# Self Assessment and Discovery Learning

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*Abstract*

Discovery learning in higher education has been reported to be effective in assisting learners to understand difficult concepts and retain long term information. This paper seeks to illustrate how one self assessment model may be used to demonstrate discovery learning in a collaborative atmosphere of students sharing and getting to know each other. Three research questions were posed to drive the research. A researcher designed instrument was used as the pre activity instrument with which the students worked in collaboration with presentations and break our group activities supported by trained proctors. Results indicated that participants experienced the discovery process through the medium of the designed model. They reported learning to work in a collaborative atmosphere where they appreciated and respected each other. This researcher hopes to stimulate readers to experiment with different models for demonstrating discovery learning.

**Keywords**: Discovery learning, self assessment, concepts, collaboration.

*Introduction*

Educators are forever seeking new pedagogic strategies that could improve teaching and enhance learning. Effective pedagogic practices are always welcomed by the academic community. Discovery Learning (DL) oftentimes referred to as inquiry-based learning is premised on the '*Aha Aha'* technique where the learner discovers for himself a principle while performing an activity. It is similar to Archimedes' shout of 'eureka' (I have found it!) when he discovered that his mass displaced an amount of water equal to his volume. More importantly, affective education (a growing field of enquiry) supports DL.

Duze (2011) posited that falling standards in education in Nigeria could be linked to skills-acquisition at school. He contested that poor quality output is a result of lacking skills in any production system and claims that this undermines nation capacity building and sustainable development. Using a sample of 522 subjects: 42 government officials, 61

employers of labour, 87 parents, 203 teachers, and 129 students in a survey done in Warri metropolis of Delta State he discovered that at all levels education standards were falling as a result of inadequate skill acquisition primarily due to poor implementation of school curricula. Duze (2011) used development indices and practices in implementing Nigeria's school curricula in an effort to determine if education standards were falling and what accounted for observed poor quality education at all levels. As a way forward he recommended a remedial package entailing rejuvenation of educational objectives and routes to implementation and utilization of research findings to improve upon educational practices in an effort to provide better outcomes.

This present paper picks up on this notion of falling educational standards and inadequate skill acquisition resulting from poor implementation of school curricula and seeks to present discovery learning as a viable alternative. To accomplish this the researcher seeks to illustrate the meaning of self assessment through an activity that is meant to have learners of higher education experience the *'Aha Aha'* moment as they find out for themselves what is involved in self assessment. Compared to merely providing learners with information, it is hoped that through discovery learning, using self assessment skills, learners would internalize fundamental concepts. The method is extremely powerful and effective especially since it is virtually impossible to formally teach an individual every thing s/he needs to know. Exposing learners to structured experiences as they are skillfully guided along from their prerequisite learning enables them to maximize on the benefits to be accrued from the discovery learning experience.

*Literature Review*

Not only have well known educators like Dewey, Rousseau and Pestalozzi postulated discovery learning as an integral part of their philosophical stance but learning

theorists and psychologists like Bruner and Piaget have supported the experience. The learner is presented with a scenario, perhaps through an activity that allows him to use his prior and present experience in a constructivist learning environment, to explicate a learning issue. Oftentimes the activity is embedded in a problem solving situation that demands certain inquiry skills focused on the learning issue. The teacher facilitates the process by carefully enabling the steps of the process to systematically follow each other in a methodical manner. The learner is forced to keep account of the information discovered and use that information in next steps until the end has been arrived at.

Discovery learning is 'an approach to instruction through which students interact with their environment-by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments' (Ormrod, 1995: 442). Learners of higher education may explore in countless environments including virtual ones. Simulations may be used. The entire process is interactive and learners may collaborate with each other creating a synergistic environment where learning becomes a pleasure. Accelerated learning takes place easily as learners have the opportunity to move at their own developmental pace and ability. Monotonous, information-loaded material could be transformed into pleasurable information through DL. Madden (1992) has expounded seven principles of accelerated learning that reinforce powerful concepts and make learning a fun activity (http://www.discoverylearning.co.uk). He posited that learning needs to match how the brain works, learning needs to be presented in a variety of ways, successful learning principles apply the principles of memory, successful learning is active experience totally involving the learner, learners learn what they want to learn, laughter lubricates learning and finally learning is a social experience. Many of these principles are used in the business community.

Many experts have attested to the value of DL.

> '… The discovery learning mode requires that the student participates in making many of the decisions about what, how, and when something is to be learned and even plays a major role in making such decisions. Instead of being 'told' the content by the teacher, it is expected that the student will have to explore examples and from them 'discover' the principles or concepts which are to be learned. Many contend that the discovery learning versus expository debate continues a timeless debate as to how much a teacher should help a student and how much the student should help himself.' (Snelbacker, 1974: 425).

More importantly, DL in higher education fosters a spirit of inquiry as learners are encouraged to ask questions and formulate their own tentative answers. Both inductive and deductive reasoning skills are honed as learners have hands-on experience with practical situations in a comfortable friendly atmosphere. Learners learn to formulate their own hypotheses and test them as the facts come to light during the course of their experiments or experiential adventures. Learners learn to be flexible to accommodate new information. The method stimulates independence and interdependence simultaneously as learners independently think through situations and discuss with each other in a spirit of camaraderie.

Learners construct their own knowledge as they experiment with a domain, and make inferences or rules from the results of their experiments. Learners take ownership of their material because they are free to construct their own knowledge as they design their own experiments in the domain and infer the rules of the domain themselves. Inevitably, one assumes that because learners can construct their own activities they are better able to comprehend the domain at a higher level than when a teacher merely presents the necessary information in an expository manner. Specific skills like hypothesis generation (generate new knowledge and ideas), experiment design, prediction, data analysis, planning, monitoring and time management are required if DL is to be successful.

Joolingen (1999) posits the use of cognitive tools defined as 'instruments that support or perform cognitive processes for learners in order to support learning' that can bridge the difference between discovery learning environments and traditional environments. Cognitive tools are included in a learning environment to allow learners to make cognitive processes, like discovery skills, and their results explicit. They have intended and unintended effects on the discovery learning processes as they influence the way discovery processes are carried out and the learner's freedom. Open learning environments that characterize discovery learning differ in numerous respects to supportive instructional environments to which the average student is accustomed. Joolingen (1999) believes that cognitive tools could serve as 'hooks for anchoring intelligent instruction'.

In this context, Joolingen (1999) designed a hypothesis editor that uses a scratchpad to assist learners to relate their variables *via* selected relations to an authentic hypothesis. In this manner the learner has the advantage of gaining from the DL experience compared to another who has no idea where to begin the process. Basically, the cognitive process of hypothesis formation is constrained by the expressions that a learner could state as a hypothesis. Further, the learner is able to view the contents of hypothesis. The notebook-like screen structures the statements that the learner can make attempts to have a valid hypothesis. Operationally, the learner has a template for a hypothesis that he can fill in with variables and relations.

Another of Joolingen's (1999) cognitive tools is a monitoring tool that keeps track of the experiment. Whilst the hypothesis scratchpad is predominantly proactive as it stimulates the learner to explore various aspects of a hypothesis, the monitoring tool is reactive because it is activated after the learner does experiments. What it does is that it assists the learner's memory by providing a summary of that part of the experiment space

that has been searched. There are numerous issues regarding design that may be integrated into cognitive tools in a discovery environment. These are outside the scope of this present paper.

Challenging the superiority of DL over direct instruction with specific focus on early scientific investigations by children, Klahr and Nigam (2004) measured the relative effectiveness of DL and direct instruction at two points in the learning process of 112 third and fourth graders. They focused on the initial acquisition of a basic cognitive objective involved in the design and interpretation of simple experiments and the subsequent transfer and application of the basic skill to more 'diffuse and authentic reasoning associated with the evaluation of science fair posters.' The researchers found that many more children learned from direct instruction than from DL. Additionally, those exposed to direct instruction performed as well as the few children who learned from DL when asked to make broader, richer scientific judgments.

Like with any other method of learning there are disadvantages and advantages just as there are supporters and critics for any innovation. Without a carefully thought –out framework for scaffolding the learner's thoughts and actions there could be chaos, disillusionment, frustration, confusion and time wasting. On the other hand, with a carefully planned framework, learners experience an enhancement in their prior knowledge and understanding. Active engagement in the learning process encourages learners to internalize concepts that would normally be difficult to grasp. Besides, developing life long learning skills, discovery learning promotes curiosity (Martin, 2000), an essential ingredient in discovering innovative methods. The learning experience is customized or personalized and serves as a means of self motivation as learners have autonomy and freedom to explore

(http://www.csd.uwa.edu.au/altmodes/to_delivery/discovery_learning.html). Several other Internet sites, for example http://school.discovery.com/, offer numerous suggestions on discovery learning that are quite instructive for the practitioner.

This present paper seeks to introduce a self assessment model that may be used to demonstrate the process of discovery learning. Self assessment has been defined as 'the involvement of students in identifying standards and/or criteria to apply to their work and making judgments about the extent to which they have met these criteria and standards' (Boud, 1986: 5). Three steps to the self assessment process include (1) the autonomous identification of commonly acceptable standards and/or criteria that pertain to the learner's work (2) application of those identified standards and/or criteria to the learner's work (3) making a judgment that clearly indicates the extent to which the learner has met the identified standards and/or criteria that were applied to his or her work. Two key elements essential to every assessment (whether conducted by teacher or learner) are (1) development of knowledge and an appreciation of appropriate standards and criteria for meeting those standards (2) capacity to make judgments about whether or not the work involved does or does not meet these standards (involves critical thinking), Boud (1986). These two key elements necessitate a desire for achievement and a clear understanding of what is entailed in the process. Testing/grading one's own skills/work is but part of the process of self assessment. Evaluating what is good, mediocre or poor work in any given situation is another essential part of the process.

As an instructional tool or an aid to instruction, students may self assessment for their own formative evaluation. Students may evaluate or monitor their own level of knowledge, performance and understanding in a metacognitive framework that takes into account the contexts in which that self assessment occurs. The individual has to

make an informed assessment of his or her own work, with an appreciation for and the understanding of those concepts of quality upheld and practised by the adjudicators of his or her work.

By its very nature self assessment, like discovery learning, is also a social activity that occurs in situations that are normally social and collaborative and frequently with others who are more expert than the self assessor. Self assessment does not occur in isolation because the self has very little meaning unless it relates to others (Van Krayenoord and Paris, 1997). Relationships with peers, significant others and teachers is an integral part of the process. Accordingly, the reliability and validity of scores from self assessment activities are formulated in relation to social interactions with assessments of peers, significant others and teachers, as well as in relation to standards and/or criteria. It is reasonable to understand that before students can decide on acceptable standards and/or criteria or for their work they must use some reliable and valid forms of reference by which they could be confident that the standards and/or criteria they propose to use to make acceptable judgments about their work are *'universal'*, as far as it exists within their locus of control.

Discovery learning and self assessment, especially in higher education, share qualities like interactivity, collaboration, assertive communication, discovery, introspection, reflection and social relations that involve the self and others in relation to standards and/or criteria. Past, present, and future perspectives are interrelated. Discovery learning and self assessment involve reflecting on past achievements, critically evaluating present performance and planning future goals. In this scenario, the teacher serves as facilitator, friend, fellow learner and partner and not as instructor or director. Educational goals underpin the questions and students are led, at different levels, to a realization of

these goals. Oftentimes the questions that teachers ask students become models for questions that learners ask themselves during discovery learning and self assessment.

It is not difficult to appreciate that discovery learning and self assessment emphasize high levels of thinking; metacognitive thinking; self-reflective thinking; self-regulated thinking; goal directed learning and preferred learning styles. The learner comes to the table with his preknowledge of the issue at hand and is not presented with instant ready-made answers but is allowed to, step-by-step, unravel nuggets of truth as he explores his environment. Cognitive, affective and psycho-motor skills are employed in harmony. Students are afforded the luxury of moving at their own developmental pace and need not be in competition with each other. They can plan future goals to suit their personal needs as they journal information systematically. Clearly, teacher expertise in portfolio and authentic/performance assessment is helpful.

Throughout the process of DL and SA, the learner must have realistic knowledge about the self in relation to educational goals. The learner often *asks "How am I doing?", "How can I do better?"* (Sekula, Buttery and Guyton, 1996). Bourke and Poskitt (1997) posit that students learn to compare and contrast their work with models and against a set of standards and/or criteria. For this reason, it is essential that students have some knowledge about what they are attempting to discover or achieve before they commence the task. Additionally, it is helpful for the student to have an understanding of the standards of performance, competence that can be applied, knowledge of what he or she is trying to achieve, and be able to compare his or her own performance to that standard.

*Research Questions*

Accordingly, the following three research questions were posed in order to drive the study:

(1) How can a self assessment model be used to demonstrate the process of discovery learning?

(2) How can a self assessment model be used to demonstrate learning in a collaborative atmosphere?

(3) How can a self assessment model be used to create an atmosphere where learners get to know each other?

*Methodology*

Using the aforementioned theory as a guide to undergird the study, and bearing in mind that the objective of this present paper was not to compare discovery learning with direct instruction, this researcher designed a one page exercise (Appendix 1). This served as a pre activity to a Power Point presentation that was part of the varied activities of a workshop on self assessment. One hundred and twenty participants from four campuses of a university attended the workshop.

A number of theoretical underpinnings and deep principles underlie the development of the instrument (Appendix 1). The roots of discovery learning are embedded in Dewey's (1933) and Piaget's (Gredler, 2001) constructivist theories: learners make their own sense of knowledge, continually receiving it and interpreting it and connecting it to previous knowledge (Herman et al, 1992). Knowledge is personally and socially mediated as the proximal zone of proximal development (ZPD: gap between what the learner can do without help and what he can do with help) narrows (Vygotsky, 1978). Hence this researcher provided participants with experiences that were within their ZPD in an effort to encourage and advance their individual learning. This meant that rather than providing

learners with academic, knowledge-based exercises to gauge their intelligence and examine what they know in order to determine intelligence this researcher found it better to examine the learner's ability to independently solve problems and their ability to solve problems with the assistance of a facilitator.

The interaction between facilitator and learner provided scaffolding: a process through which the facilitator provides necessary assistance to the learner in his ZPD while tapering off this assistance as it proves unnecessary. It is similar to the manner in which a scaffold is removed bit by bit from a building during construction. Hence, focused questions and positive interactions are hall marks of the interaction between facilitator and learner. As the sequence of activities progress the learner's interactions lead to structural changes in their thinking tings through as they accommodate and assimilate new information (Gredler, 2001). We see the organization of knowledge in mental models, knowledge structures or schema (Herman, et al, 1992) ass the activity progresses from a single personal idea to a shared idea with a neighbor to an idea shared with the entire group. Throughout the deliberating process reflection underlies the processes offering the learner sufficient time to make adjustments and move on.

The one pager was presented in Ariel font style that made it user-friendly because of the roundedness of the lettering. Bold, italics, block lettering emphasized key words that allowed participants to easily cue in on essential instructions. A basic graphic of a man with outstretched arms beaming with rays around his head provided participants with a sense of relaxation. Following the caption 'Measurement, Assessment and Evaluation Activity' four questions enclosed in a rectangle allowed participants to focus their thoughts on the purpose of the exercise. Five student-centred objectives were identified so that

participants knew exactly what was expected of them at the end of the exercise. Those learning objectives were to stimulate interest in measurement, assessment and evaluation, to connect theory of measurement, assessment and evaluation to practice, to have a practical hands-on example of a measurement, assessment and evaluation exercise, to understand the key competencies identified in measurement, assessment and evaluation and to demonstrate discovery learning. Both verbally and in writing, this researcher thanked participants for their kind cooperation at the end of the exercise.

The participants were divided into breakout groups according to their areas of teaching (Engineering, ICT and Education). Each participant was asked to write one idea he had about each of the terms: measurement, assessment and evaluation. Following this he was asked to exchange his idea with his neighbour (Measurement, Assessment and Evaluation activity on page 12). Throughout the exercise this researcher ensured that all participants were keeping in pace with the activities by repeating steps very slowly, answering questions and allowing for discussions and quiet times for concentration and reflection. Ten proctors assisted in the process by moving around the auditorium assisting participants. This researcher answered several queries and generally overseered the process in addition to conducting a number of semi-structured interviewes.

In pairs, participants mutually agreed on a common idea for each of the three terms presented. That common idea for each of the three terms presented was noted on a flipchart available. Using the pairs of mutually agreed ideas displayed on the flipchart each group of six members was required to discuss until they agreed on one common idea for each of the three terms presented. Following this, each individual was asked to rate the personal ideas he initially wrote down against the mutually agreed idea of the group. A scale of 1 to 10 was used, where 1 represented urgently needing assistance and 10 represented excellent. The process was iterative until consensus was arrived at. A general group discussion followed and the researcher noted salient features of the process. Throughout the exercise using Appendix 1 this researcher checked the work of participants' reports to ensure that they were accurately reporting exactly what had transpired; mental processes, attitudes, collaborations and other observations.

*Results*

The following table provides information regarding the demographics of the sample under study with respect to sex and age cohort.

Table 1 Demographics of sample

| | | **Number of Respondents** | **Percentage (%)** | **Cumulative %** |
|---|---|---|---|---|
| **A** | **Sex** | | | |
| 1 | Female | 84 | 70 | 70 |
| 2 | Male | 36 | 30 | 100 |
| | **Total** | **120** | 100 | 100 |
| **B** | **Age Cohort** | | | |
| 1 | 18 - 25 yrs | 65 | 54 | 54 |
| 2 | 26 - 30 yrs | 30 | 25 | 79 |
| 3 | 31- 40 yrs | 16 | 13 | 92 |
| 4 | > 41 yrs | 9 | 8 | 100 |

| | | | | |
|---|---|---|---|---|
| | **Total** | **120** | 100 | 100 |

From the analysed data 65% of workshop participants appeared to be between the ages 18 – 30 years, comprising predominantly of female students (84%) (Table 1). Less that 10 % of the workshop participants exceeded 41 years. There were about half (30%) as many 26-30 year old as there were 18-25 year olds (Table 1).

**Research Question 1: How can a self assessment model be used to demonstrate the process of discovery learning?**

Using (Glaser and Strauss', 1967) unitizing and categorising methods of qualitative analysis information gleaned from semi-structured interviews with workshop participants were categorized and coded according to commonalities. Responses obtained indicated that there were various ways in which the model could be used to demonstrate the process of discovery learning. Table 2 summarises the observations.

Table 2 Respondents' views on how the model could be used to demonstrate the process of discovery learning

| **Coded Reason** | **Respondents' views on how the model could be used to demonstrate the process of discovery learning** | **Number of Respondents** | **Percent %** | **Cum Percent %** |
|---|---|---|---|---|
| R1.1 | Movement to next step without prior knowledge | 50 | 42 | 42 |
| R1.2 | Gradual removal of scaffolding | 20 | 17 | 59 |
| R1.3 | Series of searching questions posed | 35 | 29 | 88 |
| R1.4 | Encounter inconsistent feedback | 15 | 12 | 100 |
| | **Totals** | 120 | 100 | 100 |

Note: N = 120. Response totals may not add to 120 since some respondents cited more than one reason for each category. Percentages are rounded to the nearest whole number.

Just under a half of the sample (42%) felt that having to move to the next step without having prior knowledge, as is customary, was one way of demonstrating the process of discovery learning because participants were forced to think for themselves and venture ahead in spite of what may be considered inadequate information. Close to one third of participants (29%) thought that a series of searching questions imbedded in the discovery process allowed participants to think ahead and discover for themselves important principles. Gradual removal of scaffolding and encountering inconsistent feedback were also cited as successful contributors to discovery learning exemplified by the model used (Table 2).

Table 3 Respondents' views on how the model could be used to demonstrate the process of discovery learning **by sex**

| **Coded Reason** | **…demonstrate the process of discovery learning** | **% Percentages** | |
|---|---|---|---|
| | | Male | Female |
| R1.1 | Movement to next step without prior knowledge | 19 | 81 |
| R1.2 | Gradual removal of scaffolding | 41 | 59 |
| R1.3 | Series of searching questions posed | 46 | 54 |
| R1.4 | Encounter inconsistent feedback | 29 | 71 |

Note. Percentages rounded to the nearest whole number.

The distribution of males and females with respect to their perceptions on the success of the model (Appendix 1) is presented in Table 3. Whilst similar percentages of males and females (46%, 54%) considered that a series of searching questions posed facilitated discovery learning four times as many females (81%) as males (19%) thought that movement to next step without prior knowledge was key to model success (Table 3).

Table 4 Respondents' views on how the model could be used to demonstrate the process of discovery learning **by age cohort**

| **Coded Reason** | **…demonstrate the process of discovery learning** | **Age cohorts (yrs)** | | | |
|---|---|---|---|---|---|
| | | **Percentages /%** | | | |
| | | 18- 25 | 26- 30 | 31- 40 | > 41 |
| R1.1 | Movement to next step without prior knowledge | 14 | 67 | 7 | 15 |
| R1.2 | Gradual removal of scaffolding | 71 | 5 | 10 | 7 |
| R1.3 | Series of searching questions posed | 12 | 19 | 16 | 65 |
| R1.4 | Encounter inconsistent feedback | 3 | 9 | 67 | 13 |

Note. Percentages rounded to the nearest whole number.

There appeared to be a -------- distribution among the age cohorts with respect to their views on the success of the model in fostering discovery learning. The older workshop participants (> 41 years: 65%) were very much in favour of asking a series of searching questions to draw out information and aid discovery learning. Younger participants favoured gradual removal of scaffolding to facilitate discovery learning (Table 4).

Table 5 Respondents' views on how the model could be used to demonstrate the process of discovery learning by **age cohort by sex**

| | Respondents' views on how the model could be used to demonstrate the process of discovery learning by **age cohort by sex** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | R 1.1 Movement | | R 1.2 Scaffold | | R 1.3 Questions | | R 1.4 Feedback | |
| Age/ yrs | M | F | M | F | M | F | M | F |
| 18-25 | 18 | 82 | 35 | 65 | 19 | 71 | 37 | 73 |
| 26-30 | 40 | 60 | 27 | 73 | 10 | 90 | 31 | 69 |
| 31-40 | 36 | 64 | 23 | 77 | 28 | 72 | 41 | 59 |
| > 41 | 29 | 71 | 41 | 59 | 42 | 58 | 20 | 80 |

Note. Percentages rounded to the nearest whole number.

Table 5 summarises the distribution of views supportive of discovery learning with respect to sex and age cohort. A cursory look demonstrates that generally there were more females than males overall. All age cohorts to varying extent agreed that movement to next step without prior knowledge; gradual removal of scaffolding; use of a series of searching questions posed and encounter inconsistent feedback were useful in demonstrating the process of discovery learning. Whilst 82% females in the age cohort 18- 25 considered movement to next step without prior knowledge as useful for discovery learning only 18% males shared that view. The majority of males (40%) in the age cohort 26-30 years took a similar stance. It was significant that four times (80%) as many females as males (20%) in the > 41 year old age cohort felt that encountering inconsistent feedback was useful in promoting discovery learning (Table 5).

**Research Question 2: How can a self assessment model be used to demonstrate learning in a collaborative atmospher**e?

Using (Glaser and Strauss', 1967) unitizing and categorising methods of qualitative analysis workshop participants offered responses to indicate that there were various ways in which the model could be used to demonstrate learning in a collaborative atmosphere. These ways included information sharing; teamwork; arriving at consensus and using iterative processes. The data obtained showed the following details summarised in Table 6.

Table 6 Respondents' views on h**ow a self assessment model can be used to demonstrate learning in a collaborative atmospher**e

| **Coded Reason** | **…demonstrate learning in a collaborative atmosphere** | **Number of Respondents** | **Percent %** | **Cum Percent %** |
|---|---|---|---|---|
| R2.1 | Sharing information | 62 | 52 | 52 |
| R2.2 | Teamwork | 28 | 23 | 75 |
| R2.3 | Arriving at consensus | 19 | 16 | 91 |
| R2.4 | Iterative processes | 11 | 9 | 100 |

Note: N = 120. Response totals may not add to 120 since some respondents cited more than one reason for each category. Percentages are rounded to the nearest whole number.

Whilst more than half (52%) of respondents believed that information sharing was important in developing a collaborative atmosphere for discovery learning only 9% shared that view. More respondents (23%) favoured teamwork to arriving at consensus (16%) for the development of a collaborative atmosphere to facilitate discovery learning (Table 6).

Table 7 Respondents' views on how a self assessment model can be used to demonstrate learning in a collaborative atmosphere **by sex**

| **Coded Reason** | **…demonstrate learning in a collaborative atmosphere** | **% Percentages** | |
|---|---|---|---|
| | | Male | Female |
| R2.1 | Sharing information | 14 | 86 |
| R2.2 | Teamwork | 23 | 77 |
| R2.3 | Arriving at consensus | 25 | 75 |
| R2.4 | Iterative processes | 21 | 79 |

Note. Percentages rounded to the nearest whole number.

Eighty six percent females were most in favour of information sharing as a means of developing a collaborative atmosphere for discovery learning. Generally males were more in favour of methods other than information sharing to accomplish the same purpose (Table 7).

Table 8 Respondents' views on h**ow** a self assessment model can be used to demonstrate learning in a collaborative atmosphere **by age cohort**

| **Coded Reason** | **…demonstrate learning in a collaborative atmosphere** | **Age cohorts (yrs)** | | | |
|---|---|---|---|---|---|
| | | **Percentages /%** | | | |
| | | 18- 25 | 26- 30 | 31- 40 | > 41 |
| R2.1 | Sharing information | 14 | 11 | 23 | 52 |
| R2.2 | Teamwork | 13 | 12 | 43 | 32 |
| R2.3 | Arriving at consensus | 6 | 5 | 22 | 67 |
| R2.4 | Iterative processes | 3 | 12 | 13 | 72 |

Note. Percentages rounded to the nearest whole number.

The use of iterative processes (72%) followed by arriving at consensus (67%) appeared to be more favoured by respondents in the > 41 year old age cohort compared to the 18-25 year old cohort (3%). Approximately the same percentage of respondents (6%,

5% resp.) came from the age cohorts 18-25 and 26-30 who supported arriving at consensus as a means of creating a collaborative atmosphere to facilitate discovery learning (Table 8).

Table 9 Respondents' views on how a self assessment model can be used to demonstrate learning in a collaborative atmosphere by **age cohort by sex**

| | Respondents' views on how a self assessment model can be used to demonstrate learning in a collaborative atmosphere by **age cohort by sex** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | R 2.1 Sharing | | R 2.2 Teamwork | | R 2.3 Consensus | | R 2.4 Iterative | |
| Age/ yrs | M | F | M | F | M | F | M | F |
| 18-25 | 12 | 88 | 9 | 91 | 9 | 91 | 75 | 25 |
| 26-30 | 16 | 84 | 11 | 89 | 7 | 93 | 86 | 14 |
| 31-40 | 25 | 75 | 69 | 31 | 5 | 95 | 85 | 15 |
| > 41 | 47 | 53 | 89 | 2 | 79 | 21 | 24 | 46 |

Note. Percentages rounded to the nearest whole number.

The younger female respondents in the age cohort 18-25 years favoured sharing, teamwork and arriving at consensus as a means of creating a collaborative atmosphere to facilitate discovery learning. Older males seem to prefer teamwork and arriving at consensus. Three times as many males (75%) as females (25%) in the 18-25 age cohort viewed iteration as a means of establishing a collaborative atmosphere to facilitate discovery learning (Table 9).

**Research Question 3: How can a self assessment model be used to create an atmosphere where learners get to know each other?**

Using (Glaser and Strauss', 1967) unitizing and categorising methods of qualitative analysis workshop participants offered responses to indicate that there were various ways in which the model could be used to demonstrate the process of discovery learning. The data obtained showed the following details summarised in Table 10.

Table 10 Respondents' views on how a self assessment model can be used to create an atmosphere where learners get to know each other

| **Coded Reason** | **…create an atmosphere where learners get to know each other** | **Number of Respondents** | **Percent %** | **Cum Percent %** |
|---|---|---|---|---|
| R3.1 | Constant communication | 75 | 63 | 63 |
| R3.2 | Active listening skills demonstrated | 20 | 17 | 80 |
| R3.3 | Social skills | 15 | 13 | 93 |
| R3.4 | Empathy skills | 10 | 7 | 100 |
| | **Totals** | 120 | 100 | 100 |

Note: N = 120. Response totals may not add to 120 since some respondents cited more than one reason for each category. Percentages are rounded to the nearest whole number.

Eighty percent of the sample thought constant communication and active listening skills were important in creating an atmosphere where learners got to know each other. About three quarters of the sample recorded that constant communication was important in creating an atmosphere where learners got to know each other. Respondents considered social skills (13%) and empathy skills (7%) of least importance (Table 10).

Table 11 Respondents' views on how a self assessment model can be used to create an atmosphere where learners get to know each other **by sex**

| **Coded Reason** | **…create an atmosphere where learners get to know each other** | **% Percentages** | |
|---|---|---|---|
| | | Male | Female |
| R3.1 | Constant communication | 27 | 71 |
| R3.2 | Active listening skills demonstrated | 53 | 11 |
| R3.3 | Social skills | 11 | 14 |
| R3.4 | Empathy skills | 9 | 4 |

Note. Percentages rounded to the nearest whole number.

Generally females outnumbered their male counterparts in every identified area cited as a means of creating an atmosphere where learners got to know each other. More than twice as many males felt that constant communication took precedence over social skills in establishing an atmosphere where learners got to know each other. It is interesting that 53% males favoured active listening skills compared to 11 % of females (Table 11).

Table 12 Respondents' views on how a self assessment model can be used to create an atmosphere where learners get to know each other **by age cohort**

| **Coded Reason** | | **Age cohorts (yrs)** | | | |
|---|---|---|---|---|---|
| | **…create an atmosphere where learners get to know each other** | **Percentages /%** | | | |
| | | 18- 25 | 26- 30 | 31- 40 | > 41 |
| R3.1 | Constant communication | 73 | 31 | 3 | 2 |
| R3.2 | Active listening skills demonstrated | 81 | 7 | 11 | 1 |
| R3.3 | Social skills | 72 | 9 | 16 | 3 |
| R3.4 | Empathy skills | 61 | 5 | 15 | 19 |

Note. Percentages rounded to the nearest whole number.

Approximately the same percentage of respondents in the age cohort 18-25 felt that constant communication (73%) like social skills (72%) was essential to creating an atmosphere where learners were able to know each other. Eighty one percent of respondents believed that active listening skills were essential in creating an atmosphere where learners were able to know each other. There were comparatively fewer responses from all other age cohorts: 26-30; 31-40 and > 41 years (Table 12).

Table 13 Respondents' views on how a self assessment model can be used to create an atmosphere where learners get to know each other **age cohort by sex**

| | Respondents' views on how a self assessment model can be used to create an atmosphere where learners get to know each other **age cohort by sex** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | R 3.1 Comm | | R 3.2 List | | R 3.3 Social | | R 3.4 Empathy | |
| Age/ yrs | M | F | M | F | M | F | M | F |
| 18-25 | 24 | 76 | 14 | 86 | 32 | 68 | 24 | 76 |
| 26-30 | 32 | 68 | 40 | 60 | 33 | 67 | 19 | 81 |
| 31-40 | 37 | 63 | 18 | 82 | 64 | 36 | 29 | 71 |
| > 41 | 40 | 60 | 10 | 90 | 44 | 56 | 10 | 90 |

Note. Percentages rounded to the nearest whole number.

More than three quarters (76%) of females in the age cohort 18- 25 reported that constant communication was essential to create an atmosphere where learners get to know each other. Similar views were expressed by females from the other age cohorts (26-30; 31-40; >41 years). The 26-30 age cohort of males (40%) regarded active listening skills as pivotal to creating an atmosphere where learners get to know each other whilst 64% males in the age cohort 31-40 years felt that social skills was the key. Ninety percent females it eh age cohorts > 41 years reported that listening and empathy were essential ingredients in creating an atmosphere where learners get to know each other (Table 13).

Several samples of responses are available from the author upon request. For the purpose of illustration, the comments from three randomly drawn papers would be discussed. One individual's idea on Measurement was: *'Physical parameter, grading scheme, establish scales for quantifying a characteristic'.* That individual's idea on Assessment was: *'analyse results, compare actual value to some standard, a determination of measurement.* The same individual's idea on Evaluation was: '*how it compares to some benchmark, do a comparison of using different networks, the reason for your results'*.

That individual together with his colleague's combined idea for Measurement was: '*The process of quantifying, using the appropriate instrument, Quantifying against a scale, determining the meaning of measurement'*. For Assessment the combined idea was: *'Analyzing results of your measurements, judgement, comparison, determining the meaning of measurement'*. Finally, for Evaluation the combined idea was: *'Continually measuring and assessing results, rank against standard, summary of measurement and assessment (on going process both formal and informal)'.* Individual participant's rankings ranged from 1 to 10, where 1 represented urgently needing assistance and 10 represented excellent. As the process was repeated individual rankings improved suggesting that the concepts became clearer.

The success of tasks of this nature may best be assessed by attitudes and comments from participants. Using the unitizing and categorizing method of qualitative analysis, respondents' comments were grouped into main categories *viz.* affective nature of exercise, cognitive skills gained and psychomotor skills honed. In the area of affection, notable comments from participants included, '*I never thought that discovering new knowledge for myself could be so much fun'…'I loved evaluating my own idea against the*

*general idea of the group through a process rather than being informed'…'I got to know so many different persons that normally I would not have met in an entire year.'*

In the area of cognition, participants had much to report. The following are some salient remarks: ' …*Learning about new concepts caused me to have a paradigm shift'*. Yet another participant commented, '*What a big difference in learning style that suits me so well'*. From another participant came the comment, '… *Who would believe that learning could be so easy through self discovery?'*.

In the psychomotor area, participants were thrilled to be involved in activity that allowed them to move around that auditorium and interact with numerous other participants. An interesting comment from a participant was '*Writing on the flip chart after discussion allowed me to ensure that I was able to transcribe accurately the ideas agreed on by the group and not merely my own personal ideas.'*

*Discussion*

With a proliferation of learning strategies that professes to enhance teaching and learning in higher education, the actual process of discovery learning needs addressing at this present time particularly because discovery learning is oftentimes associated with learning for toddlers, preschoolers, infants or teenagers, using the method with tertiary level students appeared important. Methods frequently used by younger persons may be glossed over as trivial, elementary or childish. Accordingly, such methods tend to be neglected in the literature. Hence, this present paper seeks to make a useful contribution in the field of education by providing that link in discovery learning using a selected model that may be transferred to industry and other sectors in the society. As such, this present

paper sought to provide answers to three research questions: (1) How can a self assessment model be used to demonstrate the process of discovery learning? (2) How can a self assessment model be used to demonstrate learning in a collaborative atmosphere? (3) How can a self assessment model be used to create an atmosphere where learners get to know each other? and (4) How do we know students learned more using the discovery method? Numerous observations were made with respect to sex and age cohort: movement to next step without prior knowledge; gradual removal of scaffolding; posing a series of searching questions and encountering inconsistent feedback were cited as means whereby the self assessment model was used to demonstrate the process of discovery learning. Sharing information; teamwork; arriving at consensus and use of iterative processes were identified as effective ways in which the self assessment model was used to demonstrate learning in a collaborative atmosphere. Finally, constant communication; active listening skills; social and empathy skills demonstrated were perceived to be essential ingredients in creating an atmosphere where learners get to know each other.

The Measurement, Assessment and Evaluation activity model (Appendix 1) used to demonstrate the process of discovery learning was based on specified learning objectives listed under the heading 'Objectives of this Activity'. Such learning objectives were to stimulate interest in measurement, assessment and evaluation, to connect theory of measurement, assessment and evaluation to practice, to have a practical hands-on example of a measurement, assessment and evaluation exercise, to understand the key competencies identified in measurement, assessment and evaluation and to demonstrate discovery learning.

Comments received from participants indicated that the model accomplished its intended purpose to bring participants to the point of realizing that through their own

discovery fundamental concepts were internalized. Moving from an individual's personal idea to a partner-combined idea to a group idea, in that order, the process was repeated until the definition of the three terms became clearer and more detailed. Personal ratings on the scale of 1 to 10 (highest) increased as individuals became more aware of the nature of the task through a discovery method. Without indicating that the intention was to arrive at consensus and grade individual submissions against the submission of the group, participants were engaged in that activity that defined self assessment. Self assessment has been defined as 'the involvement of students in identifying standards and/or criteria to apply to their work and making judgments about the extent to which they have met these criteria and standards' (Boud, 1986: 5).

The step-by-step process began with the identification of standards or criteria that applied to the task at hand and finally led to making judgments about how well the individual participant met the agreed standards or criteria. Interviews with participants at the end of the exercise showed that they realized what the process entailed. Many participants were pleasantly surprised to discover that what they were doing was enacting a well accepted definition for self assessment as posited by Boud (1986). This discovery produced the '*Aha Aha'* moment for many participants.

In answering the second research question: 'How can a self assessment model be used to demonstrate learning in a collaborative atmosphere'?, participants testified to the positive use of the model for learning in a collaborative atmosphere. The one-on-one discussions in an iterative manner emphasized collaboration with a view to arriving at consensus. Comments like *'I loved evaluating my own idea against the general idea of the group through a process rather than being informed'*…confirmed the effectiveness of the model used.

Finally, How can a self assessment model be used to create an atmosphere where learners get to know each other? Salient comments from participants reinforced the fact that the use of the model created an atmosphere where learners got to know each other. Certain comments already expressed like '*I never thought that discovering new knowledge for myself could be so much fun'…'I loved evaluating my own idea against the general idea of the group through a process rather than being informed'…'I got to know so many different persons that normally I would not have met in an entire year'* testified to the creation of an atmosphere where learners got to know each other.

Like any other type of learning methodology there are both disadvantages and advantages. However, many are the critics and supporters for and against discovery learning. Chaos, disillusionment, frustration, confusion and time wasting could result from any activity devoid of a carefully thought –out framework for scaffolding the learner's thoughts and actions. However, with a carefully planned framework, learners stand to experience an enhancement in their prior knowledge and understanding. Learners could actively engage in the learning process as they are encouraged to internalize concepts that would normally be difficult to grasp. Learners may develop life long learning skills since discovery learning promotes curiosity (Martin, 2000) which is an essential ingredient in discovering innovative methods. Best of all, the learning experience is customized or personalized and serves as a means of self motivation as learners have autonomy and freedom to explore.

*Conclusions and Recommendations*

In today's world educators are seeking innovative methods of teaching and learning that maximize the potential of the learner and create an environment where numerous life-long skills are honed. A few of those skills may include assertive communication, wealth generation, persistence, tolerance, reliability, proactivity, entrepreneurship, respect, editing, management, teamwork, self motivation, community service, conflict management, creativity, self assessment, peer assessment, decision making, empathy, neatness, lateral thinking, divergent thinking, discipline, responsibility, multi tasking, self control, self efficacy, accountability, confidence, strength, flexibility, active listening skills, civic mindedness, decisiveness, industry, being personable, environmental consciousness, professionalism, efficiency, trust, leadership, emotional intelligence, workload sharing, research skills, question framing skills, problem solving skills, self discipline, self-direction, innovation, citizenship, mutual consideration, excellent time management, reflection, knowledge transfer, knowledge application, cooperation, openness, mediation skills, negotiation skills and finally lifelong learning. To hone the foregoing skills and competencies in students educators have postulated a number of different strategies. Discovery learning and self assessment are among the many referred to in the present literature.

Participants were exultant about the skills they gained from the exercise using the aforementioned model. They were particularly pleased with the methodology that allowed for their individual differences and yet facilitated their collective interests. For many, the exercise provided them with vital teaching strategies that they claimed they could use in their classrooms. The unfolding of the concepts in a step-by-step manner

facilitated the flow of ideas and accommodated personal likes and dislikes in a healthy collaborative atmosphere where a free flow of information for the mutual benefit of all was encouraged.

Recommendations include the use of similar one pager models to serve as the much needed skeleton for developing ideas and allowing participants to blossom to the best of their potential in a supportive collaborative atmosphere of discovery and learning to know each other. This researcher recommends allowing ample time to facilitate the process without compromise. Participants must feel comfortable moving from one step to another in an active experience and not be forced to move along with the pace of the group that may not be personally suitable for them. A multiplicity of ways of presentation could be explored to maximize on the myriad of individual differences present in the groups. Using laughter to lubricate learning goes a long way in creating a pleasant learning environment (info@discoveylearning.co.uk) where participants get to know and appreciate each other. As intimated earlier, future research could compare the performance of those exposed to discovery learning with those exposed to direct instruction at higher education levels. Investigating the long and short terms effects of discovery learning in higher education could be instructive. Other models for facilitating discovery method training may be explored in future research. The researcher hopes that the ideas presented in this paper would serve as a catalyst to further research at the higher education level into useful models to support learning through the discovery method.

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Appendix 1

Measurement, Assessment and Evaluation activity

**?** **WHAT IS MEASUREMENT?**
**WHAT IS ASSESSMENT?**
**WHAT IS EVALUATION?**

## OBJECTIVES OF THIS ACTIVITY:

- To stimulate your interest in measurement, assessment and evaluation
- To connect theory of measurement, assessment and evaluation to practice
- To have a practical hands-on example of a measurement, assessment and evaluation exercise
- To understand the key competencies identified in measurement, assessment and evaluation
- To demonstrate discovery learning.

**ACTIVITY**:

(1) Name **ONE idea YOU** have about each of the following:

| | **YOUR IDEA** |
|---|---|
| **Measurement:** | |
| **Assessment:** | |
| **Evaluation:** | |

(2) Exchange **YOUR** idea for each term with **YOUR** neighbour.

(3) In the space provided below write down **ONE** idea for each term that combines the idea of YOU and your neighbour.

| | **Combined idea from YOU and YOUR Neighbour** |
|---|---|
| **Measurement:** | |
| **Assessment:** | |
| **Evaluation:** | |

(4) Copy that one idea, **YOU** and **your neighbour**, mutually agree upon for each of the terms above, on the flip chart closest to you.

(5) As a group, discuss and agree on ***one common idea for each of the terms*** using the ideas you wrote on the flip chart.
(6) On a scale of **1 (LOWEST) to 10 (HIGHEST)** please rate **YOUR** idea for each term, written in (1) above, **AGAINST THE IDEA for each term AGREED BY YOUR GROUP**.
(7) The process is iterative.

(8) General group discussion follows until there is consensus.

**THANKS FOR YOUR KIND COOPERATION!**