Overview of Research-driven, Paradigm Shifts in Science Education

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Reflecting on Paradigm Shifts in the field of Science Education

The Impact of Research in Science Education is associated with the **WHAT? the WHY? And the HOW?**

What science? Appropriate for what?
Why teach science? To what purpose?
How to teach – a philosophical aspect

Presentation Components

- **STEM as a science education research focus** – *shifting from research on a single subject to research on integration*.

- What research says re - **preparing teachers** beyond 'what science to teach', embracing *engagement, coherence and competence.*

- **Additional science attributes** for science education research. – *passion, curiosity, grit, or self efficacy, interest and relevance.*

- **Research on the 'how',** noting' 'concerns' in the teaching of science subjects.

- Science education research promoting a **positive image of science for/within society.**

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Research in Science Education

Advances in the way conceptions of science education change need to be evidence-based changes.

- Research in science education (on the What? Why? How?) and how science learning impacts on <u>student values</u>, or the <u>teacher emphases</u> is geared to impacting on the manner in which science education is <u>refocused for the future generation</u>.
- It enables re-orientation through an awareness of <u>future career needs</u>, as well as supporting the preparation of <u>future teachers</u> so that society benefits from educational advances in a changing society.
- *This presentation seeks to reflect on and highlight the science education research advances driving the perceived paradigm shifts related to the earlier presentations.*

Science – is it the truth?

We are well aware that research and discoveries in the field of science have been with us for millennia. **But so has change** !!

The four classical elements

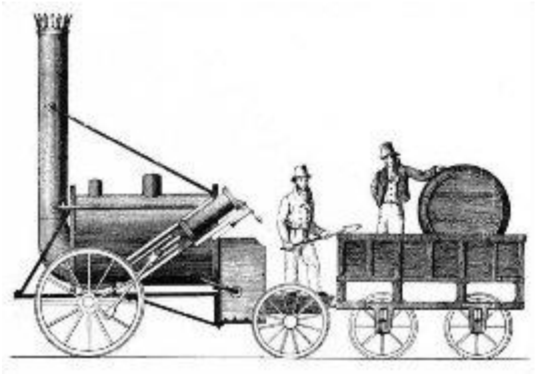
(fire, air, water, earth)

Coping with Change

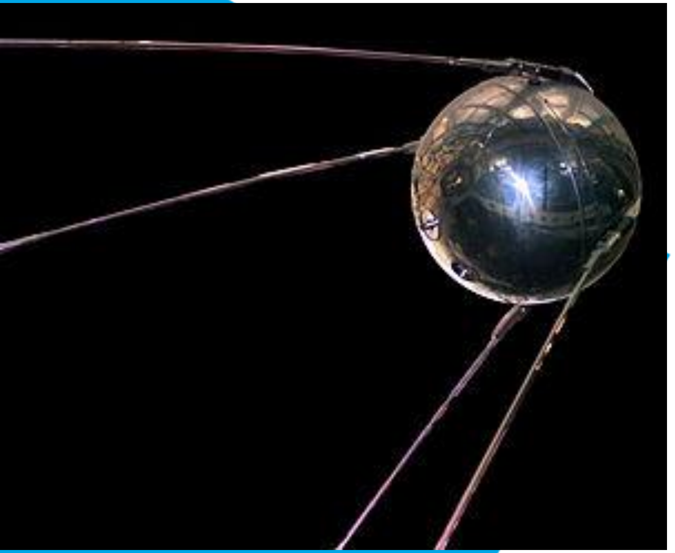
Today, **education for all** is an expectation.

But education through compulsory schooling only became a phenomena in the 19th century .

This phenomena can be identified with the impacts of the *industrial revolution* and the multitude of research developments heavily identified with technological advances, supported by scientific discoveries.



Science Education and Change



- School education has traditionally embraced the learning of science ideas. A traditional focus has been conceptualising ideas at the **macro, meso and micro levels.**
- However, it took a major technological advance to initiate a paradigm shift in **changing research directions** in the ways of teaching science (or more accurately, teaching science subjects).
- **That trigger** was the ability of the, then, USSR to successfully launch Sputnik.

THAT EVENT INITIATED MAJOR CHANGES

referred here to as **Paradigm Shifts in Science Education**

(In fact this shift can be considered the trigger for seeing

Science Education *as a separate entity from* ***Science****)*

Refocusing Science Education

This major impact was the initiation of research into how to shift the focus of the teaching of science from

A BODY of KNOWLEDGE

(A behaviourist ’fill an empty vessel’ approach)

to

A WAY OF THINKING

(A constructivist ‘learning by thinking/doing’ approach)

The purpose of education is not just to transmit information, but to create thinkers. (John Dewey)

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Science Education

The shift in Science Education,

enabled research in the learning of ’science for all’.

It triggered the focus on

‘education through science’

interrelating core ideas, skills and values

rather than simply

a focus on subject knowledge, seen as.

‘science through education’

(Holbrook and Rannikmäe, 2007).

Science through Education (focus on the science)	Education through Science (focus on the educational gain through science)
Learn fundamental science knowledge, concepts, theories and laws.	**Learn the science knowledge and concepts important for understanding and handling socio-scientific issues within society.**
Undertake the processes of science through inquiry learning as part of the development of learning to be a scientist.	Undertake investigatory scientific problem solving to better understand the science background related to socio-scientific issues within society.
Gain an appreciation of the nature of science from a scientist’s point of view.	**Gain an appreciation of the nature of science from a societal point of view.**
Undertake practical work and appreciate the work of scientists.	**Develop personal skills related to creativity, initiative, safe working, etc.**
Develop positive attitudes towards science and scientists.	**Develop positive attitudes towards science as a major factor in the development of society and scientific endeavours.**
Acquire communicative skills re- oral, written and symbolic/tabular/ graphical formats as part of systematic science learning.	Acquire communicative skills related to oral, written and symbolic/tabular/ graphical formats to better express scientific ideas in a social context.
Undertake decision making in tackling scientific issues.	**Undertake socio-scientific decision making related to issues arising from the society.**
Apply the uses of science to society and appreciate ethical issues faced by scientists.	**Develop social values related to becoming a responsible citizen and undertaking science-related careers.**

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STEM Education

A Paradigm shift from

Single subject (a science thru' education emphasis)
to Integration (an education thru' science emphasis)

STEM integration is seen as an emergent phenomenon – i.e. *a synthetic 'whole', resulting from 'disciplinary integration', being greater than the 'sum of its parts*' (Shanahan, 2016).

Research indicates that desirable learning gains are geared to:

Why? - **Learning for a Purpose** (society & career needs);

What? **Not just Knowledge, but acquiring Competences.**

(*VASK – values, attitudes, skills and knowledge*)

How? **Promoting student involvement in the learning via a real life situation**.

(*as project-based learning, or inquiry-based learning, or problem-based learning*).

The Need for Pedagogical Inter-disciplinarity

Technology advancement (eg semi-conductors) gave rise to computerization promoting research into meaningfully undertaking **teaching/learning in a digital age**.

This initiated **paradigm shifts in science education** -

e.g. how to integrate such learning (in a relevant manner) from a society, &/or student relevant perspective.

Research on interdisciplinary learning, at first, interrelating science disciplines, but the paradigm shift is based on the researching into how to also integrate **at a transversal 'skills' level**

e.g. **Problem solving skills** (approaches to inquiry–based learning) and **Decision making skills** (resolving socio-scientific issues (SSI) through <u>argumentation</u> based on <u>sound conceptual science</u>).

Researching the role played by Transversal Competences
(an example based on undertaking research via a case study)

Example of data obtained qualitatively, by:

1. **Shadowing**. - a research technique that involves a researcher closely following a member of an organization, over an extended period of time" (McDonald, 2005). (permitting inclusion of emotional and unconscious part of researchers as well as for the person shadowed).
2. **In-depth interviews**. The in-depth interview as a face-to-face meeting, so as to understand the interviewee's perspectives.
3. **Document analysis** to provide a **preliminary background study** for interviews, or the shadowing, or an observation checklist, or to gain insight into a teacher's instructional approach (Merriam, 2009).

Science Teacher Education

The **Pedagogical Content Knowledge** (PCK) framework proposed by Shulman (1986) challenged the assumption that:

Subject Content Knowledge (CK) and Teaching Pedagogical Knowledge (PK) are mutually exclusive facets affecting student science learning.

i.e. Knowledgeable about the subject matter and presenting this in a manner that benefits the audience are **two distinct teaching factors**.

Science Teacher Education Research reflects on the:

WHAT (What Content and to what degree of Conceptualisation) and

WHY (Why to Learn/conceptualisation). But also the

HOW (Identifying the Meaningful Learning Approach for the specific audience at a specific time, based on prior experiences).

Science Education Research related to Teacher Education

1. **Teacher education programmes** usually have little time to devote to the development of teacher-candidates' **CK** and consequently building on this to develop **PCK** (Shulman, 1986), or **GPK (**König et al**.** 2020**)**
2. It is usually assumed teacher-candidates have already mastered the **necessary CK** and only need to develop their classroom/laboratory functionality, or **teaching know-how** (**PK**).
3. However, ample research evidence suggests that **<u>this is not the case</u>** (Milner-Bolotin et al., 2013).

Research, based on the importance of supporting teacher-candidates to **revisit their CK and connect to the relevant PK,** becomes important

if

the science-related teaching in schools is to facilitate **paradigm shifts to maintain society and career relevance <u>in a changing society</u>.**

Science Education Research on Science Teaching of Redox

Assumption for the research - Teachers identified there was a difficulty in teaching the *balancing of redox reactions* using the ion-electron method.

The difficulty refers reactions occurring in acidic or basic medium. where the redox reactions involved the oxo-anions, like $Cr_2O_7^{2-}$.

Research data was gained by:

(1) classroom observations;

(2) audiotaped recordings of classroom practice of chemistry teachers;
(3) after the lessons, semi-structured interviews with the teachers.

Analyses of the teachers' comments clarified a number of reasons why they acted as they did.

Implications of the research.

Improvement of current chemistry classroom practice and content-related teacher PD (professional development) can be offered.

Advancing Science Education Change - based on Research driven, Evidence-based, findings.

Research enabling Paradigm shifts to be introduced e.g. for :

- Promoting STS (science, technology, society) - real world Inquiry-Based Science Education (IBSE).
- Enhancing student motivation (associated with relevance, interest, enjoyment)
- Developing and determining levels of Scientific literacy.
- Incorporating SSI (socio-scientific issues) through value-laden collaborative and cooperative, consensus Decision Making.

This leading (as an example) to

- A 3 stage teaching approach, based on Grounded theory enabling - social/student **relevance initiated**, leading to IBSE (structured, guided, open inquiry to enable gains in conceptual science), followed by SSI. (*Holbrook and Rannikmäe, 2014*)

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Transdisciplinary Science Education

Based on a plethora of research-based evidence, STEM integration research enables the bringing together of

- design-based learning,
- problem solving and the gains from project based approaches to develop scientific competences,
- involving, where appropriate, mathematical/digital learning,

seen as promoting a science in society approach to the curriculum.

BUT A possible question – is this enough?

To reflect on Science Education for and with the Future Society (Science Education for a Sustainable Future), does science education research need to embrace **transdisciplinary education?**

SUMMARISING
Science Education Research

Research is needed into the ways and focus of teaching of science in the classroom/laboratory situation giving much attention how to:

- Enhance the **relevance of science teaching** in school
- **Interrelate science and technology to the society** (STS)
- **Recognise that society/career links needs to embrace** Science Literacy involving development of Cognitive and Transversal Skills
- Build on prior **research developments** e.g. educational theories, models of learning, assessment/evaluation research.
- Embrace **Transdisciplinary Science Education** - Science Education for and with the Society of the Future (Science Education for a Sustainable Future)

Validity and Reliability in Research

Research outcomes are rather useless unless they have **validity and reliability**.

Fire, air, water, earth are aspects of life. But through asking questions and seeking reliable evidence, science recognizes that such aspects do not form the fundamental base, conceptualised through element - based matter.

By the same token, science education research needs to have validity to indicate the base for, as well as the personnel competences for, future society needs.

Just as there is a need for science research advances, so there is the need for science education research related to the what, the why and, of course, the how science is to be gained and perceived?

The ‘SciCar’ Project

ATTRACTIVENESS OF SCIENCE AND CAREER AWARENESS

THE SciCar Project TARGET

1. **Reduce** the gap between **researchers** in science disciplines **and researchers** in science education.
2. **Raise expertise** among researchers and educators involved in S&T education.
3. **Address** the academic training of **science education researchers.**
4. **Strengthen intra-institutional and inter-institutional synergies of units responsible for S&T education** at the University of Tartu (UT) and its Estonian outreach institutions.
5. **Create a Centre of Excellence for the Baltic and Eastern European countries.**

ENHANCING RESEARCH IN SCIENCE EDUCATION

THANK YOU
for your
ATTENTION

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