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Design of Experimental Laboratory, Using Micro-techniques in The Modern Chemistry Laboratory, For Students of the Secondary Stage

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Abstract
This graduation project outlines the development and implementation of a Mini Chemistry Lab, incorporating micro-techniques, tailored for secondary stage students in Egypt. The initiative aims to address current educational challenges and to enhance the educational framework by providing a cost-effective, safe, efficient laboratory environment, and environmentally friendly alternative to traditional chemistry experiments. Through the utilization of microscale chemistry, this project endeavours to foster a more interactive and engaging learning experience, thus significantly improving students' understanding and retention of chemical concepts, and also enhance their practical skills, and motivation towards the subject.

Key Words
Micro-techniques, Secondary stage, Egypt, Mini Chemistry Lab, Microscale chemistry.

Introduction

Laboratory experiments are vital to chemistry education at all levels, helping to transform abstract classroom theories and principles into practical understanding (Madeira, A.C.P., (2005)) These sessions not only reinforce theoretical knowledge but also develop essential skills such as safe chemical handling, use of scientific instruments, and problem-solving (Abdullah, M., Mohamed, N., & Ismail, Z. H. (2007, 2009)). They promote scientific thinking, collaboration, and innovation (Ben-Zvi, R., Hofstein, A., Samuel, D. & Kempa R. F., (1976). However, integrating effective laboratory work into chemistry education faces challenges, especially in many developing countries like Egypt where rote learning prevails due to a syllabus dominated by factual information (Cresswell, J. (2002)). The scarcity of hands-on laboratory activities makes science less engaging and harder to grasp, leading to student disinterest. Inadequate resources in government schools and financial constraints in private schools, limiting access to necessary laboratory experiences, further aggravate this situation (Urassa, F. M., and Osaki, K. (2002)).

Moreover, the traditional approach to laboratory work often involves mechanical execution by students without encouraging curiosity or presenting challenges (Zipp, A. P. (1989)). Despite these obstacles, innovations such as microscale chemistry, which utilizes minimal chemicals and simple equipment, present potential solutions by making laboratory work more accessible and manageable. (El-Marsafy ‹M K (1989))

The Microscale Chemistry Laboratory (MCL) Kit exemplifies such innovation by enabling students to perform experiments in a safe, eco-friendly environment. It uses small amounts of chemicals, reducing risks and pollution, and replaces traditional large-sized equipment with smaller, less costly versions (Grey ‹Egerton C (1928)). This approach is cost-effective and offers benefits to students, the environment, administrators, and teachers by:

- Lowering chemical use and accident risks.
- Reducing chemical waste and exposure to hazards.
- Decreasing operational and storage costs.
- Allowing more experiments to be conducted efficiently, enhancing student learning.

The aims of hands-on laboratory activities are to improve understanding of scientific concepts, develop procedural and observational skills, and maintain curiosity and engagement in the learning environment.

In summary, while laboratory experiments are essential for a comprehensive chemistry education, their effectiveness is often compromised by resource limitations and a curriculum focused excessively on factual knowledge. Innovation and adaptation in laboratory practices are crucial to overcoming these challenges and reinvigorating students' interest in science.

The Theoretical Framework

Statement of Problems

The chemistry curriculum aims to produce active learners. To this end, students are given opportunities to engage in scientific investigations through practical activities and experiments.

An Investigative approach that incorporates thinking skills, thinking strategies, and thoughtful learning should be emphasized throughout the teaching and learning process.

It has always been considered the science lab to be the place where students should learn the science process (Yoo, M.H., Hong, H.G. & Yoon, H. (2006)).

In fact, each student should be fully available for conducting experiments from start to finish.

While practical work in chemistry is essential in chemical education, it is largely absent from the real curriculum in schools around the world (Bradley et al., 1998).

Moreover, the keen emphasis on general examinations by teachers has led to teaching and learning that is geared towards passing these exams. Practical work and experimentation are often sacrificed, as these do not contribute a significant proportion to the overall marks.

Thus, teaching and learning in the classroom in some contexts becomes largely teacher-centered, ignoring the development of scientific and thinking skills among students.

And to overcome these problems and make the student an active learner, this can be done through microscale chemistry (Mafumiko F., Ottevanger, W. (2004)).

Microscale chemistry

Microscale chemistry is recognized as small-scale chemistry by the International Union of Pure and Applied Chemistry (IUPAC).

It is not only an analytical method; it is also a teaching method commonly used at school and university levels. It deals with small quantities of chemicals, and the accuracy of experiments is not compromised. Teachers can also use it as a tool to design new laboratory activities (Mayo ‹D W (1986)).

While many traditional methods of teaching chemistry rely on preparations that consume large numbers of grams of materials, fractional-scale chemistry only uses milligrams of chemicals.

In schools in many Southern Hemisphere countries, work is small-scale, using low-cost and even no-cost materials. There was, and still is, a place for small-scale work in the field of qualitative analysis, but recent developments

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provide a wealth of knowledge that the chemistry student expects.
This lab-based approach can improve students' skills in handling equipment, encourage them to conduct experiments, and motivate them to conduct experiments with care and patience.

Modern theory is based on two main axes.
The first is based on the idea that many experiments related to general chemistry (acids and bases, oxidation and reduction, electrochemistry, etc.) can be performed using simpler equipment (such as needles, bottles, dropper bottles, syringes, gap plates, plastic pipettes), which is naturally cheaper than conventional glass equipment used in the laboratory, facilitating the enhancement of laboratory experience for students in large classes as well as providing laboratory work within institutions that severely lack standardized work.

The initial developments in this field
Included Egerton C. Gray (1928), Mahmoud Al-Marsafi (1989), in Egypt,
Stephen Thompson in the United States, and others. Bradley's designs from the Radmast Center in South Africa are one of the applications of previous ideas, which were designed for the purpose of providing effective chemistry experiments in schools that lack technical services (electricity and running water) in developing countries, whose rights are underserved in many places.

Development of experimentation
Bigtrop (2001) conducted a small-scale filtration process using a modified plastic syringe. It is a simple pressure filtration procedure and does not require pumps, as both filtration and residue can be collected. Filtration is performed using an inexpensive and commercially available plastic syringe, which has been slightly modified to allow for repetitive piston movements without problems (Nieveen, N. (1999)).
Goling et al. (2002) designed a fast and low-cost electric heater to replace expensive hot plates used in the microchemistry laboratory. It is basically a soldering iron whose tip is replaced by an aluminium block with a drilled hole.

Advantages of microscale chemistry

1. Saves time for preparations and clean-up after experiments.
2. reduces the percentage of loss from the source.
3. Safer
4. Lower cost of chemical materials and equipment
5. Smaller places for storage
6. Reduces reliance on excessive use of ventilation systems.
7. Provides a conducive work environment.
8. Greater speed of reactions
9. Provides additional time for evaluation and communication.

There are low-cost materials and no-cost materials for secondary schools, such as:
- Ampoules, injection bottles, and dropper bottles.
- A small alcohol stoves.
- Soft drink cans.
- Drip containers.
- Disposable 1 ml syringes for smaller volumes, such as measuring cylinders, burettes, and pipettes.
- Panels with gaps.
- 9-volt battery.
- Two scales for weighing.
- Beads as models of atoms, molecules, and crystal lattices.

Scope and objective of the study

The main purpose of this study is to develop small-scale chemistry experiments according to the integrated curriculum for secondary schools and the Egyptian chemistry curriculum and to evaluate the feasibility of experimentation for the Egyptian curriculum, teachers, and students.
The objectives of the study include:
(1) Develop micro-chemical experiments for chemistry students at the upper secondary level that correspond to traditional large-scale experiments.
(2) To compare microscopic experiments with large experiments in terms of the accuracy of the results obtained, the amount of chemicals used, the devices required, the time required, and the amount of waste produced.

(3) To determine the effectiveness of the individual approach through microchemistry experiments on students' understanding of chemistry concepts, attitudes, and motivations.
Based on the purposes and objectives of this study, there is an application mechanism for applying to one of the Egyptian schools (boys or girls).

Make sure to implement the program with the following:

• Providing school microscale chemistry materials, tools, and industrial tools So that students in a school can conduct microscale experiments on their own and record the results of their own information technology.

• Asking students to search for alternatives to chemicals and tools in the surrounding environment, such as the home, pharmacies, detergents, or pharmacy stores, to reduce the cost of chemical materials and equipment and to apply microscale techniques.

The results showed that the small lab program is more effective than the traditional large-scale laboratory program in raising academic achievement, curiosity, creativity, and self-confidence.

Definitions of some terms

(1) Microscale technique:

The microchemistry technique in this study refers to the use of microchemistry to reduce the amounts of chemicals in the laboratory during a laboratory session (Grey ‹Egerton C (1928)).

(2) Traditional techniques:

The conventional technique in this study refers to the use of regular glassware and quantities of laboratory chemicals during the laboratory session.

(3) Attitude:

Attitude in this study refers to a student's attitude toward learning chemistry, including interest in doing practical applications in chemistry, enjoyment in performing practical applications and handling equipment, practical aspects of laboratory work, and how students view laboratory work as a “means of learning.”

(4) Motivation:

Motivation in this study refers to the student's motivation to learn chemistry.

Methods of Research and the used tools

All the experiments of the three years of secondary stage were collected then classified according to their difficulty and ease of carrying out the experiments then all materials in laboratory experiments were classified as whether they were liquid, powder, or solid.
The materials were classified according to their ease or difficulty in obtaining them and their availability in the surrounding environment, whether at home, in spice shops, or in pharmacies. How we obtain it from home, stores, laboratories, pharmacies in terms of easy availability of materials that are easy to obtain, eco-friendly and non-toxic.
Other experiments which are more difficult to achieve we link it with a video to illustrate it easily.

- We work on the project on the microscale, which means we take small quantities, we provide the materials, and we tell the student where to get these materials from in the surrounding environment. At the same time, they are environmentally friendly, easy to obtain, and have no side effects. Since we are doing the project on the microscale, we take small quantities, so it is a percentage. Use of substances that have almost no harmful effects.

- We used the Internet to obtain alternatives to materials in practical experiments and reliable sites. Professors were asked about the validity of alternatives to these materials and from our studies in the field of chemistry.

-We use in gathering data we conducted an interview, asking the professor in our university about the validity of these alternatives, and interviewing the students about how much they would benefit from applying these experiments with these alternatives.

-Laboratory experiments: We conducted all the experiments in the secondary curriculum with chemical alternatives to ensure that they give the same results as experiments with chemicals in laboratories.

-We conducted field study: we search about the chemical alternatives and ensure about the validity of these alternatives.

All chemicals and their alternatives and sources in the three stages of secondary

Materials	Alternatives	Sources
Tea	Tea	Home/ grocery
Vitamin C	Lemon juice	Home \ Grocery, Market \ Pharmacy
Food pigment	Food pigment	Spice shop \ Grocery
Sodium bicarbonates	Baking soda	Spice shop
Sodium hydroxide solution	Caustic soda	Detergent shop
Iron filling	Iron filling	Iron and paint shops
Distilled water	Mineral water	Grocery
Sodium chloride	Salt	Home
Acetic acid	Vinegar	Home / grocery
Sucrose	Sugar	Home/ grocery
Sodium hydroxide	Soap	Home/ grocery
Sodium carbonate	Washing soda	Grocery
Milk powder	Milk	Supermarket
Chalk powder	Chalk	Library
Starch	Starch	Home/ grocery
Indicator	Hibiscus	Home/ grocery
Indicator	Red cabbage	Grocery
Calcium oxide	Quicklime	Pottery shop
Ammonium chloride	Ammonia salt	Spice shop
Acidified aqueous solution	Vinegar diluted with water	Home/ grocery
Red litmus solution	Red cabbage juice by Boil red cabbage	Grocery
Copper sulfate	Blue bluegrass for washing	Detergent shop
Lime soda	NaoH (caustic soda)	Detergent shop
Sodium carbonate	Washing soda or replaced by $CaCO_3$ to detect carbonate anion	Detergent shop
Calcium hydroxide	Slaked lime	Iron and paint shops
Magnesium sulphate	Epsom Salt or $MgSO_4$ ampoules	Pharmacy
Magnesium carbonate	Found in some medicine & supplements such as Osteocare & Digicomag	Pharmacy
Lead acetate	Lead acetate	Pharmacy
Iodide (I_2)	Alcoholic iodide solution	Pharmacy
Potassium permanganate	Available in pharmacy as disinfectant	Pharmacy
Potassium iodide (KI)	Prepared by reaction of KCl with Iodine	Pharmacy
Sodium iodide (NaI)	Prepared by reaction of NaCl with Iodine	Home and Pharmacy
Cu	Used in wires manufacture	Iron and paint shops
HNO_3	Aqua fortis	Detergent shop
Na_3PO_4	Available as ampoules	Pharmacy
$(CH_3COO)_2Pb$	$(CH_3COO)_2Pb$	Pharmacy

Copper(ιι) sulphate	Available in washing bluing	Detergent shop
Aluminum sulfate	Available in alum	Spice shop
Ammonium carbonate	Ammonium carbonate	From apothecary
Calcium carbonate	Egg Peels	Home
Cetric acid	Cetric acid	Apothecary
Naphthaline	Naphthaline	Detergent shop
Acetone	Acetone	Pharmacy/ home
Salysilic acid	Aspirin	Pharmacy
H2SO4	-	Battery mechanic shop
Aldehydes cinnamon	Aldehydes cinnamon	At home
Ammonium	-	Apothecary
Sodium hypochlorite	Clorox	Home
Vasline	Put an appropriate amount of wax with a cup of oil	Home
Alchols	Put an amount of sugar with boiling water and a spoonful of yeast	Home

Tools and their alternatives

Tools	Alternatives
Test tubes	Insulin Injection tubes
Glass flasks of 100 ml	Cup + Syringe
Graduated cylinder	Syringe
Plastic bottle	Cup
100 ml glass cup	Syringe
Burette, Pipette	Syringe
Transparent plastic sheet	Clear plastic wallets or the student worksheets could be laminated.

Results and Discussion of Research

The present research graduation project aims to apply microscale techniques in the laboratory field of chemistry subject at the secondary stage to evaluate the effectiveness and benefits of implementing these methods in educational institutions.
Microscale chemistry involves conducting experiments using smaller quantities of chemicals and equipment, allowing for safer and more cost-effective, in addition to avoid environmental pollution. Learning experiences and that is what our results confirmed during conducting different experiments with suitable alternative together with a variety of students.

The study's findings confirmed that incorporating microscale chemistry techniques in secondary schools has several advantages:

- Enhanced Safety: microscale experiments significantly reduced the risk of accidents and exposure to hazardous chemicals, making the learning environment safer for students.
- Cost-Effectiveness: by using smaller quantities of materials, schools saved many expenses related to chemicals, equipment, and waste disposal.
- Hands-On Learning: microscale techniques enabled the students to perform experiments more frequently, allowing them to develop practical skills and a deeper understanding of chemical concepts.
- Environmental Impact: reduced material usage and waste generation contribute to a greener educational approach, promoting sustainability and responsible practices.
- Student Engagement: the smaller scale of experiments encouraged active participation and collaboration among students, fostering a more engaging learning experience.

- Preparation for Higher Education: microscale chemistry techniques closely resemble those used in university-level laboratories, helping students adapt more easily to advanced learning environments.

The research highlights the effectiveness implementing of microscale chemistry laboratory techniques at the secondary school level. This technique not only provide a safer, cost-effective, and environmentally friendly approach to learning but also enhance student engagement, understanding and better prepare them for higher education.

The idea of applying laboratory experiments on a small scale has already been proven successful, achieving most of the benefits that were mentioned previously. The tables below show some of the laboratory experiments conducted during the secondary stage along with the alternative materials and tools used, thereby achieving the research results.

Table (1): It shows part of the experiences of the stage of secondary stage:

Name of the experiment	*Class*	*Materials*	*Alternatives\ Place to buy*
Relationship between Chemistry and Biology	*First secondary stage*	**Test tubes* **Glass flasks of 100 ml* **vitamin C*	**Insulin Injection tubes* **Cup + Syringe* **Lemon juice from home*
Determining Water Density	*First secondary stage*	**Graduated cylinder* **Distilled water* **Plastic bottle* **100 ml glass cup* **Burette* **Pipette*	** Syringe* **Pharmacy* **Home/Grocery* **Cup+ Syringe* **Syringe* **Syringe*
Mole Unit and its Derivatives	*First secondary stage*	**sodium bicarbonates* **Bunsen flame* **Lime water*	**Baking soda from market* **Candle* **Slaked lime "paint shops"*
Theoretical and Practical yield	*First secondary stage*	**Crucible* **Flame* **Holder* **Iron filling*	**Soda metal cap* **Candle* **Coffee pot holder or a Clip* **Iron and paint shops*
Fountain experiment	*Second secondary stage*	**An acidified aqueous solution* **few drops of red litmus solution* **Ammonia Gas* **stream of air into the lower flask* **Flask*	**vinegar diluted with water* **Red Cabbage juice* **you can use household ammonia cleaner* **Clear plastic cups* **Clean medicine syringe without the needle*
Preparation of sodium carbonate	*Second secondary stage*	**Carbon dioxide gas* **Hot solution Of sodium Hydroxide*	**sodium bicarbonate from the grocery* **Calcium Hydroxide "slaked Lime"*
Chemical reaction concept	*Second secondary stage*	**iron Fillings* **Sulphur powder*	** you can find it in hardware stores* **Table salt*
Experiment on preparing ammonia gas	*Second secondary stage*	**ammonium chloride* **calcium hydroxide* **concentrated hydrochloric acid* **Tube holder*	**cough drugs or Ammonium salt from the market* **slaked lime* **flash* **Clip*
Preparation of petroleum products	*Third secondary stage*	**Petroleum materials are difficult to obtain*	**Oil and wax*

Name of the experiment	Class	Materials	Alternatives\ Place to buy
Prepare alcohol	Third secondary stage	*Ethyl alcohol	*Sugar *Yeast
Preparing Solutions of Different Concentrations	First secondary stage	*Sodium carbonate	*From The Apothecary
Electrolytic and non-electrolytic solution	First secondary stage	*Distilled water *Sodium chloride *Acetic acid *Sucrose *Sodium hydroxide *Ammonium hydroxide	* Pharmacy *Salt *Vinegar *Sugar *Soap *Ammonia
Distinguish between the acidic and basic solutions	First secondary stage	*Sodium Bicarbonate *Phenolphthalein *Methyl orange	*from the Apothecary *Hibiscus *Red cabbage
Exothermic reaction	First secondary stage	*Calcium oxide	*Carbonate calcium from chalk and heat
Endothermic reactions	First secondary stage	*Ammonium Chloride	*Ammonia from the apothecary
Heat of solubility	First secondary stage	*Calcium chloride	*Yeast
Preparation of methane	Third secondary stage	*Anhydrous sodium acetate Lime soda (aoH+ CaO)	*CaO (lime) *Lime soda : NaoH (caustic soda)
Distinguish between carbonate and bicarbonate anion	Third secondary stage	*Sodium carbonate *Sodium chloride *Sodium bicarbonate *Magnesium carbonate *Magnesium bicarbonate	*washing soda *Salt *baking soda * found in some medicine & supplements * available in the form of solution and prepared by the reaction of CO_2 with $MgCO_3$ in water

Contrarily, after many experiments were conducted on a small scale and with simple tools that the student can easily obtain, we found that there are some experiments that are difficult to implement due to the unavailability of their tools and their high costs, but in order for the student to be able to understand these experiments, we also developed virtual models and videos so that The student achieves the same result, and thus the project goal has been completely achieved.

Examples on the virtual experiences and video links that explain these experiences:

Name of the experiment	Class	Materials
Nuclear Isotopes	First secondary stage	https://youtu.be/42gUZNYco0c?si=9bKgTrcrEy1q6cfW
Study the stability of Nuclei	First secondary stage	https://youtu.be/gqrh8wbPXVE?si=fk7Z4wXud6luDdtQ
Quarks	First secondary stage	https://youtu.be/nlv06lSAC7c?si=IVtfWZ3Yf-TCF-_t
Radioactivity and Nuclear Reactions	First secondary stage	https://youtu.be/MmutSn-O4YQ?si=CW9l_gHadanU2EFk https://youtu.be/V4PFQpCCqzk?si=4Webk60__D51iONO
Rutherford model	Second secondary stage	https://youtu.be/9Z4RyMql3jI?si=4wybyjh9DN-GAbzX https://youtu.be/I7I2M2jSWuU?feature=shared

Illustrative Videos:

https://youtube.com/watch?v=gGJwE4Kv_zY&feature=shared
https://youtube.com/watch?v=nD2I0CRd0M8&feature=shared
https://drive.google.com/file/d/104jEK3pg-if6UZ-6uzaw60iB6cw8yaaO/view?usp=sharing

- Experiments for the first year of secondary stage were done by Khadija Mahmoud Ali and Marwa Abdelaal.

- Experiments for the second year of secondary stage were done by Nadia Sayed and Marina Fayez.

- Experiments for the third year of secondary stage were done by Nariman Khalid, Marina Tareq and Mariam Karam.

There are many authors who have applied the idea of this research in 1990, 1986, etc The result was wonderful.

Interpretation of Results

It includes a detailed explanation, and accurate and logical analysis of the results. The interpretation aims to understand the relations and connections among the variables in the scope of study and to know whether the hypotheses stated are right or wrong.

The interpretation of results is done in the light of previous theories, present scientific evidence and clarification of restrictions that might affect the results.

Moreover, interpretation also includes the statistical interpretation of results including the statistical tests and different analysis used in the study. This will help in understanding the relations among the variables.

Interpretation includes also consideration of results from different perspectives: social, cultural, historical, and economic that might affect the results.

The interpretation aims to clarify the scientific analysis of results and set them in a wider context to be beneficial in the field of study and the other related fields.

The interpretation should be accurate and comprehensive to enable others to understand the results and get benefits from them in the related fields.

Discussion

First: The Significance of Microscale Chemistry

Micro-scale chemistry represents a significant advancement in educational practices by shifting from traditional large-scale laboratory experiments to more manageable and eco-friendly practices. This change can fundamentally alter how students engage with and understand chemistry.

There are some branches of this title are the following:

1. Addressing Resource Constraints: One of the major barriers to effective laboratory education, especially in developing countries, is the lack of resources such as chemicals and laboratory equipment. Microscale chemistry offers a solution by using smaller amounts of chemicals and simpler equipment, making laboratory work accessible to a wider range of educational institutions.
2. Enhanced Student Engagement and Learning: Microscale chemistry fosters a more active learning environment. Students can engage directly with experiments, leading to a deeper understanding of scientific concepts and methodologies. This hands-on approach promotes curiosity and encourages students to ask questions and explore hypotheses.
3. Promoting Safety and Sustainability: By reducing the quantity of chemicals used and the size of equipment needed, microscale chemistry minimizes risks associated with chemical handling and storage. This approach also aligns with sustainable practices by reducing waste and pollution, contributing to the protection of the environment.
4. Overcoming Limitations of Traditional Methods: Traditional laboratory work often focuses on students mechanically executing prescribed procedures without room for creativity or inquiry. Microscale chemistry, in contrast, encourages students to think critically and explore

scientific phenomena, allowing them to apply theoretical knowledge in practical settings.

5. Curriculum Integration and Flexibility: Micro-scale chemistry can be easily integrated into existing curricula, offering educators flexibility in teaching methods and content delivery. This approach supports a shift from rote memorization to inquiry-based learning, promoting a more holistic understanding of scientific concepts.

6. Cost-Efficiency and Practicality: Using smaller amounts of chemicals and less complex equipment reduces operational costs, making laboratory work more practical for schools with limited budgets. This cost-efficiency allows more experiments to be conducted, enhancing the overall learning experience for students.

7. Potential for Educational Innovation: Microscale chemistry paves the way for further educational innovation. Offering a more engaging and accessible approach to laboratory work encourages the exploration of new teaching methods and tools that could benefit students in various scientific disciplines.

8. Building Collaborative Skills: Working with the MCL Kit can foster collaboration among students, as they share tasks and discuss their findings. This collaborative learning environment is crucial for developing communication and teamwork skills, essential in scientific and professional settings.

9. Conclusion and Future Implications: The project demonstrates how microscale chemistry can transform chemistry education by making laboratory work more accessible, engaging, and sustainable. The potential for future expansion of this approach in educational institutions worldwide could lead to a new era of science education that emphasizes practical skills, critical thinking, and environmental consciousness.

10. Potential for Professional Development: The approach can also be beneficial for teachers, providing them with new methodologies and resources to enhance their teaching practices.

This professional development can lead to improved educational outcomes and a more dynamic classroom environment.

Second: Addressing Societal Needs

As society faces increasingly complex scientific and environmental challenges, equipping students with practical, hands-on laboratory experience is essential. Microscale chemistry contributes to developing a scientifically literate population capable of addressing these challenges effectively.

By offering a comprehensive interpretation of your project, you can highlight the multifaceted benefits of integrating microscale chemistry into educational practices and its potential to create lasting impacts on students, teachers, and society as a whole the results of the evaluation showed that, both teachers and students had positive experience with microscale chemistry lesson activities. While teachers' responses indicated that they liked and appreciated their exposure to a new, simple, quick, and a relatively inexpensive approach to chemistry practical work, most Students were excited with the microscale chemistry Experience. They reported to have enjoyed the lessons in particular by engaging themselves in doing the experiments and sharing ideas in groups.

Conclusion

The Ultimate goal being to improve teaching and learning of secondary stage chemistry After designing the experiments with this technique, we found that the use of this technique helped to achieve the goals of chemistry and helped students to better understand the nature of chemistry and to keep the information in their minds, by giving them the opportunity to do these experiments despite severe financial constraints and makes chemistry classes more interactive, interesting, and enjoyable.

Here is some recommendations:

(1) Necessary to use micro techniques to overcome all the constraints that we encounter when using the lab.
(2) Provide tools and materials to enable the use of scientific laboratories.
(3) Give teachers training on how to use these techniques.
(4) Studying how effective this technology is for the students.

(5) It is recommended that further work be carried out with the microscale chemistry experimental work So that it can be spread to more school.

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References and Sources

Abdullah, M., Mohamed, N., & Ismail, Z. H. (2007). The Effect of Microscale Chemistry Experimentation On Students' attitude And Motivation Towards Chemistry Practical Work. Journal of Science and Mathematics Education in Southeast Asia, 30(2), 44.

Abdullah, M., Mohamed, N., & Ismail, Z. H. (2009). The effect of an individualized laboratory approach through microscale chemistry experimentation on students' understanding of chemistry concepts, motivation and attitudes. Chemistry Education Research and Practice, 10(1), 53-61.

Baradley eta al., 1998), Sharifah, lewin (1993).

Ben-Zvi, R., Hofstein, A., Samuel, D. & Kempa R. F., (1976). The attitudes of high school students towards the use of filmed experiments. Journal of Chemical Education, 53, 575-577.

Berg, C.A.R. (2005). Factors related to observed attitude change toward learning chemistry among university students. Chemical Education Research and Practice, 6(1), 1-18.

Bradley, J.D. (1999). Hands-on practical chemistry for all. Pure Applied Chemistry, 71(5), 817-823.

Bradley, J.D. (2001). UNESCO/IUPAC-CTC global program in microchemistry. Pure Applied Chemistry, 73(7), 1215-1219.

Cooperetal., 1995, Baradley 1999, Singh et al., 1999).Tallmadge et al, 2004.

Cresswell, J. (2002). Educational research: planning, conducting, and evaluating quantities and qualitiative research. Upper saddle River, NJ: pearson Education.

El-Marsafy ‹M K (1989). "Microscale Chemistry Experimentation". MicrEcol. M.K.El-Marsafy.

Grey ‹Egerton C (1928). Practical Chemistry by Micro-Methods. Cambridge: W Heffer & Sons Ltd.

Journal of Social Studies and Research, Martyr Hamma Lakhdar University, Al-Oued, Issue 10, March 2015, p. (24_7).

Mayo ‹D W (1986). Microscale Organic Laboratory. New York, NY: John Wiley & Sons. ISBN:0-471-82448-8.

Mafumiko F., Ottevanger, W. (2004) . Evaluation of teacher support materials for micro_ scale chemistry experimentation in Tanzanian A _level classes. In K.Osaki, K. Hosea and W. Ottevanger, (2004) . Reforming science and mathematics in sub_saharan Africa. Obstacles and opportuopportunities. TEAMS project: University of Dar es salaam. Tanzanian.

Madeira, A.C.P., (2005). The influence of practical work on chemistry teaching and learning- an approach using microchemistry kits in Mozambican Junior Secondary Schools, Unpublished M.Sc. Thesis, Faculty of Science, University of the Witwatersrand, Johannesburg.

Nieveen, N. (1999). Prototyping to reach product quality. In J. Van den Akker, R. Branch, K. Gustafson, N.

Nieveen, and T. Plomp, (Eds), Design approaches and tools in education and training (pp. 125_135).Dordrecht: Kluwer Academic publishers.

S. Breuer, Educ. Chem., 1991, 28 (3), 75.

Urassa, F. M., and Osaki, K. (2002). Pre_entry programme for science female students at the university of Dar es salaam: status and progress, 1996-2001. In K. Osaki, W. Ottevanger, C. Uiso, J. Van den Akker (Eds), science education research and teacher development in Tanzanian (pp.69_81). Amsterdam:Vriije universiteit.

Van den Akker, J. (2002) . The added value of development research for educational development in developing countries. In K. Osaki, W. Ottevanger, C. Uiso, J.

Van den Akker (Eds) , Science education research and teacher development in Tanzanian (pp.51_68).

Vriije universiteit, Amsterdam.

Van den Akker, J. (1998). The science curriculum: Between ideals and outcomes. In B. Fraser, & K. Tobin (Eds.) International handbook of science education (pp.421447). Dordrecht: Kluwer Academic Publishers. van den Akker, J. (2002). The added value of development research for educational development in developing countries. In K. Osaki, W. Ottevanger, C. Uiso, & J. van den Akker (Eds.), Science education research and teacher development in Tanzania (pp. 51 -68). Amsterdam: Vrije Universiteit.

Yoo, M.H., Hong, H.G. & Yoon, H. (2006). The effect of small-scale chemistry (SSC) lab program on students’ science achievement, science related affective domain and academic self-efficacy in high-school chemistry, poster presented at the International Science Education Conference, Singapore, 22-24 November 2006.

Zipp, A. P. (1989). Introduction to" The Microscale Laboratory". Journal of Chemical Education, 66(11), 956.