

The Perceptions of Senior High School Students and Teachers about Organic Chemistry: A Ghanaian Perspective

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ABSTRACT

The purpose of the study was to determine the perceptions that senior high school (SHS) chemistry students, and teachers have about organic chemistry as well as to compare organic chemistry topics that are difficult for students and teachers. Simple random sampling (lottery) and purposive sampling methods were used to select a sample of 100 SHS students who studied elective chemistry and ten chemistry teachers. The research instruments used to collect data for this study were the “organic chemistry perceptions questionnaire for students” and “organic chemistry perceptions questionnaire for teachers.” Descriptive statistics (frequencies and percentages) were used to analyze the data collected. The findings revealed that these SHS students have a fairly positive perception of organic chemistry while their teachers had a highly positive perception of organic chemistry. Preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes, and structural isomerism were perceived by students as difficult to understand. The rest of the Ghanaian SHS organic chemistry topics (26 out of 34 topics) were perceived as easy to understand by students. Furthermore, the teachers perceived all the SHS organic chemistry topics as easy to teach with the exception of reactions of benzene. The insights gained about teachers’ and students’ perceived difficult organic chemistry topics in this study imply that teachers’ perceptions and how these are communicated to students can have significant effects on learning. The authors believe that both teachers and learners could benefit from this increased awareness of perceptions about difficulties in teaching and learning organic chemistry. They therefore suggest that further studies into how teachers’ perceptions influence their teaching and consequently their students’ experiences are carried out. In addition, in future research, a diagnostic test based on the topics in the SHS organic chemistry syllabus could be added to ascertain whether the perceived difficult topics are actually difficult for students to answer questions on. This would help teachers to separate perceived difficulties from the actual difficulties (realities) and be able to address them in their lessons.

KEY WORDS: perceptions; difficulty; organic chemistry; students; teachers

INTRODUCTION

At a symposium organized by the American chemical society in 2016, many of the speakers who were educators agreed that organic chemistry has always been in crisis and that students have been saying that organic chemistry is difficult for a long time (Halford, 2016). A search through available literature has further revealed that a lot of researchers (Childs and Sheehan, 2009; Jimoh, 2004; Johnstone, 2006; Ratcliffe, 2002) have identified organic chemistry as one of the most difficult topics in chemistry. Topics such as petroleum, natural and synthetic polymers (Donkoh, 2017; Uchegbu et al., 2017), differentiating of functional groups (Ayalew and Ochonogor, 2015; O’Dwyer and Childs, 2017), benzene (Donkoh, 2017), drawing and representation of organic compounds (Johnstone, 2006; Taber, 2002), isomerism (Taagepera and Noori, 2000), properties of organic compounds (Anderson and Bodner, 2008), aromatic hydrocarbons (Davis, 2010), and classification of organic compounds (Domin et al., 2008; Hassan et al., 2004) have been listed as difficult for students and teachers by the various researchers.

(Hanson, 2014; 2016) also identified that the inability of Ghanaian students to understand the nature of matter and connect among the three representational levels of matter (macroscopic, microscopic, and representational) are the main factors that impede their study of chemistry. According to (Hanson, 2017), most students are unable to understand these representations well and thus form a faulty and weak foundation for further study of chemical concepts, especially in organic chemistry. Adu-Gyamfi et al. (2013) also carried out studies on students’ conceptions and performance in international union of pure and applied chemistry (IUPAC) nomenclature of organic compounds and found that Ghanaian high school students had weak performance in naming and writing structural formulae of alkenes, alkynes, alkanols, alkanolic acids, and alkyl alkanooates. Further studies by (Adu-Gyamfi et al., 2017) showed that students’ difficulties in IUPAC naming of organic compounds included their inability to identify the correct number of carbon atoms in the parent chain and to identify a substituent or functional group. Similar studies by (Davis, 2010) and (Donkoh, 2017) revealed that high school students perceived classification of organic compounds

and petroleum as difficult to understand (DU) while their teachers did not perceive any of the Ghanaian high school organic chemistry topics as difficult to teach. To remediate these difficulties, (Hanson, 2016; 2017) suggested that teachers can use concrete examples to enable students to form mental models in order to alleviate the abstractness of chemical concepts and begin their lessons by asking questions related to everyday life events so that the context of the properties or answers could be steered to the classroom and its scientific or chemical aspect emphasized through individual, small group and whole class discussions.

However, despite the efforts by teachers to improve the performance of students in organic chemistry, the main body in charge of Ghanaian senior high school (SHS) examinations the West African Examinations Council (WAEC) consistently reports poor performance of students in organic chemistry. Recent WAEC chief examiners' reports on chemistry (West African Examinations Council, 2017; 2018) note that students showed the following weaknesses: inability to recall the terms such as catalytic cracking, functional groups, aliphatic compounds, aromatic compounds, inability to draw structures of organic compounds indicating all bonds, and drawing how the carbon-carbon double bonds in alkenes are formed. These suggest that students still have problems with learning organic chemistry.

In teaching organic chemistry, it is critical that educators are aware of the cognitive level and ability of their learners, if not the learners will be overwhelmed by the multi-level cognitive demands of chemistry as well as the other scientific and mathematical demands of the subject (O'Dwyer and Childs, 2017). This is because what might be easy for the teacher to understand might not be easy for the student to understand due to their differences in experiences and cognitive abilities. It is therefore important that teachers are made aware of their learners' attitudes, preconceptions, and perceptions. So that they will be able to tailor their instructions to ensure meaningful learning as students' attitudes and perceptions about a subject can in the long run influence their performance in that subject, hence the need for this study. In this study, the perceptions of students and teachers about organic chemistry as well as difficult topics in organic chemistry for students and teachers were evaluated and compared descriptively. This study sought to:

1. Evaluate selected SHS students' and teachers' perceptions about organic chemistry
2. Compare students' difficult organic chemistry topics to teachers' difficult organic chemistry topics.

Based on the specific objectives stated above, the following research questions were formulated to guide this study.

1. What are the SHS students' and teachers' perceptions of organic chemistry?
2. Which are the differences and similarities in organic chemistry topics that students and teachers perceive to be difficult?

DESIGN AND PROCEDURES

The study, which used a descriptive survey design, involved a 100 3rd-year SHS 3 general science students and 10 elective chemistry teachers from three selected schools in the central region of Ghana. The student participants, with ages from 15 to 24 years, were selected through simple random sampling while the teacher participants were selected through purposive sampling. The student and teacher participants in the three selected schools had either been taught or taught organic chemistry.

Ethical standards were upheld during the research as the principles of confidentiality, anonymity and informed consent were applied. Before carrying out the research, the researchers sought permission from the administrators of the concerned schools. The researchers explained the purpose of the study and the methods to be used to carry out the study to school administrators and participants (both student and teacher participants). Participants were then given the option of opting out if they did not want to be part of the study. The student and teacher participants who were used for this study voluntarily accepted to take part in the study. The identity of the schools, respondents' identities and private information given during the study were kept private and confidential.

The "organic chemistry perception questionnaire for students" (OCPQS) and "organic chemistry perception questionnaire for teachers" (OCPQT) which were both adapted from (Davis, 2010) as well as (Ayalew and Ochonogor, 2015) were used in this study to secure information from the SHS 3 students and teachers on their perceptions of organic chemistry. The OCPQS (Appendix A) and OCPQT (Appendix B) were based on the Ghanaian Ministry of Education SHS elective chemistry syllabus and included both closed ended and open-ended questions. Both the OCPQS and OCPQT had three sections. The first section in the OCPQS collected respondents' biographic data. The second section which consisted of seven items focused on the students' perception of organic chemistry in general. The third section which consisted of 35 items sought to collect data on students' perception of organic chemistry topics. The items numbered one to 34 in the third section covered all the topics under organic chemistry in the SHS elective chemistry syllabus. To respond to the items, the respondents were required to indicate their perception of understanding of each of the listed topics on a six-point Likert scale: very easy to understand (EU), EU, understood only after considerable effort, DU, very DU, and not taught (NT). Item 35 solicited free responses on topics that students find most DU.

The OCPQT which was similar to the OCPQS included both closed- and open-ended items. The teachers' instrument was also made up of three sections; the first section sought information on teachers' biographic data as well as their educational background and teaching experience. The second section consisting of five items sought to find out teachers' perception of organic chemistry in general on a five-point Likert scale: strongly disagree, disagree, undecided, agree, and

strongly agree. The third section consisting of 34 items sought information on teachers' perception of the topics in organic chemistry. To respond to items one to 34, the respondents were required to indicate their perceptions of each of the listed topics on a similar five-point Likert scale which ranged from very easy to teach, easy to teach, not sure, difficult to teach and very difficult to teach.

To ensure the validity of the instruments, expert judgment of senior members in the field of science education was sought on the content and face validities of the instruments. The comments and suggestions from the experts were used in restructuring the items. Furthermore, factors that contribute to low validity such as unclear directions, and ambiguities in language were eliminated. The questionnaires were also tested in a pilot study using a sample of thirty randomly selected SHS 3 students and five teachers from a school with similar student and teacher characteristics. The pilot study was done specifically to help in checking the clarity of the items, give feedback on internal validity of the items and to ensure appropriateness of the data.

To ensure reliability, the data from the pilot study were used to test the internal consistency of the questionnaire.

ANALYSIS OF DATA

The research questions were used to guide the analysis of the data, that is, the data were analyzed to answer the research questions. The five-point Likert scales in section B of both the OCPQS and OCPQT were collapsed into 3-point scales for easy data entry and analysis. The scales "strongly agree" and "agree" were grouped as "agree" and assigned a number code of 3, "disagree" and "strongly disagree" were grouped as "disagree" and assigned a code of 1 while the "undecided" slot was also assigned a number code of 2.

For the section C of students' questionnaire, the six-point Likert scale was collapsed to 4 with "very EU" and "EU" grouped as "EU" and assigned a number code of 4, "DU" and very "DU" grouped as "DU" and coded 2, and understood after considerable effort (UCE) was assigned a code of 3, "NT" was also coded as 1. The collapsing of the six-point Likert scale to 4 was done to facilitate easy analysis of the data. The five-point Likert scale for section C of the OCPQT was also

collapsed to 3 to make the data analysis easier. The scales "very easy to teach" and "easy to teach" were grouped as "easy to teach" which was assigned a number code of 3, not sure was assigned a number code of 2, while "difficult to teach" and very "difficult to teach" were grouped as "difficult to teach" and assigned a number code of 1. The assignment of number codes to scales was done to facilitate easy entry of data into the Statistical Package for the Social Sciences (SPSS) computer software version 20 for analysis.

The coded data were statistically analyzed using the SPSS computer software version 20. Data were processed into frequencies and percentages. This was done to ensure clear description of gender, perception of students, and perception of teachers. Tables of frequencies and percentages obtained with the aid of SPSS were used to answer the research questions descriptively.

RESULTS AND DISCUSSION

Students' General Perceptions about Organic Chemistry

Presented in Table 1 is a summary of students' responses to statements in the OCPQS which sought information on students' general perceptions of organic chemistry as a subject. Students were asked to indicate their level of agreement or disagreement to statements to seek their general attitudes and perceptions of organic chemistry.

From Table 1, it can be seen that a considerable number of students (45) representing 45.0% of the student sample agreed that organic chemistry was a difficult subject for them while 48 students (48.0%) disagreed. Although a simple majority disagreed that organic chemistry was difficult, the difference between the number of students who agreed and those who disagreed was not large, so it could be inferred that almost half of the student sample saw organic chemistry as difficult while the other half saw it as not difficult. This is in contrast to findings from a study on Irish high school learners and teachers' perceptions and perspectives of organic chemistry by (O'Dwyer and Childs, 2017) which revealed that less than one third (75, 27.5%) of the high school learners they studied found organic chemistry easy while 165 (59.8%) of the learners found organic chemistry difficult to learn. In the current study, about 51% of the students agreed that organic chemistry concepts were very EU, 54% found it easy to solve organic chemistry

Table 1: Students' general perceptions of organic chemistry

S. No.	Statement	% Agree	% Undecided	% Disagree
1	Organic chemistry is a difficult topic for me	45.0	7.0	48.0
2	It is easy to solve organic chemistry problems	54.0	10.0	36.0
3	I am very happy during organic chemistry lessons	63.6	7.1	29.3
4	Organic chemistry concepts are very EU	51.0	7.0	42.0
5	My chemistry teacher's method of teaching helped me to understand organic chemistry concepts well	58.60	15.10	26.30
6	Organic chemistry is interesting	64.00	10.00	26.00
7	I enjoy learning organic chemistry more than the other aspects of chemistry	29.30	11.10	59.60

Source: Field data, 2019, EU: Easy to understand

problems, 63% were happy during organic chemistry lessons, 58% agreed that their chemistry teacher's method of teaching helped them to understand organic chemistry concepts well, while 64% found organic chemistry interesting. However, 59% disagreed with the statement "I enjoy learning organic chemistry more than the other aspects of elective chemistry" while only 29% agreed to it. It could be inferred that if given the choice, the majority (59%) of these students would choose to read the other aspects of chemistry over organic chemistry. In general, it could be said that students have a fairly positive perception of organic chemistry and a positive attitude toward it but would not choose to study organic chemistry over the other aspects of chemistry if given the chance.

Teachers' General Perceptions about Organic Chemistry

Table 2 presents a summary of teachers' responses to statements in the OCPQT which sought information on teachers' general perceptions of organic chemistry as a subject. Teachers were asked to indicate their level of agreement to statements.

It can be seen from Table 2 that all the teachers (100%) disagreed with the statement "organic chemistry is a difficult subject for me," meaning that all the teachers viewed organic chemistry as an easy subject. Eight of the teachers (representing 80%) agreed that organic chemistry concepts are very EU while two of them (20%) disagreed with this statement. Six teachers agreed that it was easy to solve organic chemistry problems, three disagreed, and one teacher did not respond to the statement. Seven of the teachers enjoyed teaching organic chemistry topics more than the other aspects of chemistry while two of them did not enjoy teaching organic chemistry more than the other aspects of chemistry. When the teachers' response to this particular statement was compared with that of the students, there seems to be a mismatch between the enthusiasm of teachers about organic chemistry and that of their students. This mismatch could be attributed to the fact that teachers are "experts" while learners are just beginners in organic chemistry.

Furthermore, 7 teachers disagreed to the statement "organic chemistry topics are not interesting" while 1 agreed. Unlike the students who perceived organic chemistry as interesting but would choose the other aspects of chemistry over organic chemistry, the teachers perceived organic chemistry as easy and interesting and would choose to teach organic chemistry over the other aspects of chemistry.

Students' Difficult Organic Chemistry Topics

The summary of responses of students to the levels of difficulty posed by listed Ghanaian SHS organic chemistry topics are presented in Table 3. Students were asked to indicate the levels of difficulty of the listed organic chemistry topics. Abbreviations in the Table would be interpreted as: EU, Understood after considerable effort (UCE), DU, and NT.

From the summary of responses presented in Table 3, 29 out of the 34 listed topics were viewed by majority of students as EU. The topics which were perceived as DU by students were preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes.

Preparation and chemical reactions of alkenes were chosen by 37% of students as difficult, and the same percentage of students (37%) also choose it as EU. However, 24% of students asserted that they understood it only after considerable effort. If a concept must be UCE, then that understanding of that concept poses some level of difficulty and could be said to be fairly difficult. In view of this, it could be concluded that preparation and chemical reactions of alkenes was perceived as difficult by the SHS students. Different reasons could be attributed to the difficulties students face in studying. However, this was not part of the current study. The identified difficulty could be as a result of teacher factors (teachers' methodologies, punctuality and attendance to class, mastery of content and ability to deliver effectively), students' factor (students' attitude to learning, motivation, attendance to class, paying attention in class), and lack of teaching and learning materials or other extrinsic difficulty; difficulty associated with the subject itself beyond the control of the learner (O'Dwyer and Childs, 2017).

Comparison of the reactions of benzene and alkenes also had the same percentage (29%) of students choosing "EU" and "DU" respectively while a greater percentage (32%) understood it only after considerable effort. As stated earlier, the fact that considerable effort had to be put in before students understood concepts could mean that some level of difficulty had to be overcome, and therefore, the topic "comparison of the reactions of benzene and alkenes" could be said to be perceived as DU by SHS students.

A slightly higher percentage of students viewed the topics "preparation and chemical reactions of alkynes", "structure

Table 2: Teachers' general perceptions of organic chemistry

S. No.	Statement	Agree (%)	Undecided (%)	Disagree (%)
1	Organic chemistry is a difficult topic for me to teach	0.0	0.0	100.0
2	Organic chemistry concepts are very EU	80.0	0.0	20.0
3	It is easy to solve organic chemistry problems	66.7	0.0	33.3
4	I enjoy teaching organic chemistry more than other aspects of chemistry	70.0	10.0	20.0
5	Organic chemistry topics are not interesting	10.0	20.0	70.0

Source: Field data, 2019, EU: Easy to understand

and stability of benzene” and “reactions of benzene” as EU (30%, 35%, and 33%, respectively) as compared to those that viewed them as DU (29%, 33%, and 30%, respectively). However, an equally appreciable percentage of students (36%, 26%, and 28%, respectively) also viewed these topics as “understood only after considerable effort.” If a topic is understood only after considerable effort, then it is DU (Davis, 2010). Conclusions could therefore be drawn that these topics were perceived to be difficult by the SHS students.

In addition, the topic on petroleum was viewed by 23% of students to be DU. About 22% of students saw it as EU while 23% saw it as a topic that could be understood only after considerable effort. This topic also recorded the highest percentage of students (27%) responding to it as “NT.” Students' difficulties in understanding “petroleum” could therefore be attributed to the probability that it was NT or the other reasons like teacher factors and student factors which have been stated earlier. Seeing that almost the same percentage of students that find petroleum DU also chose “NT,” it could be that indeed most teachers did not teach petroleum due to the fact that petroleum is the last topic under organic chemistry in the SHS chemistry syllabus. It being the last topic could imply that teachers may not get to the topic because of time constraints. Another interpretation of the gathered data or assumption could be that

the students were not present in class when “petroleum” was taught, or it was taught during extra classes where some of the students missed out. Polymers and polymerization also had quite a large percentage of students (25%) perceiving it as DU and the second highest percentage of students saying it was NT (24%).

Furthermore, students were required to list three most difficult topics in organic chemistry in item 35 of the OCPQS. From the responses students provided, the top five most difficult topics for students and their percentages were polymers and polymerization (69%), structure and stability of benzene (65%), reactions of benzene (60%), naming of alkanes and structural isomerism (56%), and petroleum (54%). Comparing the difficult topics stated in Table 3 and those listed above, it could be seen that structure and stability of benzene, reactions of benzene, and petroleum appear in both lists, and therefore, it could be said that they are the top three topics perceived to be most DU by the students. Although polymers and polymerization and naming of alkanes and structural isomerism were not chosen by majority of students as DU in Table 3, they were stated by a large number of students as difficult. In similar research works (Ayalew and Ochonogor, 2015; Davis, 2010; O'Dwyer and Childs, 2017; Uchehgbu et al., 2017), petroleum, benzene and synthetic polymers were also identified as topics that were perceived as difficult for students to understand.

Table 3: Students' level of difficulty in understanding organic chemistry topics

Topics	EU (%)	UCE (%)	DU (%)	NT (%)
Bonding in carbon	73.0	14.0	12.0	1.0
Classification of organic compounds	67.0	17.0	16.0	0.0
Identification of elements in organic compounds	56.0	24.0	20.0	0.0
Separation and purification of organic compounds.	54.0	21.0	23.0	2.0
Sources and characteristics of alkanes	58.0	18.0	23.0	1.0
Naming of alkanes and structural isomerism	65.0	18.0	17.0	0.0
Preparation, physical and chemical properties of alkanes	53.0	21.0	24.0	2.0
Sources and characteristics of alkenes	57.0	22.0	17.0	4.0
Naming of alkenes and isomerism in alkenes	55.0	18.0	24.0	3.0
Preparation and chemical reactions of alkenes	37.0	24.0	37.0	2.0
Uses of alkenes	59.0	19.0	12.0	10.0
Sources and characteristic properties of alkynes	48.0	28.0	22.0	2.0
Naming of alkynes and isomerism in alkynes	49.0	24.0	25.0	2.0
Preparation and chemical reactions of alkynes	30.0	36.0	29.0	5.0
Uses of alkynes	61.0	20.0	15.0	4.0
The structure and stability of benzene	35.0	26.0	33.0	6.0
Reactions of benzene	33.0	28.0	30.0	9.0
Comparison of reactions of benzene and alkenes	29.0	32.0	29.0	10.0
Preparation and properties of alkanols	48.0	28.0	18.0	6.0
Physical properties of alkanols	57.0	26.0	14.0	3.0
Primary, Secondary and tertiary alkanols	59.0	18.0	20.0	3.0
Chemical reactions of alkanols	46.0	24.0	25.0	5.0
Sources, preparation and properties of alkyl alkanoates	38.0	25.0	30.0	7.0
Naming and structure of alkyl alkanoates	48.0	19.0	29.0	4.0
Uses of alkyl alkanoates	42.0	23.0	29.0	6.0
Soapy and soapless detergents	39.0	23.0	21.0	17.0
Polymers and polymerization	33.0	18.0	25.0	24.0
Petroleum	22.0	28.0	23.0	27.0

Source: Field data, 2019, EU: Easy to understand, UCE: Understood after considerable effort, DU: Difficult to understand, NT: Not taught

Teachers' Difficult Organic Chemistry Topics

Table 4 provides a summary of responses of teachers to the levels of difficulty posed by listed Ghanaian SHS organic chemistry topics. Teachers were asked to indicate the levels of difficulty of the listed organic chemistry topics.

Comparatively, it can be seen from Table 4 that these teachers generally perceived all organic chemistry topics as easy to teach with the exception of reactions of benzene. This agrees with findings from (Donkoh, 2017) who also stated that chemistry teachers perceived none of the SHS organic chemistry topics as difficult to teach. It is however important to note that the fact that teachers rate a topic as easy to teach does not mean it is best taught (taught well) neither does a teacher rating a topic as difficult to teach make that topic the most poorly taught topic (not well taught) as these results are only representative of the teachers' views (O'Dwyer and

Childs, 2017). This means that a topic could be rated as easiest to teach by teachers but may end up not being well taught and a topic rated most difficult to teach might end up being well taught by a teacher. Teachers may be able to teach these topics to the understanding of their students or not.

The few topics which recorded an appreciable number of teachers viewing them as difficult to teach are identified below. The following topics were perceived as difficult to teach by at least 40% of the teachers: preparation and chemical reactions of alkynes (40%), the structure and stability of benzene (40%), reactions of benzene (50%), comparison of reactions of benzene and alkenes (40%), and polymers and polymerization (40%). A lot of factors could contribute to a teacher's difficulty in teaching a particular topic. Some of the factors may be the extensive nature of the content (loaded content), high cognitive demand of the content, lack of teaching and learning materials

Table 4: Teachers' perceptions about difficulty levels of organic chemistry topics

Topics	Easy to teach (%)	Not sure (%)	Difficult to teach (%)
1. Bonding in carbon	100.0	0.0	0.0
2. Classification of organic compounds	90.0	10.0	0.0
3. Identification of elements in organic compounds	90.0	0.0	10.0
4. Separation and purification of organic compounds, empirical and molecular formulae	90.0	10.0	0.0
5. Sources and characteristics of alkanes	100.0	0.0	0.0
6. Naming of alkanes and structural isomerism	90.0	10.0	0.0
7. Preparation and properties of alkanes	70.0	0.0	30.0
8. Uses of alkanes	90.0	0.0	10.0
9. Sources and characteristics of alkenes	80.0	0.0	20.0
10. Naming of alkenes and isomerism in alkenes	90.0	0.0	10.0
11. Preparation and chemical reactions of alkenes	70.0	0.0	30.0
12. Uses of alkenes	90.0	0.0	10.0
13. Sources and characteristic properties of alkynes	80.0	10.0	10.0
14. Naming of alkynes and isomerism	90.0	0.0	10.0
15. Preparation and chemical reactions of alkynes	60.0	0.0	40.0
16. Uses of alkynes	80.0	10.0	10.0
17. The structure and stability of benzene	60.0	0.0	40.0
18. Reactions of benzene	50.0	0.0	50.0
19. Comparison of reactions of benzene and alkenes	60.0	0.0	40.0
20. Preparation and properties of alkanols	100.0	0.0	0.0
21. Physical properties of alkanols	100.0	0.0	0.0
22. Naming of alkanols	90.0	10.0	0.0
23. Primary, Secondary and tertiary alkanols	90.0	0.0	10.0
24. Chemical reactions of alkanols	80.0	0.0	20.0
25. Uses of alkanols	100.0	0.0	0.0
26. Sources and properties of alkanolic acids	90.0	0.0	10.0
27. Naming of alkanolic acids	100.0	0.0	0.0
28. Uses of alkanolic acids	100.0	0.0	0.0
29. Sources and properties of alkyl alkanoates	80.0	10.0	10.0
30. Naming and structure of alkyl alkanoates	90.0	0.0	10.0
31. Uses of alkyl alkanoates	90.0	0.0	10.0
32. Soapy and soapless detergents	80.0	0.0	20.0
33. Polymers and polymerization	50.0	10.0	40.0
34. Petroleum	70.0	0.0	30.0

Source: Field data, 2019

such as textbooks, laboratory equipment, and lack of mastery over the content by the teacher (Mupa and Chinooneka, 2015).

Comparison of Students' Difficult Topics in Organic Chemistry to Teachers' Difficult Organic Chemistry Topics

Teaching and learning is a complex process with many internal and external factors influencing classroom experiences and relationships. The teachers' perspectives, and how the material is presented, have considerable impact on the learners' experiences and development of understanding. That is the reason why the authors saw the need to compare students' difficult topics to their teachers' difficult topics.

An appreciable number of teachers perceived the topics preparation and chemical reactions of alkynes (40%), the structure and stability of benzene (40%), reactions of benzene (50%), comparison of reactions of benzene and alkenes (40%), and polymers and polymerization (40%) as difficult to teach. On the other hand, the organic chemistry topics which were perceived to be DU by most students were: preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, polymers, and polymerization, naming of alkanes and structural isomerism and petroleum.

All the topics that teachers perceived to be difficult to teach were also perceived to be DU by their students. (O'Dwyer and Childs, 2017) explained that while teachers' positive attitudes, interest and enjoyment of organic chemistry may stimulate learners' respective experiences, teachers' perspectives and perceptions of many topics may on the other hand have substantial impact on their learners' perspectives and learning of many of the topics. The insights gained about teachers' and students' perceived difficult organic chemistry topics in this study imply that teachers' perceptions and how these are communicated with the students can have significant effects on learning. It is therefore important that teachers are aware of their influence on their learners in generating preconceptions about difficult topics. Although teachers are required to empathize with students by reassuring them, some findings have suggested that teachers' own perceptions of the difficulty of topics may influence the effectiveness of the teaching and learning of these topics and in turn influence their students' experiences and perceptions (O'Dwyer and Childs, 2017).

CONCLUSIONS

This study aimed at finding the differential perceptions of selected SHS teachers and students. The study specifically considered the general perceptions of students and teachers in selected SHSs in Ghana about organic chemistry. It perused the topics that students and teachers considered easy or DU and teach (for teachers). Findings revealed that the SHS teachers had a positive perception of organic chemistry and found 33 out of the 34 organic chemistry topics in the SHS chemistry syllabus easy to teach. Reactions of benzene of benzene was

the only topic that 50% of the teachers found easy to teach while the other 50% found it difficult to teach. The students on the other hand also had a positive perception toward organic chemistry but would be interested in studying the other aspects of chemistry rather than organic chemistry. Students found 26 out of the 34 organic chemistry topics as EU. The topics that the students perceived to be DU were preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes and structural isomerism). Based on the findings from this study, organic chemistry teachers should pay extra attention (invest more time, varied teaching methodologies) when teaching the topics that have been identified by students in this study as DU. These authors believe will go a long way to help ease the difficulties that students encounter in studying these topics.

The teachers considered some topics as difficult to teach as they realized that those are the topics that their students had difficulty understanding. The same topics which were identified by teachers as difficult to teach were negatively perceived and poorly understood by majority of their students. This suggests that if better teaching strategies or approaches are made available and are used by the teachers, these topics may become easier to teach, and in turn easier for the learners to understand if they are better taught.

IMPLICATIONS FOR CHEMISTRY EDUCATION

The insights gained about teachers' and students' perceived difficult organic chemistry topics in this study imply that teachers' perceptions and how these are communicated to students can have significant effects on learning. It is therefore important that teachers are aware of their influence on their learners in generating preconceptions about difficult topics. Although teachers are required to empathize with students by reassuring them, some findings have suggested that teachers' own perceptions of the difficulty of topics may influence the effectiveness of the teaching and learning of these topics and in turn influence their students' experiences and perceptions (O'Dwyer and Childs, 2017). The authors believe that both teachers and learners could benefit from this increased awareness of perceptions about difficulties in teaching and learning chemistry. They therefore suggest that further studies into how teachers' perceptions influence their teaching and consequently their students' experiences are carried out.

In addition, in future research, a diagnostic test based on the topics in the SHS organic chemistry syllabus could be added to ascertain whether the perceived difficult topics are actually difficult for students to answer questions on. This would help teachers to separate perceived difficulties from the actual difficulties (realities) and be able to address them in their lessons.

LIMITATIONS OF THIS STUDY

The students' and teachers' perceptions about organic chemistry and the perceived difficult topics in organic chemistry presented in this paper clearly represent a complex interplay of numerous factors, both systematic and pedagogical. This paper did not attempt to determine best practices in the teaching and learning of organic chemistry but rather provides an overview of the different perceptions about organic chemistry as well as topics that are perceived to be difficult within the organic chemistry learning environment.

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APPENDICES

Appendix A

Organic Chemistry Perceptions Questionnaire for Students (OCPQS)

This questionnaire is an instrument for a study that seeks to find out the perceptions of SHS chemistry students on organic chemistry. There is no right or wrong response.

SECTION A

BIO DATA

1. Gender (Tick): Male Female
2. AGE (Write in the box):

SECTION B

General Perception of Organic Chemistry

Kindly indicate your level of agreement/disagreement with the statements below by ticking under either strongly agree, agree, undecided, disagree or strongly disagree.

Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1.Organic chemistry is a difficult topic for me					
2.Organic Chemistry concepts are very EU					
3.It is easy to solve organic chemistry problems.					
4.I am very happy during organic chemistry lessons					
5.My chemistry teacher's method of teaching is more attractive and helped me to understand organic chemistry concepts well					
6.Organic chemistry is interesting					
7.I enjoy learning organic chemistry more than the other aspects of elective chemistry					

SECTION C

Perceptions about Organic Chemistry Topics

Tick (✓) the appropriate column corresponding to your opinion about the topic.

Please be sure to respond to all the items. If you change your mind about your response to an item just cross it out and tick (✓) another. You are assured of the confidentiality of your opinion. Thank you.

Topics	Very EU	EU	Understood only after considerable effort	DU	Very DU	NT
1. Bonding in carbon						
2. Classification of organic compounds						
3. Identification of elements in organic compounds						
4. Separation and purification of organic compounds, empirical and molecular formulae						
5. Sources and characteristics of alkanes						
6. Naming of alkanes and structural isomerism						
7. Preparation, physical and chemical properties of alkanes						
8. Uses of alkanes						
9. Sources and characteristics of alkenes						
10. Naming of alkenes and isomerism in alkenes						
11. Preparation and chemical reactions of alkenes						
12. Uses of alkenes						
13. Sources and characteristic properties of alkynes						
14. Naming of alkynes and isomerism in alkynes						
15. Preparation and chemical reactions of alkynes						
16. Uses of alkynes						
17. The structure and stability of benzene						
18. Reactions of benzene						
19. Comparison of reactions of benzene and alkenes						
20. Preparation and properties of alkanols						
21. Physical properties of alkanols						
22. Naming of alkanols						
23. Primary, Secondary and tertiary alkanols						
24. Chemical reactions of alkanols						
25. Uses of alkanols						
26. Sources, preparation and properties of alkanolic acids						
27. Naming of alkanolic acids						
28. Uses of alkanolic acids						
29. Sources, preparation and properties of alkyl alkanoates						
30. Naming and structure of alkyl alkanoates						
31. Uses of alkyl alkanoates						
32. Soapy and soapless detergents						
33. Polymers and polymerization						
34. Petroleum						

1. Indicate the topic(s) you find most DU in organic chemistry. List three of them, in order of difficulty.

1.

2.

3.

APPENDIX B

Organic Chemistry Perception Questionnaire for Teachers (OCPQT)

This questionnaire is an instrument for a study that seeks to find out the perceptions of SHS chemistry teachers on organic chemistry. There is no right or wrong response.

SECTION A

BIODATA

1. Gender (Tick): Male Female
2. Age (Tick): 23–34 years
35–44 years
45–60 years
3. Academic qualification (tick): Diploma 1st Degree 2nd Degree Others
4. Number of Years in Teaching (Write in the box):

SECTION B

General Perception of Organic Chemistry

Kindly indicate your level of agreement/disagreement with the statements below by ticking under either strongly agree, agree, undecided, disagree or strongly disagree.

Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1.Organic chemistry is a difficult topic for me to teach					
2.Organic Chemistry concepts are very EU					
3.It is easy to solve organic chemistry problems					
4.I enjoy teaching organic chemistry topics more than the other aspects of chemistry					
5.Organic chemistry topics are not interesting					

SECTION C

Perceptions about Organic Chemistry Topics

Tick (✓) the appropriate column corresponding to your opinion about the levels of difficulty of the topics listed below. Please be sure to respond to all the items. If you change your mind about your response to an item just cross it out and tick (✓) another. You are assured of the confidentiality of your opinion. Thank you.

Topics	Very easy to teach	Easy to teach	Not sure	Difficult to teach	Very difficult to teach
1. Bonding in carbon					
2. Classification of organic compounds					
3. Identification of elements in organic compounds					
4. Separation and purification of organic compounds, empirical and molecular formulae					
5. Sources and characteristics of alkanes					
6. Naming of alkanes and structural isomerism					
7. Preparation, physical and chemical properties of alkanes					
8. Uses of alkanes					
9. Sources and characteristics of alkenes					
10. Naming of alkenes and isomerism in alkenes					
11. Preparation and chemical reactions of alkenes					
12. Uses of alkenes					
13. Sources and characteristic properties of alkynes					
14. Naming of alkynes and isomerism in alkynes					
15. Preparation and chemical reactions of alkynes					
16. Uses of alkynes					
17. The structure and stability of benzene					
18. Reactions of benzene					
19. Comparison of reactions of benzene and alkenes					
20. Preparation and properties of alkanols					
21. Physical properties of alkanols					
22. Naming of alkanols					
23. Primary, Secondary and tertiary alkanols					
24. Chemical reactions of alkanols					
25. Uses of alkanols					
26. Sources, preparation and properties of alkanolic acids					
27. Naming of alkanolic acids					
28. Uses of alkanolic acids					
29. sources, preparation and properties of alkyl alkanoates					
30. Naming and structure of alkyl alkanoates					
31. Uses of alkyl alkanoates					
32. Soapy and soapless detergents					
33. Polymers and polymerization					
34. Petroleum					