additional information on these theoretical underpinnings, see NRC, 1999a.)

Here again, depth in a teacher's subject-matter knowledge is essential. When teaching the concept of force in his high school class, Jim Minstrell is aware that although students use terms like "push" and "pull" to describe "force," the understandings they have for these terms and for the concept of force differs from those shared by scientists (Minstrell, 1992). Specifically, students often believe that a push or a pull—or a force—must be due to an active, or causal, agent. With this in mind, Minstrell carefully designs his instruction, including his questions and student experiences, to help them challenge their notions as they move towards a better understanding of the scientific phenomena and explanations involved with force. After spending time discussing and drawing the forces involved as an object is dropped to the floor, he plans questions and activities to help cultivate student understandings of more passive actions of forces so they understand that the conceptual notion of force applies to both active and passive actions and objects. His class discusses the forces involved with an object resting on a table, including the reasonableness of a table exerting an upward force. They go over other situations that would help them decide what is happening in terms of force, such as discussing the forces involved as the same object sits in the student's hand, hangs from a spring, and as the object is pushed off the edge of the table. Throughout the unit, the teacher listens carefully to his students' responses and explanations. Without an understanding of both student learning and the science involved, upon hearing the proper terms from his students, he may have proceeded with his unit with the impression that the students shared a scientific understanding of force (for a class transcript and analysis by the teacher, see Minstrell, 1992).

Nature and Form of Feedback

The data produced from the variety of assessments illustrated in the vignettes are not only useful for the teachers but also as essential tools in helping students to realize where they stand in relation to their goals. Thus for the students, the journals with the teacher 's comments added, serve as a repository for one form of feedback so they can maintain a continuing record of their work and progress. It is important to emphasize that assigning grades on a student' s work does not help them to grasp what it takes on their part to understand something more accurately or deeply. Comments on a student 's work that indicate specific actions to close the gap between the student's current understanding and the desired goal provide crucial help if the student takes them seriously. There is well-researched evidence that grades on student work do not help learning in the way that specific comments do. The same research shows that students generally look only at the grades and take little notice of the comments if provided (Butler, 1987). The opportunity that Ms. R's students had to design, build, and then rebuild instruments based on their trials gives them a chance to make good use of feedback to improve their piece of work.

Providing information to students is not solely a cognitive exchange. It is intertwined with issues of affect, motivation, self-esteem, self-attribution, self-concept, self-efficacy, and one's beliefs about the nature of learning. From many studies in this area (Butler, 1988; Butler & Neuman, 1995; Cameron & Pierce, 1994; Kluger & deNisi, 1996), a further generalization emerges. This is the distinction between feedback that emphasizes **learning goals** and the associated targets and feedback that focuses on **self-esteem,** often linked to the giving of grades and other reward and punishment schemes. Upon comparison of feedback in experimental studies, it is the feedback about learning goals that shows better learning gains. Feedback of the self-esteem type (trying to make the student feel better, irrespective of the quality of the work) leads less successful students to attribute their shortcomings to lack of ability. The corollary for these students is that there is little point in trying or hoping for better.

The way in which information is provided is therefore a delicate matter. Grades, and even undue praise, can reinforce expectations of failure and lead to reluctance to invest effort. Yet this culture is deeply embedded in American schools and is hard to change. This fact highlights the importance of the nature and form of the information provided to students. Thus, priority should be given to providing students with information that they can use to reach desired learning goals (Ames, 1992; Butler, 1988; Dweck, 1986).

Timing of Assessment

In helping teachers and students establish where students stand in relation to learning goals, assessment activities are not only useful during and at the end of a unit of teaching, they also can be valuable at the start of a piece of work. Suitably open and nontechnical questions or activities can stimulate students to express how much they already know and understand about a topic. This may be particularly important when the students come from a variety of backgrounds, with some having studied aspects of the topic before, either independently or with other teachers in different schools. Such assessment can both stimulate the thinking of the students and inform the teacher of the existing ideas and vocabularies from which the teaching has to start and on which it has to build.

Formative Assessment in Scientific Experimentation—An Example

The following example from the Lawrence Hall of Science assessment handbook (Barber et al., 1995) demonstrates how assessment mechanisms can enrich science investigations and provide the teacher with useful information. In this illustration, students are challenged to design and conduct two experiments to determine which of three reactants —baking soda, calcium chloride, and a phenol red solution (phenol red and water)—when mixed together produces heat. The students already have completed an activity in which they mixed all three substances. The students are expected to refer to their observations and the results of that first activity. Box 3-4 illustrates a data sheet used by the students for the assessment activity, which provides prompts to record their experimental design and observations. Through this investigation, the teacher would be able to assess students' abilities to do the following:

i) Design a controlled experiment in which only one ingredient is omitted, so there is only one difference between the preliminary reaction and the comparison reaction.

ii) Design experiments that will provide information to help determine which reactants are necessary to produce the heat in this reaction.

iii) Record their experiments, results, and conclusions using chemical notation as appropriate.

iv) Use experiment results and reasoning skills to draw conclusions about what causes heat.

- **Heat Experiments**
- **Describe your first experiment:**
- What happened?
- What can you conclude?

- **Describe your second experiment:**
- What happened?
- What can you conclude?
- **What do you think causes the heat?**

These students were able to arrive at some part of what would be a correct conclusion, though the degree to which the students used logical reasoning, or supported their conclusions with data, varied widely. Many came up with a correct solution but featured a noncontrol, inadequate experimental design. In addition, the recording of results and observations was accomplished with varying degrees of clarity. Their responses, and the language they use to describe and explain observations and phenomena, suggest varying levels of understanding of the chemical and physical changes underlying the reactions. Because the assessment was designed primarily to tap scientific investigation and experimentation skills and understandings, other assessments, including perhaps follow-up questions, would be required to make inferences about their level of conceptual under-standing in the chemical and physical processes involved with these reactions.

With close examination of the student work produced in this activity, teachers were able to gain insight into abilities, skills, and understandings on which they then could provide feedback to the student. It also provided the teacher with information for additional lessons and activities on chemical and physical reactions. Box 3-5, Box 3-6, Box 3-7, Box 3-8through Box 3-9 offer samples of this type of student work along with teacher commentary.

Creating Opportunities

Ongoing, formative assessment does not solely rely on a small-group activity structure as in the vignettes. In a whole-class discussion, teachers can create opportunities to listen carefully to student responses as they reflect on their work, an activity, or an opportunity to read aloud. In many classrooms, for example, teachers ask students to summarize the day's lesson, highlighting what sense they made of what they did. This type of format allows the teacher to hear what the students are learning from the activity and offers other students the opportunity of learning about connections that they might not have made.

In one East Palo Alto, California, classroom, the teacher asked two students at the beginning of the class to be ready to summarize their activity at the end. The class had been studying DNA and had spent the class hour constructing a DNA model with colored paper representing different nucleotide bases. In their summary, the students discussed the pairing of nucleotide bases and held up their model to show how adenine pairs with thymine and cytosine pairs with guanine. Although they could identify the parts of the model and discuss the importance of "fit," they did not connect the representative pieces to a nitrogen base, sugar, and a phosphate group. When probed, they could identify deoxyribose and the phosphate group by color, but they were not able to discuss what roles these subunits played in a DNA helix. After hearing their remarks, the teacher realized that they needed help relating the generalizations from the model to an actual strand of DNA, the phenomenon they were modeling. Regardless of the format —individual, small group, whole class, project-based, written, or discussion—teachers have the opportunity to build in meaningful assessment. These opportunities should be considered in curriculum design.

Cultivating Student Involvement in Assessment

Student participation becomes a key component of successful assessment strategies at every step: clarifying the target and purpose of assessment, discussing the assessment methods, deliberating about standards for quality work, reflecting on the work. Sharing assessment with students does not mean that teachers transfer all responsibility to the student but rather that assessment is shaped and refined from day to day just as teaching is. For student self- and peer-assessment to be incorporated into regular practice requires cultivation and integration into daily classroom discourse, but the results can be well worth the effort. Black and Wiliam (1998a) assert, "...self-assessment by the students is not an interesting option or luxury; it has to be seen as essential" (p. 55). The student is the one who must take action to "close" the gap between what they know and what is expected (Sadler, 1989). A teacher can facilitate this process by providing opportunities for participation and multiple points of entry, but students actually have to take the necessary action.

Sample 1: JAHAR

Describe your first experiment:

C.C. + Phenol Red → heat

What happened?

produced heat, turned pink

What can you conclude?

Calcium chloride and phenol red make heat

Describe your second experiment:

C.C. + H_2O → more heat!!

What happened?

Produced more heat than first experiment; water turned cloudy, calcium chloride looked dissolved

What can you conclude?

I conclude that the water and calcium chloride produce the most heat and the phenol red has nothing to do with making the heat, even though it got hot in the last experiment.

What do you think causes the heat?

I think that the water and the calcium chloride produced the heat.

Areas for Additional Practice

Using scientific notation to record experiments and results

Jahar is very systematic in his approach. He first omits the baking soda and sees what would happen with a mixture of calcium chloride and phenol red. Based on his results, he correctly concludes that calcium chloride and phenol make heat. He next explores the effect of the phenol red as he substitutes water for phenol red solution and combines it with calcium chloride. He makes the astute observation that this reaction is even hotter than the calcium chloride and phenol red solution and correctly concludes that phenol red does not create the heat. Rather, he states that water and calcium chloride produce the heat. Jonathan uses his own abbreviation for calcium chloride, C.C. rather than $CaCO_3$, within the context of an equation format to share what ingredients were combined and the results.

Sample 2: SITAL

Describe your first experiment:

P.R. + B.S. → cold

What happened?

P.R. + B.S. stayed cold. Changed hot pink.

What can you conclude?

This mixture has nothing to do with the production of heat.

Describe your second experiment:

C.C. + H_2O → hot

What happened?

The C.C. + H_2O became hot.

What can you conclude?

This mixture provided the heat.

What do you think causes the heat?

The C.C. and H_2O make heat for sure. It's possible that the P.R. when mixed with C.C. would cause heat, but we know that P.R. is not really a heat maker all by itself or without C.C. because of the first experiment we did. And P.R. is really a solution with water so that's another reason why water is probably what's needed, along with C.C. to make heat. We'd have to try mixing P.R. with C.C. to see if that gets hot. I think it would, but I still think that just means that water or a liquid like water is needed with C.C. to make heat.

Areas for Additional Practice

i) Designing controlled experiments

ii) Using scientific notation to record experiments and results

Sital first decides to omit the calcium chloride and combine phenol red and baking soda. When the reaction's results are cold, she correctly concludes that this mixture has nothing to do with the production of heat. However, she does not control variables in her next experiment, when she combines calcium chloride and water. Her decision is based on the following logical, though faulty reasoning: If phenol red and baking soda do not produce heat, perhaps the other two reactants will! Technically, she should conduct another experiment so all variables are controlled. However, she considers this in her final conclusion when she discusses the possibility that mixing phenol red and calcium chloride (which she didn't try) would result in heat. She speculates on the results of this reaction, and goes on to share reasoning for her ultimate conclusion—that water, or a liquid like water, is needed with calcium chloride to make heat. Given the limitation of the two experiments, the combination she first chose, and the fact that she is aware of the weakness of her experimental design, hers is a good handling of the results. She implies that she would explore the unanswered questions if given an opportunity to conduct a third experiment. Like Jahar, Sital uses chemical notation of some of her own abbreviations.

Sample 3: TILAK

Describe your first experiment:

red stuff, CC

What happened?

hot pink, really hot

What can you conclude?

that red and CC make heat

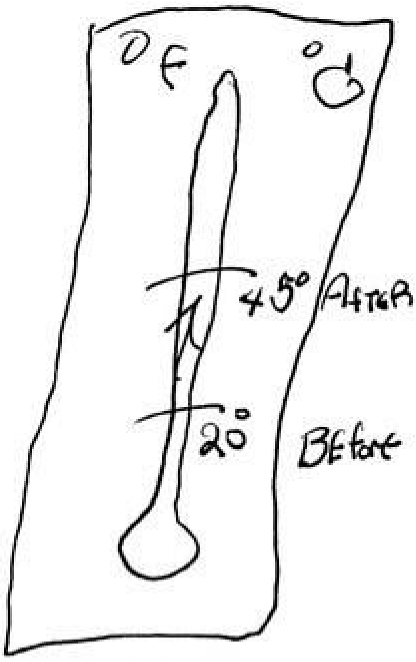
Describe your second experiment:

water, baking soda, CC

What happened?

fizzed, hot

What can you conclude?
that red stuff does nothing but change colour
What do you think causes the heat?
C.C. + water = heat



Areas for Additional Practice
i) keeping clear, detailed records of plans, results and conclusions
ii)using scientific notation to record experiments and results
Tilak's plans, observations, and conclusions are minimally described and he refers to the phenol red as "red stuff." On the other hand, his planning and reasoning show sound scientific thinking. He first omits baking soda and determines that the phenol red and calcium chloride produce heat. For his second experiment, he removes the phenol red from the original reaction and mixes baking soda, calcium chloride and water. When this mixture also gets hot, he correctly concludes that the "red stuff" only affects the colour, and therefore the calcium chloride and water produce the heat. At the end, he makes an effort at chemical notation, though he uses an equal sign (=) instead of an arrow (→).
Sample 4: MITA
Describe your first experiment:
I mixed water, calcium chloride, and baking soda.
What happened?
It fizzed and got hot. It was hottest where the calcium chloride was.
What can you conclude?
The calcium chloride makes it hot.
Describe your second experiment:
Mixing phenol red and calcium chloride
What happened?
It stayed pink but it got really hot. It didn't fizz and the bag didn't inflate.
What can you conclude?
The calcium chloride needs a liquid to conduct heat.
What do you think causes the heat?
Calcium Chloride
Areas for Additional Practice
i) designing controlled experiments
ii) drawing conclusions from experiment results
iii) using scientific notation to record experiments and results

Mita substitutes water for phenol red in her first experiment. She notices the reaction is hottest near the calcium chloride and thus concludes that the calcium chloride makes it hot. This is a good hypothesis, but not a valid conclusion at this point. A more correct conclusion, based on the experiment results, is that phenol red does not cause the heat. Next, Mita combines phenol red and calcium chloride, a change of two variables in comparison to the last experiment. This new reaction also produces heat, but Mita does not conclude that baking soda is unnecessary for the heat. Rather, she states that calcium chloride needs a liquid to conduct heat. This conclusion is not based on experimental results, and it is only partially correct because aqueous liquids mixed with calcium chloride cause the heat. In addition, Emily's final conclusion (calcium chloride causes the heat) is incorrect because it omits the addition of water or a water-based liquid. She also does not use chemical notation.

Sample 5: KISHORI

Describe your first experiment:

B.S. + C.C. + H_2O

What happened?

heat, bubbles, colour change.

What can you conclude?

Describe your second experiment:

C.C. + phenol red solution

What happened?

Turned hot, pink, boiled

What can you conclude?

Is water + C.C. or phenol + C.C.

What do you think causes the heat?

Water + C.C.

Areas for Additional Practice

i) planning experiments that address a particular question
ii) designing controlled experiments
iii) keeping clear, detailed records of plans, results, and conclusions
iv) drawing conclusions from experiment results
v) using scientific notation to record experiments and results

Kishori at first substitutes water for phenol red. Her observations of the reaction are perceptive, but she is unable to reach a conclusion. She then chooses to mix calcium chloride and phenol red solution. While technically the variables are controlled between this experiment and the original reaction—baking soda becomes the test variable—Kishori's conclusion is that water and calcium chloride, or phenol red and calcium chloride, cause the heat. These conclusions are not justified by her experiments nor is her final conclusion that water plus calcium chloride cause the heat. Her recording is minimal, though she does make an attempt to use chemical notation.

In the opening vignette, students in Ms. K's class are drawing on a range of data sources, including their own and classmates' projects, library research, and interviews with local experts. In preparation for presentations, the students are encouraged to make the connection of the small-scale study they do with plant fertilizer to the larger local system. Opportunities for revisions and regular discussions of what is good work help to clarify criteria as well as strengthen connections and analysis, thus improving learning. Class discussions around journal reflections provide important data for teachers about student learning and also allow students to hear connections others have made.

For this transition to occur, peerand self-assessment must be integrated into the student's ways of thinking. Such a shift in the concept of assessment cannot simply be imposed, any more than any new concept can be understood without the student becoming an active participant in the learning. Reflection is a learned skill. Thus, the teacher faces the task of helping the student relate the desired ability to his or her current ideas about assessing one's self and others and how it can affect learning. How do students now make judgments about their own work and that of others? How accurate are these judgments? How might they be improved? Such discussions are advanced immeasurably through the examination of actual student work—initially perhaps by the examination of the anonymous work of students who are not members of the class.

Involving students in their own and peer assessment also helps teachers share the responsibility of figuring out where each student is in relation to the goals or target and also in developing a useful plan to help students bridge the gap. In addition to helping students learn how to learn, there are pedagogical payoffs when students begin to improve their ability to peerand self-assess. Collecting and utilizing student data for every student in the classroom is made much easier with a classroom of people assisting in the same task. With a clearer vision of peer- and self-assessment and adequate time, teachers can get this help from their students and in the process help them to improve the quality of their own work.

Although there is no one way to develop peer- and self-assessment habits in students, successful methods will involve students in all aspects of the assessment process, not solely the grading after an exercise is completed. If students are expected to effectively participate in the process, they then need to be clear on the target and the criteria for good work, to assess their own efforts in the light of the criteria, and to share responsibility in taking action in the light of feedback. One method that has proved successful has been to ask students to label their work with red, yellow, or green dots. Red symbolizes the student's view that he or she lacks understanding, green that he or she has confidence, and yellow that there appear to be some difficulties and the student is not sure about the quality of the response. These icons convey the same general meaning of traffic lights and are so labelled in the class. This simple method has proved to be surprisingly useful with the colored dots serving to convey at a glance, between student and teacher and between students and their peers, who has problems, where the main problems lie, which students can help one another, and so on. The traffic-light icons can play another important role, in that they help to make explicit the “big” concepts and ideas of a unit.

With a teacher's help, much useful work in student groups can start from assessment tasks: each member of a group can comment on another's homework, or one another's tests, and then discuss and defend the basis for their decisions. Such discussions inevitably highlight the criteria for quality. The teacher can help to guide the discussions, especially during the times in which students have difficulty helping one another. Peers can discuss strengths and areas of weakness after projects and presentations. Much of the success of peer- and self assessment hinges on a classroom culture where assessment is viewed as a way to help improve work and where students accept the responsibility for learning—that of their own and of others in their community.

HOW CAN YOU GET THERE?

Much as Ms. K and Ms. R do in the snapshots of their respective classes, captured in the vignettes, teachers continually make decisions about both the teaching and the learning going on in their classrooms. They make curricular decisions and decide on experiences they think can help further students' understandings.

They decide when and how to introduce and approach a concept and determine an appropriate pace. They continually monitor levels of interest and engagement in curricular activity. They attend to the individual student, the small group, and the class as a whole. If data are collected and used to inform the teacher and student, assessment can play a significant role in all the decisions a teacher makes about what actions to take next. A focus on assessment cuts across multiple standards areas.

The teacher is able to see whether students are struggling with an activity or concept, whether they have developed fundamental understandings, whether they need to revisit a particular idea or need more practice to develop particular skills. Teachers need to understand the principles of sound assessment and apply those principles as a matter of daily routine practice.

With the knowledge gained from assessment data, a teacher can make choices. Thus, assessment serves not only as a guide to teaching methods but also to selecting and improving curriculum to better match the interests and needs of the students. According to the Assessment Standards (NRC, 1996), planning curricula is one of the primary uses of assessment data. Teachers can use assessment data to make judgments about

i)the developmental appropriateness of the science content,
ii)student interest in the content,
iii)the effectiveness of activities in producing the desired learning outcome,
iv)the effectiveness of the selected examples, and
v)the understanding and abilities students must have to benefit from the selected activities and examples. (p. 87)

Thus assessment data can be used immediately, as Ms. K does when she alters upcoming plans, and Ms. R does when she decides her students are ready to move on to the next stage of activity. The data also are useful when the teachers cover the material again the following year.

Assessment in the Teaching Standards

Teaching Standard C:

Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

- use multiple methods and systematically gather data about student understanding and ability;
- analyze assessment data to guide teaching;
- guide students in self-assessment;
- use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice; and
- use student data, observations of teaching, and interactions with colleagues to report student achievement and opportunities to learn to students, teachers, parents, policy makers, and the general public.

Assessment Should Be Consistent with Pedagogy

For the data to be useful in guiding instructional decisions, the assessment methods should be consistent with the desired pedagogy. Thus, assessment takes into consideration process as well as outcomes and products and the instruction and activities that lead to those ends. Only if assessments in science classrooms can more closely approximate the vision of science education teaching and learning can they inform the teacher's work in trying to implement the emphasis in the *Standards* on students actively doing science.

Use of Assessment Data

The extent to which any assessment data inform teaching and influence learning depends in a large part on use. Assessment-generated data do little good in the head of the teacher, in the grade book, or by failing to inform future decisions, such as selecting curricula, planning class time or having conversations with students. Teachers must use it to adapt their teaching to meet the needs of their students. In other words, just as teaching shapes assessment, assessment shapes teaching. The success of formative assessment hinges in large part on how the information is put to use.

With rich assessment data, a teacher can begin to develop possible explanations about what the difficulties might be for the student. If some pedagogical approach did not work the first time, is it likely to be more effective when repeated? Or, is some new approach required? Might other resources be provided? Setting subgoals is another strategy that is often effective. The student is encouraged to take smaller steps toward learning a particular concept or skill.

Peer instruction is another approach that can sometimes work in helping students reach a learning or performance target. If a teacher notices that one student seems to understand (for example, by displaying a green "traffic light") while another does not, the one who understands might help the one who does not. Students occasionally can assist one another because they themselves may have overcome a similar difficulty. Most all teachers use this technique from time to time during class discussion when they encourage the entire group to help a student who clearly is having difficulty. The same principle can operate with just two students working cooperatively when one may have just figured out the desired response and can explain it to the other. Ms. R brought in sixth graders to assist her third graders while they made instruments. Even though help was provided to handle materials and supplies, the older students also could have been more vocal in the design and construction of the instruments.

Assessment Data Management

Although teachers make assessments all the time, it is important that they develop a system for gathering data about student understanding and progress. This way, no child is overlooked and teachers can be sure that they focus on what they think are the most important learning goals and outcomes. The specific system certainly can vary, depending on a teacher's experience and preferences in gathering such information.

Relying on memory can be difficult with more than 150 students, with many activities, interactions, and observations and over the course of many months before summative evaluations call for the use of such information. One teacher might carry a clipboard while circulating around the room to record comments and observations. Each student has an index card on which to write questions or request an opportunity to speak with the teacher rather than to interrupt. Each day, the teacher observes a handful of students at work but this does not prevent the recording of information from conversations overheard in the room. This method of collecting data not only helps to organize the teaching but also serves as pertinent information when talking with parents and students. In a review of the relevant research in this area, Fuchs and Fuchs (1986) reported that student achievement gains were significantly larger (twice the effect size) when teachers used a regular and systematic method for recording and interpreting assessment data and providing feedback as compared to when they made spontaneous decisions.

In addition to making good use of the data, keeping good records of day-to-day assessments also is important for summative purposes. When meeting with parents or students, it is helpful to have notes of concrete examples and situations to help convey a point. Good records also can serve to address issues of accountability, a topic that will be discussed in the next chapter.

Current State and Directions for Next‐Generation Assessment in Higher Education

Critical thinking is one of the most frequently discussed higher order skills, believed to play a central role in logical thinking, decision making, and problem solving (Butler, 2012; Halpern, 2003). It is also a highly contentious skill in that researchers debate about its definition; its amenability to assessment; its degree of generality or specificity; and the evidence of its practical impact on people's academic achievements, career advancements, and personal life choices.

Despite contention, critical thinking has received heightened attention from educators and policy makers in higher education and has been included as one of the core learning outcomes of college students by many institutions. For example, in a relatively recent survey conducted by the Association of American Colleges and Universities (AAC&U, 2011), 95% of the chief academic officers from 433 institutions rated critical thinking as one of the most important intellectual skills for their students. The finding resonated with voices from the workforce, in that 81% of the employers surveyed by AAC&U (2011) wanted colleges to place a stronger emphasis on critical thinking. Similarly, Casner‐Lotto and Barrington (2006) found that among 400 surveyed employers, 92.1% identified critical thinking/problem solving as a very important skill for 4‐year college graduates to be successful in today's workforce. Critical thinking was also considered important for high school and 2‐year college graduates as well.

The importance of critical thinking is further confirmed in a recent research study conducted by Educational Testing Service (ETS, 2013). In this research, provosts or vice presidents of academic affairs from more than 200 institutions were interviewed regarding the most commonly measured general education skills, and critical thinking was one of the most frequently mentioned competencies considered essential for both academic and career success. The focus on critical thinking also extends to international institutions and organizations. For instance, the Assessment of Higher Education Learning Outcomes (AHELO) project sponsored by the Organisation for Economic Co-operation and Development (OECD, 2012) includes critical thinking as a core competency when evaluating general learning outcomes of college students across nations.

Despite the widespread attention on critical thinking, no clear-cut definition has been identified. Markle, Brenneman, Jackson, Burrus, and Robbins (2013) reviewed seven frameworks concerning general education competencies deemed important for higher education and/or workforce:
(a) the Assessment and Teaching of 21st Century Skills,
(b) Lumina Foundation's Degree Qualifications Profile,
(c) the Employment and Training Administration Industry Competency Model Clearinghouse,
(d) European Higher Education Area Competencies (Bologna Process),
(e) Framework for Higher Education Qualifications,
(f) Framework for Learning and Development Outcomes, and
(g) AAC&U's Liberal Education and America's Promise (LEAP; see Table 1).

Although the definitions in various frameworks overlap, they also vary to a large degree in terms of the core features underlying critical thinking.

Table 1. Current Frameworks of Learning Outcomes in WB

Framework	Author	Critical thinking term	Critical thinking (or equivalent) definition
Assessment and Teaching of 21st Century Skills (ATC21S)	University of Melbourne, sponsored by Cisco, Intel, and Microsoft	Ways of thinking–critical thinking, problem solving, and decision making	The ways of thinking can be categorized into knowledge, skills, and attitudes/values/ethics (KSAVE). Knowledge includes: (a) reason effectively, use systems thinking, and evaluate evidence; (b) solve problems; and (c) clearly articulate. Skills include: (a) reason effectively and (b) use systems thinking. Attitudes/values/ethics include: (a) make reasoned judgments and decisions, (b) solve problems, and (c) attitudinal disposition
The Degree Qualifications Profile (DQP) 2.0	Lumina Foundation	Analytical inquiry	A student who (a) "identifies and frames a problem or question in selected areas of study and distinguishes among elements of ideas, concepts, theories or practical approaches to the problem or question" (associate's level), (b) "differentiates and evaluates theories and approaches to selected complex problems within the chosen field of study and at least one other field" (bachelor's level), and (c) "disaggregates, reformulates and adapts principal ideas, techniques or methods at the forefront of the field of study in carrying out an essay or project" (master's level; Adelman, Ewell, Gaston, & Schneider, 2014, pp. 19–20)
The Employment and Training Administration Industry Competency Model Clearinghouse	U.S. Department of Labour (USDOL), Employment and Training Administration	Critical and analytical thinking	A person who "possesses sufficient inductive and deductive reasoning ability to perform [their] job successfully; critically reviews, analyzes, synthesizes, compares and interprets information; draws conclusions from relevant and/or missing information; understands the principles underlying the relationship among facts and applies this understanding when solving problems" (i.e., reasoning) and "identifies connections between issues; quickly understands, orients to, and learns new assignments; shifts gears and changes direction when working on multiple projects or issues" (i.e., mental agility)
A Framework for Qualifications of the European Higher Education Area (Bologna Process)	European Commission: European Higher Education Area	Not specified—defined in terms of skills related to critical thinking required of students completing the first cycle (e.g., bachelor's level)	Students completing the first-cycle qualification (e.g., bachelor's level) "can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study" and "have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical

issues" (Ministry of Science Technology and Innovation, 2005, p. 194)

In the first part of this paper, we review existing definitions and assessments of critical thinking. We then discuss the challenges and considerations in designing assessments for critical thinking, focusing on item format, scoring, validity and reliability evidence, and relevance to instruction. In the second part of this paper, we propose an approach for developing a next-generation critical thinking assessment by providing an operational definition for critical thinking and discussing key assessment features.

We hope that our review of existing assessments in light of construct representation, item format, and validity evidence will benefit higher education institutions in WB as they choose among available assessments. Critical thinking has gained widespread attention as recognition of the importance of college learning outcomes assessment has increased. As indicated by a recent survey on the current state of student learning outcomes assessment (Kuh, Jankowski, Ikenberry, & Kinzie), the percentage of higher education institutions using an external general measure of student learning outcomes grew from less than 40% to nearly 50% from 2009 to 2010 probably.

We also hope that our proposed approach for a next-generation critical thinking assessment will inform institutions when they develop their own assessments. We call for close collaborations between institutions and testing organizations in designing a next-generation critical thinking assessment to ensure that the assessment will have instructional value and meet industry technical standards.

Multiple Themes of Assessments

As with the multivariate nature of the definitions offered for critical thinking, critical thinking assessments also tend to capture multiple themes.

Authenticity Versus Psychometric Quality

A major challenge in designing an assessment for critical thinking is to strike a balance between the assessment's authenticity and its psychometric quality. Most current assessments rely on multiple-choice items when measuring critical thinking. The advantages of such assessments lie in their objectivity, efficiency, high reliability, and low cost. Typically, within the same amount of testing time, multiple-choice items are able to provide more information about what the test takers know as compared to constructed-response items. Wainer and Thissen (1993) reported that the scoring of 10 constructed-response items costs about $30, while the cost for scoring multiple-choice items to achieve the same level of reliability was only 1¢. Although multiple-choice items cost less to score, they typically cost more in assessment development than constructed-response items. That being said, the overall cost structure of multiple-choice versus constructed-response items will depend on the number of scores that are derived from a given item over its lifecycle.

Studies also show high correlations of multiple-choice items and constructed-response items of the same constructs (Klein et al., 2009). Rodriguez (2003) investigated the construct equivalence between the two item formats through a meta-analysis of 63 studies and concluded that these two formats are highly correlated when measuring the same content—mean correlation around .95 with item stem equivalence and .92 without stem equivalence. The Klein et al. (2009) study compared the construct validity of three standardized assessments of college learning outcomes (i.e., EPP, CLA, and CAAP) including critical thinking. The school-level correlation between a multiple-choice and a constructed-response critical thinking test was .93.

Given that there may be situations where constructed-response items are more expensive to score and that multiple-choice items can measure the same constructs equally well in some cases, one might argue that it makes more sense to use all multiple-choice items and disregard constructed-response items; however, with constructed-response items, it is possible to create more authentic contexts and assess students' ability to generate rather than select responses. In real-life situations where critical thinking skills need to be exercised, there will not be choices provided. Instead, people will be expected to come up with their own choices and determine which one is more preferable based on the question at hand. Research has long established that the ability to recognize is different from the ability to generate (Frederiksen, 1984; Lane, 2004; Shepard, 2000). In the case of critical thinking, constructed-response items could be a better proxy of real-world scenarios than multiple-choice items.

Instructional Value Versus Standardization

Another challenge of designing a standardized critical thinking assessment for higher education is the need to pay attention to the assessment's instructional relevance. Faculty members are sometimes concerned about the limited relevance of general student learning outcomes' assessment results, as these assessments tend to be created in isolation from curriculum and instruction.

For example, although most institutions think that critical thinking is a necessary skill for their students, not many offer courses to foster critical thinking specifically. Therefore, even if the assessment results show that students at a particular institution lack critical thinking skills, no specific department, program, or faculty would claim responsibility for it, which greatly limits the practical use of the assessment results. It is important to identify the common goals of general higher education and translate them into the design of the learning outcomes assessment.

The VALUE rubrics created by AAC&U (Rhodes, 2010) are great examples of how a common framework can be created to align expectations about college students' critical thinking skills. While one should pay attention to the assessments' instructional relevance, one should also keep in mind that the tension will always exist between instructional relevance and standardization of the assessment. Standardized assessment can offer comparability and generalizability across institutions and programs within an institution. An assessment designed to reflect closely the objectives and goals of a particular program will have great instructional relevance and will likely offer rich diagnostic information about the students in that program, but it may not serve as a meaningful measure of outcomes for students in other programs. When designing an assessment for critical thinking, it is essential to find that balance point so the assessment results bear meaning for the instructors and provide information to support comparisons across programs and institutions.

Institutional Versus Individual Use

Another concern in WB is whether the assessment should be designed to provide results for institutional use or individual use, a decision that has implications for psychometric considerations such as reliability and validity. For an institutional level assessment, the results only need to be reliable at the group level (e.g., major, department), while for an individual assessment, the results have to be reliable at the individual test-taker level. Typically, more items are required to achieve acceptable individual-level reliability than institution-level reliability. When assessment results are used only at an aggregate level, which is how they are currently used by most institutions, the validity of the test scores is in question as students may not expend their maximum effort when answering the items. Student motivation when taking a low-stakes assessment has long been a source of concern.

A recent study by Liu, Bridgeman, and Adler confirmed that motivation plays a significant role in affecting student performance on low-stakes learning outcomes assessment in higher education. Conclusions about students' learning gains in college could significantly vary depending on whether they are motivated to take the test or not. If possible, the assessment should be designed to provide reliable information about individual test takers, which allows test takers to possibly benefit from the test (e.g., obtaining a certificate of achievement). The increased stakes may help boost students' motivation while taking such assessments.

General Vs Domain-Specific Assessment

Critical thinking has been defined as a generic skill in many of the existing frameworks and assessments (e.g., Bangert-Drowns & Bankert, 1990; Ennis, 2003; Facione, 1990b; Halpern, 1998). On one hand, many educators and philosophers believe that critical thinking is a set of skills and dispositions that can be applied across specific domains. The generalists depict critical thinking as an enabling skill similar to reading and writing, and argue that it can be taught outside the context of a specific discipline. On the other hand, the specifists' view about critical thinking is that it is a domain-specific skill and that the type of critical thinking skills required for nursing would be very different from those practiced in engineering (Tucker, 1996). 678).

Tuning USA is one of the efforts that considers critical thinking in a domain-specific context. Tuning USA is a faculty-driven process that aims to align goals and define competencies at each degree level (i.e., associate's, bachelor's, and master's) within a discipline (Institute for Evidence-Based Change, 2010). For Tuning USA, there are goals to foster critical thinking within certain disciplinary domains, such as engineering and history. For example, for engineering students who work on design, critical thinking suggests that they develop “an appreciation of the uncertainties involved, and the use of engineering judgment” (p. 97) and that they understand “consideration of risk assessment, societal and environmental impact, standards, codes, regulations, safety, security, sustainability, constructability, and operability” at various stages of the design process (p. 97).

In addition, there is insufficient empirical evidence showing that, as a generic skill, critical thinking is distinguishable from other general cognitive abilities measured by validated assessments such as the SAT and GRE tests. Kuncel, therefore, argued that instead of being a generic skill, critical thinking is more appropriately studied as a domain-specific construct. This view may be correct, or at least plausible, but there also needs to be empirical evidence demonstrating that critical thinking is a domain-specific skill. It is true that examples of critical thinking offered by members of the nursing profession may be very different from those cited by engineers, but content knowledge plays a significant role in this distinction. Would it be reasonable to assume that skillful critical thinkers can be successful when they transfer from one profession to another with sufficient content training? Whether and how content knowledge can be disentangled from higher order critical thinking skills, as well as other cognitive and affective faculties, await further investigation.

Despite the debate over the nature of critical thinking, most existing critical thinking assessments treat this skill as generic. Apart from the theoretical reasons, it is much more costly and labour-intensive to design, develop, and score a critical thinking assessment for each major field of study. If assessments are designed only for popular domains with large numbers of students, students in less popular majors are deprived of the opportunity to demonstrate their critical thinking skills. From a score user perspective, because of the interdisciplinary nature of many jobs in the 21st century workforce, many employers value generic skills that can be transferable from one domain to another; which makes an assessment of critical thinking in a particular domain less attractive.

Faculty Involvement

In addition to summative uses such as accreditation, accountability, and benchmarking, an important formative use of student learning outcomes scores could be to provide diagnostic information for faculty to improve instruction. In the spring 2010 survey of the current state of student learning outcomes assessment in U.S. higher education by the National Institute for Learning Outcomes Assessment (NILOA), close to 60% of the provosts from 1,202 higher education institutions indicated that having more faculty members use the assessment results was their top priority. Standardized student learning outcomes assessments have long faced criticism that they lack instructional relevance.

In our review, that is not a problem with standardized assessments per se, but an inherent problem when two diametrically different purposes or uses are imposed on a single assessment. When standardization is called for to summarize information beyond content domains for hundreds or even thousands of students, it is less likely that the assessments can cater to the unique instructional characteristics the students have been exposed to, making it difficult for the assessment results to provide information that is specific and meaningful for each instructor.

A possible strategy is to introduce a customization component to a standardized assessment, allowing faculty, either by institution or by disciplinary domain, to be involved in the assessment design, sampling, analysis, and score interpretation process. For any student learning outcomes assessment results to be of instructional value, faculty should be closely involved in the development process and fully understand the outcome of the assessment.

5.4. The Equity Principle

The *Standards* were written with the belief that all students should be expected to strive for and to achieve high standards. According to the *Standards,* in addition to being developmentally appropriate, "assessment tasks must be set in a variety of contexts, be engaging to students with different interests and experiences, and must not assume the perspective or experience of a particular gender, racial or ethnic group" (p. 86). The corresponding principle in classroom assessment is clear: Assessment is equitable and fair, supporting all students in their quest for high standards.

Equity issues are difficult to grapple with and arise at all levels of the education system and in all components of any program. All participants—teachers, students, administrators, curriculum developers, parents—are called upon to share the belief that all students can learn, and this premise needs to infuse all aspects of classroom life. Focusing on equity in classroom assessment is one part of the challenge.

For years, assessment has been used to sort and place students in such a way that all students do not have access to quality science programs (Darling-Hammond, 1994; Oakes, 1985, 1990). Depending on the form assessment takes and how the ensuing data are used, assessment can be a lever for high-quality science education for all rather than an obstacle. In research conducted by White and Frederiksen (1998) where students engaged in peer- and self assessment strategies, traditionally low-attaining students demonstrated the most notable improvement.

Frequent and immediate feedback to students based on careful attention to daily activity—including student work, observations, participation in conversations and discussions—can provide teachers and students with valuable information. If this information is used in a manner that informs students about standards for improvement and how to attain them, it also can help support all students to achieve their potential.

Assessing students engaged in meaningful activities can promote equity in several other respects as well. For one, teachers can help create a setting where assessment related activities engage students in experiences that help them synthesize information, integrate experiences, reflect on learning, and make broader connections. Through their regular journal reflections, the students in Ms. K's class reflected on their learning, making connections between their particular project and the local ecosystem. Assessments and assessment-related conversations can help make explicit to all students standards of quality work, make clearer the connections among seemingly unrelated content, concepts, and skills, and provide a scaffold for ongoing student self-assessment (Cole et al., 1999). Misunderstandings of the task or the context, misconceptions about the nature of the task, or difficulties with the language used, can be brought to light and dealt with, often by students helping one another.

Some people believe that the different roles a teacher plays with respect to assessment perpetuates inequitable treatment. In any personal relationship, few of us succeed in treating all of our acquaintances with equal consideration. We may be predisposed by their colour, their gender, the way they talk, their social class, whether they respond to us in a warm or in a distant way, and much more. All teachers face such issues as they respond to their students as individuals.

Formative assessment requires a close and often personal response. A student's answer to a question may seem strange or not well thought out. Sometimes such reactions may be justified, but sometimes they are prejudgments that may be unfair to the student. In particular, if a student is treated dismissively, then sees another student making a similar response treated with respect, he may be unlikely to try again. So the first and hardest part of treating students equitably is to try to treat all students with the same respect and seriousness.

In particular, the idea that everyone has a fixed IQ, that some are bright and some are not, and there is nothing one can do about it, can be very destructive of the kind of interaction necessary between teacher and student to advance learning. If a teacher really thinks in this way, it is highly probable that such an attitude will be conveyed, directly or indirectly, to the student. In the case of one pigeonholed as less "intelligent, " the student might believe that this is a true judgment and therefore stop trying.

A different problem that leads to inequity in teaching is associated with problems of "disclosure," the technical label for the challenge of assuring that a student understands the context in which a question is framed and interprets the demand of the question in the way that the teacher intended. Some of these problems are associated with the language of a question or task. For example, both vocabulary and oral style differ among children so the teacher may communicate far more effectively with students from one socioeconomic or ethnic background than with those from another background. Many class questions or homework tasks are set in what are assumed to be realistic settings, often on the assumption that this will be more accessible than one set in abstract. One student's familiar setting, for example, a holiday drive in a car, may be uncommon for another family that cannot afford a car, or even a holiday. Ironically, some research has shown that questions set in "everyday" settings open up wider differences in response between students in advantaged compared with disadvantaged backgrounds than the same questions set in abstract contexts (Cooper & Dunne, 2000).

These problems of "disclosure," and the broader problems of bias in testing have been studied from many aspects in relation to summative tests, especially where these are developed and scored externally from the school. Although such external tests are not subject to the risks of bias at a personal, one-on-one level, this advantage may be offset because a teacher might see that a student does not understand a question and can rephrase to overcome the obstacle, the external grader or machine cannot.

Some people caution against complications associated with the multiple roles that teachers play in assessment, including that of both judge and jury. They see this subjectivity as a threat to the validity of the assessment. They point to a study that examined the effects of expectations on human judgment (Rosenthal & Jacobsen, 1968). Teachers were provided contrived information that a handful of students showed exceptional promise, when in actuality they were no different from the others. When questioned several months later about those students ' progress, the teacher reported that they excelled and progressed more than their classmates.
One of the basic claims made by the researchers in this study was that the teacher fulfilled the "exceptional-promise " expectation. In efforts to try to overcome or at least abate inherent bias that results in inequitable treatment, teachers, and all those working with students, need to be examined and keep a check on the bias that enters into their own questioning, thinking, and responses.

5.5. Validity and Reliability

To some, issues of validity and reliability are at the heart of assessment discussions. Although these considerations come into play most often in connection with large-scale assessment activities, technical issues are important to consider for all assessments including those that occur each day in the classroom (American Educational Research Association, American Psychological Association, & National Council on Measurement and Education, 1999). Though principles stay the same, operationally they mean and look different for formative and summative purposes of assessment.

Issues of validity centre on whether an assessment is measuring or capturing what is intended for measure or capture. Validity has many dimensions, three of which include content validity, construct validity, and instructional validity. Content validity concerns the degree to which an assessment measures the intended content area. Construct validity refers to the degree to which an assessment measures the intended construct or ability. For example, the *Standards* outline the abilities and understandings necessary to do scientific inquiry. For an assessment to make valid claims about a student' s ability to conduct inquiry, the assessment would need to assess the range or abilities and understandings comprised in the construct of inquiry.

Finally, an assessment has instructional validity if the content matches what was actually taught. Questions concerning these different forms of validity need to be addressed independently, although they are often related. Messick (1989) offers another perspective on validity. His definition begins with an examination of the **uses** of an assessment and from there derives the technical requirements. Validity, as he defines it, is "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and *appropriateness of inferences and actions* based on test scores or other modes of assessment" [italics added] (p. 13).

Thus, validity in his view is a property of consequences and use rather than of the actual assessment. Messick 's (1994) use of validity stresses the importance of weighing social consequences: “Test validity and social values are intertwined and that evaluation of intended and unintended consequences of any testing is integral to the validations of test, interpretation and use” (p. 19). Validity, he argued, needs evidentiary grounding, including evidence of what happens as a result. Moss (1996) urges that actions taken based on interpretation of assessment data and that consequences of those actions be considered as evidence to warrant validity.

Attention to issues of validity is important in the type of ongoing classroom assessment discussed thus far in this chapter. It is important to keep in mind the guideline that says that assessments should match purpose. When gathering data, teachers and students need to consider if the information accurately represents what they wish to summarize, corresponds with subject matter taught, and reflects any unintended social consequences that result from the assessment. Invalid formative assessment can lead to the wrong corrective action, or to neglect action where it is needed. Issues relating to validity are discussed further in Chapter 4.

Reliability refers to generalizability across tasks. Usually, it is a necessary but not complete requirement for validity. Moss (1996) makes a case that reliability is not a necessity for classroom assessment. She argues for the value of classroom teachers' special contextualized knowledge and the integrative interpretations they can make. Research literature acknowledges that over time, in the context of numerous performances, concerns of replicability and generalizability become less of an issue (Linn & Burton, 1994; Messick, 1994). Messick states that dropping reliability as a prerequisite for validity may be “feasible in assessment for instructional improvement occurring frequently throughout the course of teaching or in appraisals of extensive portfolios ” (p. 15).

For formative assessments, constraints on reliability are handled differently though still important to consider (Wiliam & Black, 1996). If assessment takes place all the time, a teacher can elicit information that suggests that a previous assessment and judgment was not representative of performance. Teachers are in the position of being able to sample student performance repeatedly over time, thus permitting assessment-based judgments to be adjusted and evolve over a long period of time, leading to confident conclusions.

Teachers, however, must remain open to continually challenging and revising their previously held judgments about student performance. Research suggests that teachers often look for evidence that affirms their own performance (Airasian, 1991) and do not easily modify judgments on individual student achievement (Goldman, 1996; Rosenbaum, 1980).

Although teachers do have a “special-observer” perspective from which they have access to information not generated by way of a test, consideration of technical criteria should remind teachers that careful documentation and systematic observation of all students is necessary to achieve an equitable classroom environment. Assessment data should be “triangulated,” or drawn from multiple sources, to reduce the possible bias that may be introduced by any one particular method of obtaining and interpreting evidence.

Thinking in Terms of the Classroom

Thus far, this chapter has provided a menu of strategies and principles for teachers to consider when designing and implementing a classroom assessment system organized around the goals of improved student work. As noted previously, no one system or collection of strategies will serve all teachers. When choosing among the many available assessment approaches, the following general selection guidelines may be of use. For one, assessments should be aligned with curricular goals, and should be consistent with pedagogy. Because a single piece of work or performance will not capture the complete story of student understanding, assessments should draw from a variety of sources.

On a related note, students should be provided with multiple opportunities to demonstrate understanding, performance, or current thinking. Assessments can be most powerful when students are involved in the process, not solely as responders or reactors. Also when designing and selecting assessment, a teacher should consider his or her personal style. Lastly, assessments should be feasible. With large class sizes and competing priorities, some teachers may find it impractical to employ certain practices.

Although any classroom activity can be modified to also serve as an assessment, the data must be fed back into teaching and learning for the assessment to be effective. To the extent that a teacher's decisions and judgments are informed by the information they glean from their students—for example, through observations, class discussions, conversations, written comments, reflections, journals, tests, quizzes, and presentations—teachers can base decisions on understandings of their students and significantly support their learning.

Unfortunately, there are often competing needs and demands on teachers. Teachers have little choice but to juggle the different purposes of assessment in effort to create some coherent system that can best satisfy the different, and often competing, assessment aims. Because they are stretched thin with resources and time, teachers need support in helping them realize the potential of this type of assessment.

KEY POINTS:

i) To be effective as assessment that improves teaching and learning, the information generated from the activity must be used in such a way as to inform the teacher and/or her students in helping decide what to do next.
ii) It is important for teachers to have clear performance criteria in mind before they assess student work and responses. These should be conveyed to students.
iii) Form and content of assessment should be consistent with the intended purpose.
iv) Student participation becomes a key component of successful assessment strategies at every step. If students are expected to effectively participate in the process, then they need to be clear on the target and the criteria for good work, to assess their own efforts in light of the criteria, and to share responsibility in taking action in light of feedback.
v) Assessments should be equitable and fair, supporting all students in their quest for high standards. Thus, technical issues are important to consider for all assessments, including those that occur each day in the classroom.

5.6. New Research to Improve Students' Motivation

Teachers know that motivation matters. It is central to student learning; it helps determine how engaged students are in their work, how hard they work, and how well they persevere in the face of challenges. Though we hear mostly about the "achievement gap" between demographic groups, researchers have also identified an "engagement gap," which the High School Survey of Student Engagement calls "both more pernicious and potentially more addressable."

Despite its obvious importance, student motivation is not a focus of today's education system. Motivation is hard to characterize and quantify, and it is influenced by many factors outside the classroom. Partly because of these challenges, many teachers feel they can do little to improve motivation. But a growing body of research shows that they can: teachers can employ a number of strategies that have been proven to enhance students' engagement in learning.

In a recent Carnegie report, "**Motivation Matters: How New Research Can Help Teachers Boost Student Engagement**," Susan Headden and Sarah McKay look at the new psychological and behavioural research focused on building motivation—how students respond to incentives to learn, how they see themselves as learners, and what they consider to be their place in school. As the report shows, educators can fortify the non-instructional side of student success in three essential ways: encouraging positive behaviours by offering rewards and emphasizing the value of students' work, improving their academic mindsets, and enhancing their sense of connectedness with their teachers and their peers.

Teachers can employ a number of strategies that have been proven to enhance students' engagement.

Rewards and Value

Teachers have long offered incentives for directing student behaviour. Gold stars, detentions, grades—all can light fires under students. But research shows that these sorts of extrinsic rewards can also undermine students' intrinsic motivation for learning. For example, in an oft-cited 1973 study, preschoolers were promised and received a reward for drawing. The children later chose to spend less of their free time drawing than they had prior to receiving the reward. The findings don't mean, however, that incentives have a universally negative effect on intrinsic motivation. In the same study, students who initially showed little inherent interest in drawing, and who then received an *un*expected reward for doing so, later chose to spend more of their free time on that activity.

An additional problem with rewards, says Chris Hulleman, a research associate professor at the University of Virginia, is that they offer the teacher an "out"—they allow him to disregard his role in making a lesson more meaningful. A better motivation-booster, says Hulleman and other experts, is to focus on the value of the task. This requires educators to provide meaningful activities explicitly connected to things students care about. For example, in a 2009 study, Hulleman and Judith Harackiewicz assigned over 250 high schoolers to two groups; one group regularly wrote summaries of the science material they were learning in class, and the other wrote about the usefulness of this material to their lives. In this latter group, students who had started with low expectations of their success in the course reported a higher interest in science and higher grades in the course than similar students in the group that only wrote summaries.

Extrinsic rewards can produce results, particularly if they are unexpected, prize mastery of skills over absolute performance, or encourage identifiable behaviours rather than outcomes. But getting students to see the value in their schoolwork by connecting concepts to their lives may be a more effective way for teachers to boost student engagement.

Student Mindsets

Evidence is mounting that academic mindsets are extremely important to student success. Students' sense of belonging in their learning environment, their perceptions of how or whether "kids like them" succeed academically, and the extent to which they believe that hard work and persistence pay off—all of these have a powerful effect on student motivation.

The good news for teachers is that student mindsets aren't set in stone; educators have the power to positively influence students' perceptions of themselves as learners. Research findings like the above show that even relatively simple classroom interventions can have a large effect.

The good news for teachers is that student mindsets aren't set in stone.

Student Relationships

Students care when they believe that other people care about them. They are less likely to drop out, and more likely to feel positively about school, when they have ongoing connections with teachers. Likewise, when they associate with highly-engaged peers, they become more engaged themselves.

Schools can do a lot to ensure that students feel cared about in the learning environment. Check & Connect, a program used by Chicago Public Schools, carefully monitors students' grades, attendance, and performance data to identify those most at risk of disengaging from school. Each of these students is paired with a trained mentor who helps him with personal and academic issues. In one study, chronically-absent elementary students participated in the program for two years, and at the end of that time, 40 percent were engaged in and regularly attending school.

Even smaller-scale classroom interventions can make a big difference in promoting positive school-based relationships. Teachers can hold morning meetings and encourage students to work in groups in order to foster environments in which students feel safe and supported.

An Issue of Scale

None of these strategies for boosting motivation is necessarily new; good teachers have always incentivized productive behaviours, encouraged positive mindsets, and created caring and connected classroom environments. But the new research adds evidence that these factors are vital to student success, and they show that, through practical interventions, they can be changed. The challenge now is to extend best practices beyond isolated classrooms, making the work systematic and sustained.

The barriers to scaling are many. **Measurement**, in particular, is a significant problem. Tools like Angela Duckworth's Grit Scale and the KIPP character growth card assess non-cognitive skills and dispositions, but even experts concede that measurement is difficult to do reliably and validly. Professional support for teachers is another issue. Educators need to be trained on how to incorporate motivation-boosting strategies into their everyday instruction. And the education system as a whole must do a better job of translating research findings into practice.

Though challenges remain, researchers and practitioners are conducting promising experiments aimed at identifying and scaling the most effective strategies for improving student motivation.

Motivating Students

i)Intrinsic Motivation
ii)Extrinsic Motivation
iii)Effects of Motivation on Learning Styles
iv)A Model of Intrinsic Motivation
v)Strategies for Motivating Students
vi)Showing Students the Appeal of a Subject

Intrinsic Motivation

Intrinsic motivators include fascination with the subject, a sense of its relevance to life and the world, a sense of accomplishment in mastering it, and a sense of calling to it.

Students who are intrinsically motivated might say things like the following.

"Literature interests me."
"Learning math enables me to think clearly."
"I feel good when I succeed in class."

Advantages: Intrinsic motivation can be long-lasting and self-sustaining. Efforts to build this kind of motivation are also typically efforts at promoting student learning. Such efforts often focus on the subject rather than rewards or punishments.

Disadvantages: On the other hand, efforts at fostering intrinsic motivation can be slow to affect behaviour and can require special and lengthy preparation. Students are individuals, so a variety of approaches may be needed to motivate different students. It is often helpful to know what interests one's students in order to connect these interests with the subject matter. This requires getting to know one's students. Also, it helps if the instructor is interested in the subject to begin with!

Source: Matt DeLong and Dale Winter, *Learning to Teaching and Teaching to Learn Mathematics: Resources for Professional Development*, Mathematical Association of America, 2002, page 163.

Extrinsic Motivation

Extrinsic motivators include parental expectations, expectations of other trusted role models, earning potential of a course of study, and grades (which keep scholarships coming).

Students who are extrinsically motivated might say things like the following.

i)"I need a B- in statistics to get into business school."
ii)"If I flunk chemistry, I will lose my scholarship."
iii)"Our instructor will bring us donuts if we do well on today's quiz."

Advantages: Extrinsic motivators more readily produce behaviour changes and typically involve relatively little effort or preparation. Also, efforts at applying extrinsic motivators often do not require extensive knowledge of individual students.

Disadvantages: On the other hand, extrinsic motivators can often distract students from learning the subject at hand. It can be challenging to devise appropriate rewards and punishments for student behaviours. Often, one needs to escalate the rewards and punishments over time to maintain a certain effect level. Also, extrinsic motivators typically do not work over the long term. Once the rewards or punishments are removed, students lose their motivation.

Furthermore, research indicates that **extrinsic rewards can have a negative impact on intrinsic motivation**. In one series of experiments, psychologist Edward Deci had two groups of college students' play with a puzzle called Soma. One group of students was paid for each puzzle they solved; the other wasn't. He found that the group that was paid to solve puzzles stopped solving puzzles as soon as the experiment—and the payment—ended. However, the group that wasn't paid kept solving the puzzles even after the experiment was over. They had found the puzzles intrinsically interesting. Deci argued that the group that had been paid to solve puzzles might have found the puzzles intrinsically interesting as well, but the extrinsic, monetary reward had reduced their intrinsic interest.

Source: Ken Bain, *What the Best College Teachers Do*, Harvard University Press, 2004, pages 32-33.

Effects of Motivation on Learning

Deep learners respond well to the challenge of mastering a difficult and complex subject. These are intrinsically motivated students who are often a joy to teach:

i) **Strategic learners** are motivated primarily by rewards. They react well to competition and the opportunity to best others. They often make good grades but won't engage deeply with a subject unless there is a clear reward for doing so. They are sometimes called "bulimic learners," learning as much as they need to do well on a test or exam and then promptly forgetting the material once the assessment is over. Handle strategic learners by avoiding appeals to competition. Appeal to their intrinsic interest in the subject at hand. Design your assignments (tests, papers, projects, etc.) so that deep engagement with the subject is necessary for success on the assignments. Do so by requiring students to apply, synthesize, or evaluate material instead of merely comprehending or memorizing material.

ii) **Surface learners** are often motivated by a desire to avoid failure. They typically avoid deep learning because it they see it as inherently risky behaviour. They will often do what it takes to pass an exam or course, but they won't choose to go beyond the minimum required for fear of failure. Handle surface learners by helping them gain confidence in their abilities to learn and perform. "Scaffold" course material and assignments by designing a series of activities or assignments that build on each other over time in complexity and challenge. Encourage these learners often and help them reflect on what they've learned and what they've accomplished.

A Model of Intrinsic Motivation

James Middleton, Joan Littlefield, and Rich Lehrer have proposed the following model of intrinsic academic motivation:

● First, given the opportunity to engage in a learning activity, a student determines if the activity is one that is known to be **interesting**. If so, the student engages in the activity.

● If not, then the student evaluates the activity on two factors—the **stimulation** (e.g. challenge, curiosity, fantasy) it provides and the **personal control** (e.g. free choice, not too difficult) it affords.

● If the student perceives the activity as stimulating and controllable, then the student tentatively labels the activity as interesting and engages in it. If either condition becomes insufficient, then the student disengages from the activity—unless some extrinsic motivator influences the student to continue.

● If the activity is repeatedly deemed stimulating and controllable, then the student may deem the activity interesting. Then the student will be more likely to engage in the activity in the future.

● If over time activities that are deemed interesting provide little stimulation or control, then the student will remove the activity from his or her mental list of interesting activities.

The challenge, then, is to provide teaching and learning activities that are both stimulating and offer students a degree of personal control.

Source: James A. Middleton, "A Study of Intrinsic Motivation in the Mathematics Classroom: A Personal Constructs Approach," *Journal for Research in Mathematics Education*, Vol. 26, No. 3, pages 255-257.

Strategies for Motivating Students

Following are some research-based strategies for motivating students to learn:

● **Become a role model for student interest**. Deliver your presentations with energy and enthusiasm. As a display of your motivation, your passion motivates your students. Make the course personal, showing why you are interested in the material.

- **Get to know your students.** You will be able to better tailor your instruction to the students' concerns and backgrounds, and your personal interest in them will inspire their personal loyalty to you. Display a strong interest in students' learning and a faith in their abilities.
- **Use examples freely.** Many students want to be shown why a concept or technique is useful before they want to study it further. Inform students about how your course prepares students for future opportunities.
- **Use a variety of student-active teaching activities.** These activities directly engage students in the material and give them opportunities to achieve a level of mastery.
- Teach by discovery. Students find as satisfying as reasoning through a problem and discovering the underlying principle on their own.
- Cooperative learning activities are particularly effective as they also provide positive social pressure.
- **Set realistic performance goals** and help students achieve them by encouraging them to set their own reasonable goals. Design assignments that are appropriately challenging in view of the experience and aptitude of the class.
- **Place appropriate emphasis on testing and grading.** Tests should be a means of showing what students have mastered, not what they have not. Avoid grading on the curve and give everyone the opportunity to achieve the highest standard and grades.
- **Be free with praise and constructive in criticism.** Negative comments should pertain to particular performances, not the performer. Offer nonjudgmental feedback on students' work, stress opportunities to improve, look for ways to stimulate advancement, and avoid dividing students into sheep and goats.
- **Give students as much control over their own education as possible.** Let students choose paper and project topics that interest them. Assess them in a variety of ways (tests, papers, projects, presentations, etc.) to give students more control over how they show their understanding to you. Give students options for how these assignments are weighted.

CHAPTER-VI

6.1. Students' Academic Performance: The Role of Motivation, Strategies, and Perceived Factors.

The nature of motivation and learning strategy use is vital to improving student learning outcomes. This study was intended to explore the motivational beliefs and learning strategy use by West Bengal's junior and senior high school students in connection with their academic performance. It also solicited students' self-reports about presumed factors hindering their learning. Utilizing a cross-sectional quantitative research design, 323 participants took part in the study from 2 countries. Motivated Strategies for Learning Questionnaire (MSLQ) was adapted and 12 potential learning hindrances were identified and used as instruments.

As a responsibility bearer to educate its citizens, the WB government on an annual basis gives budgetary support to the Ministry of Education to run the education sector. This is in support of GoL's constitutional obligation to provide all WBs equal access to educational opportunities and facilities to ensure the social, economic, and political wellbeing of WB. Accordingly, the WB Education Law requires for Basic Education of the country, which comprises grades 1–9, to be free and compulsory, though the compulsion part is not being fully implemented due to limited access to learning facilities, among other constraints. In compliance with Global Standards, WB Ministry of Education is working with its partners and relevant stakeholders to align the Sustainable Development Goal 4, which seeks to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, with the Ministry's Getting to Best Strategies and Education Sector Plan. This further justifies the need for government and partners to continue their support to the sector.

Emphatically, the support being provided by the WB government and donors has triggered some achievements including the provision of textbooks, learning materials, teachers' guides, the construction and renovation of schools, and education facilities around the country and the successful implementation of capacity development programs targeting school administrators, teachers, and Parent-Teacher Associations.

Despite educational inputs provided to date, the overall academic performance of WB students has not been impressive. This is indicative of the incessant drops in the passing marks of 9th and 12th graders in the regional exams, administered by the West African Examination Council (WAEC) Liberia office [5, 6].

As a consequence of the deteriorating student performance, the education sector has received serious backlashes from a cross-section of WBs including President Pranab Mukhopadhaya who had called for its total overhaul, stressing the need for concerted efforts to address the situation. In their wisdom, extraordinary actions were needed to redeem the sector, reemphasizing the necessity for collectivism to mend the sector. In an apparent response, the WB Ministry of Education has set out a number of priorities in this direction; the most paramount among them relates to dealing with underperformance of students by endeavouring to enhance students learning outcomes.

Since students are at the core of learning process, a study tailored to their motivations and strategies and factors hindering their learning is imperative as students themselves play pivotal roles in shifting their own learning and acquiring enhanced academic achievement. Accordingly, Pintrich acknowledged that research on student motivation is central to research in learning and teaching settings. Pintrich et al. have demonstrated that positive motivational beliefs positively related to higher levels of self-regulated learning.

This study is critical because it delves into WB students' motivations and strategies as well as factors hampering their learning. Cognizant of this, Zimmerman stresses that there is a growing pedagogical need to comprehend how students develop the capability and motivation to regulate their own learning. Zimmerman believes that when students monitor their responding and attribute outcomes to their strategies, their learning becomes self-regulated, and they exhibit increased self-efficacy, greater intrinsic motivation, and higher academic achievement.

Motivation is a fundamental recipe for academic success. It involves internal and external factors that stimulate desire and energy in people to be continually interested and committed to job, role, or subject, or to make an effort to attain a goal. Dornyei argued that motivation explains why people decide to do something, how hard they are going to pursue it, and how long they are willing to sustain the activity. In order words, "motivation is what gets you going, keeps you going, and determines where you're trying to go". Alderman indicates that those students who have optimum motivation have an edge because they have adaptive attitudes and strategies, such as maintaining intrinsic interest, goal setting, and self-monitoring. Besides, motivational variables interact with cognitive, behavioural, and contextual factors to upset self-regulation.

Furthermore, motivational beliefs are very essential to the academic achievement of students because they help to determine the extent to which students will consider, value, put in effort, and show interest in the task. For example, self-efficacy influences how learners feel, think, motivate themselves, and behave. This has been manifested by research, indicating students' problem solving performance significantly relates to their self-efficacy beliefs [20]. According to Zimmerman, Collins found highly efficacious students to be quickly capable of rejecting faulty strategies, solving more problems, and reworking more previously difficult problems than their less efficacious counterparts.

On the other hand, learning strategies have to do with steps taken by students to enhance their learning competencies. In the words of Zimmerman, self-regulated learning strategies are actions and processes directed at acquiring information or skill that involve agency, purpose, and instrumentality perceptions by learners. Some learning strategy uses include rehearsal, organization, critical thinking, time and study environment management, effort regulation, peer learning, and help seeking. There is a growing evidence about the importance of these strategies due to their bearings on academic performance.

Cognizant of the fact that these concepts (students' motivations and learning strategies) are teachable, this study was very beneficial because it established WB junior and senior school students motivational beliefs and learning strategy use to learn various subjects. It also identified potential hindrances to students learning and proffered suggestions for enhanced academic performance in WB. It is foreseen that this research findings would provide better and clearer comprehensibility of WB students' motivation and use of learning strategies to help students, administrators, and policymakers improve teaching and learning through the development or alignment of policies and programs in the interest of nation building.

Key Research Questions:

(1)What motivational beliefs are held by WB junior and senior high school students to learn?
(2)Which strategies do WB students prefer in their quest to learn?
(3)Does there exist relationship between students' motivations and strategy use?
(4)What factors do WB students think are hindering their learning?

6.2. Hypothesis of the Study

Mentioned below are the assumptions from the present investigation that framed its objectives:-

- The students of higher secondary level education shows a keen interest in science and technology ;
- No significant difference is found in the interest in science in the secondary students from joint family in rural and urban areas of Purba Medinipur district from where the present researcher is doing his work;
- It is observed that there is no expressive difference in interest in science and technology between male and female students belonging to secondary education;
- It is observed that the same interest is there in science and technology between secondary students those who are living in rural and urban areas of Purba Medinipur District during the said investigation work;
- It is found that the same rate of interest is there towards the science and technology of the government and private secondary school in rural and urban areas;
- Gender of students has significant effect on the attitude towards science education;
- Locality of students has also a significant effect on the attitude towards science education; and
- Socio-economic status of the students has significant effect on the attitude towards science education.

It is revealed from the study of Fazilka and Abohar in respect of secondary school students who are selected from rural and urban areas. Two schools from rural and two schools from urban area were randomly selected for collection of data. A sample of 100 students was selected for the study. Out of 100 students 50 boys (25 form rural area and 25 from urban) and 50 girls (25 from rural area and 25 from urban) were selected for the study of the present data sheet printed with socio- economic status scale and they were used to find out the actual result.

Hypothesis – I

Sl. No	Groups	No. of students	Means	SD	SED	t-ratio	Level of Significance
01	Boys	50	50.86	6.82	1.364	.191	Not significant at both .01 and .05 level
02	Girls	50	50.6	6.82	1.364	.191	Not significant at both .01 and .05 level

Table - I

It is found from the above table –I that gender does not differ significantly on attitude towards science education.

So, the so-called difference between the attitude of male and female is not accepted.

There will be no significant difference between the attitudes of male or female students towards science.

Hypothesis – I I

Expressive difference between genders is on the attitude of the rural and urban students:-

Sl. No.	Groups	No. of students	Means	SD	SED	t-ratio	Level of Significance
01	Rural	50	50.4	1.98	0.396	3.17	Ssignificant at both .01 and .05 level
02	Urban	50	51.	1.98	0.396	3.17	Significant at both .01 and .05 level

Table – II

It is found from the above table – II that the t- ratio for the main effect is 3.17 and it is more than the value 2.63 against 1/98 d. f. at 0.01 level and 1.98 d. f. at 0.05 level. So, the result of the rural and urban students towards science cannot be accepted.

There will be no significant difference between the students of rural and urban areas towards attitudes to science education in secondary stage.

The t-test summary of the effect of gender on students' attitude towards science subjects indicates that boys tends to have more positive attitude towards science subjects such as Chemistry, Physics and Biology. This is in consonance with several studies that have suggested that boys demonstrated more positive attitude towards science subjects than girls'. Boys rated science as a subject more exciting and interested than girls.

Table 1: Rural Statistics

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
RBH	20	28.00	46.00	35.8000	5.5782
DHS	20	29.00	45.00	36.2500	4.9084
RHS	20	28.00	44.00	35.3500	4.8480
SHS	20	31.00	46.00	38.5000	4.3830
HHS	20	29.00	45.00	38.2500	3.4163
MHS	20	34.00	42.00	38.8000	2.5257
KHS	20	29.00	45.00	37.3000	4.0275
GNHS	20	30.00	45.00	37.7500	3.7958
SSPHS	20	33.00	43.00	39.6000	2.7222
GHS	20	29.00	41.00	35.1000	3.8512

In rural areas students of higher secondary schools attempt to understand and follow the influential factors underlying their attitudes towards science subject and the study of the subject has been conducted in a wide area using variegated research methodology, gathering data based on interviews and the ubiquitous exploration has yielded rich results.. These methods express the students' feelings and beliefs, and they also explore the characteristics of the factors influencing students' attitudes.

Table 2: Urban Statistics

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
PHS	20	27.00	40.00	33.6000	4.2723
RHS	20	29.00	40.00	34.6000	3.2831
CTHS	20	22.00	38.00	29.4000	4.2846
HHS	20	29.00	46.00	39.3500	3.2163
TTHS	20	29.00	40.00	34.6500	3.5876
CHS	20	20.00	40.00	32.5000	5.7446
DRS	20	22.00	39.00	27.6000	3.7613
BVS	20	20.00	36.00	29.0500	4.1355
HVS	20	30.00	39.00	34.9000	3.1103
PBBS	20	31.00	39.00	36.3000	2.5772

From the literature reviewed, we can generally hypothesize that the types of motivations and strategy use are responsible for the decline in WB students' academic performance, particularly for takers of WAEC exams. Our specific hypotheses include the following.

R.Q.1. Liberian junior and senior high school students were less self-efficacious and would be extrinsically motivated to learn.

R.Q.2. Students preferred rehearsal and organization strategies most, while critical thinking and effort regulation were least preferred strategies.

R.Q.3. Students' motivational belief components showed relationship with strategy use components in learning expedition.

R.Q.4. Poor learning facilities and social media will be the most reported challenges hindering students learning, while worrying about life challenges and distance to and from school are the least factors hampering students learning.

Materials and Methods

Participants

Utilizing a cross-sectional quantitative research design, 323 participants took part in this study. Of the population, 162 were male and 161 female. They were drawn from eight public schools, comprising 182 (56.3%), and 7 private schools with 141 (41.3%) participants from Montserrado and Margibi counties. The schools were selected in consideration with different characteristics of students enrolled. Participants were randomly selected with the participation of exclusively grades 8–12, at most 10 students per class. On purpose, majority of the participants (86.7%) were 9, 10, and 11 grade students between ages 13 to 24 years and above in consideration with their reading comprehension to meticulously and objectively respond to research questions, and time left before they complete high school.

Research Instruments

The Motivated Strategies for Learning Questionnaire (MSLQ), which seems to represent a useful, reliable, and valid means for assessing students' motivation and the use of learning strategies, was adapted and used to establish the motivational component (22 items) and strategy use component (30 items), each using a 7-point scale anchored by "not at all true of me" (1) and "very true of me" (7). Scale scores were obtained by computing the average of the item scores within a scale. The internal consistency reliability coefficients for the whole and sub dimensions scale range from .55 to .92. Besides, 12 widely presumed issues were punctiliously identified which could possibly hamper students learning. Participants were required to rank on the scale of 1 to 12 in order of effect on their schooling, what is/are hampering them the most—1 means very serious effect and 12 not very serious effects.

Data Analysis

To analyze the data, a number of statistical techniques were employed. As it relates to the motivational beliefs and learning strategies of participants, one-way repeated-measures ANOVA was used. Independent samples -test was used to examine if gender differences existed, while correlation analysis was considered to determine the relationship between students' motivational beliefs and learning strategy use. This part of the analyses was conducted using the Statistical Package for the Social Science (SPSS), version 17.0. The factors hindering students' learning were analyzed based on frequency of reports by respondents.

Results & Discussion

Kolaghat Kola Union High School, BOYS – 230

Score	C.I.	Mid. Point	f	Cmf	X'	X'2	$f_{X'}$	fx'2
30 – 40	29.5 – 40.5	35	11	11	-1		-11	11
41 – 51	40.5 – 51.5	46	11	22	0		0	0
52 – 62	51.5 – 62.5	57	11	33	1		11	11
63 – 73	62.5 – 73.5	68	11	55	2		22	44
74 – 84	73.5 – 84.5	79	11	88	3		33	99
85 – 95	84.5 – 95.5	90	14	143	4		44	224

$\sum f = N = 69$ $\sum fx' = 99$

$fx'^2 = 389$ $(\sum fx'^2)^2 = 2.045$

Mean = AM+ $\frac{\sum fx'}{N}$ xi = 46+ (99)/69 x 11

= 46 + 15.78

= 61.78

Median = L + ($\frac{N}{2}$ – Cf)/f X i = 62.5+ ($\frac{69/2-33}{}$)x11

= 62.5 + (34.5-16.5)/69 x11

= 62.5 + 2.871 = 65.371

Mode = 3 x Median – 2 x Mean

= 3x65.371 – 2x 61.78

= 196.113 – 123.56

= 72.553

S.D. = i x $\sqrt{\left\{ \frac{\sum fx'^2}{N} - \left(\frac{\sum fx'}{N}\right)^2 \right\}}$

=11x√ (389/69 – 2.045)

= 11x√ (5.638 – 2.045)= 11x 1.895

= 20.845 Approx

Where, CI = Class Interval,

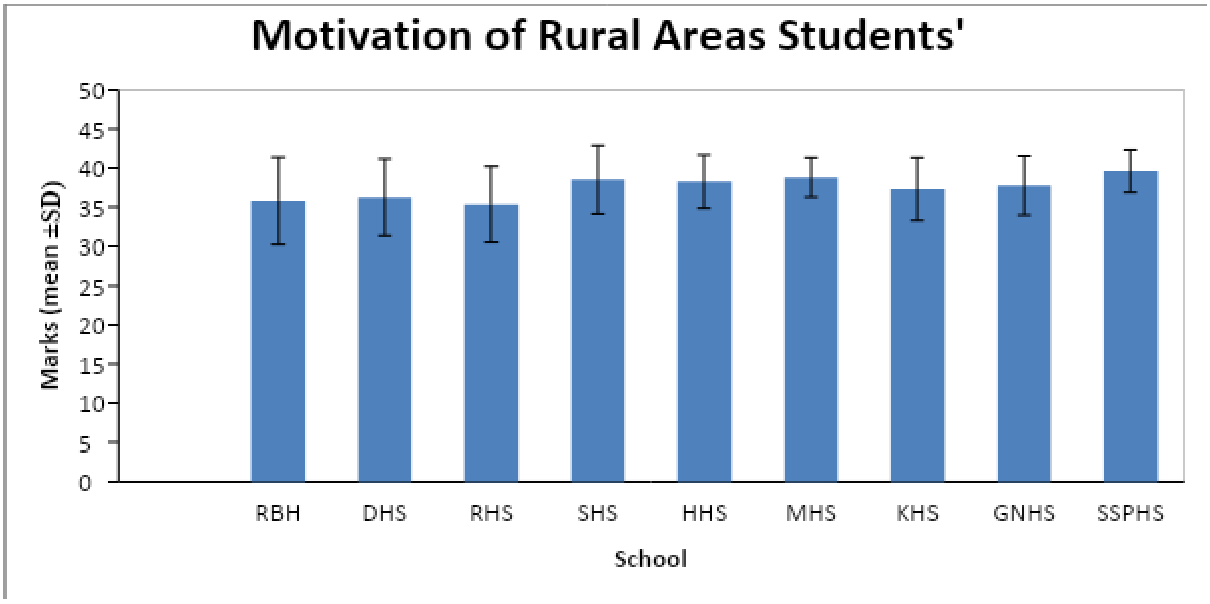
f = frequency,

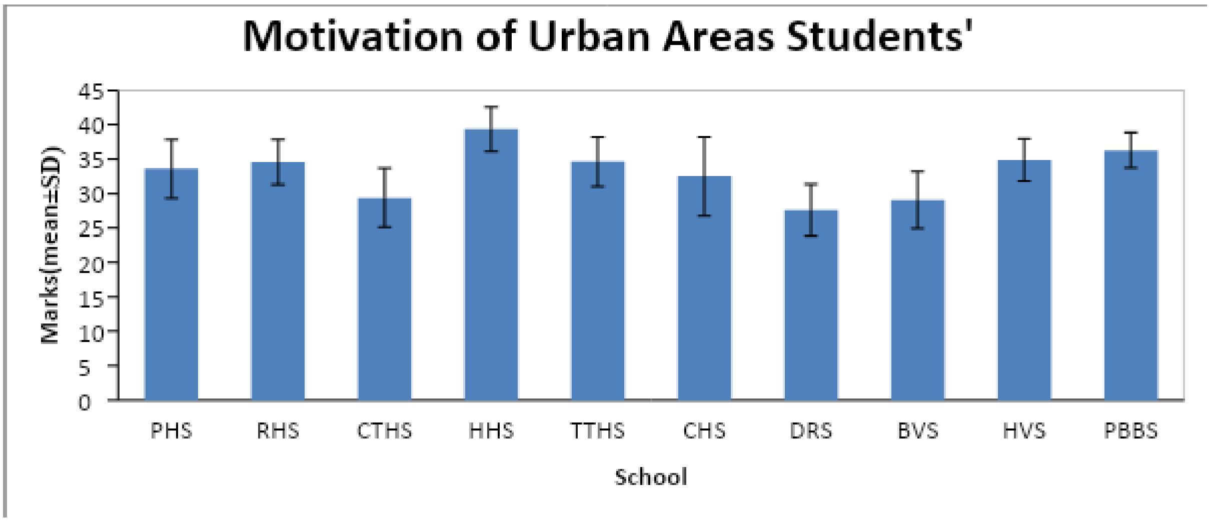
Cf = Cumulative frequency

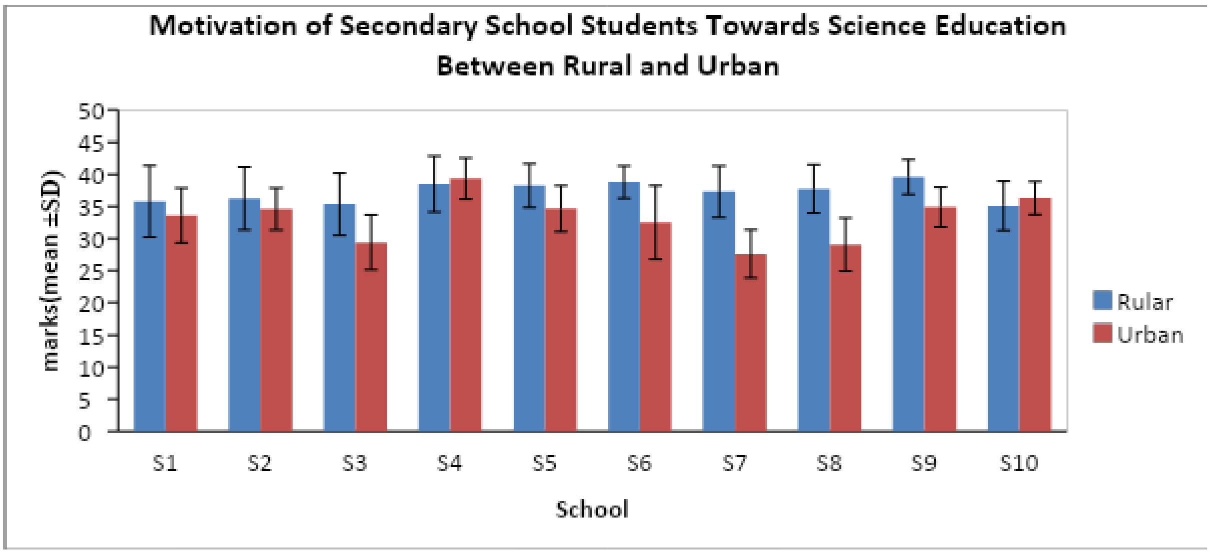
X = mid point

AM= 4 6 and i = 11

X_1 = (x – AM)/i


Motivation of Rural Areas Students'
Marks (mean ±SD)
50
45
40
35
30
25
20
15
10
5
0
RBH
DHS
RHS
SHS
HHS
MHS
KHS
GNHS
SSPHS
School


Motivation of Urban Areas Students'
Marks(mean±SD)
45
40
35
30
25
20
15
10
5
0
PHS
RHS
CTHS
HHS
TTHS
CHS
DRS
BVS
HVS
PBBS
School


Motivation of Secondary School Students Towards Science Education Between Rural and Urban
marks(mean ±SD)
50
45
40
35
30
25
20
15
10
5
0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
School
Rular
Urban

6.3. Students' Motivational Beliefs and Learning Strategy

Motivational Beliefs of Liberian Students for Learning

The means and standard deviations of each of the components were found. Table 1 presents descriptive statistical results on the coefficient alphas, means, and standard deviations of each belief component. Extrinsic goal orientation got the highest mean (M = 5.81, SD = 1.42) and Test Anxiety (M = 4.21, SD = 1.55) obtained the least mean.

Learning Strategies of Liberian Students

Descriptive statistics indicating the means and standard deviations were run, which showed mean differences. Rehearsal strategies have the highest mean (M = 3.84, SD = .85) and affective strategies obtained the lowest mean (M = 3.10, SD = .64). At this point, making straightforward generalized statements about these mean differences seems unrealistic. This is because it remains unclear as to whether the differences reached statistical significance. On this basis, one-way repeated-measures ANOVA was introduced, which confirmed that the strategy components differ significantly as [,].

In addition, it can be clearly pointed out that rehearsal strategies were preferred over effort regulation strategies by participants of the study and this was statistically significant. The significance of the main preferred strategy use (rehearsal) cut across all the components investigated in this study.

The results also pointed out that organization strategies are the second most favoured strategies by participants and they have significant mean differences with all other components, except critical thinking strategies (M = 3.69, SD = .61), and organization strategies (M = 3.70, SD = .79), = −0.004, and peer learning strategies (M = 3.68, SD = .91) and organization strategies (M = 3.70, SD = .79), = 0.023.

Results from the correlation analysis confirmed the existence of both positive relationship (i.e., as one variable increases in value, the other increases also) and negative relationship (i.e., one variable increases in value, the other decreases).

Gender Differences

Female participants obtained higher means forextrinsic goal orientation and rehearsal, the most preferred motivational belief and strategy use in this study, respectively. However, there were slight mean differences for both genders in other beliefs and strategies.

As it can be noticed that female participants reported greater extrinsic, control for learning beliefs, self-efficacy, and test anxiety motivational beliefs. Male students had higher mean differences in intrinsic goal orientation and task value. However, the differences did not reach significance for all motivational belief components.

For strategy use, the descriptive statistics on the mean differences showed slight variations in various strategy use. Unlike motivations, two strategy use components showed statistically significant differences, female participants getting the higher mean for the effort regulation strategies (mean = 3.40, SD = .74) than their male counterparts (mean = 3.02, SD = .90) = −4.445, (2-tailed) = 0.001, and with male participants getting higher mean on peer learning (mean = 3.79, SD = .95) than their female counterparts (mean = 3.58, SD = .86) (323) = 2.064, (2-tailed) = 0.040.

Learning Hindrances

To further deepen our understanding of WB junior and senior high school students apart from their motivational beliefs and learning strategy use, this study sought to generate students' self-reports about factors hindering their learning. From a list of 12 potential factors, students were required to choose, in order of effect, perceived learning hindrances. Results from frequency analyses showed worrying about life challenges (poverty) with 57.9% and access to school (distance to and from school) with 48.9% as the most critical factors affecting students learning. The least reported were peer pressure (going out friends) and video clubs/games with little over 17%.

Gender versus Learning Hindrances

When gender was plotted as a variable relative to these hindrances, female students reported higher effect on their learning for most of the factors in comparison with their male counterparts.

From Table, female students showed significant differences for worrying about life challenges (poverty) (female: mean = 2.02, SD = .98 and male: mean = 1.52, SD = .86) (323) = −4.831, (2-tailed) = 0.001. Additionally, it portrayed significant differences for selling/hustling for daily bread, poor learning environments, none academic related punishments, and distance to and from school in favour of females, indicating that the problems have more adverse effects on their learning as compared to males. However, there was statistically significant difference when it comes to games (phone, computer, and PlayStations) as follows: male (mean = 2.57, SD = .80) and female (mean = 2.18, SD = .99) (323) = 3.78, (2-tailed) = 0.001.

Discussion

Academic performance of WB students has not been satisfactory to many for nearly a decade now. A sizable number of education stakeholders believes inputs in the sector do not commensurate with student attainment in regional exams. Though their judgement might tend to be subjective and relies exclusively on 9th and 12 graders performance in the WAEC exams, it seems apparently logical. As an old age yardstick for assessing students' performance in WB, unremitting falloffs despite increased number of trained teachers with better incentive, built or renovated learning facilities, update-to-date textbooks, and so on in comparison with those of early 2000s are a matter of serious concern. Even though several challenges remain visible in Liberia's education sector, which might still be hampering quality education delivery, much has not been done to delve empirically into underlining factors for the downward trend in WB students' academic performance level.

Capitalizing on the decline of students' performance, the study anticipated that WB junior and senior high school students would be less self-efficacious and would utilize more rehearsal and organization strategies. They were also hypothesized to show limited use of critical thinking and effort regulation strategies. Further, students' motivational belief components were expected to show relationship with strategy use components as well as gender differences in both constructs. Finally, this research projected several factors deeply hampering students' chances to do well in their academics. The findings of this study, no doubt, provide salient insights into the motivation and strategy use of WB students as well as factors hindering their learning and their implications for better student learning outcomes.

The anticipated low self-efficacy for learning and performance hypothesized in this study was confirmed, which was our first aim. Students are found to be more extrinsically motivated, even though they value tasks. This signifies that WB students' quest to acquire education is being influenced by external forces. In other words, it can be explained that their devotion to learning different subjects is because of their desires for rewards and fear of penalty from teachers and parents, and not based on their inner aspirations. This result is inconsistent with a study by Marcou and Philippou who found self-efficacy for learning and performance as the most significant belief for learners.

Possibly, the high extrinsic motivation of students is triggered by their conception of education. Going to school might be viewed as a matter of satisfying parents and avoiding negative chastisements from the community. In some instances, parents are constrained to compel compliance for the younger ones to go to school, giving them negative impression that learning is meant to satisfy them. Even though this is done in good faith, it is not enough to guarantee students' success. Total involvement of parents is highly necessary. This study posits that there is disconnection between parents quest for their children to attain quality education and their corresponding involvement into children academics, which could be attributed to high illiteracy rate and purported busy schedules of educated parents.

Many parents are not fully involved in their children's learning and see it as a responsibility of the school. This is evident through their nonparticipation in some parent-teacher association activities including meetings. Another factor for students reporting more extrinsic motivation could be as a result of high emphasis being placed on grades. Teachers often consider results from quizzes and tests as the only criterion for judging students' mastery of contents and their abilities to perform better in academic and non-academic environments. Consequently, students are more interested in getting better test scores because they consider these scores to be the best rewards and a show of academic fulfilment, which in the long run adversely affects their disposition to perform well. As noted by Pintrich, Bandura advises students to believe that they are able and that they can and will do well in order to have better changes of remaining motivated in terms of effort, persistence, and behaviour. Thus, quality teachers are critical in shifting students learning in a better direction and they need to consider learners' motivation and cognition.

Despite high extrinsic motivation displayed, participants showed seemingly high task value and low test anxiety, which are healthy for improved learning outcomes. This means, WB students current performance is not as despicable as it may be perceived because they used a variety of motivational beliefs as well. Hence, there are good prospects and big room for improvement.

The second aim of this study was to determine the strategy use by WB junior and senior high school students. As hypothesized, students preferred rehearsal and organization strategies. Meaning, participants are mostly interested in repeating the words over and over to themselves to help in the recall of information (rehearsal) and they make much effort to organize learning, for instance, outlining and creating tables, which fall in the category of cognitive learning strategies. This finding is consistent with the extrinsic motivation of students displayed because they tend to memorize notes to pass exams. In addition to the extrapolations, wide use of rehearsal strategies might be influenced by teaching strategies employed in the classrooms. If teachers are not adequately contextualizing and simplifying complex information from abstract to concrete, students may resolve to memorizing and reproducing during exams. On the other hand, this study also finds students help seeking strategies to be the least utilized as they insignificantly report seeking help from peers or instructors when needed, not focusing much on the use of others in learning. Such thing might be hampering their chances of progressing deeply in their learning pursuits as it is necessary ingredient for academic success. Accordingly, students must be motivated to muster courage to solicit assistance whenever necessary.

Moreover, the relationship between motivation and strategy use by participants was confirmed with both positive and negative correlations, indicating how vital motivation is to the kind of strategies used by learners. This is supportive of exposition that the presence of motivation prompts the use of different types of strategies by learners. This finding is overwhelmingly supported by a number of previous studies and increases our comprehensibility of motivational beliefs and strategy use. Based on the way motivational beliefs influence or show relationship with strategy use in this research, coupled with the available literature, it is argued that motivational beliefs and strategy use are "inseparable academic twins." In this context, the two constructs cannot be separated or one completely goes without the other as students get involved in academic rituals. Motivation can be equated to being a bridge, and strategy use entails walking on the bridge. Therefore, motivation and strategy use relationship must be considered by teachers and school administrators and actions must be employed to suit them. Because when the motivation of students is detrimentally affected, it would have reciprocal effect on students and their learning outcomes.

Relative to gender roles, female participants reported greater extrinsic, control for learning beliefs, self-efficacy, and test anxiety, while male participants had edge when it comes to intrinsic goal orientation and task value. But these differences are infinitesimal as they failed to reach statistical significance for all motivational belief components. We can postulate that motivational beliefs are not ultimately determined by gender. However, this contravenes previous studies that male and female students have significant differences in test anxiety, self-efficacy, and self-regulated learning. The trend of motivation was taken by strategy use, but with a slight difference as two strategy use components (effort regulation and peer learning) were statistically significant in juxtaposition with gender in favour of female participants. Accordingly, females exhibited persisting in the face of difficult or boring tasks (effort regulation) as well as appreciating more learning and using a study group or friends to help learn (peer learning) as compared to their male counterparts. This result is captivating and it is a testament of enormous efforts being put in by education stakeholders to promote enrolment, retention, and completion rates of females aimed at closing gender disparity in WB's education sector.

One of the most fascinating findings of this study reveals worrying about life challenges (poverty) and access to school (distance to and from school) as the most perilous factors confronting WB junior and senior high school students' learning. This rejects our hypothesis that poor learning facilities and harassment were going to top the list of learning hindrances. Although the finding seems puzzling, it obviously conforms to entrenched high rate of poverty among the Liberian populace. BTI reports that over two-thirds of the population live in extreme poverty, defined as less than Rs 1.25 per day. This conceivably indicates that some students go to school hungry and without small cash for recess. Besides, some students have to cater for themselves, including paying some associated costs of education. The perceived uncertainty about the future might also be a source of reported worries by participants. Because of high harmful nature of worries (poverty) to academic performance, Capra urged authorities to "treat poverty, a condition that erodes our future and impedes any attempts at educational reform."

Since gender remains an important phenomenon in WB's education sector, factors affecting students learning were examined in line with gender. Somewhat surprisingly, females reported that nine out of 12 factors have serious negative impact on their learning. This was even statistically significant for worrying about life challenges (poverty) and others, in comparison with male counterparts. Harassment in schools, which is said to be an issue, was among hindrances highly identified by females. Unexpectedly, harassment as a hindrance to learning did not reach significance level for both genders. It is assumed that this is because harassment in this study was treated generally, and it was not limited to sexual harassment, which could be experienced by male students as well. Cognizant of the fact these learning hindrances have more serious consequences for girls' education, addressing these challenges would go a long way in increasing girls' chances for enrolment, retention, and completion. For instance, addressing poor learning conditions, including ensuring good water and sanitation in schools, is strongly needed to heighten girls' chances of staying in school.

CHAPTER-VII

7.1. Conclusion and scope of future Research Work

This research has provided valuable contributions to literature. It has increased our knowledge about the types of motivational beliefs and learning strategy use by WB junior and senior high school students and how these beliefs and strategies have implications for their academic performance. Specifically, we have been able to establish the stimulating forces (beliefs) and mechanisms (strategies) propelling their progression or retrogression in learning various subjects at school. At the same time, we juxtaposed the belief and strategy constructs as well as investigated participants' genders in the framework of motivational beliefs and strategy use for learning. Furthermore, the research enabled students to identify potential hindrances to their learning in order to derive a way of alleviating the challenges. Drawing from the findings, this study offers a number of conclusions, vital for teaching, learning, and policy-making, particularly in WB.

The following are conclusions of this research.

(1)WB junior and senior high school students possess various motivational beliefs in their quest to acquire education. But they are extrinsically motivated, focusing on rewards and penalties, despite valuing their tasks and being less anxious.

(2)Rehearsal and organization strategies are of priority to students as they make strides to progress through the academic ladder of high school. Nevertheless, help seeking strategies for asking for assistance from peers or instructors when needed remain the least strategy component considered.

(3)WB students with good level of motivational beliefs are capable of using numerous learning strategies.

This is, however, contingent on the sort of beliefs they hold. Learners with greater amount of beliefs such as extrinsic and task value are more likely to use strategies including rehearsal and organization. Being a male or a female does not give any WB junior or senior high school student outright advantage. Both males and females can possess different types of beliefs and strategies for learning. Such equitability does augur well towards curbing gender disparity, especially at senior high school level in WB. In spite of efforts being made, students are confronted with serious challenges that might be affecting their academic achievement levels. Students are worried about life challenges (poverty) and future uncertainties. Getting to and from school remains a paramount challenge. Contrary to presumptions, peer pressure (going out with friends) and video clubs/games have less significant effect on students' learning. Learning hindrances are having more negative blunts on female students. Alleviating these challenges including poor learning facilities would foster increased girls' enrolment, retention, and completion rates in the WB school system.

Generally, this study concludes that the performance of WB junior and senior high students is moderate in consistence with prevailing learning conditions, and there is a strong need for a paradigm shift to provide the quality of education fervently deserved and desired for all WB children. Hence, a number of recommendations and implications for action and future research are proffered. Based on the significant role of motivation recognized in this study, teachers need to focus keen attention on motivating their students to promote their self-efficacies, always urging students to believe in their abilities to do well, and they (teachers) must also believe in their students. They must also ensure that students learn to ask for assistance whenever necessary. The implication is that if learners are not motivated to enable them to believe in themselves and ask for help, it could affect their dispositions for lifelong learning and their capacities to succeed in various difficult life situations. Teachers must be trained to integrate the essence of motivational beliefs and the need for students to use all kinds of strategies during instructions.

In addition, teachers should assist their students to clearly understand the need for them to build up beliefs like task value, self-efficacy for learning and performance, intrinsic goal orientation, and control for learning beliefs as well as use of critical thinking, effort regulation, and peer and help seeking strategies to enhance their learning process. For instance, teachers can promote students' task value for lessons by stressing the value of education to students' future. Student evaluation must be meticulous and holistic. Emphasis must not only be placed on grades or rewards as the surest way to academic success, but it must also consider other skills and talents of students. Pupils must be repeatedly reminded to learn for their own good and the good of the society; hence, there is no need for bribery and other academic malpractice to get higher scores. Abolition of fire list in schools is recommended. WB government through the Ministry of Education and partners must intensify efforts to alleviate various problems confronting students including worries about life challenges (poverty), access, poor learning facilities, and harassment in schools. Recreational, school feeding, transportation, continual improvement of schools, and stringent measures against harassment must be assertively supported. Government through the Ministry of Education should make efforts to train and employ more school counsellors and psychologists to motivate, guide, and mentor students to remain focused and purposeful in their academic pursuits. Parents must desist from using children as breadwinners; National Government is recommended to compel compliance. Besides, parents must limit workloads given to school going age children and provide sufficient time for them to study their lessons. Effort must be made by both educated and uneducated parents to make time to support their children's learning at home.

There is a glaring need for the WB government (Ministry of Education) and partners to undertake or fund systematic research projects (research commissions) to promote better understanding of WB's education challenges and prospects. Not-for-profit WB research institutions like free India, higher education entities, and scholars should be supported morally or financially to routinely conduct empirical research projects in the country and disseminate findings thereof.

Interventions in the education sector must be backed by empirical evidence to enhance possibilities of programs success. Policy-making and programs must be informed by these research findings, and not by mere intuitions or presuppositions.

Finally, despite budgetary constraints, the WB government must annually endeavour to augment its education budget to enable the Ministry of Education to transcend from just paying education staff at central and decentralized levels to funding meaningful education programs that stimulate quality teaching and learning in schools.

Limitations and Future Research

Since this study only focused on WB junior and senior high school students from two counties, results cannot be generalized to other counties. Similar further study is recommended, taking into consideration students from a number of counties with increased sample size preferably focusing on the most vulnerable counties in Southeastern India. Furthermore, this research did not consider all strategy use components by students. There is a need for a study that considers all strategies including metacognitive strategies. Furthermore, this study was unable to get test/exam scores of participants in order to correlate their self-reports with their academic achievements. This could have led to making more generalized and conclusive statements about beliefs and strategies in relation to academic performance of WB students. Therefore, future study must consider such combination of both students self-reports and their academic achievements.

Conflicts of Interest

The authors hereby wish to declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Professional development that focuses on improving teaching through inquiry achieves several simultaneous objectives:

*i)*It provides teachers with learning experiences different from the more traditional college course or inservice workshop to include one-on-one experiences such as coaching, collaborative work such as study groups, and "job-embedded" learning such as action research.

*ii)*It focuses on important aspects of teachers' practice, including the organization and presentation of curriculum, student work, and teaching dilemmas.

It helps teachers think carefully about how their students come to understand important science concepts through inquiry, what help their students need in developing the specific abilities of inquiry, and what learning experiences can make the work of scientists "real" to their students.

. Coordinated efforts are required throughout the process of assessment development, including defining the construct, designing the assessment, pilot testing and field testing to evaluate the psychometric quality of the assessment items and establish scales, setting standards to determine the proficiency levels, and researching validity. An assessment will also likely undergo iterations for improved validity, reliability, and connections to general undergraduate education. With the proposed framework for a next‐generation critical thinking assessment, we hope to make the assessment approach more transparent to the stakeholders and alert assessment developers and score users to the many issues that influence the quality and practical uses of critical thinking scores.

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