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Full Length Research Paper

Teaching styles and instructional flows in chemistry course: A pattern for a 5-step, 5-cycle teaching model

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ABSTRACT

This study aimed to make a teaching model out of the instructional flows of the teachers teaching engineering chemistry course. Specifically, the study aimed to identify the teaching styles the teachers used in the actually delivery of the chemistry lessons. Thus, this is a descriptive study on the teaching style employed and learning styles catered to in the actual teaching of a general chemistry course. In the process, instructional flows were described leading to a new teaching model, the Five-Step, Five-Cycle Teaching model. This new teaching model is hoped to guide teachers who will be assigned to teach engineering chemistry course. Classroom observations were done to describe the instructional flows, teaching style and learning styles in the actual teaching of general chemistry. The general chemistry teachers employed the content-sensing, presentation-verbal, and perception-sequential teaching styles in all the meetings, participation-active TS was employed in most meetings while presentation-visual was employed the least. The teaching catered to sensing, verbal, sequential learning styles in all the meetings, to active LS in most meetings, and visual LS the least. The teachers used six (6) steps instructional flows with one to three cycles. This led to the theoretical formulation of the Five-Step, Five-Cycle Teaching model.

Keywords: Teaching model, teaching and learning, learning styles, teaching styles, pedagogy, methods of teaching.

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INTRODUCTION

According to Grossman and Loeb (2010), "the variation in teacher preparation pathways can propel understanding of how best to prepare teachers." this study aimed to describe the teaching styles employed in the delivery of the lessons and the learning styles that were catered in the actual teaching in an engineering chemistry course (ChemE). In the process, the instructional flows (actual teaching delivery) in teaching general chemistry course were observed and recorded leading to a theoretical teaching framework called The *5-Step, 5-Cycle Teaching Model* in consideration with the Felder-Silverman's teaching and learning style dimensions.

The instructional flows are detailed in the discussion below so as how these instructional flows lead to the theoretical framework.

Felder-Silverman teaching style (TS) dimension

The teaching style (TS) dimensions of Felder and Silverman's are parallel with students' learning style (LS) model (Felder, n.d.; Felder, R., n.d.; Felder and Silverman, 1988). This learning-style model as proposed by Felder,

"classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information [while] Felder's teaching-style model, classifies instructional methods according to how well they address the proposed learning style components" (p. 674).

The teaching dimensions as classified by Felder and Silverman (1988) are *content, presentation, participation, and perspective*. *Content* is parallel to the perception dimension of LS (sensing and intuitive), *presentation* is parallel on input dimension (visual and verbal) LS, *participation* is parallel on processing dimension LS (active and reflective), *perspective* is parallel on the understanding dimension of LS (sequential and global), and *organization* is parallel on organization dimension of LS (inductive and deductive). The *organization* dimension was not included in this study because this was deleted by Felder (2002). On the basis of the teaching style dimensions of Felder and Silverman's, this study categorized the teaching style (TS) as to *content TS, Presentation TS, Participation TS, and Perspective TS.*

In *Content* TS the instructor's emphasis is on the type of information being presented: sensing such as concrete, factual, or intuitive such as abstract, conceptual, theoretical. In the *Presentation* TS the instructor's emphasis is on the mode of presentation he gives: visuals such as pictures, diagrams, films, or verbal such as pure lectures, readings, discussion. In *Participation* TS the instructor's emphasis is on the mode of student participation: active such as letting student talk or move or reflective or passive such as the student listens. In the *Perception* TS the instructor's emphasis is on the type of perspective provided on information presented: sequential, a step-by-step progression, or global, on context and relevance. Felder describes sequential as the "trees" and global as the "forest". Forest means the whole, and the trees means the details.

On the more specific learning style that is dominantly catered to, this study categorized the teaching style into six (6) teaching styles that are parallel to the specific learning style being dominantly catered. The parallelism between teaching style and learning style does not mean the teacher adjusted their TS to the LS of the students, instead it means that each category of teaching style caters to certain learning styles namely: presentation-visual TS caters to visual LS, *presentation-verbal TS* caters to the verbal LS, *participation-active TS* caters to the active LS, *participation-reflective TS* caters to the reflective LS, *perspective-sequential TS* caters to sequential LS and *perspective-global TS* caters to global LS and *Content-sensing TS* caters to sensing LS and Content-intuitive TS caters to intuitive LS (Felder and Silverman, n.d.; Felder and Spurlin, 2005; Felder and Soloman, 1994).

METHODS

This study primarily made use of qualitative research design. However, quantitative data were used to describe the frequency of occurrence the teaching styles were applied in the actual teaching. Qualitatively, actual classroom observations were done to describe the delivery and teaching styles on select chemistry lessons leading to formulation of a teaching model (Boehm and Weinberg, 1977). Felder-Silverman's descriptions of teaching style dimensions were used in this study.

Four (4) sections of engineering chemistry course (ChemE) were observed. These sections were handled by qualified faculty members of the Department of Chemistry. Observations were done on a total of thirty six (36) classroom sessions at 9 sessions per section. This is a total of 36 hours observations at one hour per class observation for MWF (Monday, Wednesday, and Friday) classes and one and a half hours for TTh (Tuesday and Thursday) classes. Classroom observations were recorded on observation sheets and audio (tape) recorder. The recorded observations were transcribed and summarized. These summarized descriptions are presented below, in diagrams and written texts. Then, the teachers were requested to review and confirm the presented descriptions of their teaching.

All the teachers handling engineering course were made participants of this study. There were only four teachers (T-A, T-B, T-C, and T-D) that handled these four sections of engineering chemistry classes. These teachers are the one assigned by the Department of Chemistry to teach the course, hence, the researcher need not choose the teacher-participants. The delivery of the topics that were found to be difficult by item analysis was given priority for observations. These topics were atomic structure and periodic table, gas laws, chemical reactions and equations, stoichiometry, thermochemistry, rates of reactions, and formula writing and nomenclature (Tabinas et al., 2016).

Item analysis was done based on the results of the departmental examination, a final summative examination for engineering chemistry course. Twenty seven percent of 249 test papers were subjected to item analysis. The following were tallied: the upper group who got the item right, UR; the lower group who got the item right, LR; and the number of students who tried (have answers) on the item, TST. From these, the following were computed: total number of students who got the item right, TSR (UR minus LR); Item difficulty, P (P=TSR/TST), and the discriminating power, D. Then, interpretations of the discriminating power were made. Those topics that were

found by the item analysis to be difficult (from level of difficult, medium difficult and very difficult) items were chosen for classroom observations.

FINDINGS AND DISCUSSION

The data obtained from observations were presented qualitatively (diagrams and textual presentations) and quantitatively (Table 1). Table 1 shows the percentage occurrences of teaching style used in the actual teaching.

Teaching styles employed in the actual teaching

The teaching styles catered by the teachers were identified based on the descriptions of teaching styles as classified by Felder and Silverman (1988). Should the teacher presented pictures diagrams, flowcharts, films, and the like in the delivery of the topics, the teacher used the presentation-visual TS catering to visual learning style. Should the teacher presented the lesson in spoken or written words, the teacher used the presentation-verbal TS catering to verbal learning style, etc. [Refer to Felder-Silverman's Teaching Style (FSTS) model].

Table 1 shows all the teachers (T-A, T-B, T-C, and T-D) made use of Presentation-verbal TS, Perception-sequential TS and Content-sensing TS in all the classroom meetings observed (100%). The four teachers (T-A, T-B, T-C, T-D) catered least to presentation-visual TS (Ave. 27%). Thus, all the teachers catered most to verbal, sequential and sensing learning styles and least to visual learning style. It should also be noted that participation TS was not used by the teachers in all the meetings observed (active, ave. 75%; reflective, ave. 53%), so as the perception-global TS (Ave. of 67%).

With less than 50 percent occurrence, T-A can be said to have catered least to visual (22%), reflective (22%), and global learners (33%). Teachers B, C, and D catered least to visual learners with 22, 33 and 33% occurrence respectively.

Instructional flows

Instructional flow is the sequential presentation of the chemistry lesson by the teachers. These flows are described in text and diagrams. The instructional flows presented in diagrams were based on 9 sessions' observations. These were the steps (sequential flow) often used by the teachers in their teaching.

The sample teaching presented here is a transcription of one of the teaching deliveries observed (on observation sheets) and recorded (on audio tape). The samples were chosen as support to the instructional flows described.

The sample teaching is presented with classification of the teaching style used. The classification of teaching styles was based on the Felder-Silverman Teaching Style (FSTS) model.

Table 1. Teaching styles employed and the learning styles catered to in the actual teaching.

Felder-Silverman's teaching style (TS)	Number of observations (n=9)										
	Learning style (LS)	Teacher A		Teacher B		Teacher C		Teacher D		Average	
		F	%	F	%	F	%	f	%	f	%
Presentation-visual	Visual	2	22	2	22	3	33	3	33	2.5	27
Presentation-verbal	Verbal	9	100	9	100	9	100	9	100	9	100
Participation-active	Active	8	89	6	67	6	67	7	78	6.75	75
Participation-reflective	Reflective	2	22	6	67	6	67	5	56	4.75	53
Perception-sequential	Sequential	9	100	9	100	9	100	9	100	9	100
Perception-global	Global	3	33	5	83	8	89	8	89	6	67
Content-Sensing	Sensing	9	100	9	100	9	100	9	100	9	100
Content- Intuitive	Intuitive	2	2	5	83	8	89	8	89	5.75	64

Note: "f" means the frequency the style is observed and "n" means the total number of meetings observed.

Instructional flow of teacher A

T-A generally followed a 6- step instructional flow (Figure 1). The teacher starts the lesson proper by distributing activity sheets. This gives the students the idea of what they are going to do. Few students immediately tried to answer the activity written on the sheet. One student was observed to be doing this every meeting while others

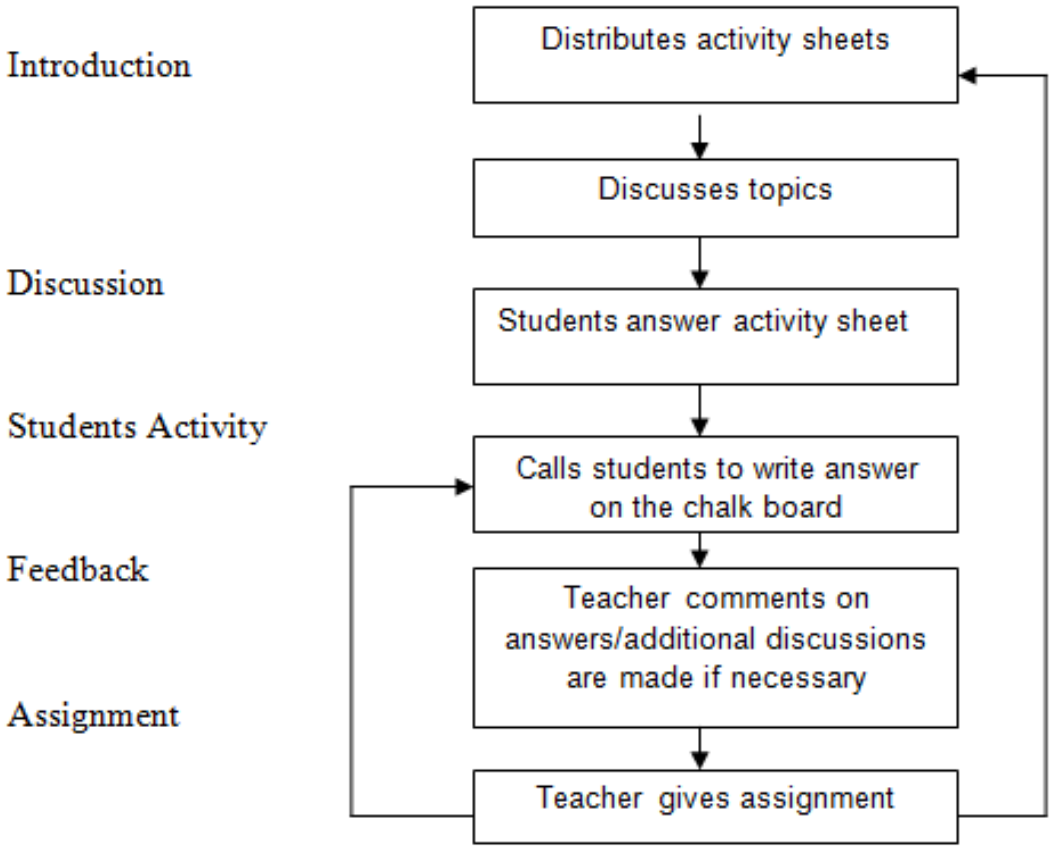

Figure 1. Instructional flow of teacher A.

waited for the teacher to discuss the topic first. During the lecture-discussion, concrete facts were presented; T-A used a variety of methods such as demonstration, showing transparencies and asking questions. After the teacher discussed the topic (concrete) of the meeting, the teacher asks the students to answer the activity sheet. The teacher gives time limit for the students to answer. After answering the Activity, the teacher asks the students to write their answers on the board. Then, the teacher comments on the answers. The teacher discusses further the topic in relation to the answers on the board. Then, the teacher gives assignment either to finish the unfinished activity or to do something for a new topic. In some meetings, the teacher starts on the students' answers of their assignment. The teacher calls students to write their answers on the board and comments on them or discusses further the topics.

Sample teaching of teacher A (T-A)

Below is a sample of actual teaching by Teacher A on the topic, Stoichiometry–Moles and Molar Mass (This is a synthesis of T-A teaching on one of the teaching observations recorded on observation sheets, and transcript from audio recorder).

Topic: Stoichiometry – moles and molar mass

Teacher A distributed activity sheets for the students to answer later.
Teacher A started the discussion about mole by writing this on the chalk board (Presentation-verbal and presentation-visual TS)

1 mole = 6.022 × 10^{23} particles (atoms, ions, molecules)

Teacher A stated that mole is a collection of particles equivalent to 6.022 × 10^{23}. (Content-Sensing TS) Then T-A proceeded to write an example on the chalk board while talking out what T-A was writing as follows: (Presentation-verbal & Presentation-visual TS)

*1 mole NaCl = 6.022 × 10^{23} [formula units of NaCl]**

T-A proceeded to write a problem from the activity sheet on the chalk board as follows:

5.78 mole NaCl = ___?__[formula units of NaCl]

T-A asked the students to solve the problem saying, "Class how many [formula units of NaCl] are in 5.78 mole NaCl?" (Participation-ActiveTS)

The students tried to solve the problem in their seats. After a few minutes, the teacher writes the solution of the problem on the board while talking out what the teacher was writing as follows:

$$5.78 \text{ mole NaCl} \times \frac{6.022 \times 10^{23} \text{ [formula units of NaCl}}{1 \text{ mole NaCl}} = \_\_\_$$

Before continuing to write the final answer, T-A called a student saying, "what is your final answer?" (Participation-reflective TS)
The student answered, "3.48×10^{24}". T-A completed the solution by writing the final answer on the board.
T-A demonstrated how to press the calculator keys when using it to calculate exponents. This was done using an actual calculator (Presentation-verbal & Presentation-visual TS).
T-A proceeded with the discussion saying, "This time class we will take up how to calculate molar mass". Then the teacher wrote the following on the chalk board while talking out what the teacher was writing: (Perception-sequential TS)

12.01 a.m.u C = 12.01g C = 1 mol C
Molar mass of C is 12.01 g/mol C
Molar mass of Na = 12.99 g/mol Na
Molar mass of Cl = 35.45 g/mol Cl

T-A said, "the molar mass of the combination of atoms is equal to the molar mass of sodium chloride". Then wrote the solution on the board as follows while talking out what the teacher was writing:

Na = 1 × 22.99 g/mol = 22.99
Cl = 1 × 35.45 g/mol = 35.45
58.44 g/mol NaCl

T-A gave another example on how to determine the molar mass. T-A used CH_3OH as example and wrote the solution on the chalk board while talking out what the teacher was writing (Perception-Sequential TS).

1C = 12.01 g/mol × 1 = 12.01 g/mol
4H = 1.00 g/mol × 4 = 4.032
1O = 15.999 g/mol × 1 = 15.999
32.041 g/mol CH_3OH

T-A asked the students to solve and answer the problems in the activity sheet. (Participation-active TS)
A student asked, saying "...are we going to express the final answer[s] in correct significant digits?" (Participation –reflective TS)
T- A replied: "not necessary, just give two decimal places [for your final answer]". T-A went around inspecting students who were answering the problems in the activity sheet.
After sometime, around 15-25 minutes, T-A called students to write their answers on the board. T-A asked the class to comment on the answers, nobody commented. The answers were correct (Participation-reflective TS).

T-A proceeded to advance the discussion by solving a problem that involves both the mole and molar mass. T-A wrote the problem and solution on the chalk board while talking it out as follows: (Presentation- verbal & Presentation-visual TS)

145 g CH_3OH = __?___ moles CH_3OH
Molar mass CH_3OH = 32.041 g/mole
145 g $CH_3OH \times \frac{1 \text{ mol}}{} = 0453$ or 4.53×10^{-2} mol CH_3OH

T-A gave the other problems in the activity sheet as an assignment for the students to solve at home (Presentation-verbal TS & participation- active TS).

TS employed by teacher A and LS catered to

As shown in Table 1, T-A discusses concrete facts (sensing) of the subject matter verbally (verbal) in a logical sequence (sequential) in all the meetings (100%) observed. Thus, T-A employed the content-sensing, presentation-verbal, and perspective-sequential teaching styles in all the meetings observed. T-A employed the participation-active teaching style in 89% of all the meetings, as evident by distributing activity sheets for the students to work with in almost all the meetings observed.

Eventually with those TS's employed, Teacher A catered to sensing, verbal, and sequential learning styles in all the meetings, and least on intuitive, visual, reflective, and global learning styles. Active learning style was catered in most of the meetings.

T-A did not give much attention to cater to the visual, reflective, global, and intuitive learning styles, thus

employed the least, the content-intuitive TS, presentation-visual TS, participation-reflective TS, and perception-global TS. These TS's were observed only in 22% of the meetings. Here is a sample teaching of T-A in which the said teaching styles were employed, though not frequently: (This was taken from recorded observations from observation sheets, and transcript from audio recorder).

Teacher A Demonstrated (presentation-visual) the topic on Limiting Reactant (content-intuitive). Teacher A proceeded as follows:

"….. Teacher A. (put a combo plate on the overhead projector) I am going to put five drops of Iron(III) chloride to plate number 1 and plate number 2. Now, I will add five drops of potassium thiocyanate to the iron(III) chloride in plate number 1 and 1 drop of potassium thiocyante in plate [number] 2, Teacher A: Which reactant limits the color? (pause)

Students: potassium thiocyanate.
……"

In the sample teaching above, T-A employed the content-intuitive, presentation-visual participation-reflective and perception-global teaching styles, thus catering to the intuitive, visual, reflective and global learning styles of the students.

The topic introduced by T-A was an abstract one, thus employed the content-intuitive TS. T-A employed the presentation-visual TS by demonstrating using visual materials. T-A employed the participation-reflective by pausing after asking a question and giving time for the students to think for the answer. T-A also employed the perception-global learning styles by letting the students come up with the answer to the question on the limiting reactant without first defining it.

Instructional flow of teacher B (T-B)

T-B the same as T-A followed a 6-step instructional flow (Figure 2). Unlike T-A instead of distributing activity sheets, T-B offered introduction by citing practical examples such as combustion of methane gas, chemical labels found in the lab, etc. and at times making connections of the previous topics to the topic to be discussed in that meeting; oftentimes shows transparencies at the start or during lecture discussion, T-B used transparencies to show diagrams of steps to solve stoichiometric problems. On the student activity, T-B, unlike T-A who distributed a teacher-made activity sheet, let students do the exercises found in the textbook. The same as T-A, T-B called students to write their answers on the board and commented on them. In some instances, T-B discussed further the topics based on the students answers then asked students to answer another set of exercises, called students to write on the board, and comments on them. Finally, gave assignments to the students. In other meetings T-B, the same as T-A, started by calling students to write their answers of the assignment on the board and comments on them or discusses further.

Sample teaching of teacher B (T-B)

Below is a sample of actual teaching done by Teacher B on the topic, Gases (this is a synthesis of T-B teaching on one of the teaching observations recorded on observation sheets, and transcript form audio recorder).

Topic: Gases

Teacher B distributed papers from previous meeting. T-B mentions the topics about gases that were taken up in the previous meeting. (Perception-global TS) T-B proceeded by asking the students about the parameters involve in gases, then wrote on the board, the parameters while talking it out, saying that the parameters involve in gases are pressure, volume, temperature, and number of moles of the gas, as follows: (Presentation-verbal TS & Presentation-visual TS)

Parameters

P, V, T, N

T-B proceeded to write the relationship between volume and number of moles of gas as follows:

V α n Avogadro's law

T-B mentioned, "Gas is ideal when there are no forces of attraction between gaseous particles". (Content-intuitive TS) Then wrote the ideal gas equation on the chalk board while talking it out as follows: (Presentation-verbal TS / Presentation-visual TS/ Perception-sequential TS)

Ideal gas Equation PV=nRT

$$P = \frac{nRT}{V} \qquad T = \frac{PV}{nR} \qquad n = \frac{PV}{RT}$$

R = 0.08201 L-atm/mol K

T-B mentioned about STP as standard temperature and pressure. T-B proceeded by saying, " a gas is at STP if its temperature is equal to zero degrees Celsius which is equal to 273 Kelvin and its pressure at one atmosphere". T-B then wrote it on the chalk board as follows: (Content-sensing TS)

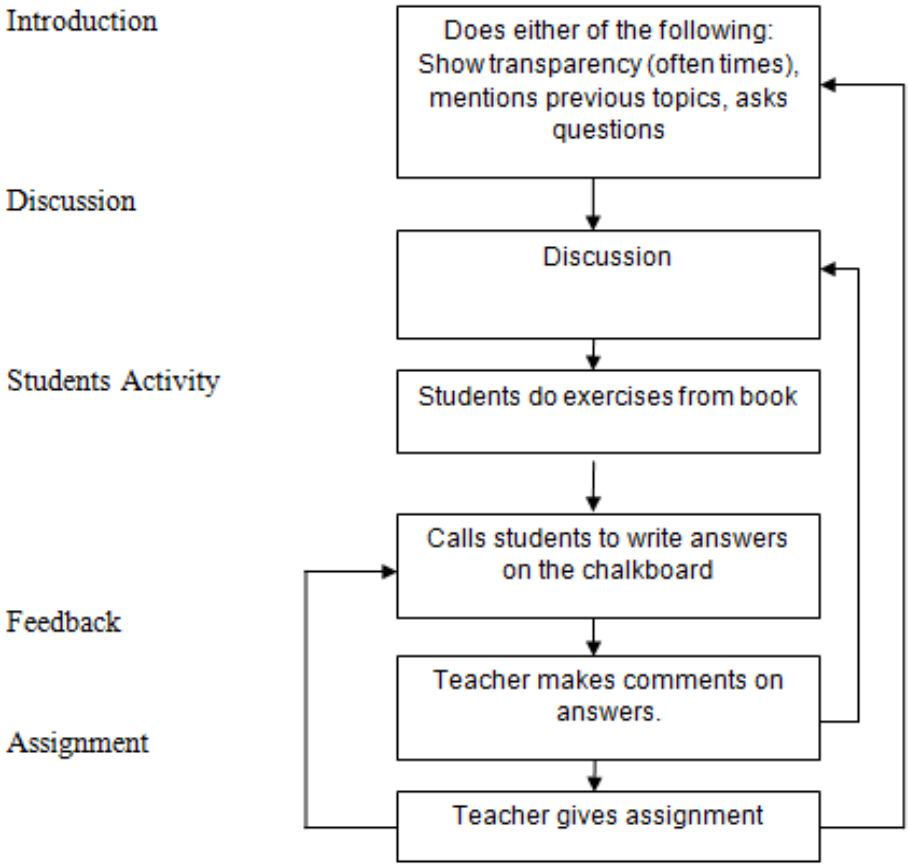

Figure 2. Instructional flow of teacher B.

STP Temp = 0°C = 273K P = 1.00 atm

T-B asked the students, "If a gas is at STP, what is the volume of the gas?" (participation-reflective TS) T-B proceeded to answer the question by writing the solution on the chalk board while talking it out as follows: (Perception-sequential TS)
1.0 mol of a gas at STP

$$V = \frac{nRT}{1.00\ atm} = \frac{(1.00\ mol)\ (0.08201 L\text{-}atm/mol\ K(273K)}{1.00\ atm} =$$

= 22.4 L

T-B reiterated saying "the volume of 1.0 mole of any gas at STP is 22.4 L"
"Let's answer some problems" said T-B and let the students open their book to page 190 to answer problem 5.32. T-B proceeded saying, "Exercise 5.32 on page 190 asked for gram of a gas given the volume, temperature and pressure, [you] have to find the mole then convert the mole to gram". Then the students answer the problem in their seats. (Participation-active TS) After sometime, T-B called a student to write the answer and solution on the chalk board. The student wrote the solution and answer on the chalk board as follows: (Participation-active TS and Perception-sequential TS)

$$n = \frac{VP}{RT} = \frac{1.4L\ (1.00atm)}{0.08201\ \frac{L\text{-}atm}{mol\ K}\ (273K)} = 4700\ mol\ SO_2$$

$$4700\ mol\ SO_2\ x\ \frac{64.0507\ g\ SO_2}{1\ mol\ SO_2} = 301100\ g\ SO_2$$

T-B commented on the answer saying "the solution is correct but the answer is wrong." The student recalculated and found the answer as follows: (Participation-reflective TS)

$$n = \frac{VP}{RT} = \frac{1.4L\ (1.00atm)}{0.08201\ \frac{L\text{-}atm}{mol\ K}\ (273K)} = 0.062\ mol$$

$$0.062\ mol\ x\ \frac{64.058\ g\ SO_2}{1\ mol\ SO_2} = 40g\ SO_2$$

Another student was made to answer problem letter b on the chalk board. The teacher examined the calculations and said "the answer is correct". Some students approached the teacher to show their calculations of the problem 5.31 on page 190. After examining their solutions, the teacher wrote on the board the solution of the problem while talking out what the teacher was writing, as follows: (Participation-active TS/Presentation-verbal TS/ Presentation-visual TS)

$$n = \frac{VP}{RT} = \frac{12.0\ L\ (0.95atm)}{0.08201\ \frac{L\text{-}atm}{mol\ K}\ (298K)} = \frac{m}{MM} = \frac{5.6\ g}{MM} \quad MM = 12g/mol$$

After writing the solution/calculation above the teacher asked the students saying, "How can we incorporate the molar mass into the equation?" (Participation-reflective TS) Students did not answer the question, then the teacher proceeded to answer the question verbally. (Presentation-verbal TS)
while writing on the board what the teacher was saying as follows: (Presentation-visual TS & Perception-sequential TS)

$$n = m/MM \qquad n = VP/RT \qquad \frac{m}{MM} = \frac{VP}{RT}$$

Teacher B called students to answer problem 5.33 letter a. Few students raised their arms and the teacher called one of them to show the solution/calculation on the chalk board as follows: (Participation-active TS)

$$a.\ CF_2Cl_2 \quad l' = \frac{120.913g}{22.4\ L} = 5.40\ g/L$$

Teacher commented saying, "the answer is correct except the unit of MM where it is written in g". The teacher corrected the answer by writing this as the teacher talked out what is being written as follows: (Presentation verbal TS/ Presentation visual TS)

$$l' = \frac{120.913\ g/mol}{22.4\ L/mol}$$

The teacher proceeded to introduce partial pressure by asking the class, "What do you mean by partial pressure?" Without waiting for answer, the teacher proceeded to say, "We are actually considering mixture of gas" then the teacher wrote an example of a mixture of gases on the board as follows: (Presentation-verbal TS/ Content-intuitive TS/Participation-reflective TS)

CO_2, H_2, O_2 :

$$PCO_2 + PH_2 + PO_2 = P_T$$

1 atm + 3 atm + 0.5atm = 4.5 atm

Then the teacher proceeded to explain, "if other gases are removed, the partial pressure of the gas is the same to the pressure of the gas if it is alone in the container.' Then the teacher proceeded to write the following on the chalk board while talking out what the teacher was writing: (Presentation-verbal TS/ Presentation-visual TS/Content-sensing TS/Participation-reflective)

$$P_T = P_A + P_B + P_C + \ldots\ldots P_Z$$
$$P_A = X_A\ P_T$$
$$X_A = \text{mole fraction} = \frac{\text{moles A}}{\text{total \# of moles}}$$

After explaining and writing the equation on the board the teacher asked the students to answer problem 5.42 on page 191 of the textbook. The teacher went around to check on the students. After sometime, the teacher proceeded to write the solution to the problem on the board as follows while talking out what the teacher was writing: (Presentation verbal TS/Presentation-visual TS/Participation-active TS/Perception-sequential TS)

Given: $P_T = 740$ Torr
$n_{N2} = 1.3$ mol
$n_{O2} = 0.33$ mol
$n_{Ar} = 0.061$ mol

Solve for P_{N2}? P_{O2}? And P_{Ar} ?

$$P_{N2} = X_{N2}P_T$$
$$= \frac{(1.3\ mole\ N_2)}{1.691\ mol}\ (740\ Torr) = 568\ Torr$$

The students did not ask any any question about the problem and solution to the problem. The teacher announced to the student that next meeting there will be a quiz from gases to partial pressure. (Presentation-verbal TS)

TS employed by teacher B and the LS catered to

T-B discussed concrete facts (sensing) of the subject matter verbally (verbal) in a logical sequence (sequential)

in all the meetings observed. Thus T-B employed the content-sensing TS, presentation-verbal TS, and perspective-sequential TS in all the meetings observed.

Here is a sample of what T-B did in teaching stoichiometry. Figure 2 shows a diagram through a transparency, T-A proceeded as follows:

Ok, I will show you this transparency (pause, adjusting the acetate and overhead projector). This is a diagram on how to solve stoichiometry problems. You see from gram you can convert [it] to moles using the molar mass. From moles of substance A, you can convert it to moles of Substance B using the coefficients in the balanced chemical equations…"

In this particular instance of T-B's teaching, T-B presented the topic visually by showing a diagram through the overhead projector. The teacher also presented the topic verbally in a logical sequence. It is quite obvious that T-B in this instance used the presentation-visual TS, content-verbal TS and perception-sequential TS catering to the visual, verbal, and sequential learning styles of the students.

Though T-B was noted to employ the presentation-visual teaching style in teaching stoichiometry, this teaching style was not observed in all the meetings. The presentation-visual teaching style was only observed in 22% of all the meetings (Table 3).

T-B employed the balanced presentation TS: active and reflective. T-B, unlike teacher A, used the problems in the textbook for activities (active) without imposing time limit (reflective). Eventually, with those TS's employed by T-B, the teaching delivery catered to the sensing, verbal, and sequential LS's in all the meetings observed, and catered to the visual LS the least.

Instructional flow of teacher C (T-C)

T-C, the same as T-A and T-B followed a 6-step instructional flow (Figure 3). What makes T-C different from the other teachers is that, T-C kept writing on the board a list of topics to be discussed in that meeting. This guided both the teacher and the students on the subtopics to be discussed that meeting. Another, T-C also used a variety of methods such us demonstration, using transparencies, and asking questions (Socratic Method) but on some occasions T-C answered the questions by himself, probably to save time. T-C like T-B let students do the exercises on the textbook. The same as the other Teachers, T-C calls students to write answers on the board, commented on their answers and finally gave assignment. Like T-A, in some meetings the teacher started by calling the students to write their answers on the board and commented on them or discussed further.

TS employed by teacher C and LS catered to

T-C, the same as T-A and T-B, employed the content-sensing, presentation-verbal, and perception-sequential teaching styles. Evidently as observed T-C presented in logical sequence the topics, mostly concrete facts in oral and written words. T-C employed the presentation-visual teaching style. This was observed only in 33% of all the meetings. T-C, the same as T-B, employed a balance presentation TS: active and reflective. Eventually, with those TS's employed by Teacher B, Teacher B catered to the sensing, verbal, and sequential LS's in all the meetings, and the least on the visual LS

Here is a sample teaching of T-C where the teacher employed presentation-verbal, presentation-visual and perception-sequential learning style: (This was taken from recorded teaching from observation sheets and transcript from audio recorder).

"…Teacher C: (directing the students to look at the transparency on periodictable) Look at the elements, they are arranged according to what order?
Students: (some) atomic numbers (some) atomic weights
Teacher C: Weights? Look at it first, don't answer that way.
Students: Mass, atomic mass …….. (Pause, then teacher talked again, then)
Teacher C: (pointing to the elements) look at [the atomic mass of elements] 106 and 107…. As you can see 106 and 107, 106 are 2-6-[3, while] 107 is 2-6- 2…. It is not atomic mass. It is ….what?
Students: Atomic numbers."

TS employed by teacher D (T-D) and LS catered to

T-D employed the presentation-visual TS by showing a transparency on the periodic table. T-D also employed perception-sequential TS by sequentially leading the students to the correct answer. Presentation-verbal TS and participation-reflective teaching styles are also evident in this sample teaching, the teacher presented verbally the topic and allowed reflective thinking for the students. Thus the T-D in this sample teaching, catered to verbal, visual, reflective, and sequential learning styles. Though presentation-visual TS was employed in this particular sample, this was only observed in 33% of all the meetings (Table 3).

T-D as the other teachers discussed concrete facts

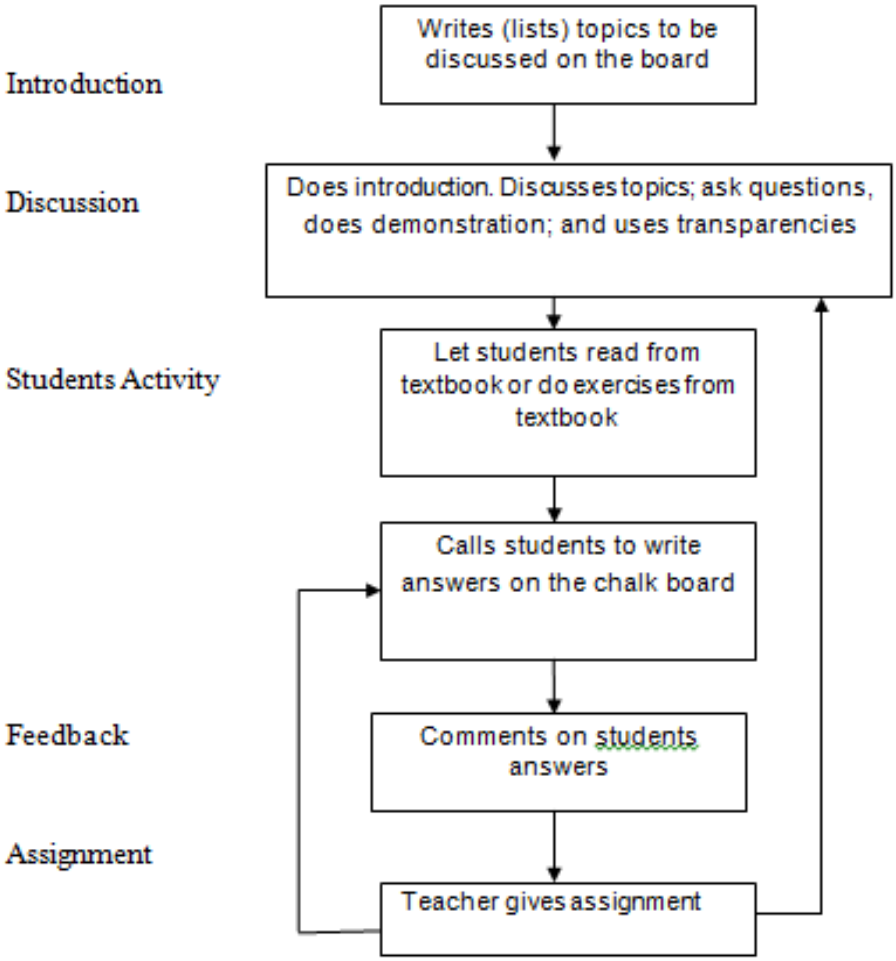

Figure 3. Instructional flow of teacher C.

(sensing) of the subject matter verbally (verbal) in a logical sequence (sequential) in all the meetings observed. Thus T-D employed the *content-sensing*, *presentation-verbal*, and *perspective-sequential* teaching styles in all the meetings observed. T-B employed the *presentation-visual* teaching style the least. This was observed only in 27% of the meetings. Eventually, with those TS's employed by T-D, T-D catered to the sensing, verbal, and sequential LS's in all the meetings observed, and catered the least on the visual LS.

Content-Intuitive TS, participation-reflective TS, and *participation-active TS* were also employed by T-D, though not in all the meetings observed. Here is a sample teaching where T-D employed the participation-reflective, participation-active and content-intuitive (abstract), perception-sequential, and presentation-verbal teaching styles: (This was taken from recorded observations from observation sheets, and transcript from audio recorder).

"……..
Teacher: Called students to show solutions on the board
Student: wrote solutions on the board.
(Pause while the student was writing on the board, the others students were focusing on what is being written on the board, most probably reflecting
On the steps)
Teacher: Ok, let us solve [the problem on page 116] 3.65a. What are given? (No answer) Before you solve the problem [you] analyze the problem first.
What are given?
Few Students in chorus: 37.2 mL of 0.471Molar HBr.
Teacher: What is asked? What is asked/
Students: Number of grams solution
Teacher: Solution? Solute?
Students: Solute
Teacher: What is the solute here?
Students: HBr

……..."

In this sample teaching, T-D presented the abstract (intuitive) topic, molarity of solutions, verbally and sequentially on how to solve the problem. The asking of questions encouraged students to reflect in order to understand the solution to the problem. Letting the students show their solutions on the board encouraged active learners. Asking "for the given" then, for "what is asked" by the problem was T-D's way to introduce the steps on how to solve the problem sequentially. Thus, in this particular sample of teaching, T-D employed the content-intuitive TS, presentation-verbal TS, perception-sequential TS participation-reflective TS, and participation-active TS. Thus, catering to the intuitive, verbal, sequential, reflective and active learning styles of the students.

Instructional flow of teacher D (T-D)

T-D followed a 6-step instructional flow (Figure 4). What is unique with T-D is that without much ado started the lecture- discussion of the topics. On most meetings (6 out of 10), T-D started by letting the students write their answers of the assignment on the board then proceeded to step 5 on giving comments on the answers of the students (5^{th} box from top of the flowchart). In other cases, T-D reviewed previous topic in relation to the new topic. The rest of the steps are the same as the other teachers. Unlike T-B, T-D did not use transparencies in most of the meetings observed. In some meetings, T-D, the same as T-B, discussed further the topic based on the answers of the students on the board and gives another set of exercises from the textbook then went the cycle.

Overall TS employed and LS catered to

Table 1 showed, on the average that the ChemE teachers employed the content-sensing, presentation-verbal, and perception-sequential teaching styles in all the meetings observed. In most of the meetings, participation-active TS were employed. The teachers employed the presentation-visual the least. Thus, the teachers teaching catered to sensing, verbal, sequential learning styles in all the meetings. In most of the meetings, the teacher catered to the active LS. The teachers catered the least to the visual LS.

CONCLUSIONS

Based on the findings the following conclusions were drawn:

1. The teachers followed six-step instructional flows in one to three cycles, but differ in their introduction and in carrying out the discussion. Synthesizing the steps common to them and the steps they differed, a five-step, five-cycle teaching model immerged.
2. The teachers catered least to visual learning styles and more focused on the content-sensing, presentation-verbal, perception-sequential teaching, and participation-active teaching styles catering to sensing, verbal, sequential, and active learning styles of the students.

Synthesis: The five-step, five-cycle teaching model

Based on the analysis and synthesis of the instructional flows of teachers in general chemistry, a new theoretical framework was developed which I called the Five–Step, Five-Cycle Teaching Model (Figure 5). The five steps were taken from the sequential presentation of the teachers in teaching to which the researcher identified and labeled as Introduction, Lecture-Discussion, Students Activity, Feedback, and Assignment. The five cycles are synthesis of the different cycles the teacher used in all their teaching observed.

According to Grossman and Loeb (2010), "the variation in teacher preparation pathways can propel understanding of how best to prepare teachers" (p. 22). The Five-Step, Five-Cycle Model can be used for a week (3 hours) or more preparation of classroom teaching. Thus, this model is flexible to topics of long coverage that one classroom meeting may not suffice. The first classroom session starts with lecture/discussion (with introduction). In the process of classroom teaching, the actual teaching delivery may happen to turn in five ways creating five cycles within the five steps of classroom teaching (Tabinas, 2018).

The five steps

The teaching flows of the delivery of the topics by the teachers observed are synthesized into five-steps. These steps were taken from the instructional flows of the teachers observed.

All the teachers observed followed five steps in their teaching which the researcher identified and labeled as Introduction, Lecture-Discussion, Students Activity, Feedback, and Assignment. Hence the following steps:

(1) The step ***"Lecture/ discussion with Introduction".*** This step has two (2) components, namely: introduction,

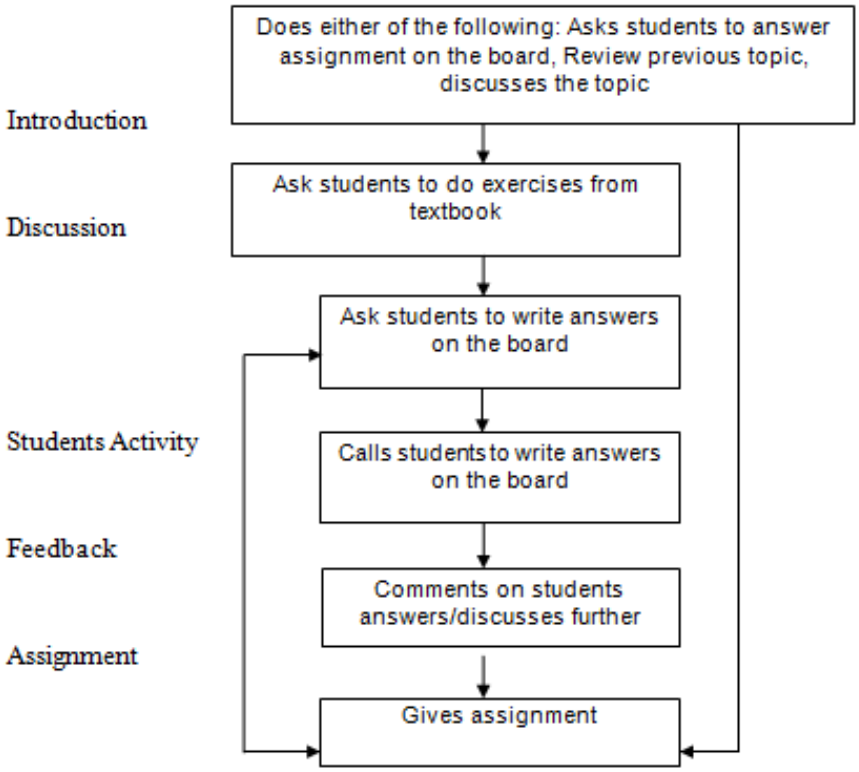

Figure 4. Instructional flow of teacher D.

and lecture proper (with discussion). In the introduction, the teacher focuses on the understanding dimension of the learning styles (global/sequential) where the teacher motivates the students, discusses previous topic inrelation to the topic to be discussed that day, reveals what activities or topics are expected to be covered that day, and/or cites practical examples in relation to the topics to be discussed. Information is presented sequentially and globally, where relationships and connections of the topics are given in sequence or just inferred. In the lecture proper or during lecture, the teacher focuses on the input (verbal/visual) and perception (sensing/intuitive) dimensions of the learning styles, where the teacher lectures in parts or the entire topic for the day. The teacher in this case presents information visually and verbally thus, aside from writing on the board and giving information orally, shows diagrams, pictures, transparencies, slides, lecture notes (Grondlund, 1994); or does demonstration. The teacher may also apply "progressive drawing" as lid opener which also can be used later as "monotony breaker" (Nayak and Kodimajalu, 2010). The teacher does not occupy all the time talking and writing on the chalk board because reflective learners appreciate time gaps for them to be able to think and process the information. Learning styles in the perception dimension (sensing/intuitive) are also catered when the teacher, in lecturing, balances the presentation of concrete information, facts, and real data with theories, principles, and mathematical models. During discussion, the teacher focuses on the processing dimension (active/reflective). This may come during or after the lecture; the teacher asks students questions, opinions or ideas about the topics, thus focusing on the reflective learning style of the processing dimension. Letting the students explain their answers in class caters to the active learning style in the processing dimension. The teacher in this part may apply blunder lecture, where the teacher allow himself/herself to commit mistake and the students spot the mistake. The teacher may ask the students to explain why it is a mistake and ask to correct the mistake (Satheesha et al., 2005). In time, when the lecture is too lengthy, it can be broken into segment to prevent boredom (Nayak, 2006). This maybe interruptive by brief question and answer portion, funny short story telling related to the topic, or the students answer sample exercises. However, this method may be time consuming, in the time when the teacher is short of time to cover the needed topic coverage this may not apply.

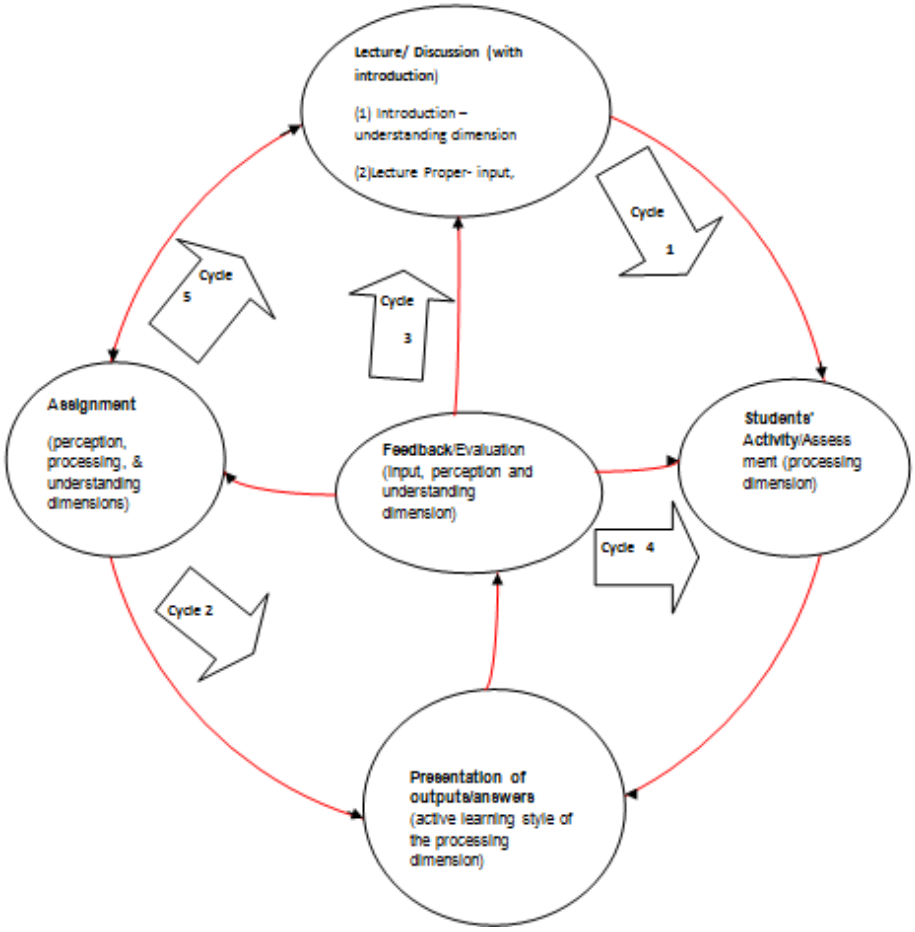

Figure 5. 5-step, 5-cycle teaching model perception (sensing/intuitive), processing (active/reflective), and understanding (sequential/global) dimensions (Tabinas, 2018).

There may be a need for the teacher to trust the capability of the college students to adjust to a lengthy lecture. Step 1 focuses on all the four (4) dimensions of Felder-Silverman's learning styles, namely: input (verbal/visual) (Figure 5).

(2) The step "***Student activity"***. This is where the teacher may assess, supplement, emphasize the learning of the students by letting them answer teacher-made activity sheets, answer the exercises in the textbook, or by letting them do group activities. The teacher also guides the students on how to turn theories into practice (Johnson and Mighten, 2005). In this step, the teacher focuses on the processing (active/reflective), perception (sensing/intuitive), and understanding (sequential/global) dimensions of learning styles. Exercises may be done as individual activity at first. A balance on drills/exercises that simply provide practice on the fundamentals and those that demand analysis and synthesis may be given to cater to the perception, processing, and understanding dimensions of the learning styles. Students may be made to do activity individually at first (reflective) then let students share their answers in groups (active). The teacher may also apply redistribution of students in groups in order to encourage reluctant students to share more and participate as member of the group (Nayak et al., 2005).

(3) The step "***Presentation*".** This is where the students present to the class their outputs or answers to the activity. In the actual teaching delivery observed, this was done through board works. In this step, the students present information; conversely, the teacher should give allowances to the manner the students present their outputs. In the process, students may reveal their preferred learning styles by the manner they present their outputs. Students may present their answers through diagrams, pictures (visual) or orally and/or in written texts (verbal). They may present their answers in concrete details (sensing) or abstractly using theories, principles,

and mathematical models (intuitive). They may present in logical sequence (sequential) or leaps, introducing gaps of understanding (global). On the side of the presenters, the presenters learn through the processing dimension of the learning style specifically, on active learning style. In the process, the presenters may cater to the different learning styles of their classmates as they present their outputs. Thus, Step 3 in the point of view of the presenters is more focused on the active learning style; and on the point of view of their classmates to whom the presenters present, may focus on all the four dimensions of learning styles depending on how the presenters present their outputs.

(4) The step **"*Feedback*"** is where the teacher may evaluate and comment on the presented answers and discuss further when necessary. The teacher evaluates the outputs of the students and comments based on a given standard, criteria, or a rubric. The teacher appreciates creative solutions even if incorrect in order to give motivation to intuitive and global learners of the perception and understanding dimensions, The teacher may show concrete and abstract examples (sensing/intuitive), show connections (global/sequential), show pictures, diagrams, and explanation (verbal/visual) to provide emphasis in correcting errors. Thus, Step 4 is more focused on the input (visual/verbal), perception (sensing/intuitive) and understanding (sequential/global) dimensions of Felder-Silverman's learning styles.

Contrary to Gallos & Berg's observations (2011) *that during feedback, oftentimes the conversation was only between the board worker and teacher*, the teachers that were observed in this study addressed their comments to the entire class and discussed the topics further to the entire class. Thus, the students are made to participate in giving feedback to the student-presenter (Ion et al., 2016). This is, probably, an improvement that the teachers learned from Gallos & Berg's study. It should be noted that these teachers were also participants in the Gallo's study, thirteen (13) years before this study was conducted.

(5) The step **"Assignment"** is where the teacher gives "learning activities" to be done outside the classroom. "Learning activities" here is not just simply letting the student bring something for an activity in the classroom but activities that give opportunities for the students to learn. The assignments are usually written on the board and in other times, announced orally. Though for college level learners, the giving of instructions orally for assignments is acceptable, it is best to write (on the chalk board) and then read to the class the instructions of assignments. The teacher asks the students to finish an undone activity or to read the textbook (the textbook used is the book "Chemistry for Engineering Students by Brown and Holme (2007) on a new topic or to answer exercises in the book either about the topic discussed or about a new topic for next meeting. The teacher balances the assignment of activities and exercises on drills that provide practice on the fundamental methods taught (sensing/active/sequential) and on activities that demand analysis and synthesis (intuitive/ reflective/global). The teacher may give activities that require cooperation with other students (active). Thus, Step 5 is more focused on the perception (sensing/intuitive), processing (active/reflective), and understanding (sequential/global) dimensions of Felder-Silverman are learning styles.

The five cycles

The cycles of classroom instruction happens in five (5) ways in three to five steps: Cycle 1 includes "**lecture/discussion**" followed by "**students activity**", "**presentation**", "**feedback**", and then back to "**lecture discussion**"; Cycle 2 includes "**assignment**" followed by "**presentation**", "**feedback**", and then back to "**assignment**", and Cycle 3 includes "**feedback**" followed by "**lecture/discussion**", "**assignment**", "**presentation**", then back to "**feedback**"; Cycle 4 includes "**feedback**" followed by "**students activity**", "**presentation**", then "**feedback**"; and Cycle 5 that includes "**lecture/discussion**" to **students activity**" and proceeds to "**presentation**", "**feedback**", and "**assignment**". Turns can also happen from "feedback" of Cycle 1 or Cycle 2 going to Cycle 3 or Cycle 4. *The cycles have different starting points and the teacher is allowed to shift from one cycle to the next without completing yet the first cycle, as the need arises. The teacher may or may not maximize the use of the five (5) cycles depending on the length of the topic, the number of subtopics involve, and the allotted time.*

In a classroom meeting (usually one hour for MWF or one and a half hour for TTh), or in two succeeding meetings, one cycle or combination of two or three or four cycles may happen.

Cycle 1 (Figure 6) is a cycle that includes "lecture/discussions with introduction" going to "students' activity" and proceeds to "feedback." Then back to "lecture/discussion" connecting oa new topic from the previous one.

Cycle 2 (Figure 7) happens when the assignment is a learning activity. It goes from "assignment" to "presentation" where the students are asked to present their assignment orally or written on the board. From here, goes to "feedback" where students (classmates) are asked to comment on the answers and the teacher gives the final comments. Then, back to "assignment" of a new topic or as intervention such as giving more exercises to improve the understanding of the recently

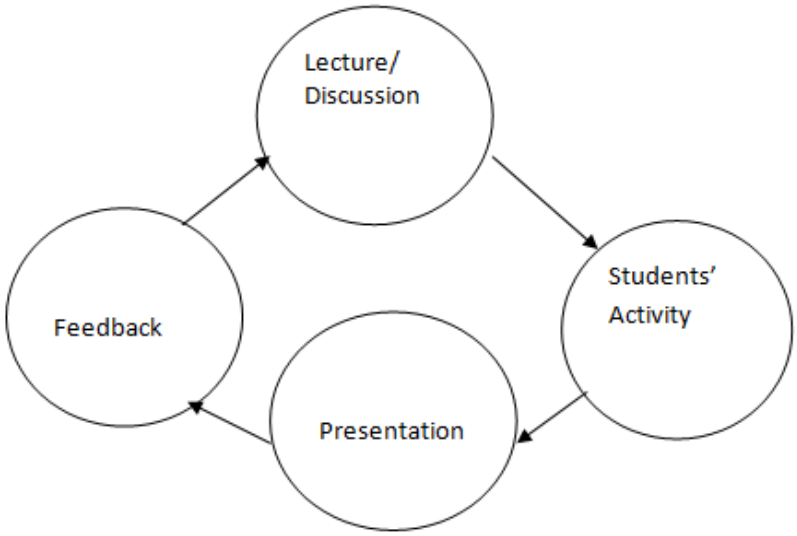

Figure 6. Cycle 1.

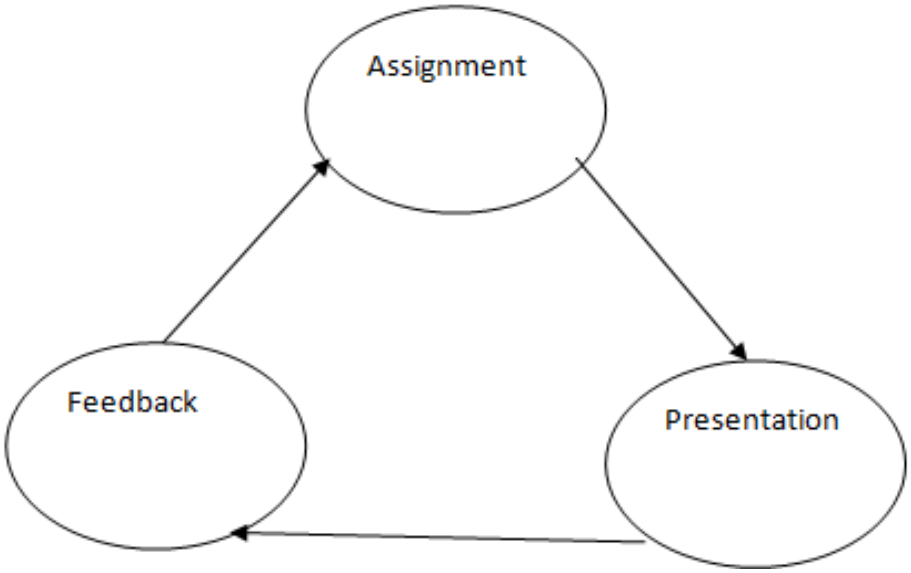

Figure 7. Cycle 2.

discussed topic or to review what the students failed to learn.

Cycle 3 (Figure 8) happens if the feedback is extensive. Further discussion is addressed to the entire class, that is, the cycle goes from "feedback" to the "lecture-discussion," "students activity", "presentation," then back to "feedback." The feedback becomes Step 1 going to "lecture-discussion" starting another cycle. This cycle also happens when connections are made from "feedback" to a new topic.

It has to be noted, that "presentation" is always followed by "feedback". The teachers in this study never jumped from presentation to assignment without giving feedback. Though it may not be wise to proceed from "lecture-discussion" to "assignment" without giving yet the feedback on the presentation, this can happen when time runs out during the presentation; it may be continued in the next meeting. This is Cycle 3 that is completed the

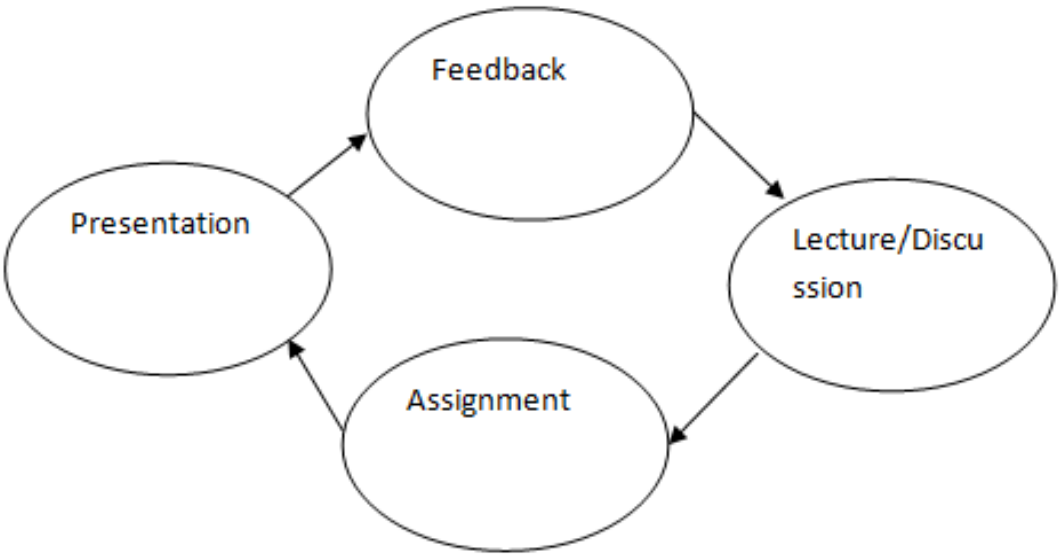

Figure 8. Cycle 3.

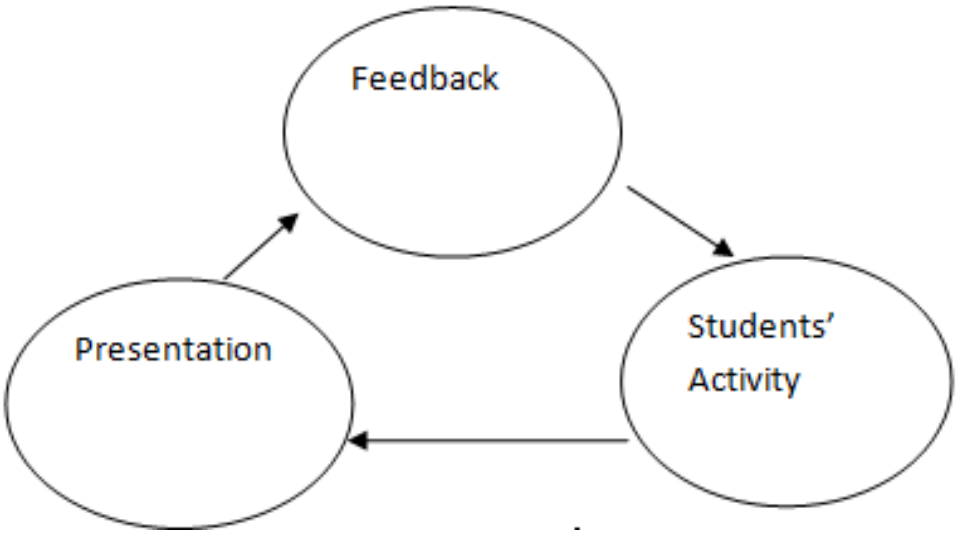

Figure 9. Cycle 4.

following meeting going to "presentation" then back to "feedback". This cycle only happens when time runs out.

Cycle 4 (Figure 9) includes "feedback" going to "students' activity" and proceeds to "presentation" and back to "feedback". This cycle happens especially when the teacher is not satisfied with the results of the activity that after giving the feedback, the teacher may see the need for more students' activity. So, may proceed to "students' activity." Cycle 5 (Figure 10) includes "assignment" going to "lecture/discussion" going to "students' activity" and proceeds to "presentation" and "feedback". Assignment may be used to start a new topic or as motivation to introduce a new topic in "lecture/ discussion". Thus, goes this cycle. This is the complete cycle which is can be used as the starting point in planning the lesson. Then, other cycles may follow.

Two points are unique with "Five-Step, Five-Cycle" teaching model. One is that this model can be used for topics that require a week or more preparation; and formally incorporates teaching styles that cater to the

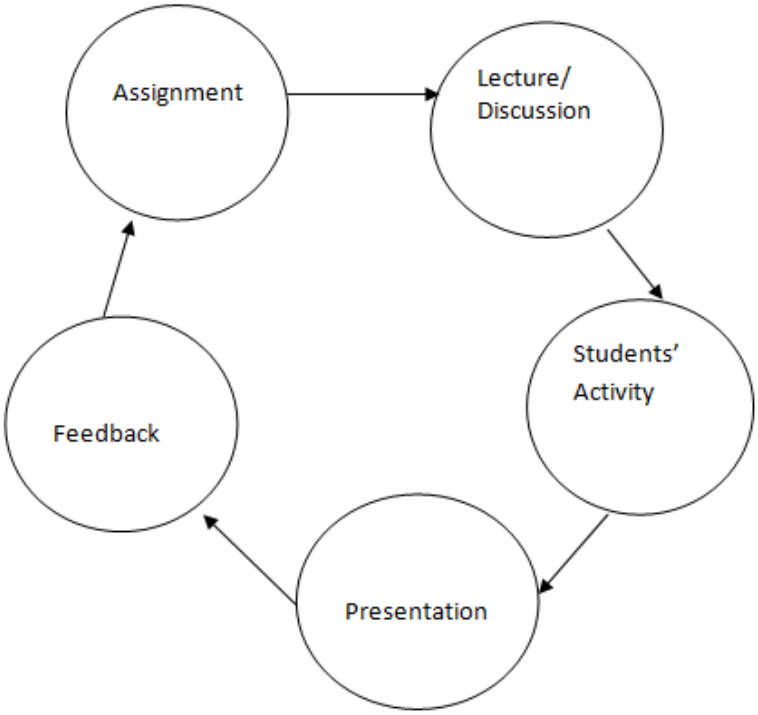

Figure 10. Cycle 5.

learning styles of the students.

RECOMMENDATIONS

Anchor to the theory of Grossman and Loeb that the variation in the pathways to which teachers prepare for teaching can lead to the understanding on how teachers can prepare best, it is recommended that the use of the 5-step, 5-cycle teaching model should be done in consideration to the learning styles of the students. It should be noted that instructional model is expected to promote students learning. This is in line with the findings that 5E;s learning model is potential in enhancing academic performance in chemistry subject (Umahaba, 2018). Thus, inventory of the learning styles of the students should be conducted prior to the delivery of the lesson. Then, the teachers should align their teaching styles to the leaning style of the students. Also, the students should be made aware of their learning styles so that they can also adjust their ways of studying in a manner that suits their learning styles.

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