ENHANCING CHEMISTRY EDUCATION: IMPLEMENTATION OF CERAMIC CLEANER AND LAUNDRY SOAP MAKING TO FOSTER SUBJECT INTEREST AMONG SECONDARY SCHOOL STUDENTS

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ABSTRACT

The integration of practical learning components is crucial in promoting students' interest in STEM education, improving the application of acquired competencies, and achieving learning outcomes. This study was carried out to investigate the impact of integration of practical application on students' subject interest. The study employed a quantitative approach with posttest-only control group designs. It randomly assigned 205 respondents to control and experimental groups. To ensure similarity between groups, block randomization based on characteristics such as prior exposure to ceramic cleaner and laundry soap activities, Academic performance and parents' occupations were used. It involved random sampling of schools (N = 4) and purposive sampling of Form four science students (N = 205). A Likert scale questionnaire was used to collect data. An independent sample t-test was used in data analysis. An independent sample t - test revealed a significant mean difference between the control group (N1 = 3.6) and the experimental group (N2 = 4.4). The experimental group showed considerably more interest in the subject than the control group (t = -9.199, p < .001, effect size 0.29). This study recommends that educators prioritize strongly the practical application of chemistry in everyday circumstances to improve students' interest in chemistry and persistence in STEM education**.** *[African Journal of Chemical Education—AJCE 14(3), July 2024]*

BACKGROUND

The term *chemistry practical* refers to the laboratory experiments and activities that are carried out to investigate and comprehend different chemistry concepts with the goal of connecting theoretical understanding to practical application [1]. Currently, exposing leaners to chemistry practical activities likely to increase their understanding of chemical concepts by linking a theoretical concept to practical knowledge[2]. Through practical knowledge, a leaner may develop important skills such as innovation, problem solving abilities, creativity as well as critical thinking which are important for life support. Additionally, hands-on activities in chemistry may motivate leaners to develop curiosity and passion to explore and experiment abstract concepts which could be transformed to simple and understandable one and influence an interest in chemistry [3]. Practical teaching strategies are among the important educational strategies to improve the learning process at all educational levels in science subjects so as to align with the 21st century skills.

A study conducted Albania in revealed the considerable negative interest in chemistry subject among students[4]. The study findings showed that large number of students had little passion and eagerness to learn chemistry. Despites the initiatives to promote Science, Technology, Engineering and Mathematics education (STEM), the study revealed disconnections between curriculum and students' interest in chemistry. This was further explained that absence of tangible learning experiences affected students subject interest [4]. Having a positive interest in chemistry subject reveals numerous advantages including a career choice in a chemistry-related field. This study highlights the importance of Improved teaching and learning strategies like incorporating practical activities related to real life situation to promote a positive outcome on students' subject interest.

In Sweden, the literature highlights that lack of clear information about the future of chemistry towards the development of science and technology was among the contributing factors to little interest in chemistry subject in secondary school students [5]. Additionally, abstract chemical concepts and the absence of teacher motivation toward the practical reality of chemistry contributed to lower students' interest in chemistry subject [5]. [6]argues that despite factors affecting students' interest in chemistry, practical teaching could be dedicated to increasing student curiosity towards a subject matter and grasp of practical knowledge; hence, improving the learning experience.

In Pakistan, a study conducted by [7] found that students had less interest in science in private schools compared to government schools. Similarly, students from higher education levels expressed less curiosity than those at lower classes. Older students were considering their future, therefore uncertainty in chemistry-related opportunities reduced their interest in the subject[7]. Understanding students' interest is important in determining learning outcomes, promoting students' engagement levels as well as proposing teaching and learning strategies suitable for achieving education goals [8] .

[9] did a study in Rwanda and discovered that students had a negative interest in chemistry disciplines, despite the fact that they are crucial for economic development and daily life. Some of the reasons for this were unsuitable learning environment for hands-on experiments, such as insufficient laboratory facilities and equipment to promote chemistry-based practical, a lack of student-teacher engagement, and time limits for chemistry teachers. Students had a negative interest of chemistry, which hindered both their interest and grasp of the subject. The situation in East Africa, as in most undeveloped countries, is similar, with pupils showing minimal interest in the subject of chemistry [10]. This reduce their performance and development of critical skills for technological and economic improvement in industries such as food, pharmaceuticals, nanotechnology, biotechnology, green technology, and water treatment [4].

Many attempts have been made in Tanzania's education system to provide the required educational output, particularly those that are connected with 21st century skills. It was shown that students had less interest in science subjects compared to other disciplines. However, only a small percentage of students choose to study science, whilst others are forced by teachers and parents to specialize in science, particularly chemistry [10]. To address the issue, the government implemented curriculum reforms to improve learning, built laboratories and classrooms to facilitate learning of science subjects, particularly chemistry, and launched education development plans to ensure access to quality education [11]. There is a narrow research gap notably on the implementation of theory to practical's related to real life scenarios in chemistry. These highlighted the need to evaluate the effectiveness of integrating practical applications of chemistry to real world scenarios in promoting student's subject interest.

The main objective of this study was to evaluate student's interest in chemistry subject through the integration of practical into the secondary school chemistry content. The research tried to answer the following question: To what extent did the integration of practical's impact students' subject interest compared to traditional theoretical instruction? In line with this inquiry, the research hypothesis was structured as follows:

H_0: There is no significant impact of practical applications on students' subject interest between experimental and control groups.

The research aimed to offer valuable insights into enhancing chemistry subject interest in Tanzanian secondary schools. By integrating practical applications of chemistry knowledge into real-world contexts, the study sought to contribute to the development of more effective and engaging teaching strategies within the chemistry content. Additionally, it aimed to equip students with practical knowledge and skills relevant to life support beyond the classroom. Through this approach, the study strived to foster a deeper appreciation and understanding of chemistry among students, thereby enriching their educational experience and preparing them for future endeavors.

THEORETICAL FRAMEWORK

Pragmatism theory

The theory provides a clear stance on how the study should be conducted. Integrating pragmatism theory in learning settings produces the combined achievements important to the learning experience, which are knowledge, skills, and subject interest. This work was guided by the pragmatism theory as proposed by John Dewey (1859–1952). The theory emphasizes exposing learners to practical applications to transform learning into concrete ideas [12]. Application of scientific principles to resolve practical challenges of life through creativity and problem-solving abilities is also among the aspects of pragmatism theory. The current study matched pragmatism theory by exposing learners to hands-on activities essential for job creation and improving the living standards of people [13]. Learners participated in processing different chemical substances into useful products, which could transform learning into reality and promote their interest in the chemistry subject.

By using pragmatism theory, educators are more likely to create relevant, engaging learning materials that promote chemistry topic interest. Exposing students to ceramic cleaners and soap production is expected to improve their understanding of chemical reactions such as hydrolysis, standard solution preparation, and reaction mechanisms, potentially increasing interest in the topic. Furthermore, the approach promotes learning by simplifying abstract concepts to simple and understandable ones. During chemical processing activities, a researcher served as a facilitator and provided learning assistance while students actively participated in the production of selected products. Pragmatism emphasizes the importance of the learner's positive, active, creative, and critical thinking skills [14]. This encouraged creativity and problem-solving skills, which improved students' engagement.

METHODS

Research approach

The study adopts a quantitative approach, a method deemed suitable for analyzing large sample sizes and exploring relationships between independent and dependent variables [15]. Quantitative methods allow for the quantification of these relationships, facilitating conclusions based on numerical data [16]. Moreover, quantitative approach equips researchers with statistical tools to test hypotheses, providing a clearer understanding of cause-and-effect relationships between variables and the characteristics of a given population[17]. It employed a randomized posttest-only control group design to investigate the impact of practical chemistry on students' subject interest[18]: [19]

Participants

The sample consisted of 205 Form Four students pursuing chemistry. It involved simple random sampling by using the lottery technique to select four schools from Ilemela Municipality, while purposive sampling was used to obtain form four students pursuing chemistry at each school. Respondents were randomly assigned at student level into control and experimental groups. It involved block randomization in which respondents were grouped into block of characteristics such as prior exposure to ceramic and laundry soap making activities and academic abilities. From block of characteristics, lottery method was applied to obtain experimental group (n=101) and control group (n=104), both groups being equal in terms of respondent’s characteristics. Systematic sampling was used to obtain 17 groups each containing 6 respondents from experimental groups. The experimental group involved in ceramic cleaner and laundry soap making activities while control group were doing regular class activities. Both groups were tested, later control group received similar treatment as experimental groups.

Data collection

Respondents were explained on the importance of participating willingly, and give the correct information’s. A brief information’s on ceramic cleaner and soap making process were provided in user guide. Students were provided with necessary reagents for ceramic cleaner and laundry soap making including Hydrochloric acid, surfactants, distilled water, plant oil, caustic soda, caustic potash and additives.

A posttest involved Likert scale questionnaire containing fourteen variables reflecting students subject interest ranging from 1 strongly interested to 5 strongly not interested and participant observation by using Interest rubric evaluation form rated from 1 low - 3 High were used in collection of data. In observation, it involved collaboration and engagement levels aspects such as active participation in practical activities, curious about availability of materials, eager to know function of different reagents, frequency of asked questions for clarifications.

Data analysis

Before data analysis, the data entry was done using SPSS version 25, followed by data cleaning by correcting some errors like identifying missing values, correcting duplicates, and removing typing errors. Data were then transformed and coded into analyzable and understandable information. Data were examined using descriptive statistics in which frequencies, percentages, standard deviation, and variance were used to attempt the research questions, while independent sample t-tests measured at a 95% confidence interval were used to test the hypothesis. Furthermore, the eta squared technique was used to describe the effect size obtained from the formula

Ethical consideration

Students were asked to participate willingly in ceramic cleaner and soap-making activities the goal of the study was also fully explained to them without exaggerating or underestimating anything. Anonymity was maintained by securing respondents names. Also, the information gathered was kept confidential and utilized exclusively for study reasons. Safety and environmental protection were greatly enhanced by the use of protective equipment and the avoidance of unnecessary chemical spills. Academic integrity was achieved by clearly stating the intended learning outcomes.

FINDINGS AND DISCUSSION

Demographics of information's of respondents

The survey included 205 Form Four science students from Ilemela municipal secondary schools, including 108 males (52.7%) and 97 females (47.3%). The sample was chosen from four secondary schools: two private and two public. The study had experimental and control, which were assigned randomly. The experimental group comprised 104 responders, whereas the control group had 101. Table 1 shows each variable concerning the participant's attributes in terms of frequency and percentage.

Table 1: Demographic distribution table showing frequency and percentages

Variable name	Sub variable	Frequency	Percentage (%)
1. Sex	Male	108	52.7
	Female	97	47.3
2. Participant Group	Control	101	49.3
	Experimental	104	50.7
3. School Name	Mnarani	62	30.2
	Kitangiri	59	28.8
	Rorya	43	21.0
	Sunrise	41	20.0

Student engagement and collaboration levels in chemistry.

Collaboration and engagement levels are key determinants towards students' subject interest, also may influence achievement of intended learning outcomes in chemistry [20]. Ceramic cleaner and laundry soap making activities provides an opportunity for cultivating engagement and collaboration among students. During practical activities respondents were observed based on the criteria's such as frequency of asking questions for clarifications, active participation in practical activities such as measurements and mixing, an interest in understanding chemistry behind soap making and environment protection as well as Attentiveness towards teachers' instructions. These observational data provides an insight towards effectiveness of intervention in cultivating students subject interest through engagement and collaboration. This, in turn, promotes a more in-depth knowledge of abstract concepts, material retention, critical thinking, and problem-solving skills.

Students in experimental group were evaluated on engagement and collaboration levels during practical activities so as to determine their status of chemistry subject interest.

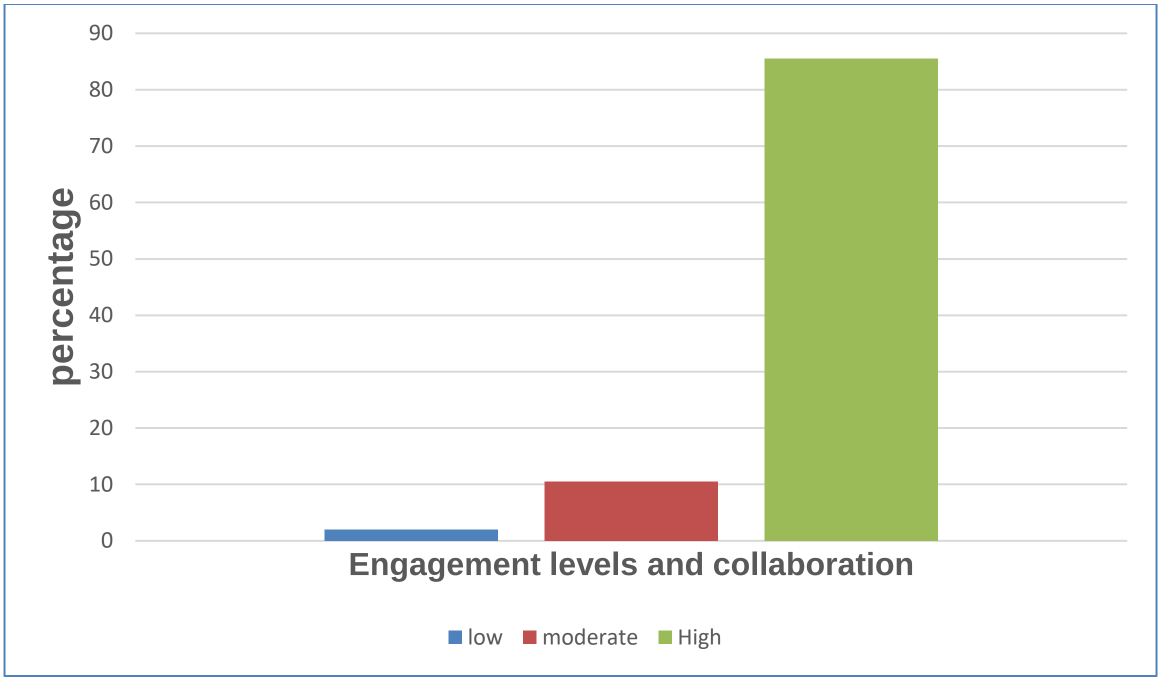

Figure 1: Engagement levels and collaboration in chemistry

Figure 1 shows that 87.5% of the experimental group had high levels of collaboration and engagement in chemistry, this was further explained by high level of participation during practical activities excelled by students. The study findings highlights the influence of practical application towards students' collaboration and engagement levels which impacts the learning outcomes in chemistry subject compared to traditional teaching in which such aspects are limited [21].

Career options in chemistry-related fields.

Empowering students to pursue a career in chemistry is critical since chemistry is useful in a variety of industries, which can lead to different job opportunities. Figure 2 depicts the results of incorporating practical activities to promote students' career choices in the experimental and control group. In the experimental group, 92.3% of students expressed a substantial interest in chemistry-related jobs, whereas the control group, 54.4% expressed a strong interest in chemistry career choice.

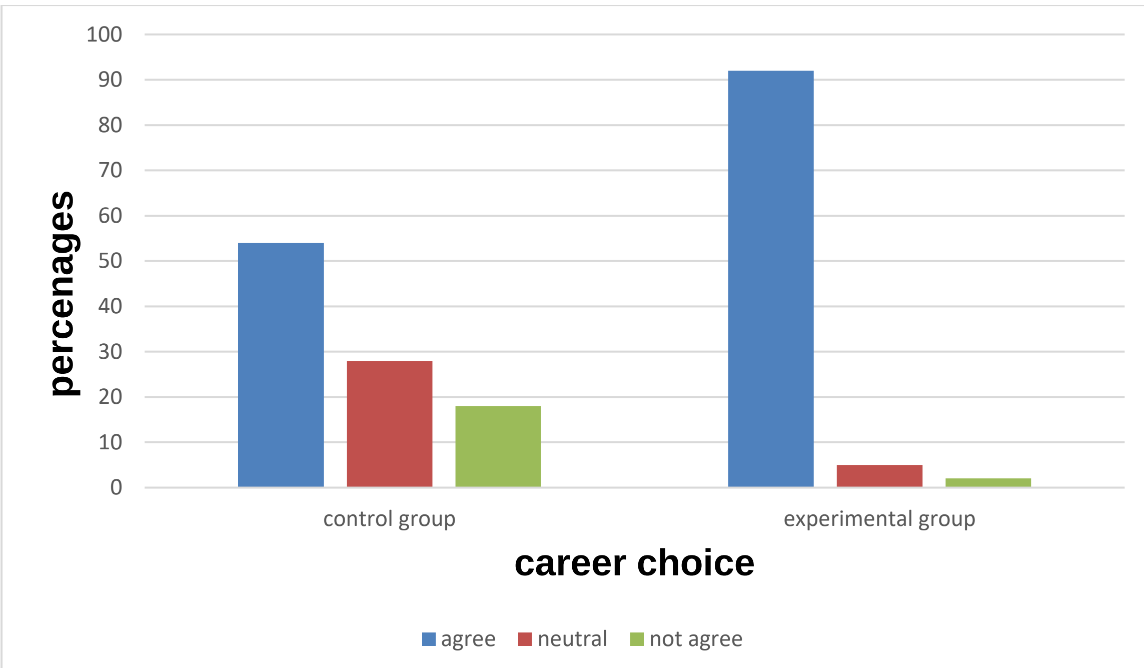

Figure 2: Career choice in chemistry-related field between control and experimental group.

Figure 2's findings suggest that practical chemistry is likely to empower students' mindsets and interest in pursuing chemistry-related occupations. Exposing students to various chemical experiments exposes their future potential, which is vital for career specialization. However, educational background plays an important part in profession decision. Students who have an excellent foundation in scientific knowledge and experiments are more likely to opt chemistry as career path[22]. A practical teaching technique, as well as strong mentorship from chemistry professional facilitates career choice. Students who actively participate in practical activities are likely to explore real-world applications of chemistry outside of the classroom, paving the way for careers in chemical processing industries such as soap soap-making, pharmaceuticals, chalk making, oil extraction and refining, water treatment and purifications, waste management, and more. The findings of this study were comparable to those [8], who noticed the importance of practical applications in terms of exposure to various chemistry-related opportunities and career choices.

Student's interest in the chemistry subject

Table 2: Mean comparison on subject interest between control and experimental group

Participant group	N	Mean	Std. Deviation	Coefficient of Variation
Control	101	3.5658	.85635	$0.24 \approx 24\%$
Experimental	104	4.4148	.36177	$0.082 \approx 8.2\%$

From table 2 findings, the control group with a mean score of 3.6 suggests moderate interest in the chemistry subject. In general, students' interest in chemistry was intermediate, approaching on positive. A greater standard deviation in the control group indicates that response were dispersed from the mean score, whilst a coefficient of variation of 24% suggests that responses in the control group were highly variable. In the experimental group, a mean average of 4.4 indicated a positive interest in chemistry, with a standard deviation of 0.4 indicating that scores are more closely clustered around the mean score. This implies that there is an almost homogeneous distribution of responses in the experimental group. Based on the data in Table 2, it is possible to conclude that practical applications of chemistry might be helpful in increasing student interest.

Table 3: Results for Independent Samples t-Test on subject interest

t-test for Equality of Means (control-Experimental group)						
				Std. Error	95% CI of the Difference	
T	Df	Sig. (2-tailed)	Mean Difference	Difference	Lower	Upper
-9.199	133.767	.000	-.84906	.09230	-1.03162	-.66651

Table 3 indicated P < 0.01 and t-value of -9.199 which suggests a significant difference in subject interest between the experimental and control groups. The eta squared value of 29% reflects a considerable effect size possibly caused by an intervention.

According to the statistical findings in Tables 2 and 3, the experimental group that received treatment showed high interest in the chemistry subject, as evidenced by high mean scores with small standard deviation and coefficient of variation; Also, the smaller t value and large effect size support the effectiveness of practical applications in promoting student subject interest. Learners must be exposed to a variety of activities based on diverse scientific ideas in order to broaden their interests and equip them with life skills. The findings of this study are consistent with those of [23], who investigated the effectiveness of hands-on learning using mole concepts and volumetric analysis to increase students' subject interests and involvement. Furthermore, [7] found that practical applications had a substantial impact on students' subject interest.

Teaching chemistry must be linked to other fields and real-life contexts in order to expose students to the realities of chemistry, which may foster their love and curiosity about the subject. Engaging students in hands-on activities fosters knowledge of the subject matter by fostering material grasp rather than rote memorization. All of these factors boost understand of chemical concepts and principles, which in turn increases subject interest. Practical activities encouraged problem-solving skills and originality by allowing for various experiments with different materials[2] For example, during the saponification process, students tested different oils and strong bases to determine the appearance of the soap that would be generated. Through various experiments, creativity evolves, resulting in the production of numerous special products.

In general, hands-on activities served as a powerful and modernized teaching technique to foster understanding of most chemical concepts by providing active engagement of all students, as well as concrete and memorable learning, resulting in a remarkable learning experience [24]. Example, in soap making activities it involved the saponification reaction which included several reactions at distinct pH levels, which students observed to improve soap-making results. Furthermore, using plant or animal fat to make soap could help students grasp oil extraction and qualities. Subjecting students to a variety of laboratory activities linked to real-life techniques is likely to boost students' motivation to acquire diverse chemical ideas outside of the classroom, as well as facilitate creativity and problem-solving abilities [1].

CONCLUSION

Incorporating hands-on activities into the core curriculum would improve students' understanding of abstract concepts while transforming scientific principles and equations into reality, raising subject interest. Learners need to be exposed to a variety of life-long activities in order to make the chemistry subject a reality and reveal the future possibilities of science, particularly chemistry. Hands-on activities help to reveal career opportunities available from chemistry. By exposing these benefits at the grass root level, learners enjoy the subject matter. Education practitioners and policy makers should thoroughly assess chemistry curricula to ensure that they represent real-life situation. Students should be empowered in science subjects, by offering mentorship and equipping them with problem-solving skills and ideas. Subjecting leaners to scientific initiatives and competitions such as young scientist forums, science clubs, and science displays increases their interest in the topic of chemistry. When students are provided with the necessary supplies, mentorship, and display platforms, they are more likely to create diverse and unique goods. by dedicating their time to exploring different materials beyond the classroom, problem-solving, and being eager to know different scientific principles and applications.

LIMITATIONS AND FUTURE DIRECTIONS

The current study only included form four pupils and employed a sample size of 205. A larger sample size than this one, encompassing a diverse range of science students from various educational levels, may be more appropriate for improving study generalizability. However, because to the lack of regular follow-up, a posttest-only control group design may fail to detect long-term effects of practical chemistry applications on subjects' interest; consequently, longitudinal studies should be conducted to investigate long-term changes. Involving various activities other than ceramic cleansers and soap production could develop a wide range of interests and career options in chemistry-related fields. Further research should focus on teacher professional development, specifically chemistry hands-on activities, in order to promote these activities for students.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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APPENDIX

Introduction to the soap making user manual

The goal of this handbook is to assist students in doing the soap-making process correctly and safely. To guarantee safety, follow all of the procedures and regulations outlined in this guide. Take these safety precautions:

1. Use safety goggles to shield your eyes from splashes and other chemical pollutants.
2. When handling hot items or Lye, wear heat-resistant gloves.
3. To protect your skin from chemicals, wear a lab coat and closed-toed shoes.
4. Work in a well-ventilated environment or fume chambers to prevent breathing gaseous emissions or wear industrial musk.
5. When mixing lye (caustic) with water, use heat-resistant containers.
6. Keep lye out of the hands of children and other domestic animals.
7. Label all chemicals and store them in a cool and safe place.
8. When mixing lye and oil be carefully, it becomes hot. Stir gently to avoid splashing.
9. Clean up any spill immediately using safety measures.
10. Dispose appropriately any waste and by products

Procedures and materials for soap Making

Materials:

Distilled water, plant oil or animal oil, caustic soda, Protective gears, Digital scale, soap mold/shaper, fragrance, colorants, stir, Thermometer, hydroscope, Soap additives

Procedures:

Using a Digital balance measure the required amount of oil and Caustics (KOH/NaOH) for soap recipe. Ensure accuracy in the following order:

Caustic soda or Potash	1kg	25kgs
Distilled water	3.5 litres	87.5 litres.

Using a measuring cylinder, measure triglyceride(oil) in the given ratios relative to caustic solutions (KOH/NaOH) and sodium silicate (Na_2SiO_3)

Oil (L)	LYE CAUSTIC SODA/CAUSTIC POTASH (NaOH/KOH) in L	SODIUM SILICATE (Na_2SiO_3) in mL
1	0.5	100
2	1	200
3	1.5	300
4	2	400
5	2.5	500

Mixing

Add a little amount of water to a heat-resistant container, then gradually add caustic soda (Lye) to form a solution while gently stirring and allowing to cool. Prepare the oil in a separate container, pour caustic soda solution (lye) into the oil while blending with a stick blender. Continue blending until you reach 'trace'. (Until it thickens like custard). Add additives, such as sodium silicate, and blend. Add fragrance oil for scent and colorants (if desired). Put the mixed material into a mold. Molds made of wood, household containers, or silicone can all be used. Leave it uncovered to allow for evaporation and soap solidification. To cure a mold, keep it cool and dry for 24-48 hours. This makes soap tougher.

Cutting and unmolding

Using a knife or soap cutter, remove the soap from the soap mold and cut it into bars or the appropriate shape. Place the soap bar in a tray in a well-ventilated location. Allow the soap to cure for extra days. Once fully cured, mark your soap with the date and components used in its manufacturing.

Ceramic cleaners

Materials: Distilled water (H20), Surfactants (Empigen) and Hydrochloric acid (HCl)

Procedures:

Take 15 L of distilled water and add 500 gm of Empigen. Add 5 L of hydrochloric acid and stir. When dealing with HCl, take precautions such as wearing gloves, safety goggles, mask, and apron or lab coat. Let the mixture cool for a few minutes and pack the product in the storage bottles, ready for use. Label for ingredients and manufacture date.