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Students’ engagement in learning by indigenous knowledge-chemistry lesson

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This study was aimed at assessing students’ engagement in an integrated indigenous knowledge-chemistry lesson (IIK-CL) designed using the processes involved in cassava dough production. The paper focuses on the behavioural, emotional and cognitive engagement and their impact on students’ construction of knowledge of the factors affecting rate of chemical reactions. The study was conducted in Swedru senior high school in the Agona East municipality of the Central Region of Ghana. A purposively sampled intact class of 26 students aged between 14 and 18 years formed the study. The control group for this study encompassed also 26 students randomly sampled from the remaining chemistry classes in the same grade as the study group. The IIK-CL, which employed the use of field trip and other interactive learning activities, was used to engage students in the learning concept. A quantitative research approach was used. Data before and after students’ engagement in the IIK-CL were collected using questionnaires and an observational schedule. The IIK-CL recorded a significant level of behavioural, emotional and cognitive student engagement. This implies that students are most likely to be engaged in lessons that are relevant to their everyday lives thereby helping them in constructing understanding of scientific concept in their personal context.

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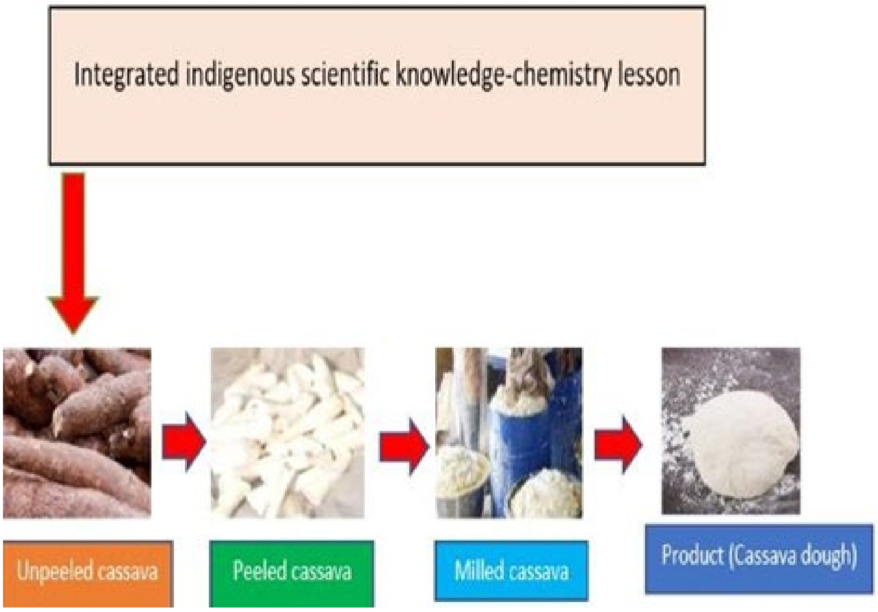

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1 Introduction

Chemistry teaching must focus on engaging students in the learning process where students can construct knowledge and understanding on their own. The active participation of students can help promote knowledge retention and application. The general aims of learning chemistry as outlined in the teaching syllabus for senior secondary schools in Ghana are to provide knowledge, to help students understand, appreciate, and to apply scientific methods and principles among others (Ministry of Education, 2010). These profile dimensions are to make chemistry more interesting, self-motivating and further emphasise the ability to process and link chemistry in the classroom to traditional and modern technologies for sustainable development.

To achieve the general aims of teaching and learning chemistry and further improve upon students' performance, an alternative approach to the teaching and learning of the subject ought to be considered globally and specifically in Ghanaian schools. The effective communication of chemistry to learners can be achieved through the identification of relevant starting points in imparting concepts and embedding chemistry learning in situations meaningful to the learners for content relevance and practicality and applicability (Ausubel et al., 1978; Eilks & Hofstein, 2013). According to Kaino (2013), various tribes possess unique indigenous knowledge (IK) practices that can be meaningfully integrated into teaching and learning processes to improve the learning outcome of students. Convincingly, Thaman (2002) further argued that formal education can not exclude IK in any indigenous environment since IK consists of values that can practically and efficiently support the classroom-based formal education. Effective and efficient access to suitable contexts to make chemistry relevant to students personally, socially, and economically does seem likely to come through the informal and non-formal routes or indigenous scientific knowledge practices. The relevance of concepts taught to students is also likely to encourage students' engagement in lessons thereby helping them to construct knowledge and understanding as well as to develop skills and competences building up personal scientific literacy.

Student engagement (SE) encompasses three dimensions including (i) behavioural, which incorporates participation, effort, persistence and positive conduct; (ii) emotional, which covers interactions with teachers and classmates and involves a sense of belonging; and (iii) cognitive, which focuses on self-regulated learning (Fredricks et al., 2004). SE in teaching and learning processes are essential for the construction of concepts in chemistry (Eilks & Hofstein, 2013). Students who are engaged in the learning process develop a sense of belonging and self-worthiness, and thus are more likely to succeed academically, graduate, and avoid engaging in delinquent behaviours (Wentzel, 1997). Students' engagement in the teaching and learning process is receiving increasing recognition from researchers worldwide as means to improve academic achievement (Beale, 2018; Fredricks et al., 2004). Several studies have suggested how beneficial engagement is to behavioural, emotional and cognitive achievement (Eccles & Midgley, 1989; Connell, 1990; Newmann, 1992; Skinner & Belmont, 1993; Beale, 2018; Fredricks et al., 2004). Having realised its importance to science education, researchers are now concerned with activities that could be employed in teaching and learning of chemistry that encourages students' engagement. (Wehlage et al., 1989; National Research Council, 2003).

Cassava dough is a dough made from cassava (manioc) and used for food. The production of the dough that serves as a staple food was dominantly produced by individuals in their own homes. Therefore, the domestic manufacturing processes involved in this activity is not foreign to most West Africans, specifically the Ghanaian students. Up to date, the domestic production is done in most communities by the roadside and in the open air, which makes it visible to the people in the community, and an integrated part of the everyday life of the students.

Connecting the teaching and learning of a chemistry concept to what has become a part of the students' life will communicate to them the relevance and applicability of the concept. Hence, this may attract the attention and interest from the scientific understanding point-of-view and engage the students to become personally involved in such an activity. This narrative is adopted in this study by including personal engagement as part of chemistry lesson at school. The concept behind the integrated indigenous knowledge-chemistry lesson is illustrated in Figure 1.

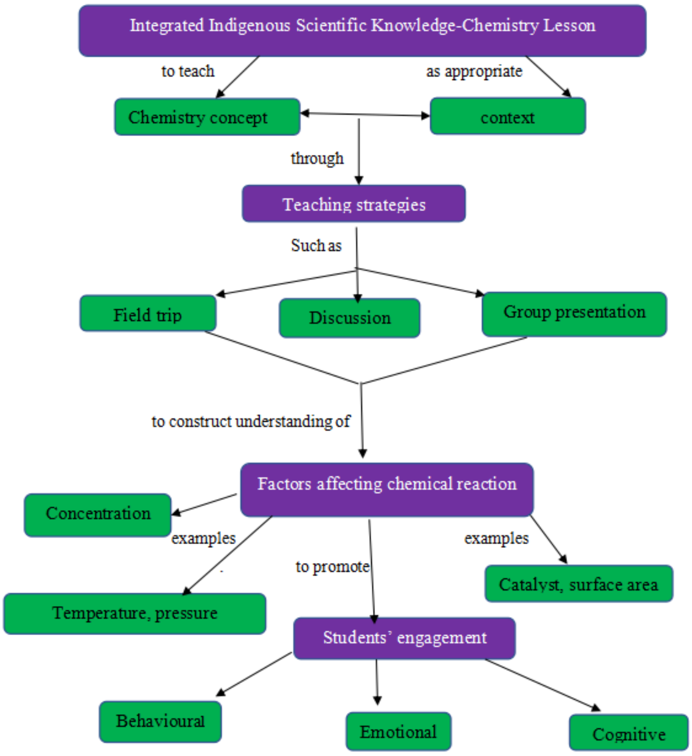


Figure 1. Concept of the "IIK-CL"

2 Background

Chemistry is very useful in daily life applications. However, the study of this discipline poses challenges to students as it is perceived to include numerous abstract concepts (Chang, & Overby, 2019). These 'abstract' concepts, if not properly and pedagogically taught, interfere with students' learning by making them unable to construct understanding and relate principles in chemistry to real life situations. The situation also leads to the development of negative attitudes towards chemistry. Students in bid to pass their examinations and progress to a higher educational level resort to rote learning which according to Anamuah-Mensah (2004) and Foster et al. (2021) contribute to the poor performance of students in general and specifically in chemistry.

The West African Examinations Council (WAEC) has expressed concern over the decline in the performance of candidates in science, specifically chemistry (Sakiyo & Badau, 2015; Kale-Derry, 2019). The statistics of WAEC results for Ghana and four Senior High Schools in the Agona municipality revealed that 32.4%, 17.6%, 19.3%, and 30.2% of students from the study area performed poorly in chemistry (WAEC, 2015; 2016; 2017; 2018). This poor performance according to the WAEC Chief Examiners' Report is as a result of students' inability to construct understanding of basic chemistry concepts (WAEC, 2018). It is further believed that the poor performance of students in chemistry was due to the teaching approach that ignored the use of IK in engaging students in the learning process for knowledge construction (Brown et al., 2013).

IK is a locally based knowledge which is experience-driven, implicit, constantly changing, learned through repetition, transmitted orally and, in many cases, through imitation and demonstration. IK is the philosophy that gives rise to a diversity of indigenous technologies observed in preparation and preservation of food, manufacturing, agriculture, purification of water, healing and weather forecast among others (Ankrah et al., 2021). Some researchers also argue that sustainable education can be achieved through the complementary use by scientists of science and IK (Keane, 2006; Hewson & Ogunniyi, 2011; Parsons et al., 2021) where students see the relevance of learning of a particular concept in their daily lives. Brown et al. (2013) and Simonsmeier et al., (2021) also emphasised that the challenge in science, and specifically chemistry, can be addressed by using domain-specific and prior knowledge from IK practices as starting points to enhance understanding. Hence, for the integration of IK practices into chemistry teaching to be beneficial to students, consideration should be given to the use of suitable contexts from the students' environment. Therefore, lessons that reveal the relevance of concepts to students' everyday life and encourage students' engagement should be designed.

The concept of engagement Fredricks et al., (2004) noted is receiving increased attention because it offers several benefits for research and practice. Fredricks et al. (2004) further explained that the multidimensional nature of engagement has the potential to link areas of research about antecedents and consequences of how students behave, how they feel, and how they think. Ultimately, although engagement might begin with liking or participating, it can result in commitment or investment and thus may be a key to enhancing learning (Fredericks et al., 2004). This makes it appropriate to consider all the three components that engagement encompasses, that is behavioural, emotional and cognitive engagement when discussing engagement for learning and teaching.

Several studies have been conducted on engagement in science education. Especially, some improvement on learning outcomes of students were realised when indigenous knowledge was integrated into the teaching of science, specifically chemistry.

Lee et al. (2012) reported a lesson design to teach the concept of 'Measuring Time' to grade 4 students in Taiwan. The study focused on how indigenous traditional knowledge can be incorporated into school science and what students learned as a result. Lee et al. (2012) used the indigenous knowledge experts in the community of the study as resource persons. A science module 'Measuring Time' that combined indigenous knowledge and western science knowledge was designed and used for the instruction. The study found out that students' pre-instructional fragmented concepts from both knowledge systems became more informed and refined. Just like the instructional module of Lee et al. (2012), the designed chemistry lesson in this study, using the concept of the processes involved in cassava dough, was used to help students construct knowledge and understanding of the' Factors' affecting chemical reaction. The lesson was designed with the primary focus on the 'Factors' for which the IK served the purpose since it was familiar to all students. Students were to compare each stage of the cassava dough production process and relate to a factor or two that affect chemical reactions. This was to enable students to construct their understanding of the concept.

A study by Rahmawati et al. (2019) engaged science students in learning about environmental pollution through the integration of indigenous strategies in a wastewater treatment project. Indigenous practices in dealing with environmental pollution in the study area were used. The results showed that integration indigenous knowledge in science learning aided students' conceptual understanding. The study suggests that when the appropriate IK is used to engage students in learning science, specifically chemistry concepts, students are most likely to construct understanding. Cassava dough production is an indigenous practice in Ghana that has been passed on from generation to generation. This practice has become a part of students' lives and hence could serve as a relevant previous knowledge for any concept that can be appropriately linked to it.

A more recent study by Zidny and Eilks (2020) focused on integrating perspectives from indigenous and Western science into chemistry learning. Zidny and Eilks used a planned lesson with the integration of the indigenous knowledge into western knowledge and engaged students in a discussion to learn a chemistry concept. The framework for the integration considered teachers' perspectives, content structure, students' perspectives, science content, western view on content, selection of relevant context, development of pedagogical structure, development of a lesson plan, as well as implementation and evaluation. Zidny and Eilks (2020) explained that socio-cultural aspects of indigenous science can be used in education for sustainable development as potential contexts to achieve science learning. The conclusion made based on their study was that chemistry learning can be enriched by encouraging higher levels of students' engagement and increasing the personal perception of a topic's relevance.

According to Fredricks et al. (2004) research has not capitalised on the potential of engagement as a multidimensional construct that encompasses behaviour, emotion, and cognition. Rather, many of the studies of engagement include one or two types but do not consider all three. Fredricks et al. (2004) further added that combining all three components of engagement in a study offers some level of richness which leads to the challenge of defining and studying each component, and their combination in conceptually subtle ways. This also allows for rich characterisations of individuals based on the ways engagement is mapped. The study subjects in our research comprised of 52 students whose engagement in terms of behavioural, emotional and cognitive is assessed by means of questionnaires and an observational schedule. The assessment is performed before and after the implementation of the lesson intervention which involves the engagement of the students in a designed integrated indigenous knowledge- chemistry lesson.

3 Objectives

The objectives of the study were to:

- assess the level of students' behavioural, emotional, and cognitive engagement before the 'integrated indigenous knowledge-chemistry lesson' (IIK-CL)
- assess the level of students' behavioural, emotional, and cognitive engagement after the IIK-CL.

4 Hypotheses

- Ho_1: There is no statistically significant difference between the study and control group in terms of behavioural, emotional, and cognitive engagement before the IIK-CL.
- Ho_2: There is no statistically significant difference between the study and control group in terms of behavioural, emotional, and cognitive engagement before the IIK-CL

5 Research method

The study was conducted in the Agona East Municipality of the Central Region of Ghana. The quantitative research approach was used to assess the engagement of students in an 'integrated indigenous knowledge-chemistry lesson' (IIK-CL). A total of 52 students participated in the study. An intact class of 26 students in Swedru senior high school form 2 (aged between 14 and 18) were purposely sampled and engaged in the study. The selection was based on teachers' views on the negative attitudes and responses of the study group to chemistry lessons relative to the other classes. The control group, also comprising 26 students, were randomly selected from the other chemistry classes in the same grade and school whose attitude to the teaching and learning of chemistry were perceived by the teachers to be relatively better. Pre-intervention data were collected on the study and control group students, engagement during the teaching and learning of the factors affecting the rate of chemical reaction. The study group was then engaged in the IIK-CL which was designed using an indigenous knowledge practice they were familiar with and relevant to their life. The lesson integrated indigenous knowledge practices involved in cassava dough production into the learning of the chemistry concept and thus the lesson was named integrated indigenous knowledge-chemistry lesson (IIK-CL). As independent variables, the IIK-CL was used to teach the concept with focus on the factors of pressure, concentration, and surface area. Simultaneously, assessing students' behavioural, emotional and their subsequent cognitive engagement provided the dependent variables that were the focus of this study. The traditional method of teaching the concept was maintained for the control group. However, post-intervention data were collected on both groups to have data allowing comparison of the effect of the intervention performed. In developing the concept of the factors, the study group was guided to link what happens at every stage of the cassava dough production process, explain the chemistry behind the activity and the chemistry concept it can be used to explain. The data were collected using questionnaires and an observation schedule which was preceded by the analysis and presentation of results in tables and graphs.

The questionnaire and the observational schedule were designed based on Fredricks et al. (2004) research findings in order to obtain comparable information about students' engagement. The development of the questionnaires involved a researcher with relevant knowledge and experience in chemistry education and engagement. The questionnaires were face validated by lecturers University of

Jyväskylä, Finland and University of Education, Winneba, Ghana. The Cronbach's alpha gave internal consistencies, 0.87, 0.88 and 0.91 as reliability coefficients for responses to questionnaires on behavioural, emotional and cognitive engagement, respectively, when the questionnaire was trial tested on 26 students who did not form part of the study group.

To further ensure the reliability of the questionnaire response, the observational schedule was also used by an interrater to assess students' total engagement in the lesson. The observational schedule made it possible to rate all the engagement types including cognitive engagement which included the accuracy of students' response to assessment questions. A 6-point Likert scale response, ranging from "strongly disagree" to "strongly agree" were used to rate students' responses. The first three options on the 6-point Likert scale were rated negative (strongly disagree, SD; disagree, D; and slightly disagree, SLD) while the other three rated positive (slightly agree, SLA; agree, A; and strongly agree, SA). The positive and negative ratings were used as a diagnostic tool to obtain an idea of the overall picture of students' engagement. While assuring students' confidentiality and anonymity the students were provided with the questionnaire made up of questions on all three types of engagement as illustrated in Table 1. The students were to choose the response they deem appropriate and deposit the completed questionnaire in a pin hole provided. The completed questionnaires and observational schedule ratings were analysed and the results are presented in tables and graphs for easy comparison.

Table 1. Statement on students' questionnaire and the engagement type being assessed

Statement on questionnaire	Engagement Types being assessed
Statement 1: It was easy to follow the instructions during the lesson. **Statement 2**: I understood what is expected from me during the lesson	Behavioural
Statement 3: The lesson felt meaningful for me **Statement 4a**: I enjoyed the lesson. **Statement 4b**: Why? …………………… **Statement 5**: I want more such lessons.	Emotional
Statement 6: I understand the concept learnt **Statement 7**: I am able to apply the concept learnt in relevant situation	Cognitive

5.1 The integrated indigenous knowledge-chemistry lesson (IIK-CL)

An IIK-CL plan was designed which included a field trip to a cassava dough production site nearby the school to engage the study group students in learning the concept. The IIK-CL plan is illustrated below.

Topic: Rates of reactions
Sub-topic: Factors affecting the rates of reactions
Time: 2 hours (After trip lesson in the classroom)
Objectives: By the end of the lesson, the student will be able to:

1. explain at least three factors that affect the rate of reaction
2. give at least one example of an everyday practice for at least three of the factors
3. explain how the factors are applied in the given example

RPK (relevant previous knowledge the students are expected to have)

1. Students live in communities where cassava dough is processed and used.
2. Students consume 'gari' (a coarse to fine granular flour prepared from cassava dough) and 'banku' (a Ghanaian staple food prepared from a mixture of corn dough and cassava dough).

5.1.1 Activities before and during the field trip

1. A place in the community where cassava dough is produced was identified
2. The IK experts in the cassava dough production were informed of the visit and its purpose.
3. A permission was secured from the head of the institution
4. The students were made aware of the relevance of the visit
5. The students were asked to observe the production process and note the stages as the IK experts educate them on the importance of each stage.
6. The students were encouraged to take part in the production process with guidance from the IK experts
7. Students' observance to safety protocols were encouraged
8. The students were guided to link the relevance of each stage in the production process to the factors that affect the rate of reaction.

9. Emphasis was laid on the relevance of the stages involved in the production process and the time taken for the fresh cassava to be converted to the cassava dough.

Figure 2 describes the different steps in the cassava dough production process.

Figure 2. An illustration of the cassava dough production process serving as the context

5.1.2 After field trip activities

A. Project work

1. Put students into groups of 4
2. Let students write a report on the field trip

B. Classroom activities

1. The students were guided to identify and link the various stages in the production process to the factors that affect the rate of chemical reaction and explain their choice. Table 2 illustrates the steps in cassava dough production process and the chemistry concept it can be used to explain.

Table 2. Relationship between the stages in the cassava dough production process and the factors affecting the rate of chemical reactions.

Stages involved in the cassava dough production	What is observed	Chemistry behind the activity	Chemistry concept
Peeling and milling	Cassava tubers are broken down into smaller pieces	Particle size reduction increases the surface area for the action of microorganisms which aids in a faster reaction.	Effect of increasing surface area
Addition of few fermented cassava tubers before milling	Was explained to aid in producing a smooth dough	Enzymes and microorganisms in the fermented cassava tubers digest the dough making it smooth to feel. The milled cassava tubers provide a larger surface area for the action of the microorganisms and speeding up the fermentation process of the entire dough.	The effect of enzymes on reactants
Bagging and compressing	Compressing allows for more of the milled cassava to be added to fill every available space in the sack	Increasing reactants will lead and increase in product concentration	Effect of concentration
Dewatering	A weight is placed on bagged dough to remove excess water	Applying a weight is to press one particle against the other for effective dewatering of the dough	Effect of pressure on reactants

2. As part of the after-trip project, the study students were to prepare two sets of cards, one set with the main stages of cassava dough production processes and the other set with the factors affecting the rates of chemical reaction. They were to match the cards and give reason(s) for the order. Each group presented their ideas to the class which also engaged the class in a discussion. The students' engagement in the learning process was assessed in terms of behavioural, emotional, and cognitive engagement. Behavioural engagement entails positive conduct, such as following the rules and adhering to classroom norms, involvement in the learning process as well as the absence of disruptive

behaviours (Finn et al., 1995; Finn & Rock, 1997). Hence, the focus for students' behavioural assessment was on involvement. Emotional engagement refers to students' affective reactions in the classroom, including interest, boredom, happiness, sadness, sense of belonging and anxiety (Connell, 1990; Skinner & Belmont, 1993; Connell et al, 1995; Fredricks et al., 2004; Beale, 2018). The assessment of the emotional engagement of the students focused on expressions of enjoyment. Finally, cognitive engagement relates to students' desire and eagerness to take on a learning task. The assessment of cognitive engagement thus incorporated whether students derived motivation to learn when the IIK-CL was used.

Figure 3 presents the summary of activities that students were engaged in during the teaching and learning process in order to enable them to construct their understanding of the concept of factors affecting chemical reaction. Notable here is that the focus was to help students to construct knowledge on the factors and not the chemical reaction itself.

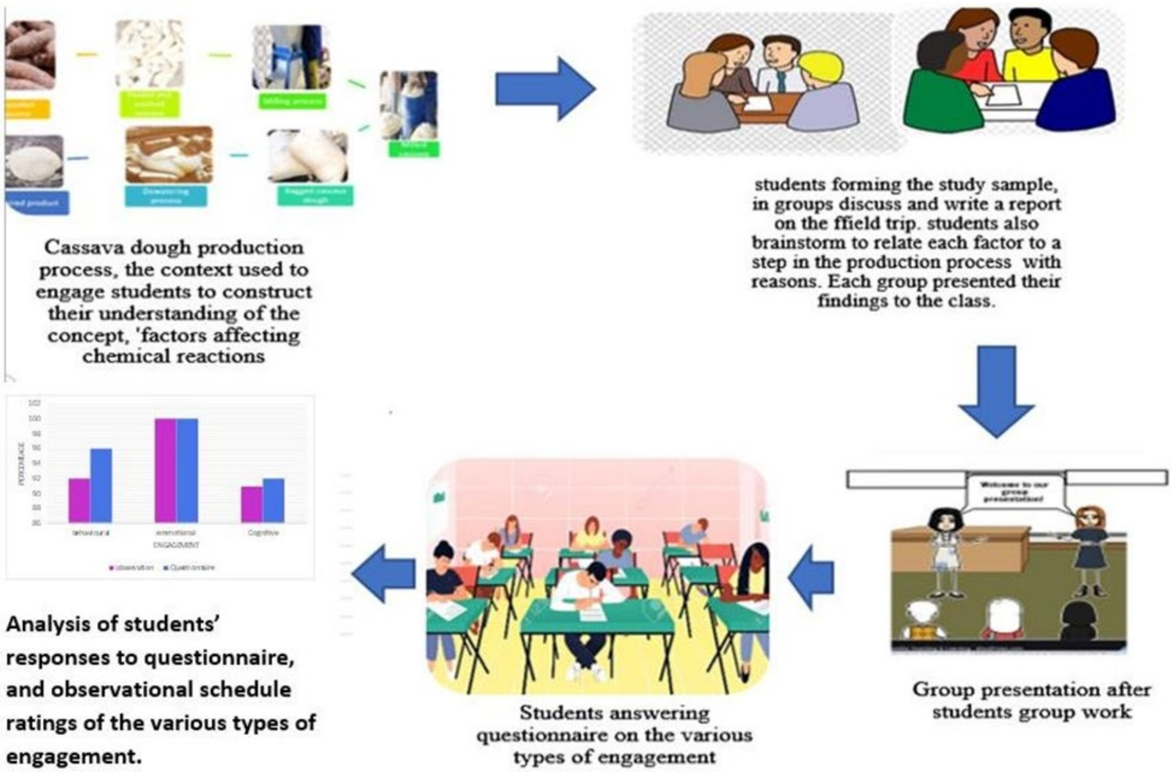


Figure 3. A summary of students' engagement activities used

5.1.2 Assessment for proof of cognitive engagement

1. Explain the effect of pressure on the rate of chemical reaction.
2. What is the effect of increasing surface area on the rate of chemical reaction?
3. Why does decrease in concentration of reactants decrease the rate of chemical reactions?
4. Give one example each of everyday life application of the following factors with regards to rates of reaction.
   i. Increase in surface area
   ii. Decrease in pressure
   iii. Decreasing concentration.
5. Briefly explain how the factor is applied in each example you provide in question 4.

The students were expected to relate the factors affecting chemical reaction as stated in their syllabus to the main stages involved in the cassava dough production process as shown in Figure 4 and explain their choices during the discussion period.

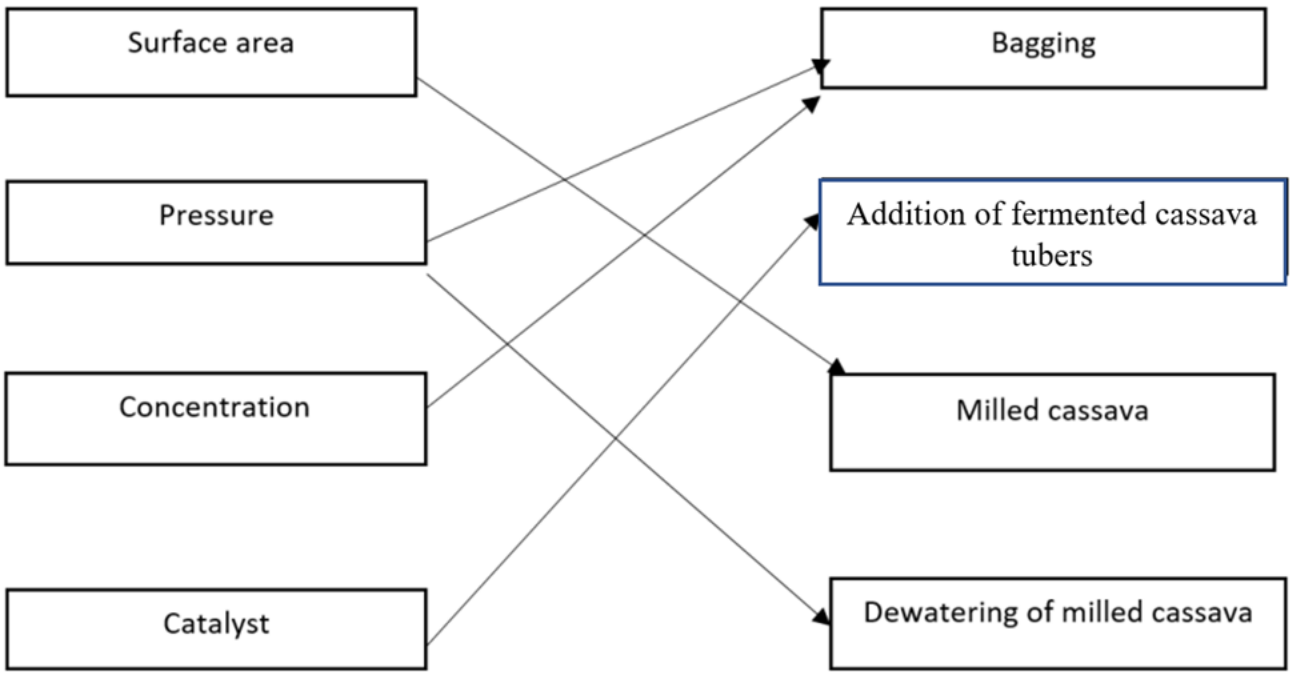


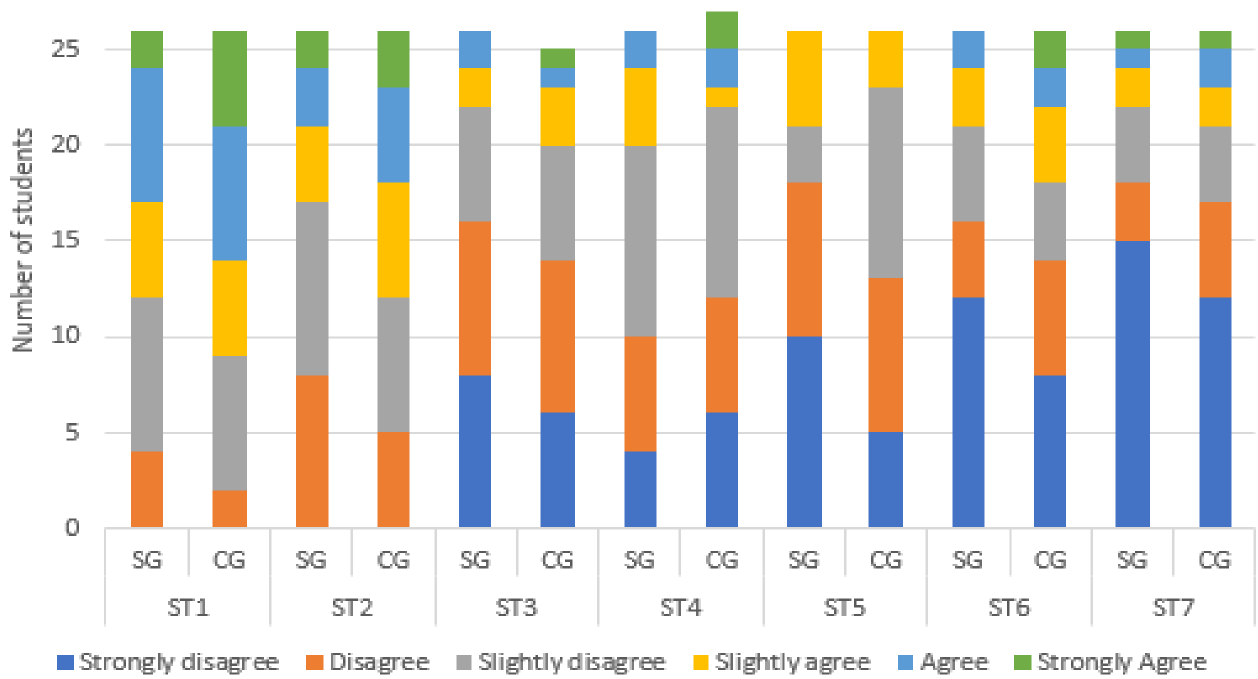
Figure 4. Relating the factors affecting chemical reaction to the stages involved in cassava dough production

6 Results

The results presented the findings based on objectives 1 and 2 and their implications.

6.1 Objective 1

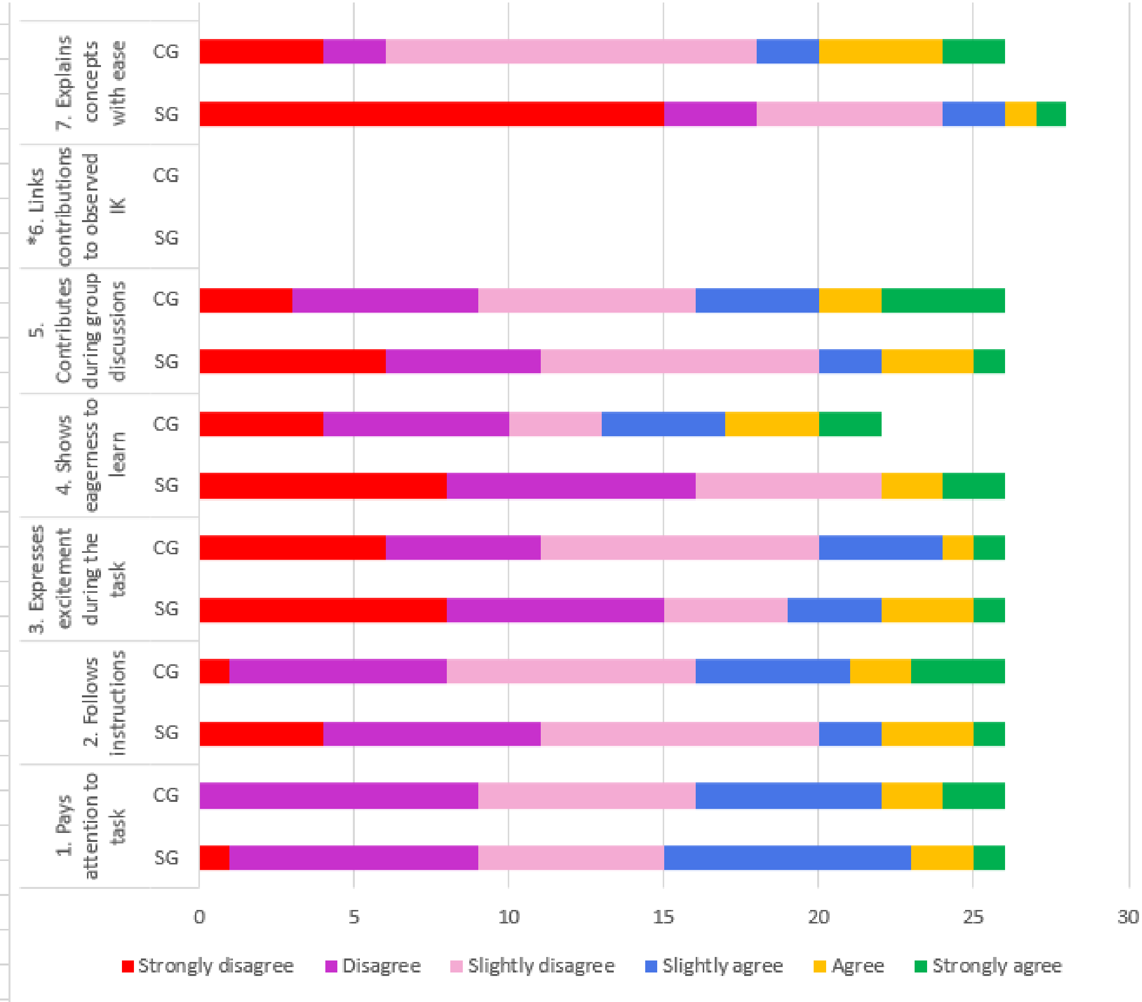
The objective 1 was to assess the level of students' behavioural, emotional and cognitive engagement before the 'integrated indigenous knowledge-chemistry lesson' (IIK-CL). The pre-intervention response from both the study and control group depicted a low level of students' engagement in the lesson. However, it was noted that the control group showed a relatively high level of engagement compared to the study group in the pre-test. The responses of the students are illustrated in Figure 5.



Key: SG –Study group, CG – Control group

Figure 5. Questionnaire response ratings of students before the intervention

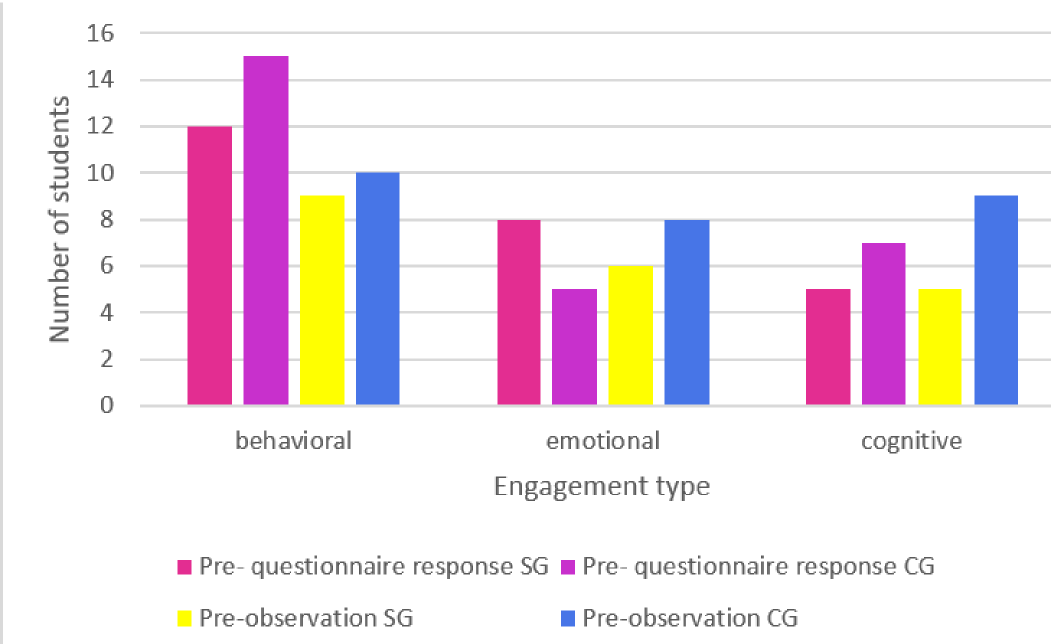
Item 6 on the chart was only applicable during the post-observation hence the absence of the bar at the pre-observation stage (*6). The pre- observation ratings of the study and control groups are compared and presented in Figure 6. Clearly, the graph in Figure 6 confirms the low level of engagement as depicted by the questionnaire response ratings. The number of students that were observed to be engaged in the lesson as shown in the blue, yellow and green colours were small compared to those not engaged.



Key: SG – Study group, CG – Control group

Figure 6. Pre-observation ratings of study and control group

The total number of students that were assessed to engage in the lesson in one or the other ways during the pre-intervention stage is presented in Figure 7.



Key: SG - Study group, CG - Control group

Figure 7. Pre-intervention assessment of the various engagement types

Though the control group students were found to have been relatively engaged behaviourally and cognitively in the pre- questionnaire responses and the observation ratings compared to the study group, the t-test analysis recorded a p-value of 0.12 (shown in Table 3) when the means of positive ratings were compared. This indicated that there was no significant difference in the engagement of the study and control groups during the pre- intervention. The null hypothesis was therefore confirmed, and hence, the engagement of both groups can be concluded to be similar before the teaching intervention took place.

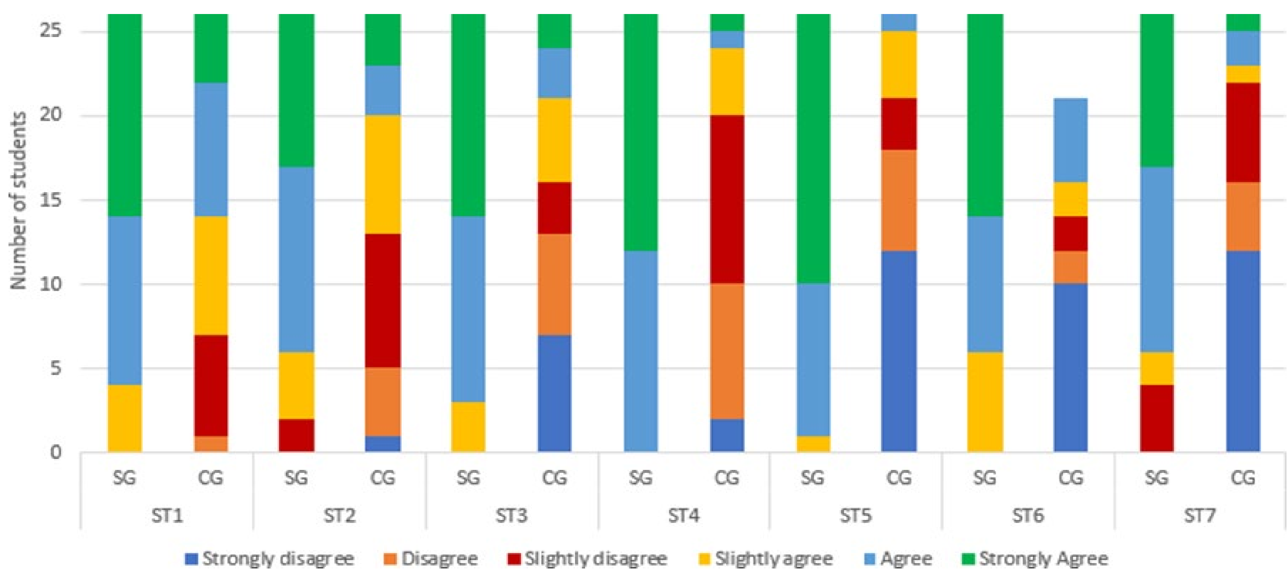
Table 3. T-test analysis of pre-intervention ratings of both groups.

Pre- intervention	Mean	Mean difference	t	Sig.(2-tailed)
Study group	6.67			
		-2.33	-2.65	0.12
Control group	9.0			

$p > 0.05$

6.2 Objective 2

The objective 2 was to assess the level of students' behavioural, emotional and cognitive engagement after the intervention. The IIK-CL was used to engage the study group students in learning the concept, while the traditional classroom mode of teaching was maintained for the control group. The post-intervention responses of the students were again compared to determine if there has been any improvement in students' engagement. The post-test responses however, showed that the study group were effectively engaged in the lesson when IIK-CL was used. Again, the rated responses of the control group in post-intervention were very similar to that of the pre-intervention which indicated that the control group was not effectively engaged behaviourally, emotionally and cognitively. The graph in Figure 8 showed the post-intervention responses to questionnaires by both control and study groups. The graph depicts that the IIK-CL helped to engage the study group students during the lesson.



Key: ST- Statement, SC- Study group, CG Control group

Figure 8. Post-intervention questionnaire response of study and control groups

Figure 9 provides a graphical illustration of the post intervention observation ratings. The observation item 6 (statement 6) is focusing on how well the student explained the concept by relating it to the indigenous knowledge observed.

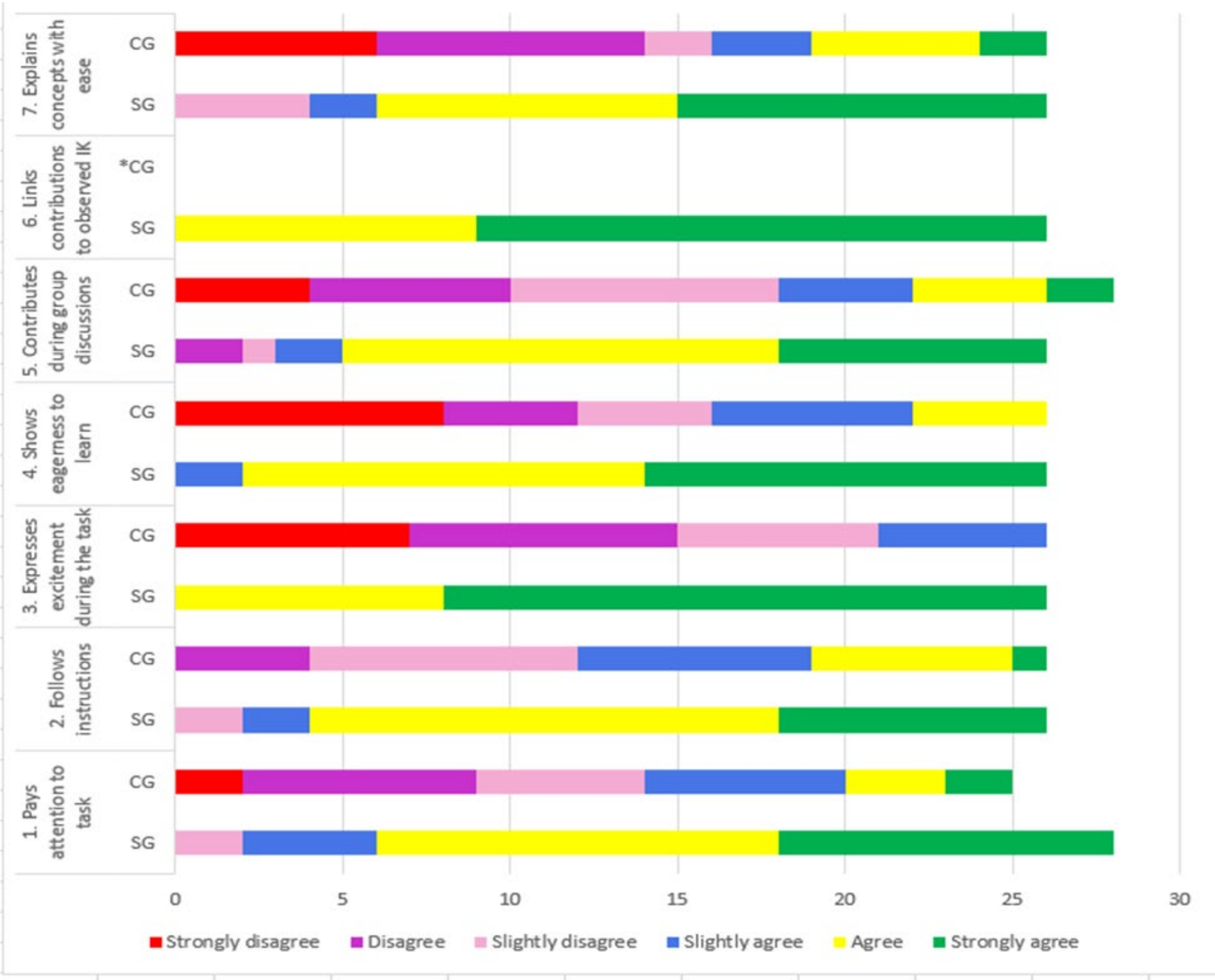
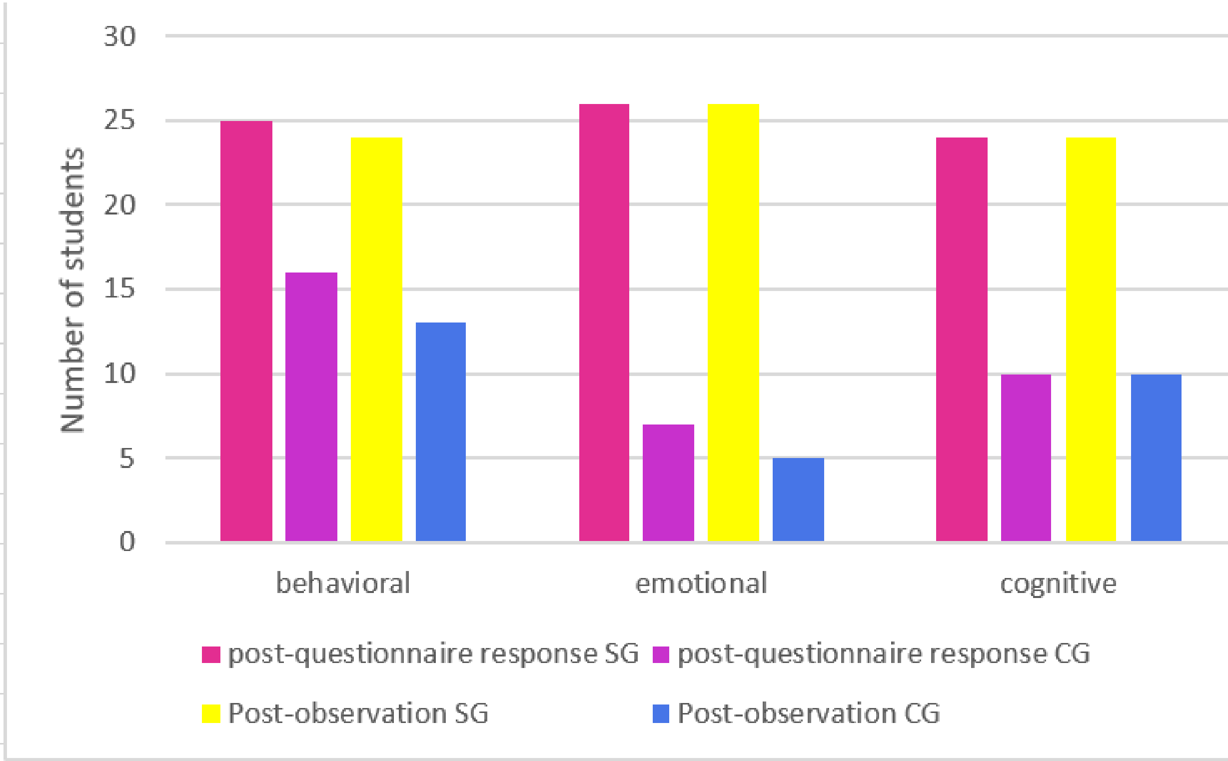


Figure 9. Post intervention observation ratings

Additionally, Figure 10 illustrates post responses of control and study group students to questionnaire and observation ratings in order to help visualise the engagement with the students with respect to each engagement type.



Key: CG – control group, SG – study group

Figure 10. Post intervention responses to both questionnaire and observation ratings of control and study groups

A follow up on statement 4a requested that the students express their views on the option selected. Hence students were asked to state why they enjoyed or did not enjoy the IIK-CL. The result from statement 4a revealed that all the students enjoyed the lesson. The responses from the students to statement 4b can be summarised into 8 main points;

- 'I was happy to see chemistry in something so relevant in my environment.' (S2)
- 'The lesson really was meaningful to me, I can remember, explain and apply this knowledge.' (S4)
- 'The lesson was so real.' (S9)
- 'I have engaged in cassava dough production before but never thought it can be related to this concept.' (S12)
- 'The lesson was so amazing; I did all learning by myself.' (S15)
- 'I could see the importance of each of the factors on cassava dough production and ways the production can be improved.' (S17)
- 'I can transfer this understanding to other areas where applicable.' (S22)
- 'This lesson cannot be forgotten.' (S26)

The numbering in the parentheses indicate the student who gave that particular statement according to the anonymised research data.

To ascertain the level of improvement in students' engagement, the post observation ratings of the study and control group were subjected to the t-test analysis. A p-value of 0.035 was recorded (Table 4) which confirmed that study group students were indeed engaged behaviourally, emotionally, and cognitively when the IIK-CL was used. The second null hypothesis which stated that there was no statistically significant difference between the study and control group in terms of behavioural, emotional, and cognitive engagement before the IIK-CL is therefore to be rejected. As a conclusion it can be stated that the students are most likely to be engaged in chemistry lessons if the appropriate indigenous knowledge is integrated into its teaching and learning allowing personal experiences connected with the learning process.

Table 4. T-test analysis of post observation ratings of the study and control group.

Post- observation	Mean	Mean difference	t	Sig.(2-tailed)
Study group	24.67	15.33	5.18	0.035
Control group	9.33			

< 0.05

A pre and post test was conducted to assess students' claim of cognitive engagement and the result are presented in Table 4. The ability of students to explain the effect of factors such as pressure concentration and increasing surface area on the rate of chemical reaction were assessed. The data presented in Table 5 confirms the hypothesis that larger ratio of students in the study group express cognitive learning that what is found for the students in the control group.

Table 5. Content analysis of pre-test and post-test analysis of students

Item	Points	Concept assessed	Item that assessed concept	No. of students (pre-test)		No. of students (post-test 1)		No. of students (post-test 2	
				SG	CG	SG	CG	SG	CG
1	3	Pressure	1, 4, 5	6	7	23	11	24	9
2	3	Surface area	2, 4, 5	7	9	26	10	24	10
3	3	Concentration	3, 4, 5	8	10	25	12	26	10
4	3								
5	6								

7 Discussion and summary

The study was aimed at assessing the level of students' engagement in an integrated indigenous knowledge-chemistry lesson (IIK-CL) to help them construct knowledge and understanding of the concept of the factors affecting chemical reactions. The study used the context of cassava dough production. An 'IIK-CL' was developed strategically with the constructivist idea of structuring knowledge for beneficial learning (Bodner, 1986; Vygostky, 1986). The context was carefully integrated into the teaching process, through the adoption of various teaching strategies to engage students in the lesson (Lyman, 1981; Kagan & Kagan, 1994; Eilks & Leerhoof, 2001; Feierabend & Eilks, 2011). Students' engagement in terms of behavioural, emotional and cognitive was assessed during the teaching and learning period using the 'integrated indigenous knowledge-chemistry lesson' (IIK-CL). Data collection on 52 students between the ages of 14 and 18 was carried out, using students' responses to statements for students' engagement assessment sheet and engagement observation schedule. The analysis of results from the study revealed interesting trends worthy of discussing.

The behavioural engagement of the students was analysed based on a suggestion by Fredricks et al. (2004) who stated that behavioural engagement refers to the students' participation and involvement in school activities, academic, social or extracurricular. The participation of the students in the 'IIK-CL' was assessed based on students' response to whether the instructions were easy to follow and whether they clearly understood what was expected from them during the lesson. Though the analysis of the results revealed a slightly different trend in students' response to statements 1 and 2, the 'IIK-CL' recorded a high total behavioural achievement through participation and co-operation. According to Fredricks et al. (2004), participation, effort, time spent on a particular task may indicate a strongest engagement as students really take part in schooling by displaying such active behaviours. The level of students' behavioural engagement achieved by the IIK-CL is an indication that lessons of this nature are capable of not just keeping students in school but also enabling them to be active participants in lessons both on-site and off-site learning environments.

The emotional engagement of the students in the lesson was observed to be very visible. Hence, to have support for this, the students were to respond to whether the lesson was meaningful to them, whether they enjoyed the lesson and whether they would like more lessons to be taught using the same strategy. While the analysis of responses to statement 3 revealed individual differences among the students in relation to the meaningfulness of the lesson, statements 4 and 5 revealed a unanimous acknowledgement among students. Of the three types of engagements assessed, emotional engagement recorded the highest positive response. The expression of joy and relevance of the lesson to the students was evident in their responses to why they enjoyed the lesson. This was also confirmed by the ratings on the observational schedule. The students' responses showed the importance of the socio-cultural connection in the lesson. The students realised that school knowledge was not entirely different from knowledge exhibited in their surroundings but rather an effort to explain what happens therein. The school community relationship was also deepened as the students and the expert and practice community both saw the relevance of each other. The students further implied that understanding was constructed by themselves, and hence the concept could not be forgotten and could be applied in relevant situations. This also sets an example for the students themselves for efficient learning: Is this learning focus connected with everyday life? Similarly, this IIK-CL intervention showed the teachers and researchers the power of teaching with everyday context.

According to Beale (2018), emotional engagement can be a highly advantageous educational tool but getting students emotionally engaged in lessons is sometimes difficult, given the abstract nature of some subject matter. The 'IIK-CL' has proved otherwise since it demystified the concept and resulted in stimulating students to be emotionally engaged in the lesson thereby constructing their understanding.

The impact of the 'IIK-CL' on cognitive engagement of the students in the lesson was assessed. Cognitive engagement according to Fredricks et al. (2004) is a matter of students' will, that is, how students feel about themselves and their work, their skills, and the strategies they employ to master their work. Education for sustainability (Breiting et al., 2005; Burmeister & Eilks 2012; Burmeister et al., 2012; UNESCO, 2021) and the quest for chemical literacy for all (Holman & Hunt, 2002), demand that the effective teaching of any chemistry concept should be reflected in the students' life not only in terms of understanding but also as the ability to apply the concept learnt in relevant situations. The cognitive assessment therefore inquired students' understanding of the concept and whether they feel they can apply the concept learnt. Achieving this in this study is supported by the data analysed (see Table 4), where a clear positive cognitive engagement effect by IIK-CL is evidenced.

In general, the IIK-CL intervention therefore achieved its purpose in fulfilling its' target. Indeed, it could be deduced that the emotional and behavioural engagement that created joy and the sense of belonging contributed to the students' cognitive engagement. The relationship between behavioural and emotional to cognitive engagement was also noted by Li and Lerner (2013) and Skinner et al. (2008) who stated that the former two types of engagements correlate positively with the latter.

8 Conclusion

The findings from the study reveals that the devised integrated indigenous knowledge-chemistry (IIK-CL) lesson including a visit to the cassava dough production site encouraged students' engagement behaviourally, emotionally and cognitively. The lesson ensured a systematic delivery of complete and accurate knowledge based on the concept hence developing students' positive attitudes towards learning. The lesson incorporated activities that engaged students during the lesson. Students interacted and shared knowledge with their peers and experts from the community. The relevance of the activities to the students' everyday life encouraged and motivated their participation in the lesson. The context used was appropriate for the concept of the factors affecting chemical reactions since the lesson was successful in realising significant behavioural emotional and cognitive engagement of the students. This is also demonstrated in the mapping of learning outcomes.

Indeed, students' involvement in the appropriate activities during the teaching and learning process has a high potential of increasing students' engagement in their schooling. The engagement of students in a lesson is also enabled when students realise the relevance of the concept in their lives. This enables them to construct a meaningful understanding of concepts and their subsequent application in relevant situations. This also affects their attitude for learning by increasing their own awareness of their learning skills and habits.

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