THE SYSTEMIC APPROACH TO TEACHING AND LEARNING [SATL]: OPERATIONAL STEPS FOR BUILDING TEACHING UNITS

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ABSTRACT
Systemic diagrams are the key to creating units of study for the method described as the Systemic Approach to Teaching and Learning (SATL). Here we present a detailed description of the generation of systemics. The general approach is first discussed to establish the basic ideas of SATL. The general method is then specifically applied to a portion of the aromatic chemistry of benzene and its simpler derivatives. Finally, examples of SATL-oriented questions for student assessment are presented. [AJCE, 1(1), January 2011]

INTRODUCTION

In a previous paper (1) we have described the intellectual antecedents of the Systemic Approach to Teaching and Learning (SATL) techniques, namely, the constructivist theory (2), and concept maps (3) as well as our observation that a part of the success of the methods appears to mimic the current ideas of general brain function. Here we present the details of constructing and using systemic units for teaching and learning.

The key teaching device in the SATL technique is the Systemic Diagram (SD) which is a two-dimensional representation of the concepts that are to be taught to, or learned by the students in a class. As we described earlier (1), a systemic diagram can be thought of as a "closed concept map cluster" (Fig. 1). The person (teacher) who created the Systemic Diagram (Fig. 1B) has decided that not all of the concepts 1-6 displayed in Fig. 1A could be effectively incorporated in the Systemic Diagram, Fig. 1B. Apparently concept 4 will be picked up in another systemic diagram when it will, ultimately, be reunited with the other concepts. The minor excursion into creating a systemic diagram illustrates the flexibility of creating systemic diagrams.

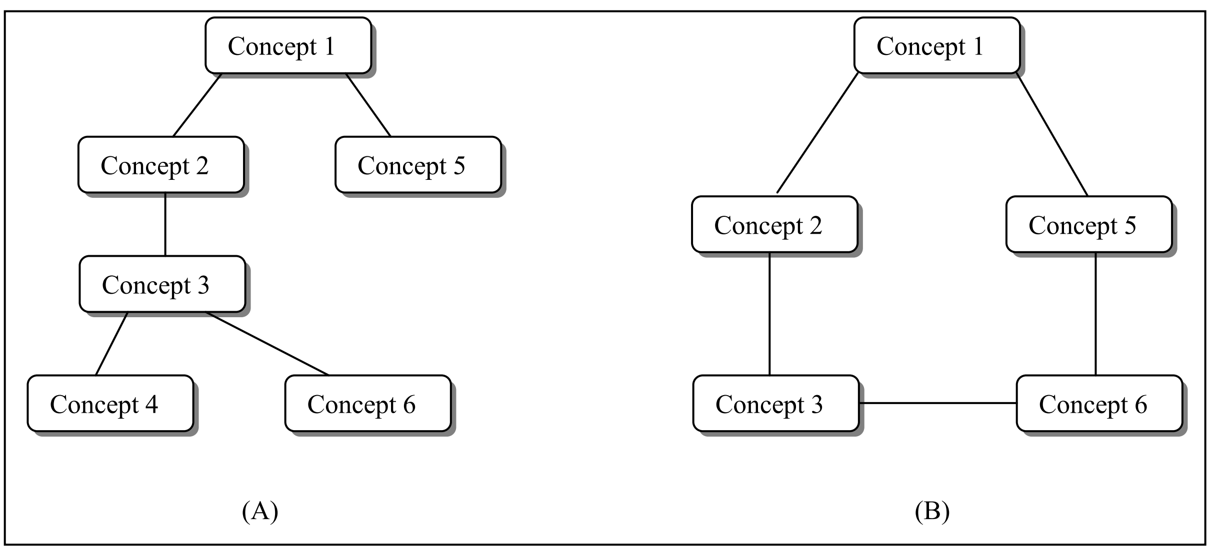


Fig. 1. A comparison of a concept map (A) and a systemic diagram (B).

Any unit to be taught using SATL methods involves the building of a systemic diagram (SD_0) that has been determined as the starting point of the unit; SD_0 incorporates the prerequisite concepts. Recall that Ausubel has suggested (2) that, in order to teach effectively, a teacher should start with what the students know and build upon this. The SD_0 unit assures that all students will have the same starting point as they progress through the entire set of systemic diagrams. The unit ends with a final systemic diagram (SD_f) in which all the relationships between concepts in the unit that have been taught to the student are known (Fig. 2). From SD_0 through SD_f we encounter several smaller systemics with known and unknown relationships (SD_1, SD_2, etc.).

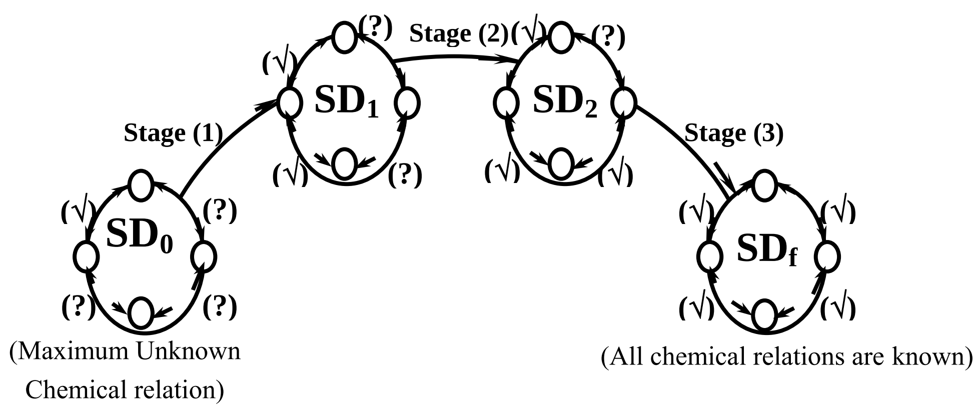


Fig. 2. Systemic teaching strategy

BUILDING UNITS

The strategy of building SATL units is to convert the linearly based approach most often used to teach chemistry (and other subjects) into systemically-based units according to the following process;

1. The general systemic aims and the operational objectives for the unit should be defined.
2. The prerequisites needed for teaching the unit from previous studies (concepts, facts and skills) should be tabulated into a list.

3. The organization of the linearly-based list of materials (see step 2 above) into concepts, facts, laws, relations, skills, and affective issues should be established.
4. Draw a diagram (Fig. 3) illustrating linear relations among the concepts collected in step 3 above.

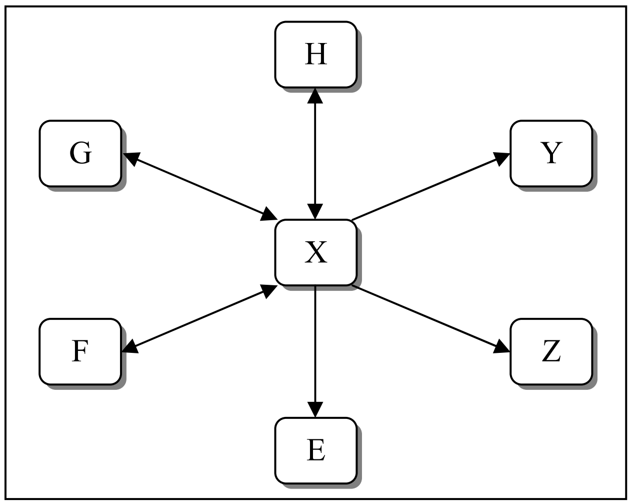


Fig 3. Linear relations between concepts

Consider the concepts X, Y, Z, E, F, G, and H that are contained in the teaching unit in question with its relevant facts and skills etc. Generally these concepts would be addressed linearly as shown in Fig. 3. We put a check (√) on the relationships that are known (by the student) from previous studies, see Fig. 4. In this example, assume the linear relations (X-E), (X-Z), (X-Y) are known to the students from previous work, then the remaining linear relations (X-F), (X-G), and (X-H) are unknown to the student and are indicated by the question mark symbol (Fig. 4). In other words, the student knows the checked (√) relationships and the point of the unit work is to learn the "unknown" (?) relationships. So the diagram in Fig. 3 will be modified as shown in Fig. 4.

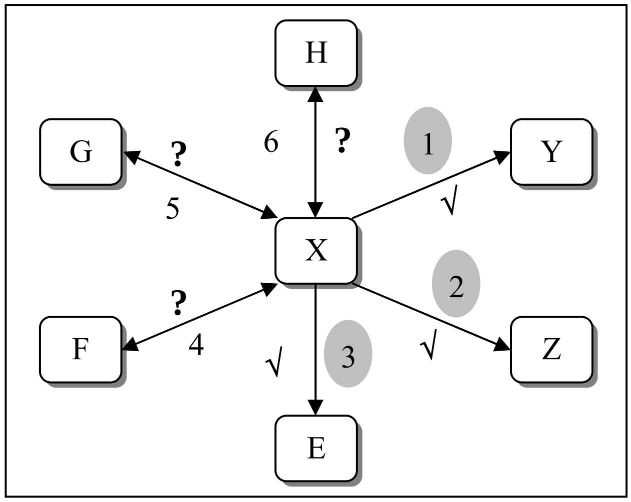


Fig. 4. Showing linear relations between concepts after defining the known from the unknown ones.

Notice in Fig. 4 that linear relations (1-3) are known and are indicated by the sign (√), and the heads of arrows are defined (→), those "known relationships: represent the previous knowledge upon which the systemic diagram will be built. In other words, these relationships are assured or known to be within the knowledge structure of the students who will learn from systemics. The relationships (4-6) are undefined and indicated by the sign (?) and the heads of arrows are not defined (↔); these represent the new knowledge that is to be learned by the students using this systemic diagram. Fig. 4 is modified to a systemic diagram by adding relationships between the concepts (H-Y), (Y-Z), (Z-E), (E-F), (F-G), and (G-H) (if such exist) which are indicated by the numbers 7-12; the result is shown on Fig. 5 and is identified as SD_0.

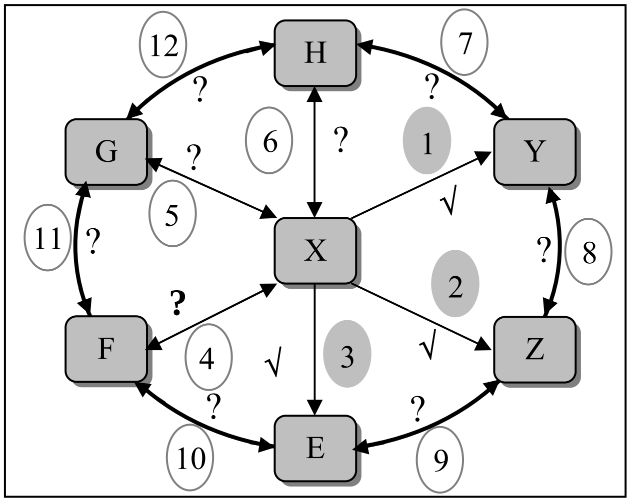


Fig. 5. The systemic diagram derived from
Fig. 4. using the process described in the text.

The systemic diagram, SD_0 (Fig. 5) has the following features:

a) Because the relationships (1-3) are known the heads of arrows are defined (→) and the relationships are indicated by the check mark (√).

b) The known relationship between two concepts may go in both directions as indicated by double-headed arrows (↔), but, to simplify in this case, we consider the relationships between concepts to have one direction (→).

c) The relationships from 4-12 are not yet defined and are indicated by the question mark (?) and the double-headed arrows (↔). These will be refined during the study of the unit.

d) The systemic diagram shown as Fig. 5 is called the starting systemic diagram (SD_0) because it contains relationships 1, 2, and 3 that are previously known to the student.

In the scenario for teaching this unit we start by teaching the relationships (7, 8, and 9), then all relationships are known to the student.

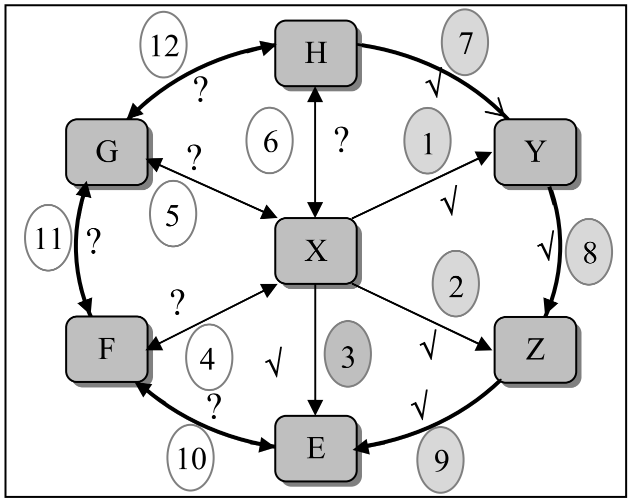


Fig. 6 (SD_1)

In the systemic diagram, SD_1 (Fig. 6) the relationships 7, 8, and 9 have become defined—known by the student—and the arrow directions determined (→), but the remaining relationships, 4, 5, 6, 10, 11, and 12, are still unknown to the students and will be defined later during the study of the remaining parts of the unit. The student in the first stage of this study of unit has identified the relationships 7, 8, and 9; connecting them with the formerly studied relationships 1, 2, 3 and those that will be studied in the remaining parts of the unit.

In this stage of the study of this unit we can ask the students to build the systemic diagrams showing the relations between the concepts of X, Y, Z, and E during the systemic assessment.

In the next stage of the study, the student can study the relationships 4, 5, 10, and 11 and add them to SD_1, (Fig. 6), to obtain SD_2, (Fig. 7). In this systemic diagram all the relationships became known except 6 and 12, which will be identified in the later stage of the study of this unit. At this stage of the study, the student could study the relationships of 4, 5, 10, and 11 in view of the previously studied relationships followed by those that will be studied, namely, 6 and

12. Finally, the student can build several systemic diagrams showing the systemic relations in the systemic assessment (*vide infra*).

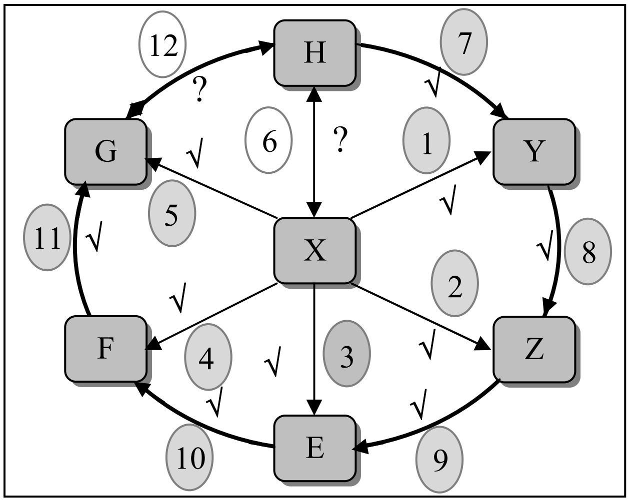


Fig. 7 SD_2

In the last stage of the study of this unit, the student studies the two remaining relationships, 6 and 12, based on the previously studied relationships, then the student adds them to SD_2 to obtain $SD_{\mathbf{f}}$ (Fig. 8) which is the end of the systemic teaching and learning of this unit.

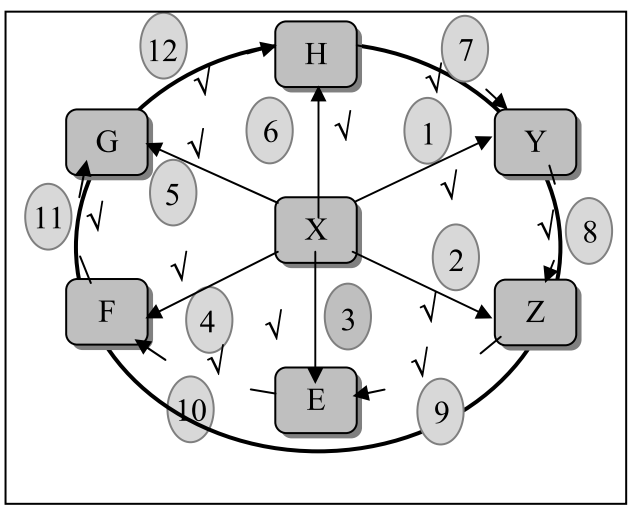


Fig. 8. $SD_{\mathbf{f}}$

All the relationships between concepts 1 – 12 have become known in $SD_{\mathbf{f}}$ (Fig. 8); and $SD_{\mathbf{f}}$ is the terminal systemic diagram for teaching this unit.

From the scenario of teaching this unit, we extract the following general observations. We started teaching the unit using the systemic diagram SD_0, that has been determined by the teacher as the starting point of the unit, and we ended with the systemic diagram SD_f that defined the terminal point of the unit; between the two systemics we pass through the diagrams SD_1 and SD_2.

The systemic diagrams involved using the approach to study are similar except that the number of known relationships (√) and the unknown ones (?). As we proceed in teaching the unit, the unknown relationships become diminished while the known ones increase until we reach the end where all the relationships become known as indicated in Fig. 2. The systemic diagrams are used in the related processes of teaching and learning, but not as summaries for memorization. It is the process of building (constructing) the overall diagram that helps both teacher and student; it helps the teacher to teach and the student to learn and the process can be utilized from the beginning to the end of teaching material in the unit. In a sense, the terminal systemic diagram is a summary of the unit contents, but the important aspect of SATL techniques is the process.

In our experience, students become aware of the characteristic pathways of teaching the unit from its beginning to its end, which can raise their motivation and can help them to interconnect the knowledge they study at any of the teaching stages with the past and the next concepts in the unit. Repeating this process appears to help students to build a richer cognitive structure of the subject of study.

At the end of their study, students could be asked to build numerous systemic diagrams that show the relationships between 3, 4, 5, or 6 concepts. The results can indicate the extent of student achievement of the unit objectives through the final systemic assessment (*vide infra*).

SATL—Aromatic Chemistry: a specific example

It is often difficult to employ a detailed, but generalized approach of a new teaching/learning paradigm. We present here a specific chemically-related example of the application of SATL methods. We use, namely, aromatic chemistry—the chemistry of benzene—to illustrate how a subject can be organized systemically, to help students to fit new concepts into their own cognitive structure.

The details of the transformation of the linear approach usually used to teach students about aromatic chemistry such as the separate chemical relationships among benzene and other related compounds are shown in Fig. 9, which is a representation of a linear approach to teaching. The corresponding systemic diagram SD_0 appears in Fig. 10.

The chemical relationships between benzene and benzene derivatives (toluene, bromobenzene, phenol, nitrobenzene, benzenesulphonic acid, etc.) are summarized in the diagram shown in Fig. 9, which looks like a series of linear relationships are connected by benzene. Fig. 9 looks a bit like it may have started to be a concept map, but the person generating it gave up. In effect, Fig. 9 is a summary of the individual reactions that makeup the chemistry of benzene, but it has very little use as a teaching device.

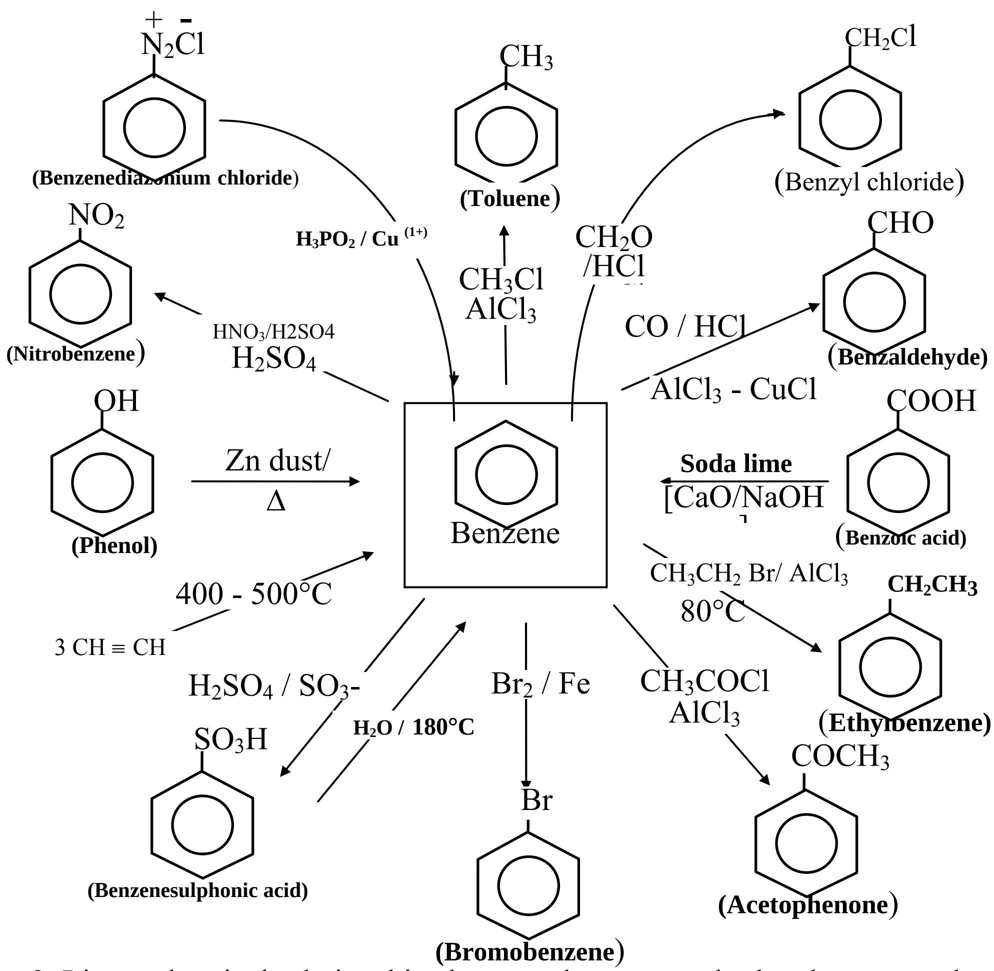


Fig. 9. Linear chemical relationships between benzene and related compounds.

We can illustrate the linear chemical relationships that appear in Fig. 9 in the following systemic diagram, shown as Fig. 10 (SD_0).

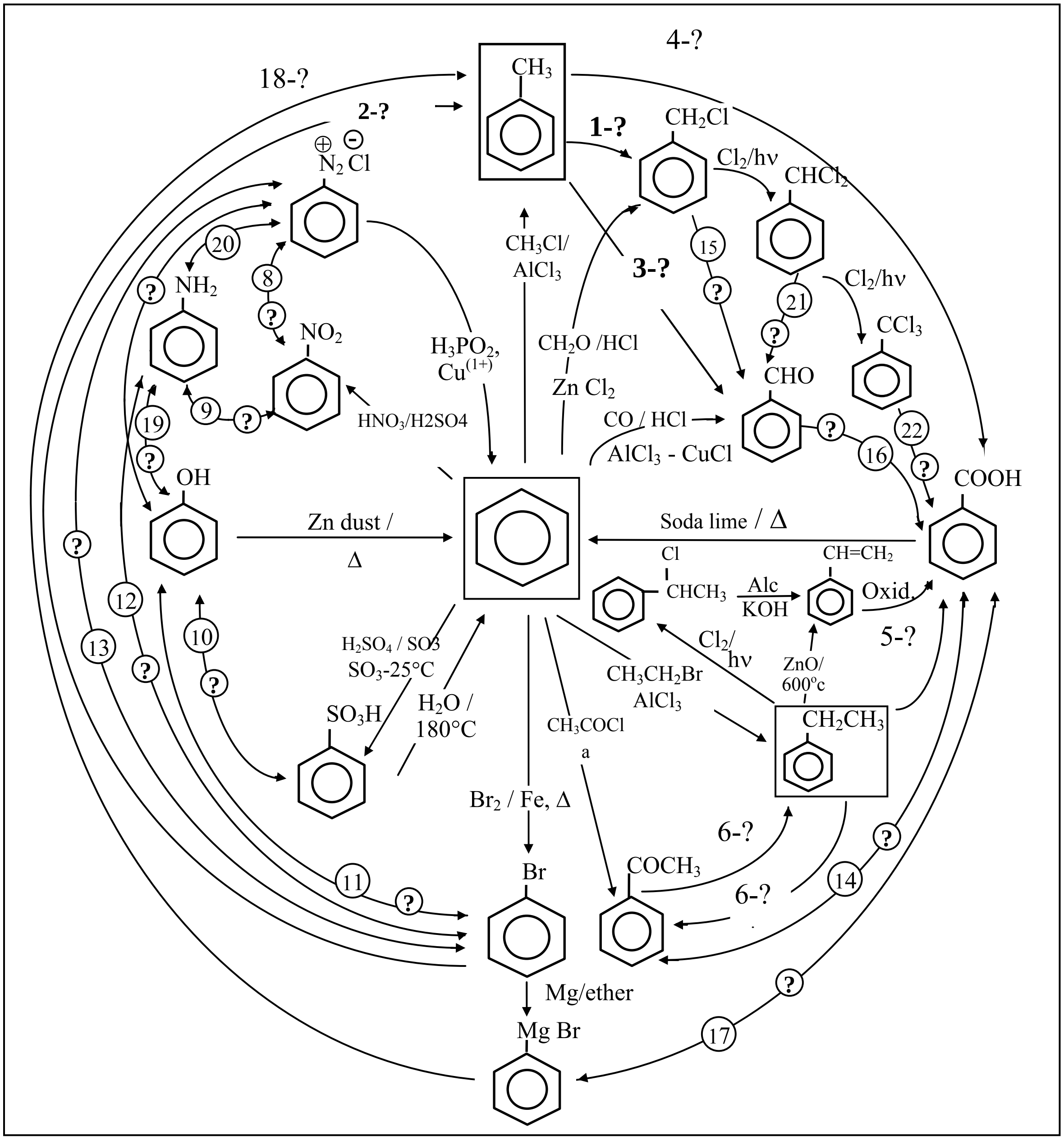


Fig. 10. SD_0 represents some of the major reactions of benzene and benzene derivatives.

In the systemic diagram SD_0 (Fig. 10.) some of the chemical relationships are defined (known to the student) whereas others are undefined (to be learned by the student). The known relationships have to be carefully defined by the teacher. They may be based on prior knowledge, or they will be discussed initially in some detail. The undefined relationships are developed systematically.

After using the diagram shown in Fig. 10 as the basis for the study of the synthesis and reactions of alkyl benzene, we can modify this systemic diagram (SD_0 in Fig. 10) to accommodate other chemistries of benzene and alkyl benzenes as shown in SD_1, Fig. 11.

We can modify the SD_0 to SD_1 by adding the defined chemical relations of 1-6 and 18. But we still have undefined chemical relationships of 7-17 besides the other four unknown chemical relationships, 19 - 22.

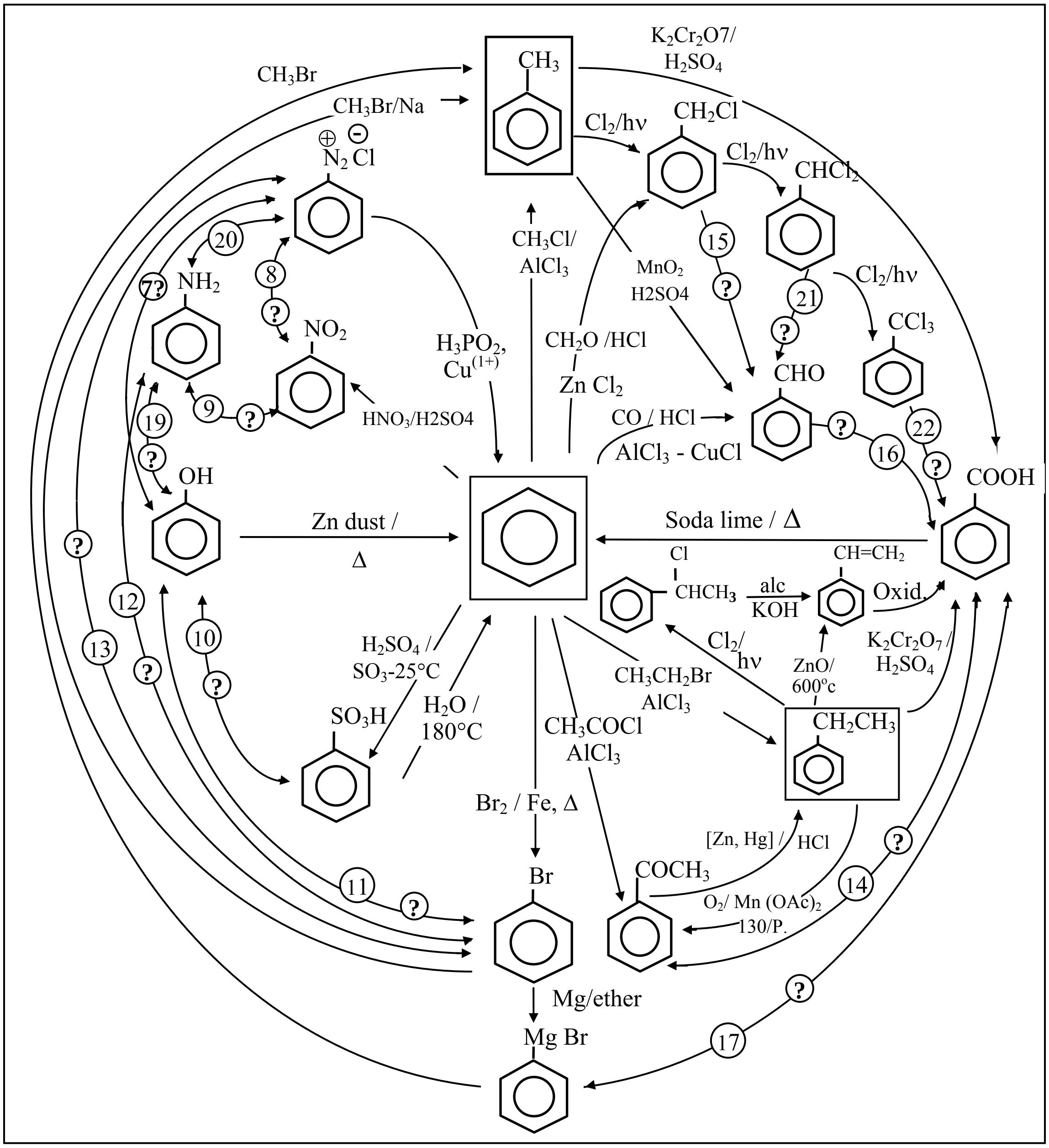


Fig. 11. SD_1 represents some of the major chemistries of benzene and alkyl benzene.

After studying synthesis and chemical reactions of halogen derivatives of benzene, we can modify this systemic diagram, SD_1 (Fig. 11), to accommodate other chemistries of halo benzene as shown in SD_2, Fig. 12.

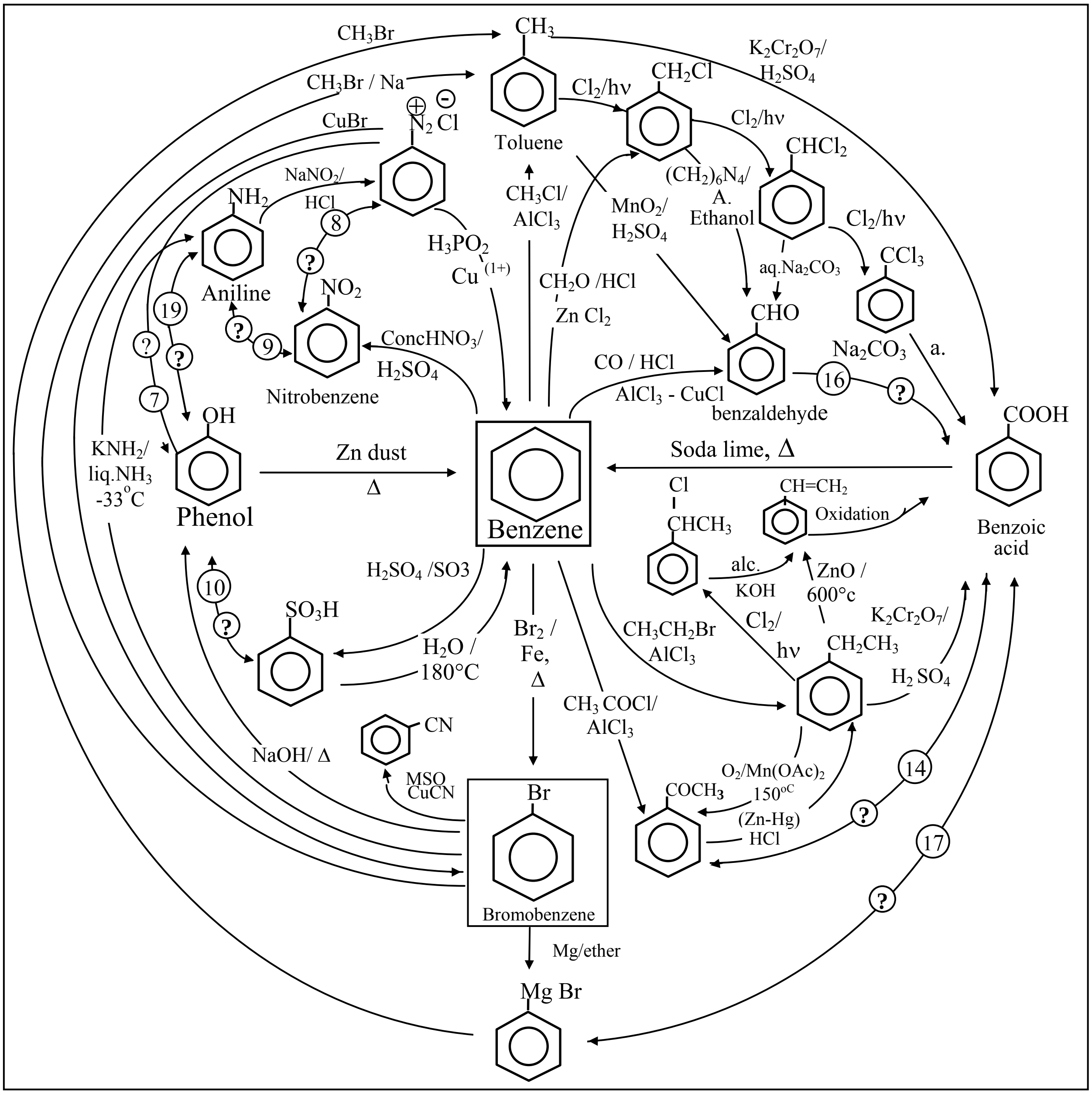


Fig. 12. SD_2 represents some of the major chemistries of benzene, alkyl benzene, and halo benzene.

In SD_2, Fig. 12, we still have undefined chemical relationships between 7-10 besides the four other relationships, 14, 16, 17,and 19. These will be clarified after studying the remainder of the course.

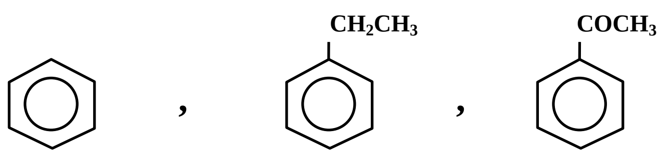
A course on aromatic chemistry using the SATL technique was organized and taught to 2nd year students at Menoufia University [4]. The one-semester course (16 lectures, 32 hours) was taught successfully to 28 students during the academic year 2000/2001.

SYSTEMIC ASSESSMENT ON [SD_1 AND SD_2] IN THE AROMATIC CHEMISTRY UNIT

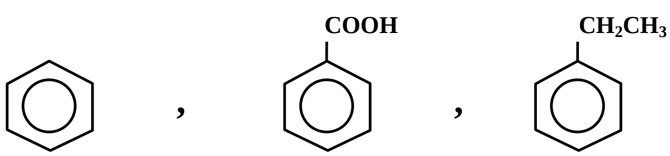
Assessment of student learning using SATL methods can be made as in the case of any teaching/learning paradigm. The following illustrate the kinds of questions that have been used successfully for assessment purposes.

I) Draw systemic diagrams illustrating chemical relationships between the compounds of each of the following sets.

a.

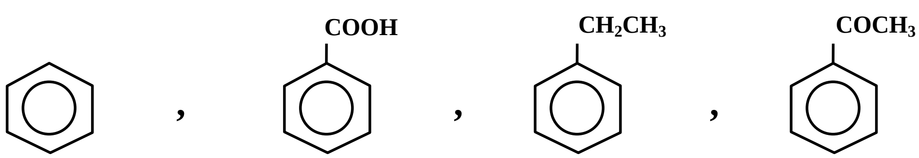


b.

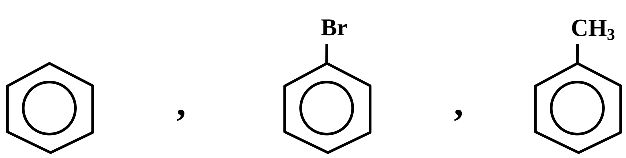


(Clockwise)

c.

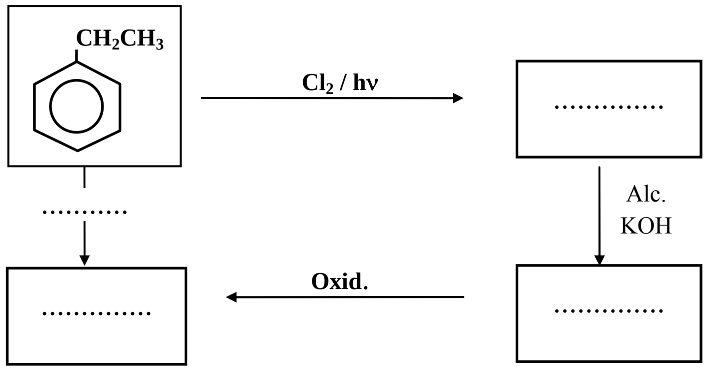


d.

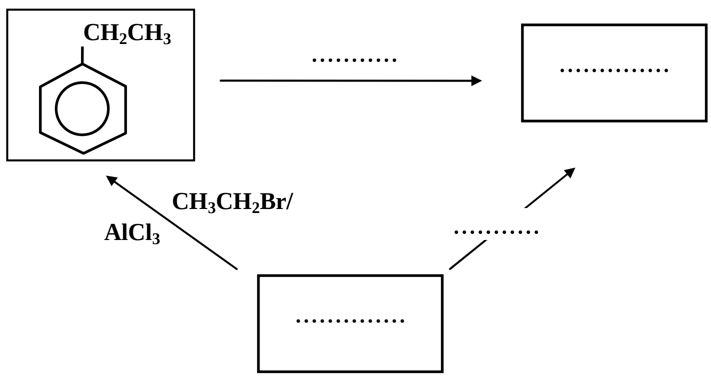


II) **Complete the following systemic diagrams**.

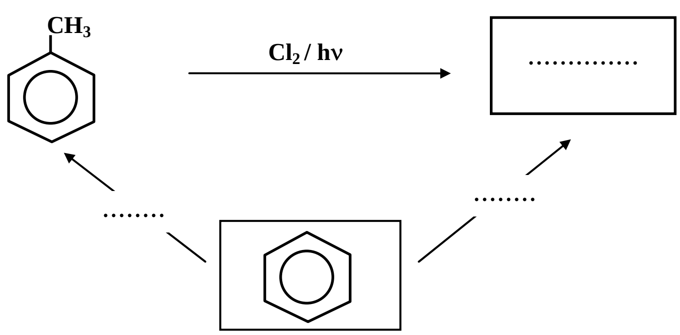
a.



b.

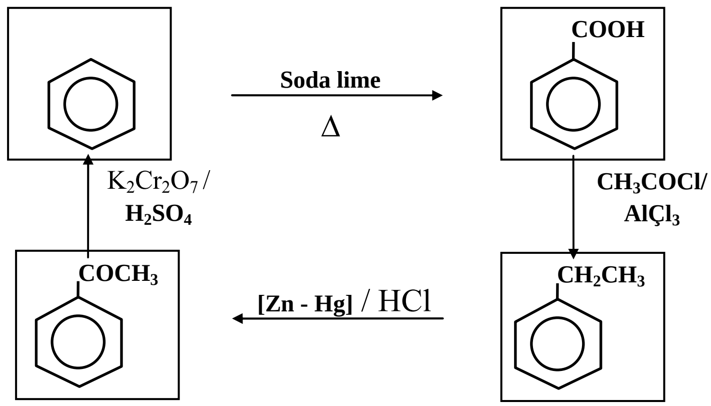


c.

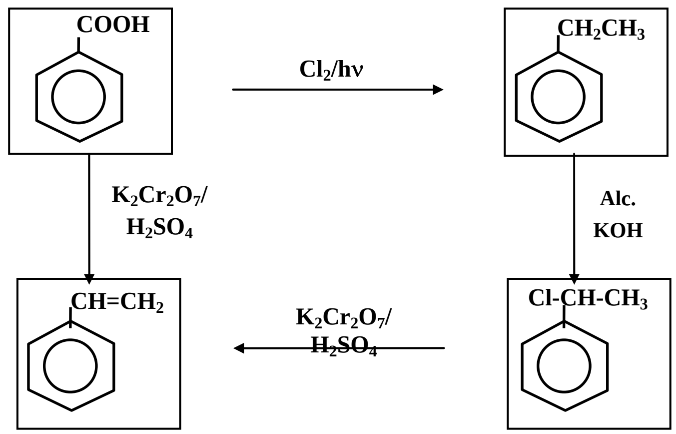


III) Correct the following systemic diagrams.

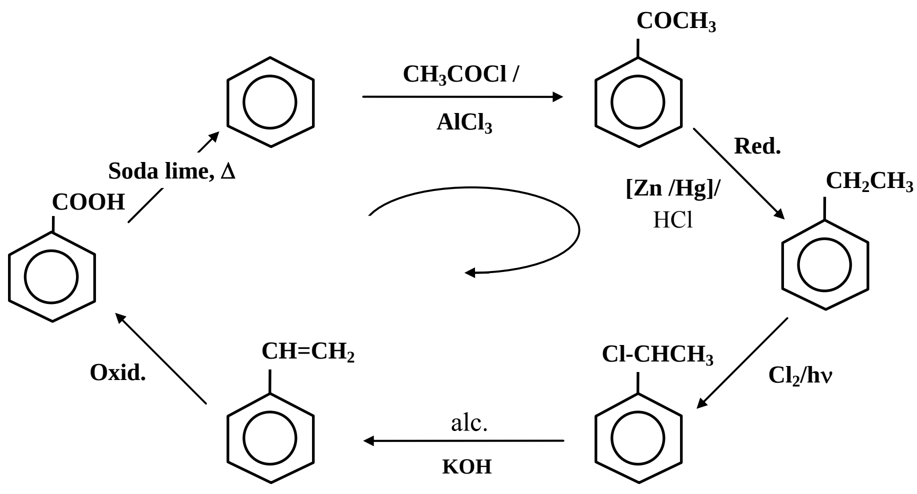
a.



b.



IV) Convert the following SD into the equivalent chemical equations.



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