Impressive Science Teaching Experiments (ISTE) presenting "Tsipouro", the Traditional Greek Spirit, in the University Laboratory

Topic number: 4
Type of proposal: Workshops

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Introduction

Main reasons behind students' unsatisfactory performance in the cognitive and affective domains:

- lack of perceived relevance of the topics
- poor motivation
- lack of prior success
- low self-efficacy

Many chemistry instructors aim to cover every aspect of foundational knowledge, but this often results in instruction that does not include many of the connections between chemistry topics and issues relevant to real-world applications (Mahaffy, 2015).

Introduction

- *“If we are to support and encourage our students to learn better, we must first seek to understand how students learn, and then adapt our teaching to support this process”*

- *“Behaviourism can certainly be helpful in understanding the simple issues associated with basic training processes, BUT it has proved much less successful when it comes to understanding important issues of higher level learning, such as concept acquisition, problem solving and creativity” (*Byers & Eilks, 2009).

- *“Constructivists, in contrast, attempt to foster active learning, guiding learners to create their own constructs, using a process of peer and teacher-facilitated learning. Under constructivism, the teacher holds a totally different role; that of a facilitator rather than transmitter of knowledge” (*Coll & Taylor, 2001).

Introduction

The teaching approach of

Impressive Science Teaching Experiments (ISTE),

is based on the constructive model

previously acquired knowledge and experience

implemented in all levels of education

- stir up students' interest
- help the teacher to evaluate their knowledge and views
- help students to refrain from misinformation
- evaluation of students who are indifferent to sciences

Introduction

Students engage in experiments that are directly related to everyday life

New knowledge based on their previous experiences

learning as a product of conceptual changes

ISTE is based on David Ausubel's Theory of Assimilation:

New ideas and concepts can be learned effectively only through their assimilation into pre-existing concepts and ideas, which provide the necessary mental support (Ausubel, 2000).

Introduction

- ✓ True knowledge and understanding based on existing knowledge
- ✓ Comprehension is linked to prior knowledge
- ✓ New knowledge is in harmony with pre-existing knowledge
- ✓ Learning is not assimilated according to the curriculum
- ✓ Existing knowledge does not remain unaltered
- ✓ New information helps to consolidate previous knowledge.
- ✓ Students can learn by comprehension
- ✓ISTE > interesting and meaningful learning processes and activities > learning material presented in view of students' cognitive background

The ISTE teaching approach

Stages of the ISTE method:

a) Lesson starts by sparking students' interest

> Provide a conceptual framework for the learning activity

> Curiosity and innovation increase internal motivation

> Attract attention though an impressive science experiment.

> *The experiment must not be a show*

> *A "showman-teacher" attracts unnecessary attention*

> *Impressive experiments without meaning and reasoning must be avoided (e.g. containers with colored liquids that boil, explode or emit smoke)*

> *Experiments related to the learning material and objectives*

> *Draw students' attention through personification (examples relevant to children's cognitive level & emotions)*

The ISTE teaching approach

b) Active participation of students in the experimental process

> Enhance their occasional interest

> Encourage them to become cognitively active

> Engagement is effectively encouraged through questions/ teamwork

> Students' performance is constantly monitored by the teacher.

c) Constant reference to new relevant knowledge and feedback

> Motivates students

> Provides information about learning at a given time

> Helps to understand their efforts and experiences

d) Homework

> At the end of the presentation, ask questions and give students comprehension exercises

> Motives for further learning and consolidation

> Exercises that require the study of bibliography (400-500 words).

The ISTE teaching approach

Impressive Science Teaching Experiments (ISTE) can be implemented in all levels of education, in many teaching modules

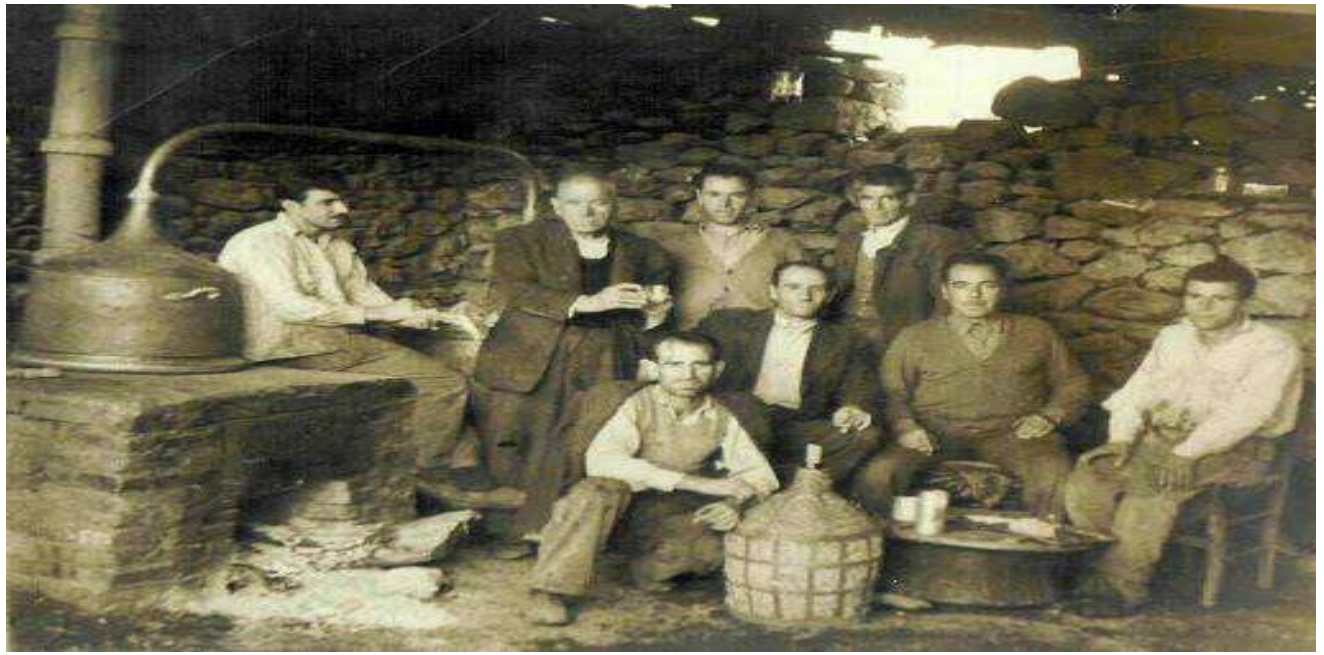
Case study: teaching **distillation**

Instead of following the simple procedure, using the glass distillation apparatus of the laboratory (Kahl et al., 2014), we use a copper still (alembic) for the distillation process.

- Traditional alcoholic drink of tsipouro
- Similar drinks in other countries: zivania (Cyprus), grappa (Italy), arak (Middle East)
- Raki stafylis (tsikoudia): similar to tsipouro, produced in Crete. Only difference: raki is distilled once, while tsipouro is doubly-distilled

The lesson starts in a way that sparks students' interest and provides a conceptual framework for the learning activity.

- Tsipouro: for many centuries, produced by amateur villagers to utilize the grape pomace (otherwise thrown away as useless)
- Production was carried out in small copper stills of old technology, beyond state regulation and under substandard hygienic conditions



Traditional distillation of tsipouro by villagers of the previous century

The lesson starts in a way that sparks students' interest and provides a conceptual framework for the learning activity

- The better the grapes > the better the wine/ tsipouro
- Grapes need to be clean and ripe. No spraying with insecticides, organic fertilizers & sulfur before harvest
- Grapes must be crushed or pressed immediately after harvest
- Fermentation: 1st step in producing distillates from white or unfermented red grape pomace of good quality
- Lasts approximately 30 days (pomace fermented on its own) or much less (pomace fermented with the must)
- Should be done at the lowest possible temperatures, in order to bring out the finer aromas.
- Stems must be removed to limit the formation of furfural (dangerous to health) during distillation

Fermentation of pomace from red grapes

Active participation of students in the experimental process

Offer students some important information before assembling the alembic:

- Introduction of European regulations on spirit drinks > production and bottling of tsipouro by official distillers.
- Improved quality of tsipouro > establishment of “distillation culture” > industrial production of tsipouro

Modern industrial copper stills for tsipouro

Active participation of students in the experimental process

- Alembics (stills) for tsipouro < made of copper
- Copper binds sulfur compounds and the fatty acids that may result from fermentation or distillation
- Removes unpleasant odors from the distillate
- Black coating on the interior of copper must be periodically cleaned
- Modern alembics largely improved.
- Their bottom is hollow to prevent “sticking” – Some have mechanical stirrers
- Lids equipped with thermometers (or a bell) to help control distillation process
- Boiler covered with copper lid connected to a condenser
- Important to use pipes or other connecting parts made solely of copper, NOT lead or plastic.

Active participation of students in the experimental process

Modern alembic on top of iron cast gas stove

Active participation of students in the experimental process

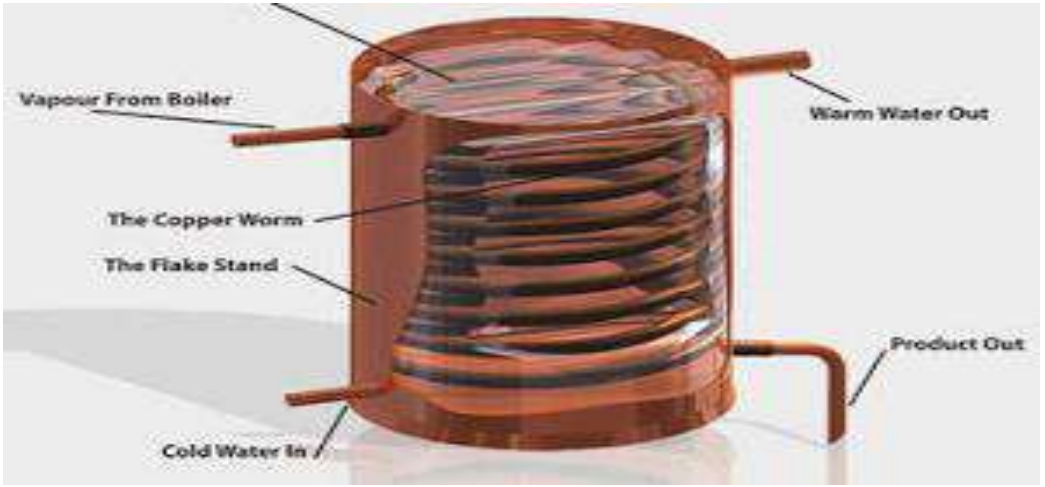
- Modern condensers comprise vertical copper pipes (spirals) > steam produced during distillation moves inside them

- Condenser placed inside container where water flows backwards

- Earlier condensers for tsipouro made of tin

- Nowadays made of stainless steel or glass

- Plastic containers are dangerous for our health.



Copper distillation condenser

Active participation of students in the experimental process

- Students assemble the experimental copper apparatus and the experiment begins

Experimental copper apparatus for the distillation of tsipouro

Active participation of students in the experimental process

- **First distillation** (“souma”): amounts to 15%–20% of initial volume of pomace.
- Remains are discarded after distillation
- **Second distillation**: alembic filled with 80%-90% of the first distillate
- We remove the first fraction (approximately 5% of initial distilled volume)
- This fraction is called the **“head”** and has high alcohol content
- We then collect the **“heart”** (50% of initial volume) > desired ingredients
- Remaining fraction is called the **“tail”** > collected and put in the still along with the pomace or souma for a new cycle of distillation
- Desired alcohol by volume in this latter distillation is 38–45 ABV
- Doubly-distilled tsipouro is a more clear spirit with finer aroma and taste

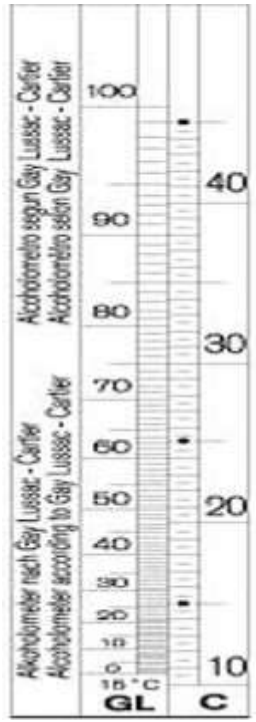
Active participation of students in the experimental process

Measuring the alcohol content of tsipouro

- Based on the ratio of the distillate's density to its alcohol content
- Distillate is put in a volumetric graduated cylinder
- Alcohol hydrometer (calibrated to 0–44.9 Cartier alcohol density degrees) is vertically immersed in the distillate
- Measurement is simple and easy
- Distillate's temperature adjusted according to instrument's reference temperature (usually 15 ^{o}C) prior to the measurement (density is influenced by temperature)
- Two different scales on the instrument:
  - percentage (%) of alcohol by volume (Gay Lussac scale)
  - density expressed in Cartier degrees (grada)

Active participation of students in the experimental process

Reading the indication of the alcoholmeter on the surface of tsipouro



Relationship of Cartier and Gay-Lussac scales on the alcoholmeter

Constant reference to new relevant knowledge and feedback

Chemistry and tsipouro:

- Tsipouro: aqueous solution of primarily ethyl alcohol, other alcohols (methanol, propanol, amylase), volatile acids (acetic acid), aldehydes (furfural), esters (ethyl acetate) and various other volatile acids that were present in the initial mix and passed on to the distillate, imparting its distinctive flavor, aroma and properties.
- Small quantities of non-volatile substances can remain in the distillate, especially when the rate of distillation is intense (Apostolopoulou et al., 2005)
- Besides **desired ingredients** (ethyl alcohol & aromatic substances) > **undesired substances are also present** (dangerous to consumers' health):
  - **Cis-Anethole**: toxic isomer that stems from the anise used in distillation (Jurado et al., 2006)

Constant reference to new relevant knowledge and feedback

- **Methanol**: distilled together with water after ethyl alcohol > product mainly of the tail fraction (Leaute, 1990).
  - Concentration of methanol in tsipouro: 50–84 grams per hectoliter of anhydrous alcohol during the distillation of pomace in a traditional alembic (Soufleros & Bertrand, 1987).
  - Values mentioned in international literature vary widely: in Italian grappa, methanol reaches 400 grams per hectoliter of anhydrous alcohol (Versini & Odello, 1991)
  - European legislation (Regulation 110/2008 of the EU): maximum permissible content of methanol in pomace distillates > less than 1,000 grams per hectoliter of 100% vol. alcohol
- **Furfural**: the result of bad winemaking.
  - Distilled throughout the process of distillation, primarily in the heart fraction.
  - Tsipouro contains amounts of furfural and its derivatives, stemming from sugars that remained unfermented (hexoses), non-fermentable sugars (pentoses) and the stems that have not been removed.
  - Tsipouro contains between 0.5 and 1.2 grams of furfural per hectoliter of 100% vol. alcohol (Soufleros & Bertrand, 1987).

Constant reference to new relevant knowledge and feedback

- **Toxic metals**: arsenic, copper, lead, etc.
  - Strict control is necessary (Soufleros et al., 2005)
  - Must remain within the maximum permitted limits (European legislation)

Storage of tsipouro:

✓special stainless steel or glass containers

✓Plastic packaging (PVC) must be avoided > phthalates dissolved in tsipouro

✓Phthalates: used as plasticizers > toxic effects on human body (damage DNA, burden the liver and kidneys and hinder hormonal system)

✓Contamination by phthalates < temperature, duration and surface of contact with plastic packaging made of PVC (Messadi & Vergnaud, 1982)

✓Storing in glass containers or bottles > fundamental parameter for safety & hygiene of consumers (Commission Directive 2007/19/EC)

Constant reference to new relevant knowledge and feedback

Is drinking tsipouro healthy?

The following facts MUST be pointed out to our students:

- Alcohol in empty stomach reaches maximum concentration in blood within an 1,5 hours
- Same amount takes 6 hours to reach the same levels when consumed during or after a rich meal
- Alcohol: swift absorption &slow metabolization
- Behavior after consuming alcohol & negative effects (dizziness, headache) depend on physical condition, composition of the spirit, etc.
- Substances in tsipouro of poor quality (e.g. higher alcohols & fusel oils) cause hangover (headache, thirst, vertigo & psychological disorders)
- Abuse linked to chronic problems: cirrhosis of the liver & alcoholism
- Alcohol PROHIBITED for minors
- Alcohol and driving is a fatal combination (Mason & Dubowski, 1974)

Homework

- At the end of the presentation, we should ask **questions** and give students **comprehension exercises** and **motives** for further learning and consolidation, or exercises that require the **study of bibliography** (400–500 words):

  - Similar alcoholic distillates from around the world
  - Comparison of ethanol & methanol toxicity
  - Frauds in alcoholic beverages
  - Methods of producing pure ethanol, etc.

Conclusion and discussion

- **Impressive Science Teaching Experiments** (ISTE) in all levels of education, from Kindergarten to the university
- Teachers must be prepared (scientific material related to the experiment)
- **Main aims** of this teaching approach:

  a) attract and maintain the interest of students in the laboratory course

  b) associate Chemistry with daily life

  c) enrich students' knowledge

  d) assist in the fight against scientific illiteracy

  e) inform about counterfeits in consumer products, myths, fake news & related internet pranks (hoaxes)

Conclusion and discussion

Today I present ISTE for the first time.

Essentially is a highly enriched method of teaching experiments.

ISTE will hopefully gain the necessary support,

in order to be applied in school and university laboratories,

serving as a tool for innovative teaching!

References

- Apostolopoulou, A. A., Flouros, A. I., Demertzis, P. G., & Akrida-Demertzi, K. (2005). Differences in concentration of principal volatile constituents in traditional Greek distillates. *Food Control, 16*(2), 157–164.
- Ausubel, D. P. (2000). *The acquisition and retention of knowledge.* Dordrecht: Kluwer.
- Byers, B., & Eilks, I. (2009). The need for innovations in higher level chemistry education–A pedagogical justification. *Innovative methods of teaching and learning chemistry in higher education,* 5-22.
- Coll, R. K., & Taylor, T. G. N. (2001). Using constructivism to inform tertiary chemistry pedagogy. *Chemistry Education Research and Practice, 2*, 215-226.
- Forbes, R. J. (1948). *Short History of the Art of Distillation from the Beginnings Up to the Death of Cellier Blumenthal.* Leiden: E. J. Brill. pp. 29-38.
- George, A., Zowada, C., Eilks, I., & Gulacar, O. (2021). Exploring Chemistry Professors' Methods of Highlighting the Relevancy of Chemistry: Opportunities, Obstacles, and Suggestions to Improve Students' Motivation in Science Classrooms. *Education Sciences, 11*(13), 1-12.
- Kana, K., Kanellaki, M., Papadimitriou, A., & Koutinas, A. A. (1991). Cause of and methods to reduce methanol content of Tsikoudia, Tsipouro and Ouzo. *International Journal of Food Science and Technology, 26,* 241–247.
- Kahl, A., Heller, D., & Ogden, K. (2014). Constructing a Simple Distillation Apparatus To Purify Seawater. A High School Chemistry Experiment. *Journal of Chemical Education, 91*(4), 554-556.

References

- Leaute, R. (1990). Distillation in alembic. *American Journal of Enology and Viticulture, 41*(1), 90-103.
- Mahaffy, P. (2015). Chemistry Education and Human Activity. In J. García-Martínez, & E. Serrano-Torregrosa, *Chemistry Education: Best Practices, Opportunities and Trends* (pp. 1-5). Weinheim: Wiley-VCH Verlag GmbH & Co. KGaA.
- Mason, M. F., & Dubowski, K. M. (1974). Alcohol, Traffic, and Chemical Testing in the United States: A Resumé and Some Remaining Problems. *Clinical Chemistry, 20*(2), 126–140.
- Messadi, D., & Vergnaud, J. M. (1982). Plasticizer transfer from plasticized PVC into ethanol–water mixtures. Journal of Applied Polymer Science, 27, 3945–3955.
- Soufleros, E., & Bertrand, A. (1987). Study on “Tsipouro”, traditional spirit made from grape pomace, precursor of ouzo. *Vigne et du Vin, 21*(2), 93–111.
- Soufleros, E. H., Natskoulis, P., & Mygdalia, A. S. (2005). Discrimination and risk assessment due to the volatile compounds and the inorganic elements present in the Greek marc distillates Tsipouro and Tsikoudia. *Journal International des Sciences de la Vigne et du Vin, 39,* 31-45.
- Versini, G., & Odello, L. (1991). La grappa: considération sur la distillation traditionelle en Italie. In: Bertrand A (ed), *Les eaux-de-vie traditionelles d’origine viticole.* Paris: Lavoisier. pp. 32–37.

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Thank you all for your patience and interest.
Have a great evening!

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