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Students' Perception of Kitchen Activity Groups in Promoting Understanding of Thermodynamics Concepts and Problem-Solving Skills in Secondary School Chemistry

OKAFOR NGOZI
University of Lagos, Akoka, Yaba, Nigeria

Abstract. This study investigated students' perception of kitchen activity groups in promoting understanding of thermodynamics concepts and problem solving skills in chemistry. Four null hypotheses guided the study. It was quantitative survey and correlational research designs which involved 250 coeducational public Senior Secondary School 3 (SSS 3) chemistry students in Lagos State of Nigeria. Three instruments were used in data collection and data were analyzed using mean, standard deviation, Pearson correlation coefficient, MANOVA and ANOVA. Results show that students perceived Energy Transfer (ET) and Thermodynamics Meaning (TM) as kitchen activity groups that promoted students Understanding of Thermodynamics Concepts (UTC) and Problem-Solving Skills (PSS) respectively. Gender was also perceived to significantly contribute in promoting students' UTC and PSS in chemistry respectively in favour of male students. The results also show significant combined contributions of kitchen activity groups, gender and age groups in promoting students' understanding of thermodynamics concepts and problem-solving skills in chemistry. The paper concludes that to be successful in post-primary environment, school leavers should embrace learning of chemistry at home that is fun and inspiring in solving learning difficulties of the 21st century education and suggests that since good education and skills acquisition begin at home, therefore, secondary school chemistry teachers should liaise with parents or guardians to synergize difficulties students encounter in learning chemistry concepts by relating them to home chores around the kitchen.

Keywords: Gender, Age, Kitchen Activities, Thermodynamics

1. Introduction

The expectations of secondary school students' achievement in the classroom have changed over the years to the learning of chemistry at home due to its abstract nature as found in thermodynamics. Thermodynamics involves heat, temperature, and their relation to energy, work and properties. The behavior of these quantities is governed by the four laws of thermodynamics (Turanyi & Toth, 2013). Charity begins at home, and the home is the first laboratory children encounter some common chemical compounds (Jones, 2011; Okafor, 2019). Johnson (2005) stated that kitchen chemistry makes teaching and learning fun, enhance weaker students' achievement, and self-confidence as well as reasoning ability during science activities. Therefore, chemistry students should be motivated in interpreting some chemical reactions that occur in the kitchen during cooking (Nja and Neji, 2013). Perhaps, only a few chemistry teacher with ingenuity can connect the teaching of chemistry concepts in the kitchen. For instance, the boiling of water can be used to teach change of state. Some chemistry experiments can be explored and appreciated in the kitchen such as energy transfer (thermodynamics), chemical reactions among others (Jones, 2011 & Johnson, 2005). Problem solving skills are the most important qualities in decision making. An individual who thinks critically, acts logically and assesses situations before solving problems (Hersch, 2008). Okafor (2017) concluded that problem solving ability could help students build stronger cognitive skills, higher academic achievement and choice of job in future careers. This paper therefore, examined students' perception of kitchen activity groups, gender and age influences in promoting secondary school students understanding of thermodynamics concept and problem solving skills in chemistry.

1.1 The Role of Kitchen Activities in the Teaching and Learning of Chemistry

Charity they say, begins at home, therefore, the study of science should start from the home which is the first environment of the child while kitchen is the first laboratory to learn common chemical compounds such as sugar, starches, fats, protein and heat flow (Jones, 2011; Okafor, 2012). Johnson (2005) had set up kitchen chemistry to create innovative science resources that make teaching and learning fun and inspiring to teachers and students as well as enhancing achievement of weaker students. He posited that students who participate in the kitchen show self-confidence, reason critically and creatively during science activities. Thus, a good cook is often regarded as a chemist. Cooking can also be compared to the synthesis of organic materials in the laboratory, only that the kitchen is filled with jars of beans, rice, spices, cereal, pots, kettles (metals), and plastics among others while chemistry laboratory is equipped with consumable and non-consumable materials. Cooking is chemistry experiment in the kitchen because when food is cooked, myriads of physical and chemical changes occur simultaneously (Helmenstine, 2011). Chemistry teachers and students therefore should be inspired and motivated in interpreting some chemical reactions during cooking (Nja and Neji, 2013; Okafor, 2019). The role of kitchen in the teaching of some chemistry concepts is vastly significant from cooking food, mopping, washing clothes and utensils which result to change of states. Helmenstine (2011) and Jones (2011) viewed kitchen as the safest laboratory stocked with food materials which increases students' active learning. To effectively apply kitchen knowledge in chemistry, the teacher should be conversant with some chemical processes taking place during cooking. Perhaps, only a few chemistry teachers with special ingenuity can connect the teaching of chemistry concepts in the kitchen. For instance, boiling of water can be used to teach change of state. Disappearance of camphor balls can be used to teach sublimation. Some chemistry experiments can be explored, conducted and appreciated as exciting experiment in the kitchen such as radiation, convection, conduction, energy transfer (thermodynamics), chemical reactions, chemistry of carbohydrates, acids and bases (Jones, 2011 & Johnson, 2005). Once students have acquired knowledge on how the chemical properties of food are affected by heat during cooking, they can be skillful in understanding scientific thoughts in solving problem (Helmentine, 2008; Johnson, 2005; Jones, 2011; Okafor, 2018 & Sirhan, 2007). Helmentine (2008) and Johnson (2005) explained that learning established during kitchen chemistry could foster students' interactions, team building, problem-solving skills and understanding of scientific concepts.

1.2 Problem-Solving Abilities in Decision Making

Problem-solving skills are the most important fruitful qualities in decision making. An individual who thinks critically, acts logically and assesses situations before solving problems (Hersch, 2008). Ryan (2013) posited that individuals with interpersonal and problem solving skills are bound to succeed in innovative environments. She outlined three components of problem-solving ability such as: (1) ability to understand the problem, (2) ability to connect the related concepts, theory, formulae and equations and (3) ability to solve the problem scientifically or mathematically to get correct answers. P21 (2011) explained that reasoning skills have empowered American education and some business stakeholders in assessing, analyzing and evaluating the credibility, accuracy and value of information in taking purposeful actions. These skills are consciously and unconsciously transferred to students not only in the school system but during kitchen chemistry activities (Helmenstine, 2008; Helmenstine, 2011). Okafor (2018) asserted that chemistry instruction that uses unfamiliar materials and language from its discipline could make learning and problem-solving difficult. Okafor (2012) stated that good education and acquisition of relevant skills begin at home, and so, school should not be blamed for the values or skills which the home has failed to instill in the learner. Therefore, if good education and acquisition of relevant values or skills for positive learning outcomes begin from home, then, there will be need to ascertain students' perception of kitchen activities in promoting students understanding of some basic concepts of thermodynamics (heat transfer) and problem-solving skills in Lagos State of Nigeria.

1.3 Gender in Science Education

Gender issue in science education has attracted the attention of many scientists in various dimensions. Achor, Kurumeh & Orokpo (2012) reported that boys performed better than girls and more aggressive in laboratory activities that require manipulation, critical reasoning and problem solving. Also girls have been ascribed to be excellent in house hold chores, kitchen activities and communication skills (Okafor, 2019). Okafor & Okewale (2016) asserted that secondary school girls are rated highly in home learning opportunities for completion and retention of

chemistry education. Igbojinwaekwu (2002) observed that boys are more mechanical, technical, confident, assertive and scientifically inclined than girls with high achievement in job situations. Many studies have reported male students' superiority in chemistry over the female counterparts. However, a study undertook by Okafor (2016) on perceived influence of learning styles showed that gender has no influence on secondary school girls' achievement in chemistry. Thus, the students' perception of kitchen activities, gender influence and age in promoting secondary school students understanding of thermodynamics and problem solving skills in chemistry.

2. Theoretical/ Conceptual Framework

Ausubel (1986) assimilation theory of learning explained that people learn better when they find meaning in the learning process. To learn meaningfully, students should be given freedom in their learning process to take full responsibility of their own learning. Teachers can provide such freedom of learning during cooking in the kitchen as a tool. Chemistry concepts are learned as building blocks from home through nursery to higher level of education whereby prior knowledge gives meaning to new knowledge when interpreting a given phenomenon. This paper agreed with Ausubel (1986) theory of advanced organizer which explained that concepts are meaningfully learned when the learner can visualize them based on prior knowledge and subsume them within its cognitive structure. The hypotheses of this study are situated below in Figure 1 of Biggs (1993) Model on students' learning which is limited to operationalization of three independent variables of students' perception (kitchen activities, gender and age) on two dependent variables(Understanding of thermodynamics concepts and problem-solving skills).

Fig. 1: Modified 3P-Model of Biggs (1993)

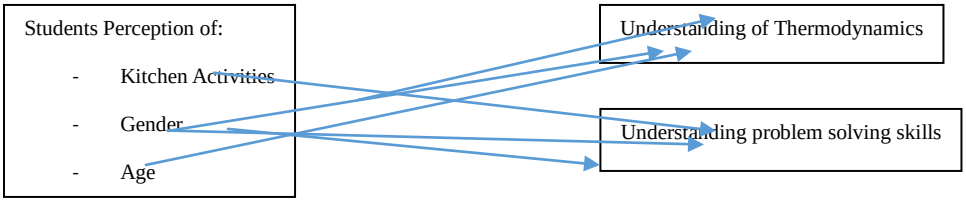

Figure I: Study Model of Students' learning: A Modified 3P-Model of Biggs (1993)]

3. Statement of Research Problem

Nigeria researchers and West African Examination Council (WAEC) chief examiners' reported poor achievement and inadequate skills of secondary school chemistry students during external examinations and emphasized that they could be attributed to inappropriate teaching pedagogies, abstract nature of chemistry, inadequate problem solving and 21st century skills, as well as disconnection of classroom laboratory from home environment (Okafor, 2018; Okafor, 2019; Okafor & Uzoechi, 2017; Okafor, Yewande, & Okafor, 2015; WAEC 2015; Yusuf & Adigun, 2010). Conley (2007a) measured the new employees' problem solving ability on Annual Performance Review (APER) and found that new graduate employees lack adequate problem solving skills when compared with the more experienced non-graduates. Despite the excitement chemistry brings to students' lives, most of them still believe that chemistry is boring, and gender insensitive (Igbojinwaekwu 2002).There is an evolution in support of home learning through kitchen activities when Helmestine (2008) and Johnson (2005) stated that learning established during kitchen chemistry could foster students' team building, problem solving skills and understanding of scientific concepts. Chemistry students and teachers keep asking how, what topics and skills that could be understood and promoted during kitchen activities. It is not the classroom reality that determines students learning irrespective of age groups but how they perceive a given learning situation. Previous studies on students' perception of kitchen activities in promoting learning outcomes are scarce. The purpose of this study was to explore students' perception of kitchen activities, gender and age groups influence in promoting understanding of thermodynamics concept and problem-solving skills in chemistry within Lagos State of Nigeria. Four null hypotheses guided the study as stated below:

HO_1: There will be no students' positive perception of Kitchen Activity (KIA) groups in promoting

understanding of Thermodynamics Concept (TC) and Problem Solving Skills (PSS) in secondary school Chemistry;

HO_2: There will be no significant female and male (gender) influence in promoting understanding of TC and PSS in secondary school Chemistry;

HO_3: There will be no significant contribution of KIA and Gender in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

HO_4: There will be no significant positive influence of age groups in promoting students' understanding of TC and PSS in secondary school Chemistry.

4. Research Methodology

This study used quantitative survey and correlational research designs which involved 250 public coeducational Senior Secondary School III (SSS3) chemistry students (136 females' and 114 males) with the average age of 16 years. The sample was purposively selected from Eight Secondary Schools (SS) in Education District Six of Lagos State, Nigeria whose teachers participated in the 2018 Teacher Vacation workshop organized by the Early Years Exposure to Science (EYES) in Nigeria. Thermodynamics concept was considered because chemistry teachers outlined it as difficult for students to comprehend though had been taught to them in third term of SSII. Kitchen Chemistry Activity Rating (KCAR); Thermodynamics Concept Test (TCT) and Problem Solving Rating Scale (PSRS) were used in data collection.

KCAR was developed by the researcher which comprised of 16 kitchen chemistry activity statements (grouped into five sub-headings: meaning of thermodynamics, its laws and systems, energy transfer and kitchen resources). Each Respondent was to read the statements and responds on each of the groups that promotes chemistry students' understanding of thermodynamics concept on a Four Point Likert-Scale of Strongly Agree (SA); Agree (A); Strongly Disagree (SD) and Disagree (D).

Thermodynamics Concept Test (TCT) was Four essay questions that require 20 short answers including examples drawn from basic concepts of thermodynamics using test-Blue Print such as (1) Explain the meaning of thermodynamics in not more than two sentences with examples. (2) Distinguish between kinetic and potential energy in two sentences. (3) Discuss the four laws of thermodynamics in not more than four sentences and (4) Give the meaning of a system and briefly discuss the five classes of thermodynamics systems with examples. A marking guide was drawn to ensure uniformity on correct responses. Each correct answer attracts five marks and 20 correct answers were expected.

Problem Solving Rating Scale (PSRS) was adapted from Ryan (2013) with modifications which consists of Ten Statements on Problem-solving Skills grouped into three: (1) Ability to understand problem; (2) Ability to connect related concepts to real life (3) Ability to solve problem scientifically. Respondents were to read and rate one box that describes a particular problem-solving skill(s) in each of the three groups on a Five points Scales of 'I have not been taught this skill'; 'I know what this skill is but have not practiced it'; 'I am working to develop and improve'; 'I can do this reasonably well' and 'I am really good at this'. It has also gender and age column.

Validity and reliability of KCAR, TCT and PSRS were determined by administering them to 97 public SSS3 chemistry students that did not form part of this study. Cronbach Alpha of .79; .83 and .93 respectively were obtained showing evidence of internal consistency. The administration of instruments lasted for two weeks with the support of chemistry teachers in the sampled schools. Data collected were analyzed using percentages, mean, standard deviation, Correlation coefficient, regression analysis, MANOVA and Analysis of Variance (ANOVA).

5. Results

The results of the findings are discussed based on the three hypotheses raised.

HO_1: There will be no students' positive perception of Kitchen Activity (KIA) groups in promoting understanding of Thermodynamics Concept (TC) and Problem Solving Skills (PSS) in secondary school Chemistry;

Table 1a: Descriptive Analysis of Kitchen Activities Relevant in Basic Concepts of Thermodynamic in Chemistry

ITEMS	Agree S+SA	Disagree D+SD
Kitchen Resources		
Addition of salt to soup during early cooking process concentrates its flavor as water evaporates due to heating	65	35
When a kettle of water at room temperature is heated the temperature and energy of water are decreased	10	90
Energy Transfer		
Stainless spoon dropped inside a boiling pot of meat increases the rate at which meat is cooked	88	12
Frying of fish in a deep hot oil gives some explanations on heat transfer	78	22
Thermodynamics Meaning		
Activities of cooking in the kitchen such as heating, energy conversion, freezing, temperature, pressure, volume and others are found in thermodynamics basic concepts	72	28
Absolute zero is the lowest possible temperature where nothing can be colder and no more heat energy can be extracted from a substance	68	32
Thermodynamics Laws		
Heat transfer from one metal pot to another in the process of cooking in the kitchen is an example of 1^{st} Law of thermodynamics	96	04
2^{nd} law of thermodynamics explains that after heat energy is converted to mechanical, it cannot be reversed by converting to heat energy	91	09
3^{rd} law of thermodynamics reinforces ideas of reaching measurement of absolute zero, when a system losses all values & ability to function	83	17
Zeroth law explains that when two thermodynamic systems are in thermal equilibrium with the third, they are thermally in equilibrium with each other	78	22
Thermodynamics Systems		
A pot of boiling water, ocean, rivers, open container are eg of an open system bcos of exchange of both heat(energy), work and matter between the system and surrounding.	14	86
A person cooking in the kitchen is an example of open system.	60	40
A gas cylinder is an example of an isolated system because matter and energy cannot be exchanged with the surroundings	82	18
Thermostat and insulated containers in the kitchen are examples of an isolated system	89	11
Closed system does not allow exchange of matter with surrounding (matter does not cross boundary) but allows heat(energy) and work e.g. closed pot of boiling water, pressure cooker(pot), vacuum cleaner	35	65
In adiabatic system, heat does not cross the boundary but heat crosses boundary in diathermic system	70	30

Table 1a, shows students' perceptions of kitchen activities groups in promoting their understanding of thermodynamics concepts. Considering kitchen resources group, 65% is in agreement while 35% disagree. Also 90% disagree while 10% agree on kitchen resource group. In energy transfer group, 88% and 78% are in total agreement; considering the meaning of thermodynamics group, 72% and 68% are in total agreement. Furthermore, 96%, 91%, 83% and 78% agree on thermodynamics laws; while 86% and 65% disagree completely; while in thermodynamics systems group, 60%, 82%, 89% and 70% are completely in agreement. Showing the effectiveness of kitchen activities in understanding thermodynamics concepts in chemistry

Table 1b: Correlation analysis among kitchen Activity (KIA) groups in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

KITCHEN ACTIVITIES		**UTC**	**PSS**
KR	Pearson Correlation	.778	.867
	Sig. (2-tailed)	.000	.000
	N	250	250

ET	Pearson Correlation	.834	.870
	Sig. (2-tailed)	.000	.000
	N	250	250
TM	Pearson Correlation	.692	.885
	Sig. (2-tailed)	.000	.000
	N	250	250
TL	Pearson Correlation	.577	.423
	Sig. (2-tailed)	.000	.000
	N	250	250
TS	Pearson Correlation	.723	.563
	Sig. (2-tailed)	.000	.000
	N	250	250

Kitchen Resources (KR); Energy Transfer (ET); Thermodynamics Meaning(TM); Thermodynamics Laws (TL); Thermodynamics Systems (TS*)*

Table 1b shows the correlation values for each group of kitchen activity that promotes students UTC and PSS. The correlation value for each of the groups on UTC ranges between 0.577 and 0.834 while that of PSS ranges between 0.423 and 0.885.This depicts the extent to which each of the kitchen activity groups contributed in promoting secondary school students Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry.

Considering UTC, the highest contributions for Kitchen Activity Groups include; ET (0.834) > KR (0.778) > TS (0.723) > TM (0.692) > TL (0.577) while PSS, follow descending order of TM (0.885) > ET (0.870) > KR (0.867) > TS (0.563) > TL (0.423). However, Energy Transfer (ET) and Thermodynamics Laws (TL) of kitchen activity groups have the highest and least contributions respectively in promoting secondary school students UTC in chemistry while Thermodynamics Meaning (TM) and Thermodynamics Laws (TL) have the highest and least contributions respectively in promoting secondary school students PSS in chemistry. However, among the groups of kitchen activity, Energy Transfer (ET) and Thermodynamics Meaning (TM) are perceived to be very efficient in promoting students UTC and PSS respectively while Thermodynamics Laws (TL) had the least contribution in both UTC and PSS. Table 1b has shown a significant positive relationship among groups of KIA in promoting understanding of TC and PSS. This is evidenced in the p-values of 0.00 for each of TC and PSS with correlation values of 0.834 and 0.885 respectively indicating positive relationship among KIA groups in promoting secondary school students understanding of TC and PSS in chemistry.

Table 1c: Correlation Analyses of Kitchen Activiti\y (KIA) Groups in promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

ITEMS		**UTC**	**PSS**
KITCHEN	Pearson Correlation	.834**	.885**
ACTIVITIES	Sig. (2-tailed)	.000	.000
	N	250	250

Level of Significance: 0.05

Table 1c shows a significant positive relationship among groups of KIA in promoting UTC and PSS. This is evidenced in the p-values of 0.00 for each of UTC and PSS as well as correlation values of 0.834 and 0.885 respectively which are greater than 0.05 level of significance. This is an indication of positive relationship among KIA groups in promoting secondary school students UTC and PSS in chemistry. Hence, the perception of Energy Transfer (ET) and Thermodynamics Meaning (TM) in promoting Understanding of Thermodynam8ics Concepts (TC) and Problem-Solving Skills (PSS) in secondary school chemistry.

HO_2: There will be no significant female and male (gender) influence in promoting Understanding of TC and PSS in secondary school Chemistry;

Table 2a: The Summary of the Frequency and Percentage by gender

		Frequency	Percent	Cumulative Percent
Valid	Male	114	45.6	45.6
	Female	136	54.4	100.0
	Total	250	100.0	

The result in Table 2a indicates that 114 respondents are males and 136 respondents are females. Therefore, 46% of the 250 respondents are males and 54% of the respondents are females. It is inferred that female students who are always preoccupied during kitchen activities may have higher perception of kitchen activities in promoting understanding of thermodynamic concepts and problem-solving skills in chemistry than the male counterpart.

Table 2b: The Summary of One Way MANOVA on Gender (female and male) influence in promoting UTC and PSS

	Df	Ms^2	F	Sig.	n^2	Variable
GENDER	**1**	**.010**	**.025**	**.874**	**.001**	**UTC**
	1	**.480**	**1.367**	**.243**	**.003**	**PSS**

The M ANOVA Table 2b shows significant values of 0.001 and 0.003 for each of UTC and PSS respectively which are less than 0.05. This means that gender has significant influence in promoting secondary school students' Understanding of Thermodynamics Concepts (UTC) and Problem Solving Skills (PSS) in chemistry in favour of male students.

Table 2c: Mean and Standard Deviation of Gender (Male and Female) influence on Secondary School Students UTC and PSS in chemistry

	Gender	N	Mean	Std Dev.	Mean Diff
UTC	**Male**	**114**	**20.000**	**0.0 00**	**1.84**
	Female	**136**	**18.162**	**2.016**	
	Total	**250**	**19.000**	**1.745**	
PSS	**Male**	**114**	**78.763**	**1.542**	**19.35**
	Female	**136**	**59.412**	**9.865**	
	Total	**250**	**68.236**	**12.129**	

Table 2c shows mean and standard deviation of male and female respondents in promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in chemistry. Males had the highest mean score (20.000) rating in the UTC Test than the females (18.162) rating. Also, in PSS rating, result shows that males excelled in the *ability to understand problem and solve problem scientifically or mathematically* with mean rating of (78.763) and *'they know what problem skills are but have not been practicing'* while the females have the mean rating of (59.412) on PSS ratings indicating that they have the *ability to connect the related concepts to real life* and '*are working to develop and improve in the skills'*. More so, the overall mean difference of 1.84 and 19.35 were obtained in favour of male students.

HO_3: There will be no significant contribution of KIA and Gender in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

Table 3: Linear Regression Model Summary and ANOVA Result on Contributions of Kitchen Activities and Gender in promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

	Sum of Square	Df	R Square	R	Mean Square	F	Sig	Remark
Regression	**2776.383**	**2**	**0.239**	**0.489**	**1388.192**	**38.756**	**000***	**Significant**
Residual	**8847.313**	**247**			**35.819**			**p<0.05**
Total	**2090.496**	**249**						

Table 3 shows that the R square value is 0.239 which means that 23.9% of the variation in kitchen activities and gender combined in promoting understanding of thermodynamics and problem-solving skill in chemistry. The p-value (sig) showed significant relationship on understanding of thermodynamics and problem solving skills in chemistry at 5% level of significance when other possible predictors factors are kept constants (R Square = 0.239, $p<0.05$) though the extent of the combined influence is very low. The F value of .38.75 and sig. value of 0.00 means that when the kitchen activity groups and gender combined, they will significantly predict students' understanding of thermodynamics and problem-solving skills in chemistry with the significant value of 0.00 which is less than 0.05.

HO_4: There will be no significant positive influence of age groups in promoting students' understanding of TC and PSS in secondary school Chemistry.

Table 4a: Percentage Responses on Descriptive Analysis of Age Group

Age	Frequency	Percentage %
11-13 Years	18	7.2
14-16 Years	215	86.0
17-19 Years	17	6.8
Total	250	100

Table 4a shows that 7.2% of the respondents was within the age range of 11-13 years, 86% was within the age range of 14 -16 years while 6.8% was within age range of 17-19 years.

Table 4b: Correlation Analysis of Age Group in Promoting UCT and PSS in Chemistry

	Pearson Correlation	UCT	PSS
AGE GROUP		-.571**	-.478**
	Sig. (2-tailed)	.000	.000
	N	250	250

Level of Significance: 0.05

The Correlation Analysis of Age Groups in Table 4b shows that age has a significant negative influence in promoting Understanding of Thermodynamics Concepts (UTC) and Problem Solving-Skill (PSS) in chemistry with correlation values of -.571** for UTC and -.478** for PSS with significant values of .000 and .000 respectively which are less than 0.05 value. This implies that as the age group increases, promoting the understanding of UTC and PSS reduces and vice-versa. This further explains that students whose age is older have higher understanding of thermodynamics and problem solving skills in chemistry.

6. Discussions

Students' perception of Kitchen Activity (KIA) groups in promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Secondary School Chemistry

Table 1a explains how students perceived the contributions of each of the Kitchen Activities (KIA) groups in promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry. Energy Transfer (ET) has the highest influence in promoting UTC, followed by Kitchen Resources (KR), then Thermodynamics Systems (TS); next is Thermodynamics Meaning (TM) and Thermodynamics Laws (TL). This is achieved in decreasing order of ET > KR > TS > TM > TL for UTC. Thermodynamics Meaning (TM) group has the highest influence in promoting PSS in chemistry, followed by ET, KR, TS and TL. That is TM > ET > KR > TS >TL. However, Energy Transfer (ET) and Thermodynamics Laws (TL) of kitchen activity groups have the highest and least influence respectively in promoting secondary school students UTC in chemistry while Thermodynamics Meaning (TM) and Thermodynamics Laws (TL) have the highest and least contributions of KIA groups respectively in promoting secondary school students PSS in chemistry.

However, the findings explained that during the kitchen activities in all groups, Energy Transfer (ET) and Thermodynamics Meaning (TM) promote students UTC and PSS respectively while Thermodynamics Laws (TL) had the least influence in promoting secondary school chemistry students UTC and PSS respectively in Lagos State of Nigeria. This corroborates with Helmenstine (2011) and Johnson (2005) who inferred that participation during kitchen activities builds students self-confidence in problem solving since they learn common chemical reactions during cooking in the kitchen. It also supports studies of Jones (2011) and Helmenstine (2008) who posited that kitchen activities enhance students' independent inquiry on concept knowledge and once knowledge is acquired on how food is affected by heat during cooking, students can be skillful in understanding scientific thoughts and problem solving skills in secondary school chemistry. It could be inferred that once students can explain the meaning of thermodynamics, the principles of energy transfer during cooking in the kitchen can easily be understood by analyzing the chemical properties of cooked food, thus solving problems that may conflict meaningful understanding of thermodynamics concepts in chemistry.

The Influence of Female and Male (Gender) in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Secondary School Chemistry

Tables 2b and 2c revealed that gender has significant influence in promoting secondary school students' Understanding of Thermodynamics Concepts (UTC) and Problem Solving Skills (PSS) in chemistry in favour of male students. In Table 2c, males excelled in the *ability to understand problem and solve problem scientifically or mathematically.* The overall mean ratings favours male students in both UTC and PSS than females. This negates the work of Okafor & Okewale (2016) and Okafor (2016) whose findings revealed a non-gender influence on girls achievement and completion of secondary school chemistry but supports Achor, Kurumeh & Orokpo (2012) as well as Igbojinwaekwu (2002) who reported that boys were more mechanical, technical, scientifically inclined with high achievement in job situations and also outperformed girls in critical reasoning, problem solving, practical and theory examinations. In addition, since females participate more during cooking in the kitchen, this could be inferred as the reason why they excelled in *'having ability to connect the related concepts to real life'* on PSS. The differing perception of male and female students on PSS is also evidenced in the work of Okafor et.al. (2015) who identified that problem solving skills could help students relate chemistry to everyday life as well as solving problems from various dimensions.

Contributions of Kitchen Activities (KIA) and Gender in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

Table 3 shows the significant combined contributions of kitchen activity groups and gender in promoting students' understanding of thermodynamics concepts and problem-solving skills in chemistry. The influence of kitchen activities and gender in promoting secondary school students understanding of thermodynamics and problem solving skills in chemistry is in agreement with Helmentine (2008) and Johnson (2005) explanations that learning established during kitchen chemistry could foster students' interactions, team building, problem-solving skills and understanding of scientific concepts. The result supports the recommendations of Okafor (2019) and Nja & Neji (2013) that chemistry teachers and students should be inspired and motivated in interpreting some chemical reactions during cooking irrespective of gender. However, it negates the work of Okafor (2016) on perceived influence of learning styles which showed that gender has no influence on secondary school girls' achievement in chemistry.

Influence of age groups in Promoting Understanding of Thermodynamics Concept (UTC) and Problem Solving Skills (PSS) in Chemistry

Table 4b shows a significant negative influence of age groups in promoting students UTC and PSS in chemistry. This entails that the older students may not be favourably disposed in self-guided learning and teamwork that enhance UTC and PSS other than the average or younger students who may be thirsting for novel knowledge in chemistry from home environment. This supports Ryan (2013) and Hersch (2008) who explained that problem-solving skills are emphasized in the schools irrespective of age group for building future career choice and job opportunities as well as bridging institutional gaps in both academics and performance skills. The finding further corroborates with Helmenstine (2011) who reported that the major defect in science education is disjointed facts and concepts most schools present to the different age groups in the school with inadequate emphasis on the activities of the home environment rather, on expository method that makes understanding of chemistry concepts uninspiring and uninteresting in the real life situation. It can be deduced that younger and average students can easily connect new information to the existing knowledge acquired during cooking in the kitchen.

7. Conclusion

The students' perception of kitchen activities in promoting understanding of thermodynamics concepts and problem solving skills in secondary school chemistry supported Vygotsky (2008) believe that learners' do not learn by listening, memorizing and spitting out answers but they relate what they have learned at home during daily activities for its applications in a new situation. He also posited that learning takes place in a social context which is an interaction with others. This explains why chemistry teaching requires familiar objects for illustrations through interactions. The process of knowledge construction can be improved upon through discovery learning during kitchen activities which is the ultimate purpose of understanding the realities of chemistry in everyday life to minimize learning difficulties of some abstract chemistry concepts.

It is good to know that today's workforce requires 21st century graduates who have broad knowledge in problem solving (AES, 2019). Teaching with home resources (kitchen) could make teachers work easier, help in arousing students' interest, enhance their problem solving skills and academics excellence. Gender inequity observed does not depict male intellectual superiority over female but requires all round exposure of both male and female students in areas that will make them to fulfil their potentials and innate tendencies. However, to be successful in post-secondary environment, the Nigeria secondary school leavers should embrace learning of chemistry as fun, inspiring and interesting for improved academic excellence especially in solving global problem of the 21st century. Okafor (2012) explained that good education and acquisition of relevant skills begin at home, and so, school should not be blamed for the values or skills which the home has failed to instill in the learner. Therefore, if good education and acquisition of relevant values or skills for positive learning outcomes begin from home, them there will be need to positively perceive kitchen chemistry activities in promoting students understanding of basic concepts of thermodynamics (heat transfer) and problem solving skills in Lagos State secondary school chemistry since to be successful in post-primary environment, school leavers should embrace learning of chemistry at home that is fun and inspiring in solving learning difficulties of the 21st century education.

8. Recommendations

Based on the findings of the study, the following recommendations are made:

- Student should be given opportunity to construct problem-solving tasks in chemistry based on their prior knowledge during kitchen activities at home for conceptual understanding and problem-solving skills acquisition.
- Teacher education programme should prepare the 'Would-be.-Teachers' on usability of kitchen resources as innovation in the teaching of abstract secondary school chemistry concepts for them to appreciate chemistry in everyday activities.
- Chemistry teachers should be motivated through in-service training, seminars and workshop on how to synergize kitchen (home) activities with school laboratory experiments by giving regular chemistry assignments that could be done during cooking in the kitchen.
- They should be inspired with ingenuity to connect and apply the teaching of chemistry concepts in the kitchen especially on some physical and chemical reactions taking place during cooking.
- Chemistry teachers should make teaching

and learning of some difficult concepts interactive, interesting and participatory with adequate illustrations from the kitchen during cooking since charity begins at home.

- Students learning during cooking should be adequately tailored to build strong cognitive skills, higher academic achievement as well as foster interactions, team building, problem solving skills and understanding of chemistry difficult concepts.
- Young girls and boys should be encouraged to be part of food preparation in the kitchen for enhancing team building, and equitable understanding of some abstract concepts in chemistry.
- Secondary school chemistry curriculum should be reviewed to incorporate kitchen activities into the teachers' and students performance activities. This would require training on item writing through workshops, seminars and conferences to be sponsored by the State and Federal Ministries of Education.
- Every parents' should be scientific literate and better informed that the kitchen is a home laboratory where children construct meaningful learning of science and chemistry in particular.
- Teacher education programme in Nigeria should prepare the would-be teachers on how to teach difficult concepts in chemistry using locally made resources from the kitchen for improved learning outcomes in secondary school chemistry.
- Good education and skills acquisition begin at home, therefore, secondary school chemistry teachers should continuously liaise with the parents or guardians to synergize difficulties students encounter in some chemistry concepts by relating them to all the activities at home and kitchen in particular.

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