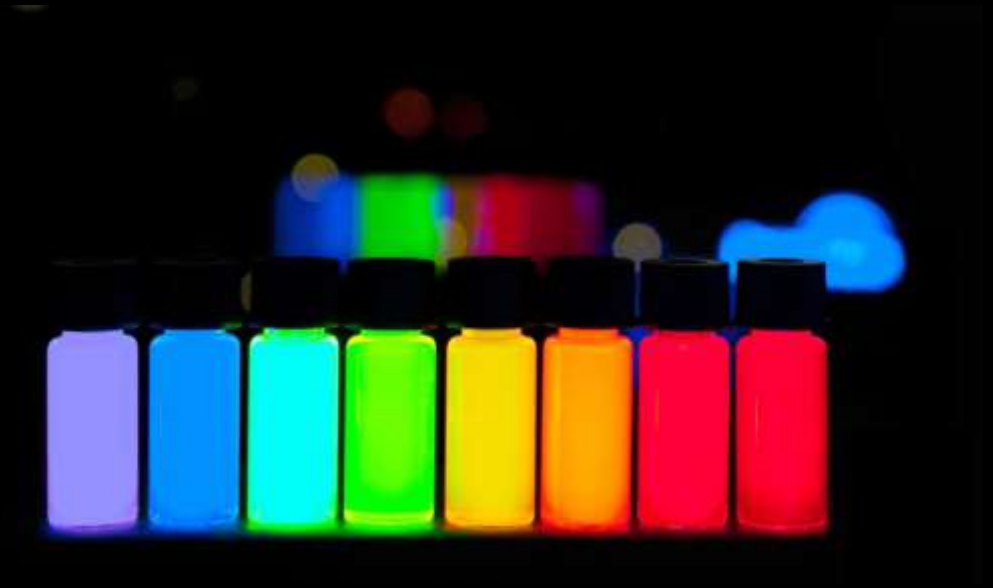
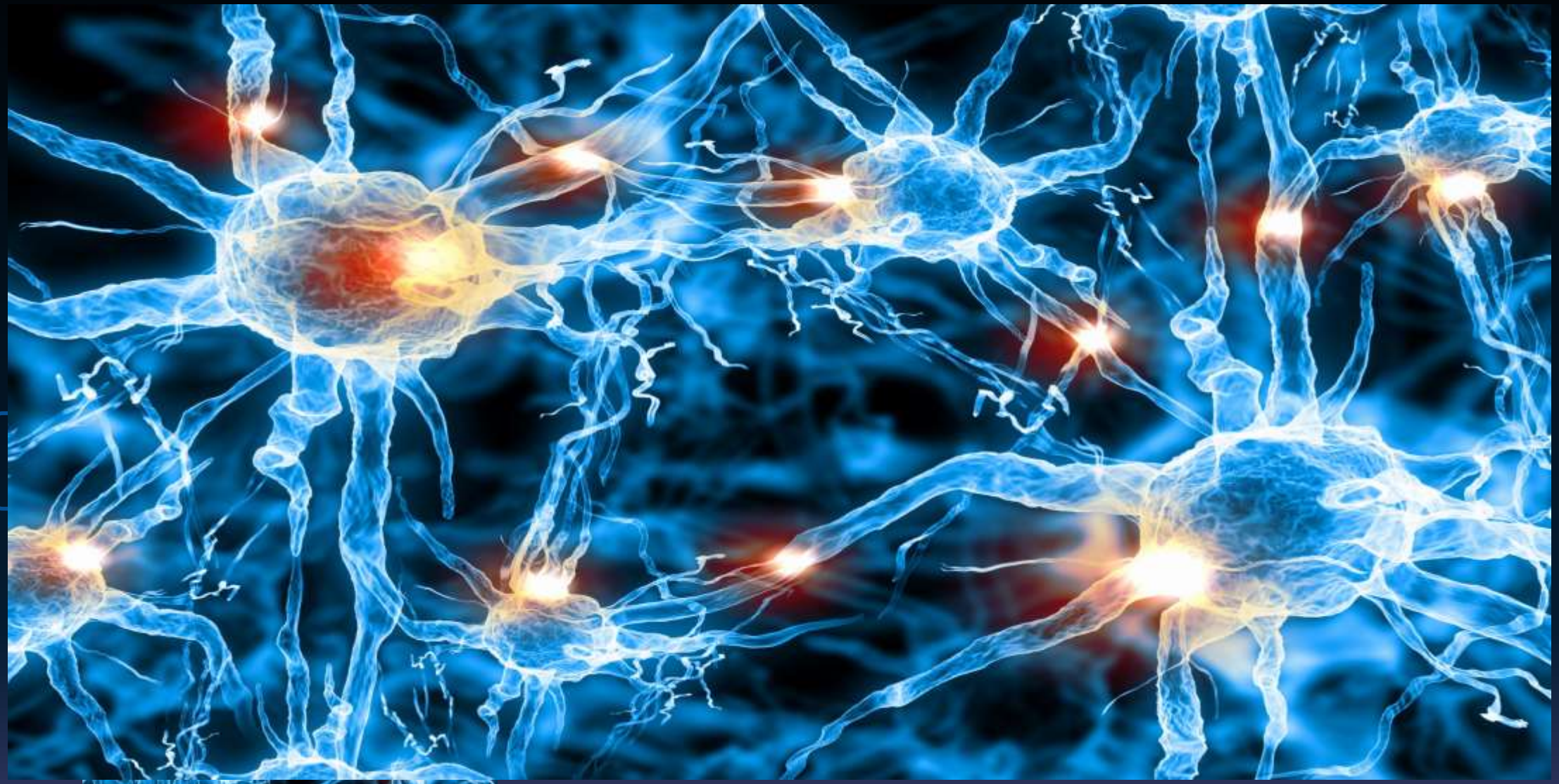
The story of a course "Introduction to Materials and Nanotechnology"



Ron Blonder

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

Building a Course: “a Thinking Exercise”



What should be included in “Introduction to nanotechnology” course?

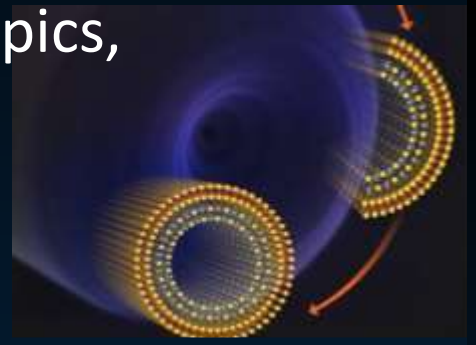
Introduction to Materials and Nanotechnology *for teachers*

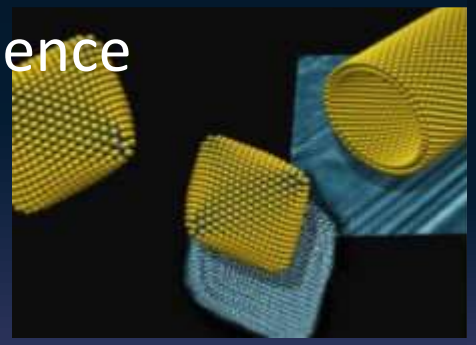
The course was originally designed and taught by:
Reshef Tenne & Ron Blonder

Aims:

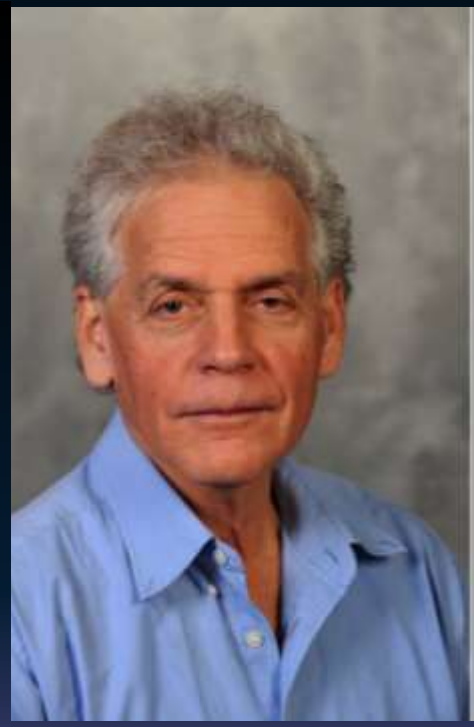
- Expose high school teachers to modern research topics,
- Introduce teachers to nanoscience,
- Generate teacher interest,
- Increase chemistry teachers' nanoliteracy

By providing them with the basic principles of nanoscience





Prof. Reshef Tenne



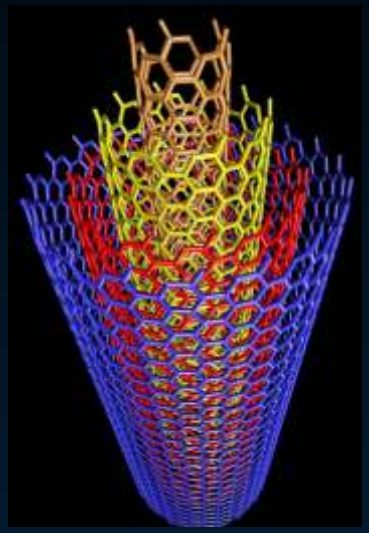
Introduction to Materials and Nanotechnology

Course Modules	Nanoscience and Nanotechnology Topics	Time Allotted
0. Introduction	First look on nanotechnology A short description of 14 advanced topics in materials science and nanotechnology	2 h
1. Qualitative quantum mechanics	Difficulties with classical physics Quantum mechanics as a wave theory Schrodinger's equation Selected predictions of Schrodinger's equation Chemistry as a many-electron quantum problem	12 h
2. Characterization methods: Each of these methods was introduced through a lecture (2 h) and a lab demonstration (1 h)	AFM; STM—Atomic force microscope; Scanning tunneling microscope TEM—Transmission electron microscope SEM—Scanning electron microscope XPS—X-ray photoelectron spectroscopy XRD—X-ray diffraction Transport measurements	18 h
3. Students' lectures: Selected advanced topics in materials science and nanotechnology	Superconductivity Photovoltaic cells Light-emitting diodes (LED) Organic light-emitting diodes (OLED) Shape memory alloys Quantum dots Carbon fullerenes and nanotubes Nanocomposites	18 h
4. Research lab experiments	Drawing with nanotubes *(13, 14)* Electrospinning nanotube-reinforced composites *(15, 16)*	8 h
5. Connection to education	How to write a scientific report The structure of a good presentation Transferring content to the teacher's classroom	28 h

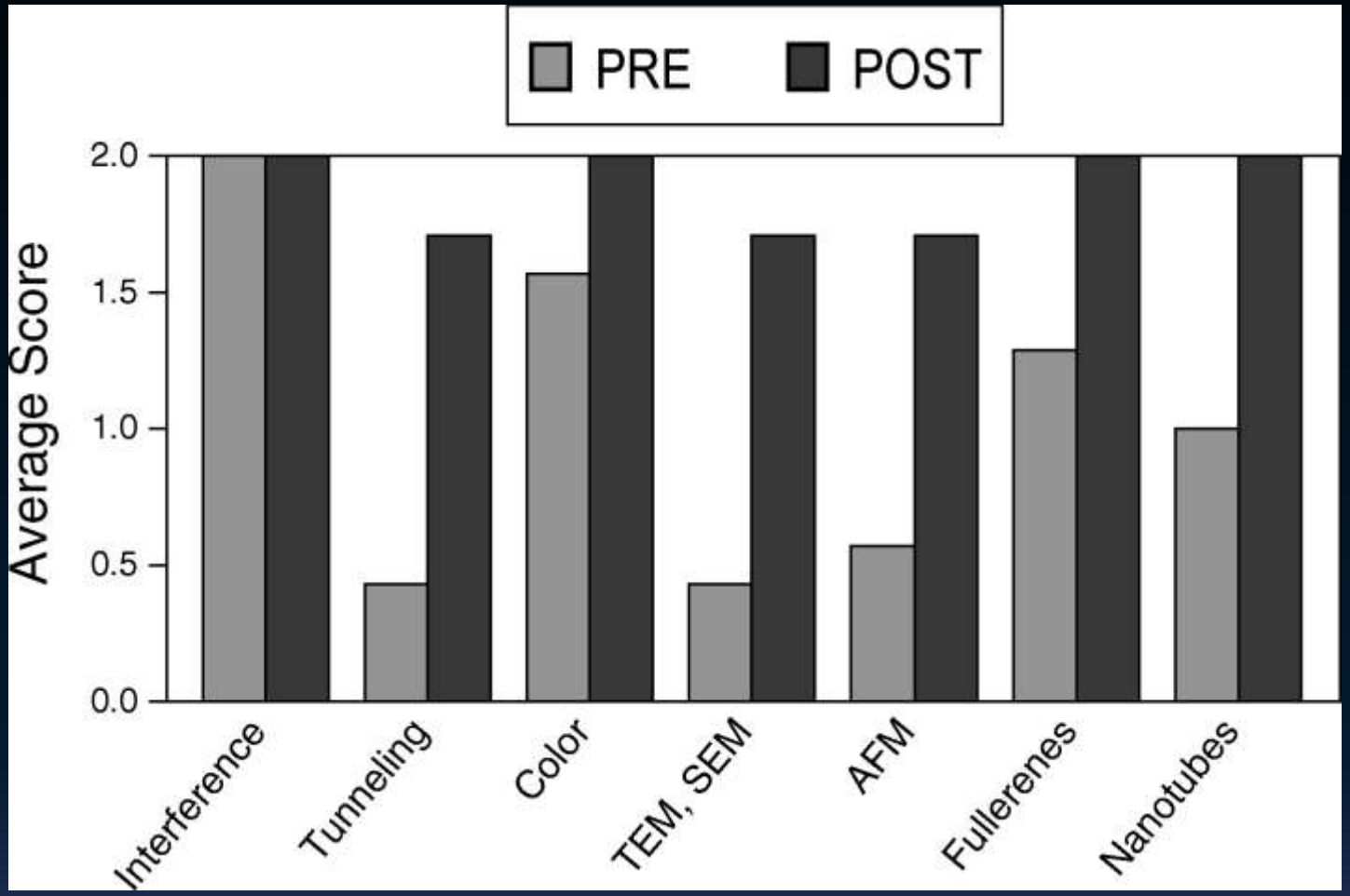
Blonder, R. (2011). The story of nanomaterials in modern technology: An advanced course for chemistry teachers. *Journal of Chemical Education, 88*, 49-52. doi:10.1021/ed100614f

The contents of the course
Introduction to Materials and Nanotechnology

- Introduction: nanotechnology applications
- Qualitative quantum mechanics
- Characterization methods
- Research lab experiments
- Students lectures: selected advanced topics in materials science and nanotechnology
- Connection to education



Teachers' knowledge



The Wilcoxon signed rank test, $p < 0.05$

Teachers' responses: impact on their knowledge

Tal:

Before I took this course I knew nothing about Nanochemistry…the most exciting part for me was self-learning of a whole new topic...

I even told my son that he should specialize in nanotechnology when he grows up.

Teachers' responses: impact on their knowledge

Shir:

I am now clearly aware that some concepts in nanochemistry were unclear to me even though I was teaching a nano program. Now I feel that I have acquired greater knowledge and deeper understanding in this field.

Teachers' responses: The importance of self-efficacy beliefs

Nitzan:

The course assignments, like preparing a lecture and writing a scientific report on a selected topic was be very difficult for me…

I think that these contents are too difficult for my students.

Blonder, R., Benny, N., & Jones, M. G. (2014). Teaching self-efficacy of science teachers. In R. H. Evans, J. Luft, C. Czerniak, & C. Pea (Eds.), *The role of science teachers' beliefs in international classrooms: From teacher actions to student learning* (pp. 3-15). Rotterdam: Sense Publishers.

Teachers’ responses

Teacher feedback was very positive and their content knowledge improved in the target area in accordance with our goals

Should we be satisfied with the course?

We asked ourselves…

- Do we really provide the teachers with the essential principles and concepts of nanoscience?
- What should we change to help teachers to integrate NST in their teaching?

Coming back to the question:

What should be included in “Introduction to nanotechnology” course?

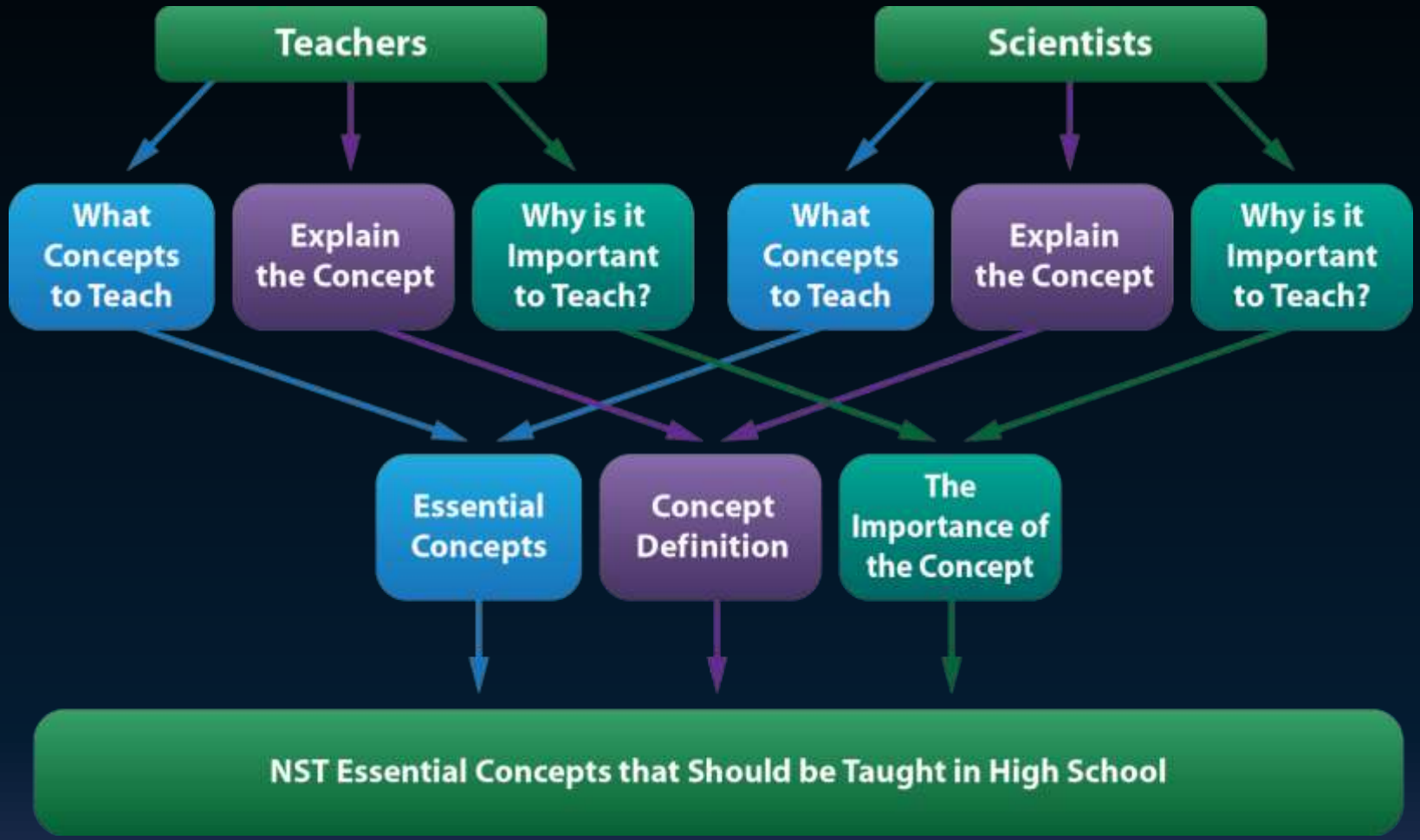
The Delphi methodology

- The Delphi methodology is a research instrument when there is incomplete knowledge about a problem or phenomenon (What are the essential concepts of NST)
- It is useful for consensus building by using a series of questionnaires

NST = Nanoscale Science & Technology

Dr. Sohair Sakhnini

The Delphi process



Essential concepts of NST for high school level based on the Delphi study

1. Size-dependent properties
2. Innovation and application of nanotechnology
3. Size and scale
4. Characterization methods
5. Functionality
6. Classification of nanomaterials
7. Fabrication approaches of nanomaterials
8. The making of nanotechnology

Sakhnini, S., & Blonder, R. (2015). *International Journal of Science Education*, *37*(11), 1699-1738
Sakhnini, S., & Blonder, R. (2016). *International Journal of Science Education*, *38*(3), 521-538

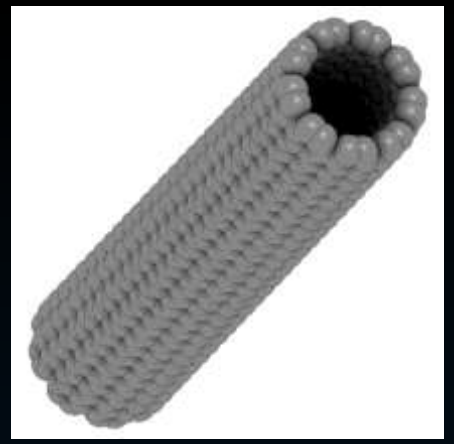
$1\ nm$

$= 1 \times 10^{-9} m$

$= 0.000000001 m$

NANO small is NANO?

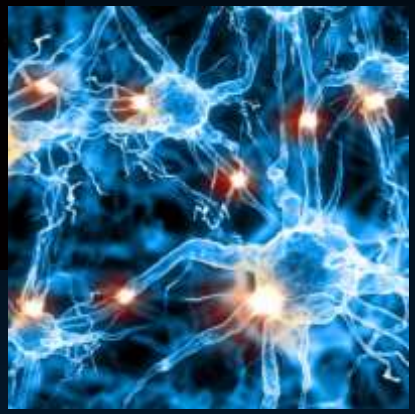
NANO small is very very very very small size



Size-based effects

Defects…

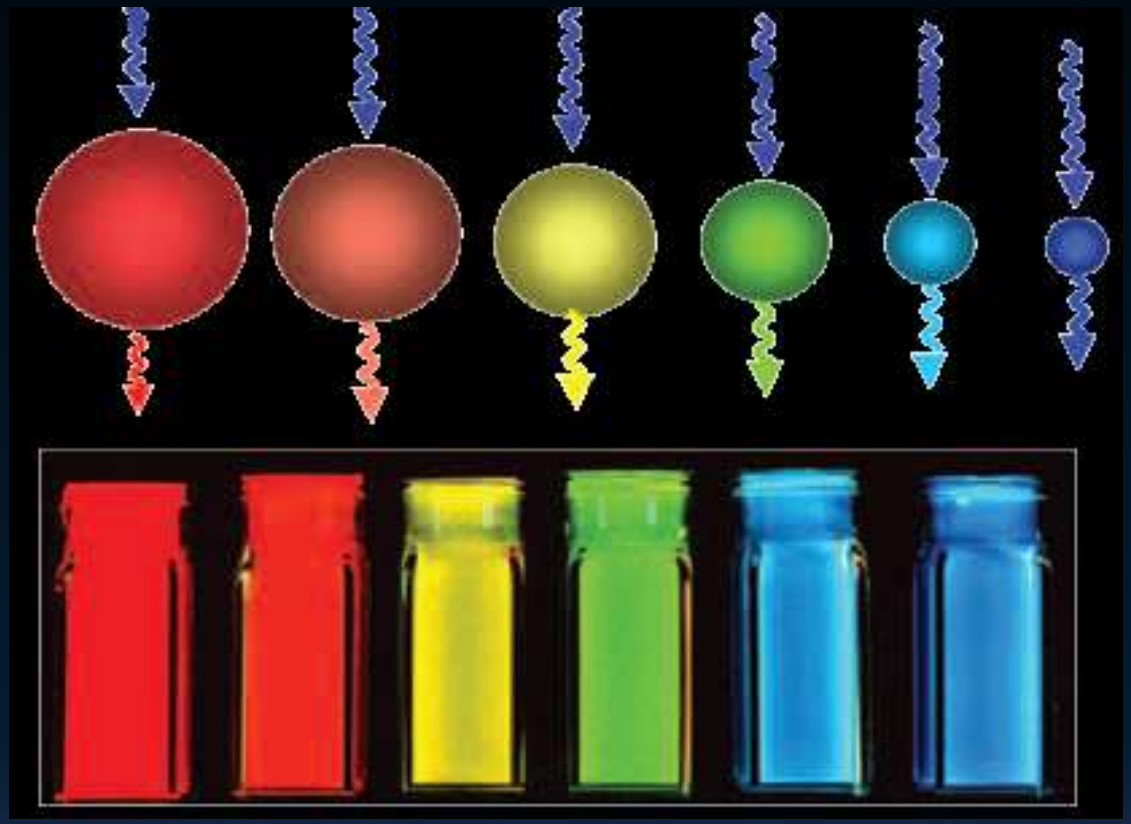
Effects



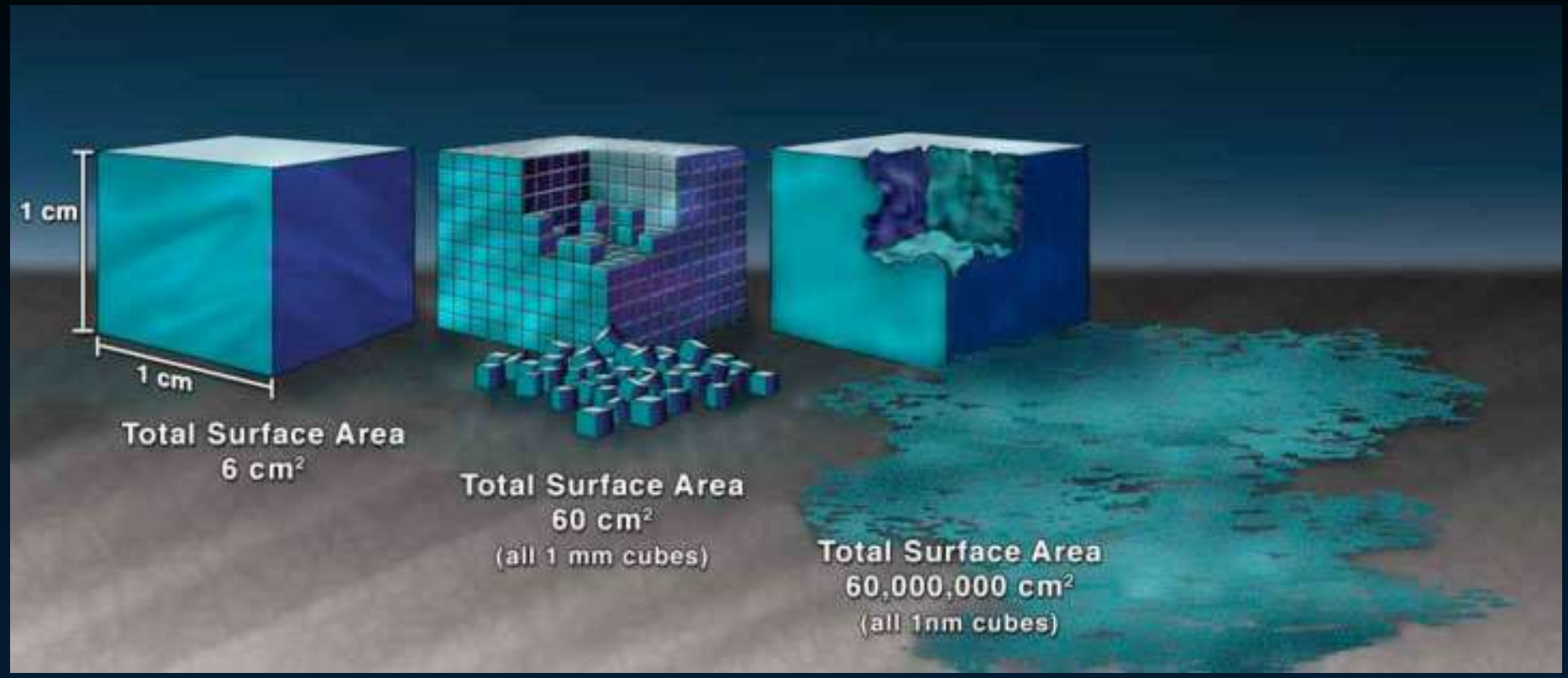
Biology World

What is so unique in the nanometric scale?

Size dependent properties



Surface-to-Volume Ratio (SA/V)
First, we calculate…



An animation explaining the exponential change of SA/V in the nano-scale
Nano.gov

Then, we demonstrate…

The challenge

Suggest how to integrate the topic of SA/V in the curriculum

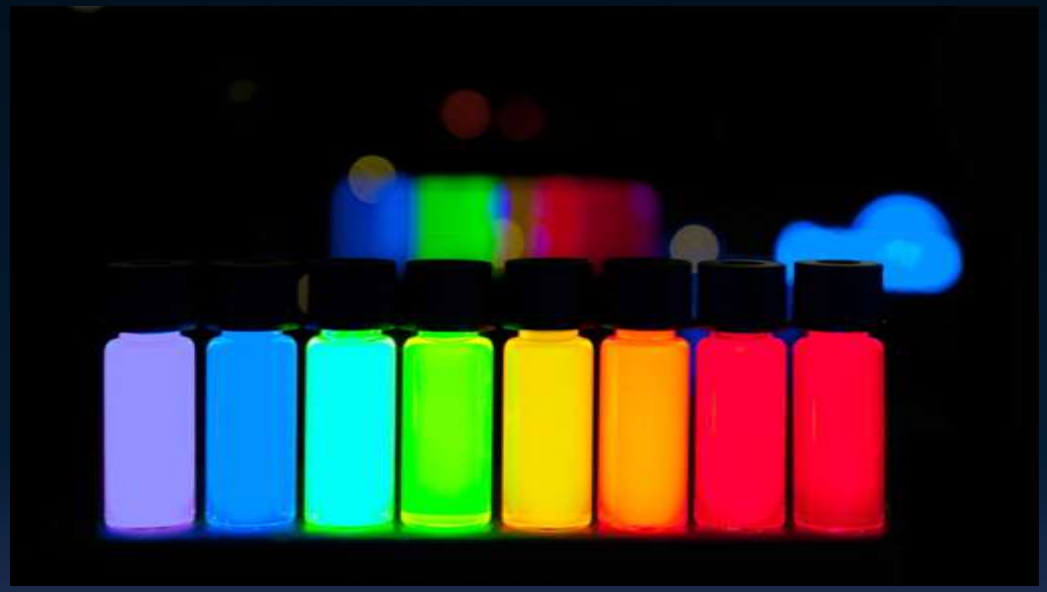
In chemistry?

In biology?

In physics?

In mathematics?

In geology?



CdSe nanoparticle – fluorescent (QD)

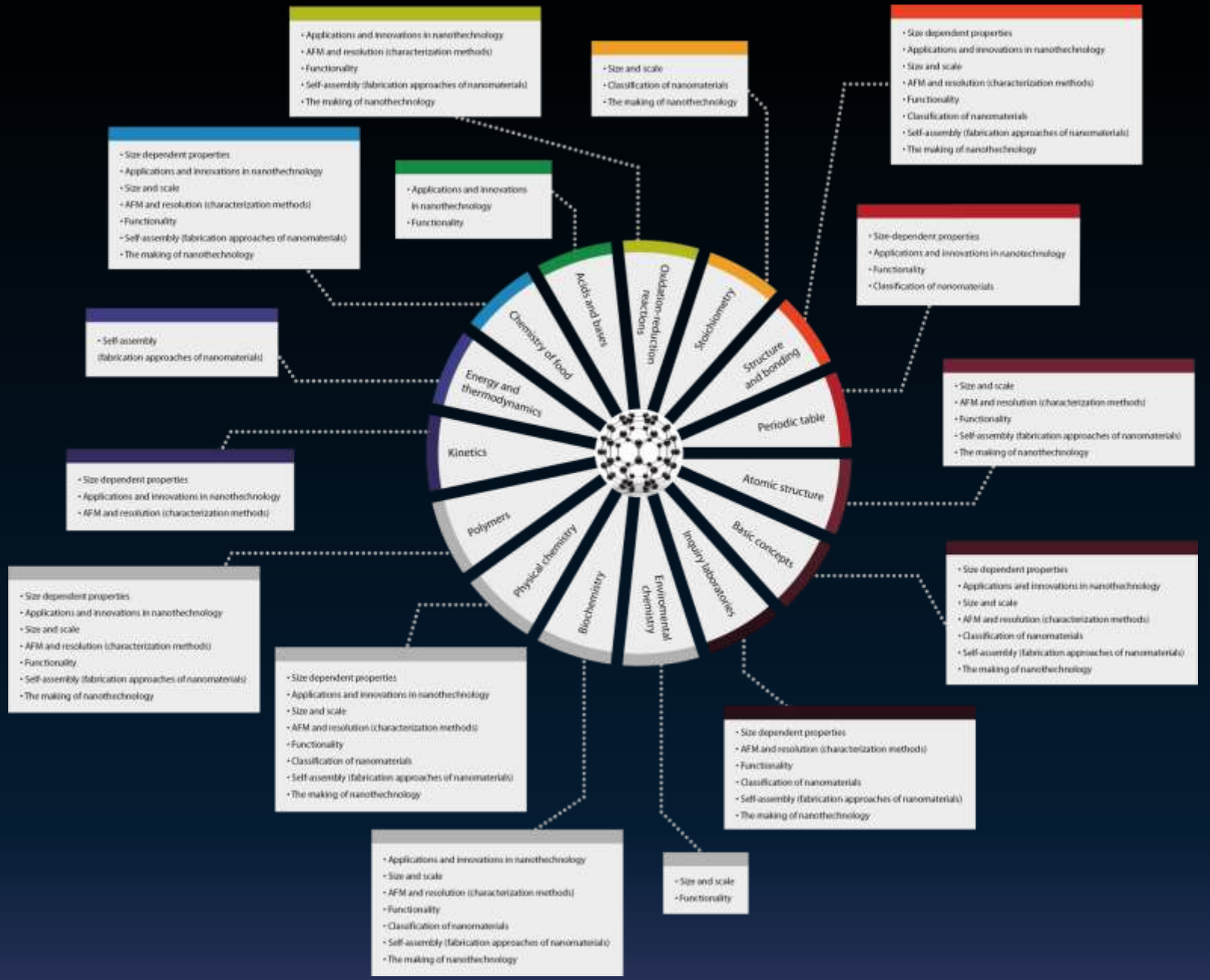
Finding the insertion point of NST essential concepts with school curriculum

- Blonder, R., & Sakhnini, S. (2017). Finding the connections between a high-school chemistry curriculum and nano science and technology. *Chemistry Education Research and Practice. 18*, 903-922. doi:10.1039/C7RP00059F

- Sakhnini, S., & **Blonder, R.** (2018). Insertion points of the essential nanoscale science and technology (NST) concepts in the Israeli middle school science and technology curriculum. *Nanotechnology Reviews, 7*(5), 373-391. doi:10.1515/ntrev-2018-0026

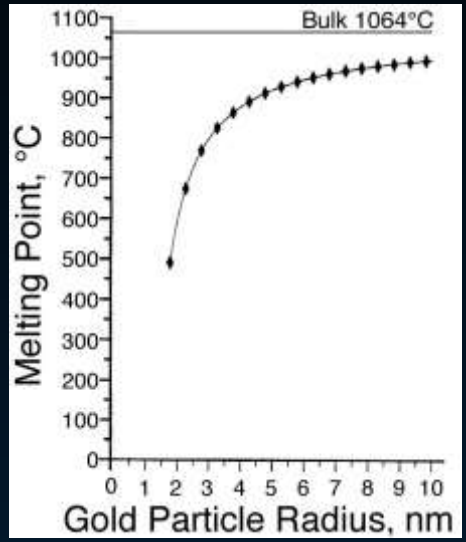
- Yonai, E., & Blonder, R. (2020). Scientists suggest insertion of nanoscience and technology into middle school physics. *Physical Review Physics Education Research, 16(1), 010110. https://doi.org/10.1103/PhysRevPhysEducRes.16.010110*

connections between the high-school chemistry curriculum and NST



What is the importance (SA/V) in the chemistry curriculum…

- High catalytic properties
- Changes in materials melting point
- Support “functionalization” of nanoscale material surfaces
- Influences interactions of the surface



Nanoscale Materials in Chemistry, K. J. Klabunde, ed., Wiley, 2001

Blonder, R., & Sakhnini, S. (2017). Finding the connections between a high-school chemistry curriculum and nano science and technology. *Chemistry Education Research and Practice. 18*, 903-922. doi:10.1039/C7RP00059F

A three-stage model

Stage 1: Lecture

Course lectures given by experts (CK)

Stage 2: Follow-up

A "follow-up" of tutoring lessons, aimed at elaborating on the course's lectures (CK)

Stage 3: Adaptation to education

A workshop coordinated by an educational guide, in order to apply the scientific knowledge to the field of education (PK + PCK)

Mamlok-Naaman, R., Blonder, R., & Hofstein, A. (2010). Providing chemistry teachers with opportunities to enhance their knowledge in contemporary scientific areas: A three-stage model. *Chemistry Education Research and Practice, 11*, 241-252. doi:10.1039/C0RP90005B

Re-designing the NST teachers' course to enhance teachers' implementation

- Chemistry teachers knowledge and nano-literacy were developed (8 NST essential concepts)
- Chemistry teachers connected the 8 NST concepts to school curriculum

Blonder & Sakhnini, 2017; Sakhnini & Blonder, 2018; Yonai & Blonder, 2020

- Chemistry teachers developed NST modules for their students
- Teachers applied educational research tools for a methodological investigating their teaching
- Teachers developed their self-efficacy for teaching NST and for using innovative pedagogy and transfer these to their science teaching

Blonder & Mamlok-Naaman, 2016

Evaluation framework for teacher's online PD courses

Application of the framework to evaluate a nanotechnology PD course

1) Assessment of learning the contemporary contents

2) Assessment of the level of complexity of teachers' connections of the NST concepts to the curriculum

3)Identification of teachers' difficulties during the online course using Learning Analytics (LA)

Feldman-Maggor, Tuvi-Arad & Blonder (Submitted)

Application LA methods

- Identification of Learning Patterns using LA tools
- Teachers' course completion rates are strongly associated with their online learning patterns.

Dr. Yael Feldman-Maggor

Meeting authentic contemporary science for teachers' PD

The 8 NST Essential Concepts

1. Size-dependent properties
2. Innovation and application of nanotechnology
3. Size and scale
4. Characterization methods
5. Functionality
6. Classification of nanomaterials
7. Fabrication approaches of nanomaterial
8. The making of nanotechnology

Participating in the NanoIsarel scientific conference (Blonder & Sakhnini, 2015)

Joining an active research group (Blonder, Rap & Benny, 2020)

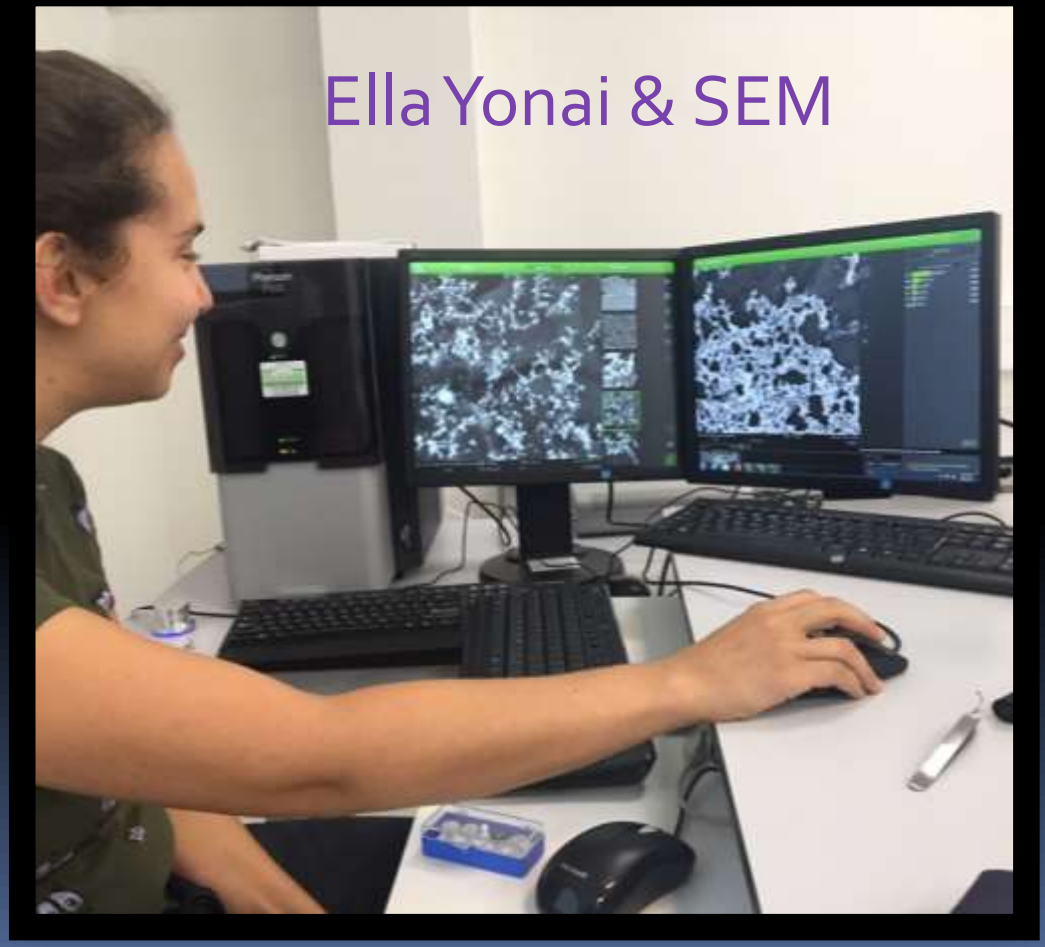
Upscaling (I): Working with the Scanning Electron Microscope (SEM)

Authenticity

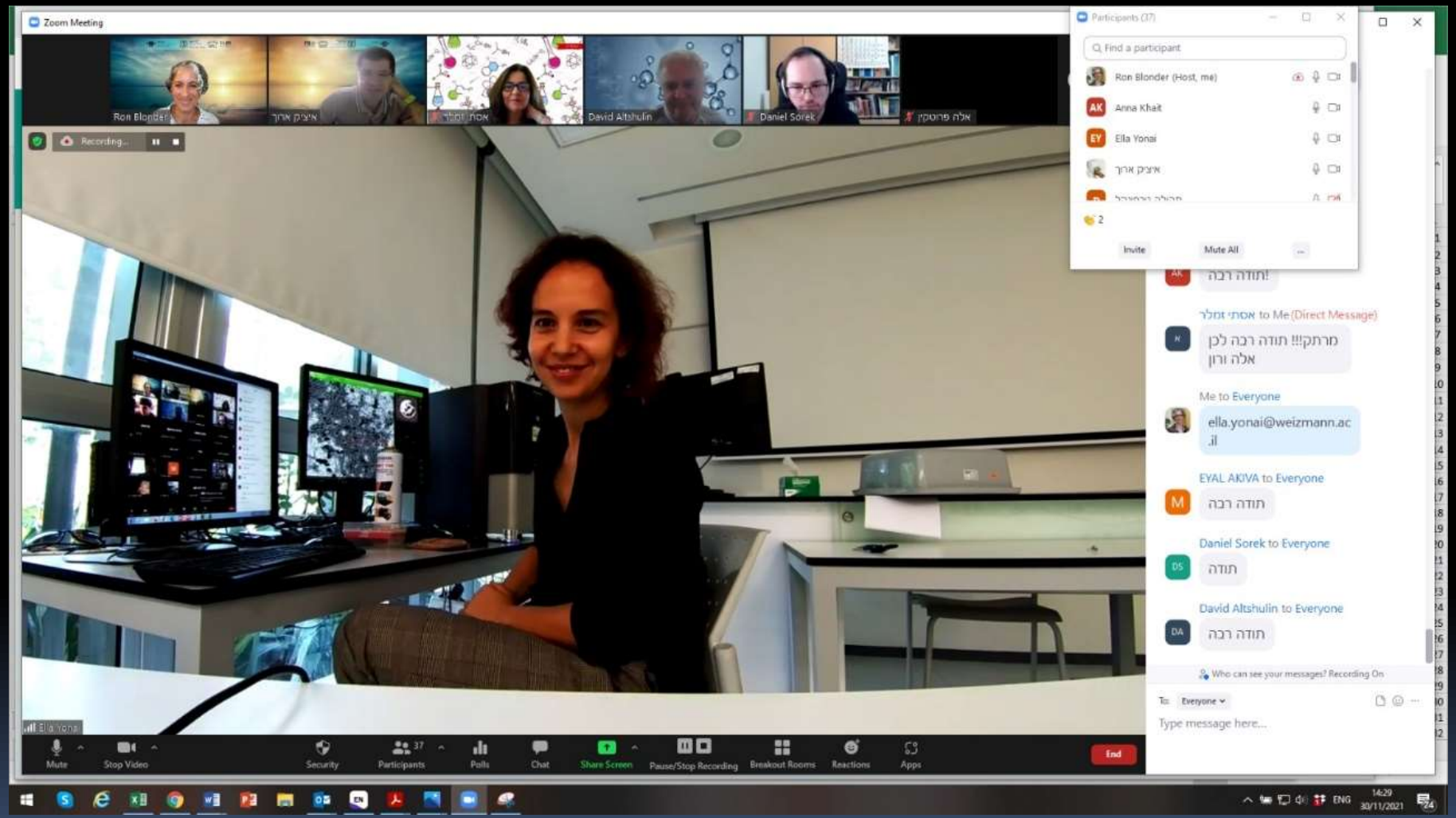
Defined as the ordinary practices of the culture (Brown, Collins & Duguid, 1989)

Research institutes can provide passage into the authentic world of science research (Braund & Reiss, 2006)

Contribute to students' engagement and motivation to learn science (Braund & Reiss, 2006; Svärd, Schönborn & Hallström, 2017; Murphy, Lunn & Jones, 2006)



Upscaling (II): Designing Remote SEM activity



Yonai, E., Shimoni, E., Kahil, K., & Blonder, R. (2022). Authentic Science Learning During COVID-19: The Adaptive Design of a SEM Outreach Activity. The Biophysicist. https://doi.org/10.35459/tbp.2021.000206

Future plans in teachers' PD research: Develop models for Differentiation Instruction

To focus on

Analyzing teachers' characteristics

- Learning patterns in online courses
- Scientific knowledge & background
- Expertise in technology integration and TPACK (Rap et al., 2020)
- Different career stages (Blonder & Vescio, 2021)

Applying the differentiation instruction approach for teachers PD

- Online teachers' courses
- Models for learning how to teach online
- Chemistry teachers' Professional Learning Communities (PLCs) network

How do chemistry teachers develop when they interact with contemporary science?

Contemporary Contents

- NST Concepts
- Curriculum
- Authentic Science

NanoScale Science & Technology (NST)

Educational Technology

- Social Networks
- Multiple Modalities
- Covid-19 Period
- Personalization
- Online Learning

Theoretical Models

- Knowledge Development
- Self-efficacy
- Affective aspects
- Career Stage

PD frameworks

- Online courses
- PLCs
- Academic Courses

(almost all) The Chemistry Group

Ron Blonder

Nanotechnology from
Research to Educational Research to Schools

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