

WHAT DO CITIZENS NEED TO KNOW ABOUT ENERGY?

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ALL PEOPLE SHOULD LEARN SCIENCE – WHY?

Millar (1996)

- National economics
- Personal utility
- Democracy
- Social support for science
- Culture



SCIENTIFIC LITERACY

- Ideally, all citizens are mindful consumers of scientific knowledge.
- Much scientific knowledge is accessed by the public by reading texts.
- Many newspapers and journals aimed at the general public offer items about science.
- A central goal of science education is to motivate people to read and then to comprehend news articles with a science component in them.

PLEASE IMAGINE

Giraffe



Zebra



Energy



BACKGROUND



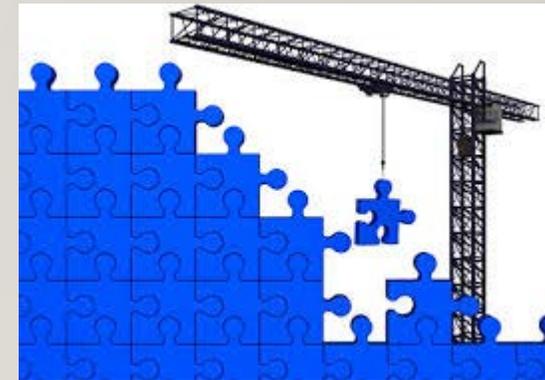
- Energy is one of the fundamental concepts of science, in all disciplines.
- It is central to the understanding of a broad range of phenomena and to the solution of many science-related problems that occur in our daily lives.
- Energy was identified by the Framework* and the NGSS* as both disciplinary core idea and a cross-cutting concept.

* (National Research Council, 2012; NGSS Lead States, 2013)

A LEARNING PROGRESSION FOR ENERGY?

Duit, 2014

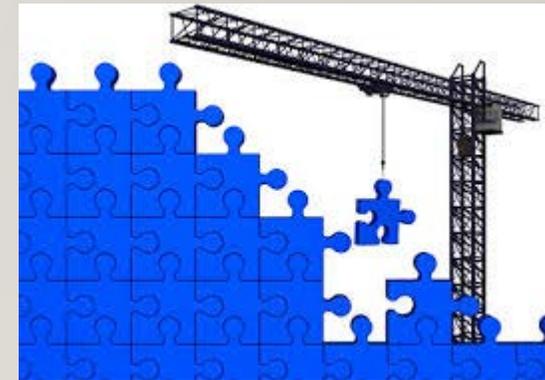
- The ability to do something, a resource
- Forms of energy
- Transformation from one form to another
- Transfer between systems
- Dissipation to the surroundings
- Conservation



A LEARNING PROGRESSION FOR ENERGY?

Duit, 2014; Opitz et al., 2014

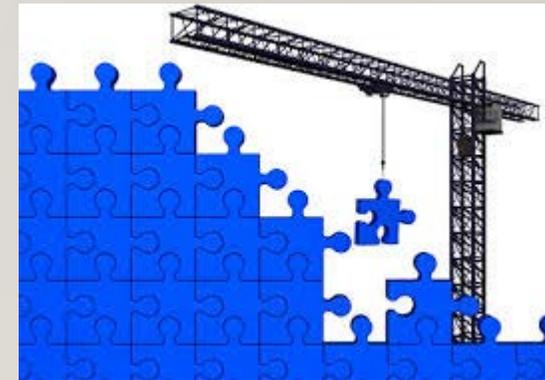
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A LEARNING PROGRESSION FOR ENERGY?

Neumann et al., 2013

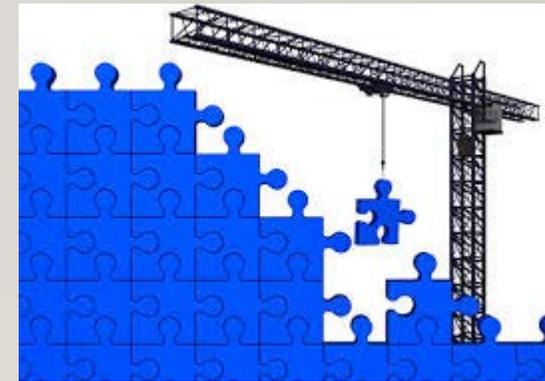
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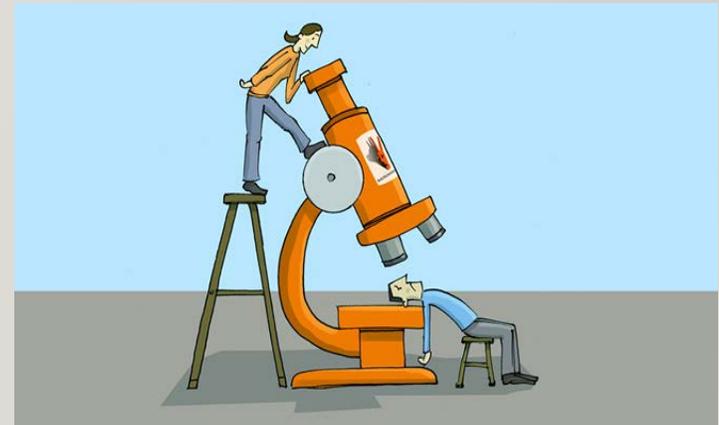
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ENERGY IN SCIENTIFIC LITERACY

- A goal of science education is to prepare people to be mindful consumers of news articles with a science component to them
- What conceptualizations of energy are needed to make sense of energy-related topics in top-level journalism for non-scientists?



METHOD OF INQUIRY

Baram-Tsabari, 2016

- We choose to analyze energy-related articles from three journals: Scientific American, Discover, and the science section of Ha'Aretz.

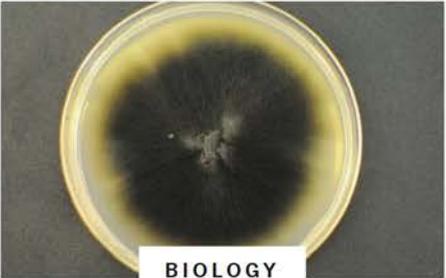
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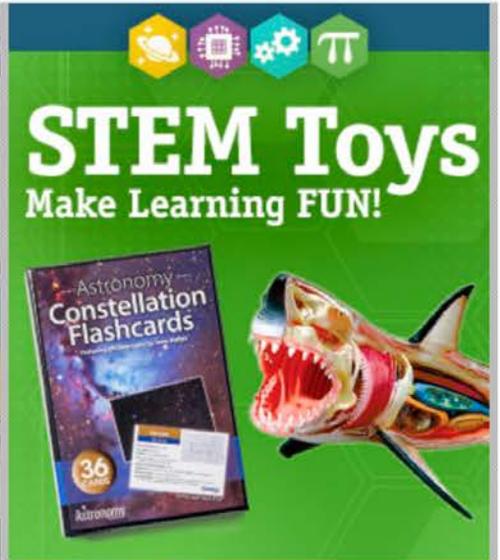
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HA'ARETZ



The screenshot shows the Ha'aretz website's navigation bar with the logo and menu items: 'Israel News' and 'All'. Below the navigation bar are several topic filters: 'Trump - Kim', 'Syria - Israel', 'Israel - U.S. Jews', 'Trump - Iran', and 'Trump - North Korea'. A 'Breaking' banner at the top right displays a video player with the title '04:34 U.S. charges 5 Russians, 3 Syrians with violating sanctions (DPA)' and playback controls. The main content area features a large image of Ayatollah Khamenei speaking at a podium. Below the image is the article title 'Analysis // Trump-Kim Summit: Iran's Khamenei Can't Smile Just Yet' and a sub-headline 'If a paper like the one the U.S. and North Korea signed in Singapore had been signed by Iran, not only Israel would'. To the right of the main article is a 'Top News' sidebar with three items: 'Kim-Trump meet: Trump and Kim accept mutual invitations to each other's countries', 'Syrian army 'boosts air defenses near Israeli border'', and 'Future of U.S. Jews 'keeps me up at night,' minister Bennett tells Jewish gathering'.

HAARETZ Israel News All

Trump - Kim Syria - Israel Israel - U.S. Jews Trump - Iran Trump - North Korea

Breaking: 04:34 U.S. charges 5 Russians, 3 Syrians with violating sanctions (DPA)



Analysis // Trump-Kim Summit: Iran's Khamenei Can't Smile Just Yet

If a paper like the one the U.S. and North Korea signed in Singapore had been signed by Iran, not only Israel would

Top News

Kim-Trump meet: Trump and Kim accept mutual invitations to each other's countries ■ Kim is big winner, Trump comes up short | **Analysis** ■ Trump proves how easily he'll sell out U.S. allies | **Opinion**

Syrian army 'boosts air defenses near Israeli border'

Future of U.S. Jews 'keeps me up at night,' minister Bennett tells Jewish gathering

Iran's Rohani tells Macron: We're not ruling out military withdrawal from Syria

METHOD OF INQUIRY

- A search was done for the keyword "energy" in the journals' websites for a period of 12 months.
- Each article was categorized according to (A) the scientific discipline it belonged and (B) which of the key elements of the energy concept were needed to comprehend the article.

CODING – SCIENTIFIC DISCIPLINARY CONTEXT

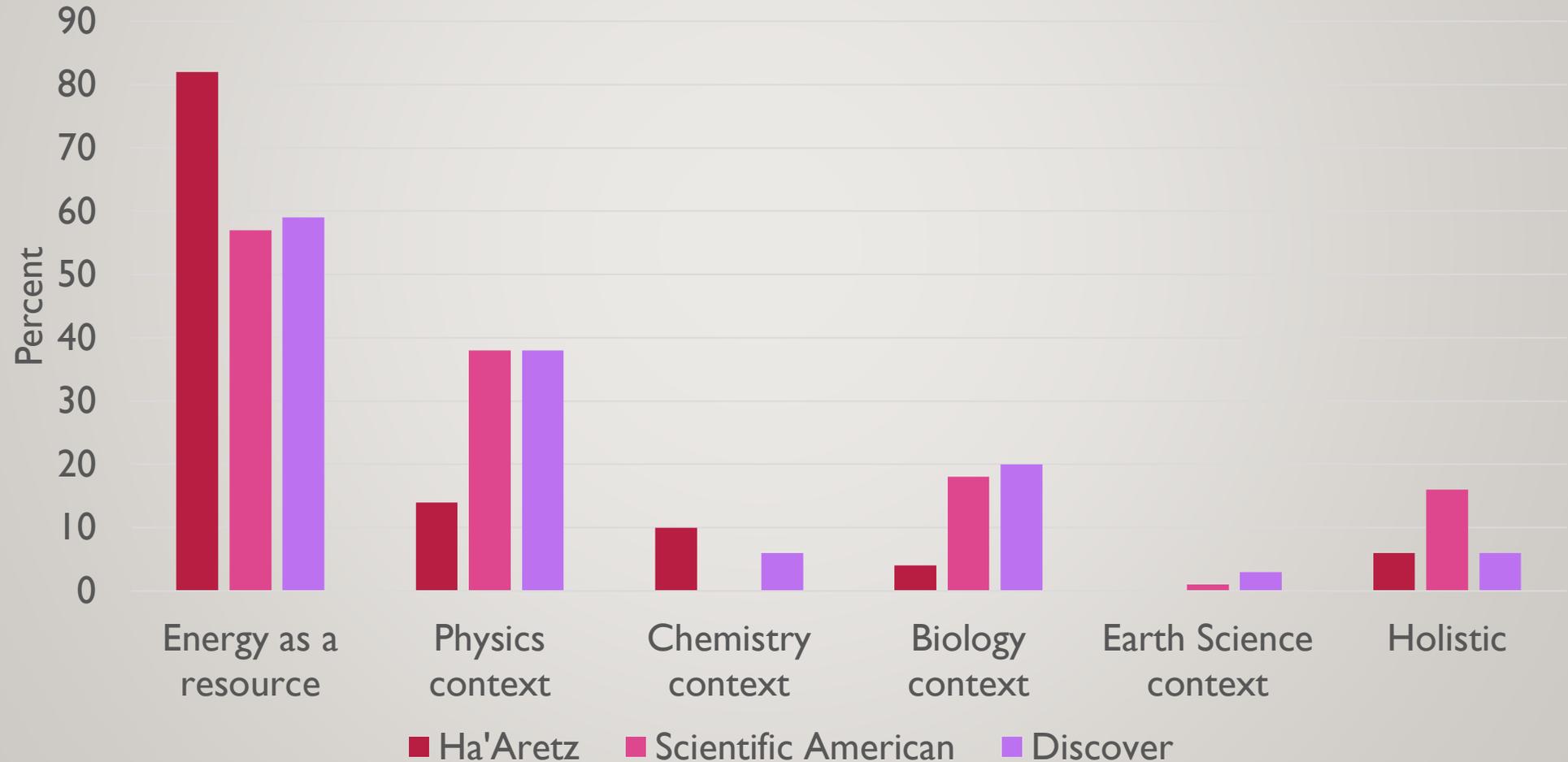
1. Energy as resource – energy is needed in order to make something happen or for an action to take place: "Because the vehicle was so small it didn't need a lot of energy".
2. Physics context: "The local group of galaxies is gravitationally bound by the matter they contain, so if the dark energy is indeed a cosmological constant, then the acceleration will have no effect on the collision".
3. Chemistry context – energy is mentioned in relation to a chemical reaction. For example: "The reaction between the two substances releases enormous amount of energy".

CODING – SCIENTIFIC DISCIPLINARY CONTEXT

4. Biology context: "Older animals (including us) are less efficient than younger animals in processing energy—metabolism runs down during life".
5. Earth Science context: "Warming sea surface temperatures should help pump up storms with greater energy and water vapor."
6. Holistic context – energy mentioned in relation to energy drinks, energy foods, or energetic feelings: "Americans as a whole invest more time and money and emotional energy in the explicit pursuit of happiness than any other nation on earth".

RESULTS

Disciplinary Context

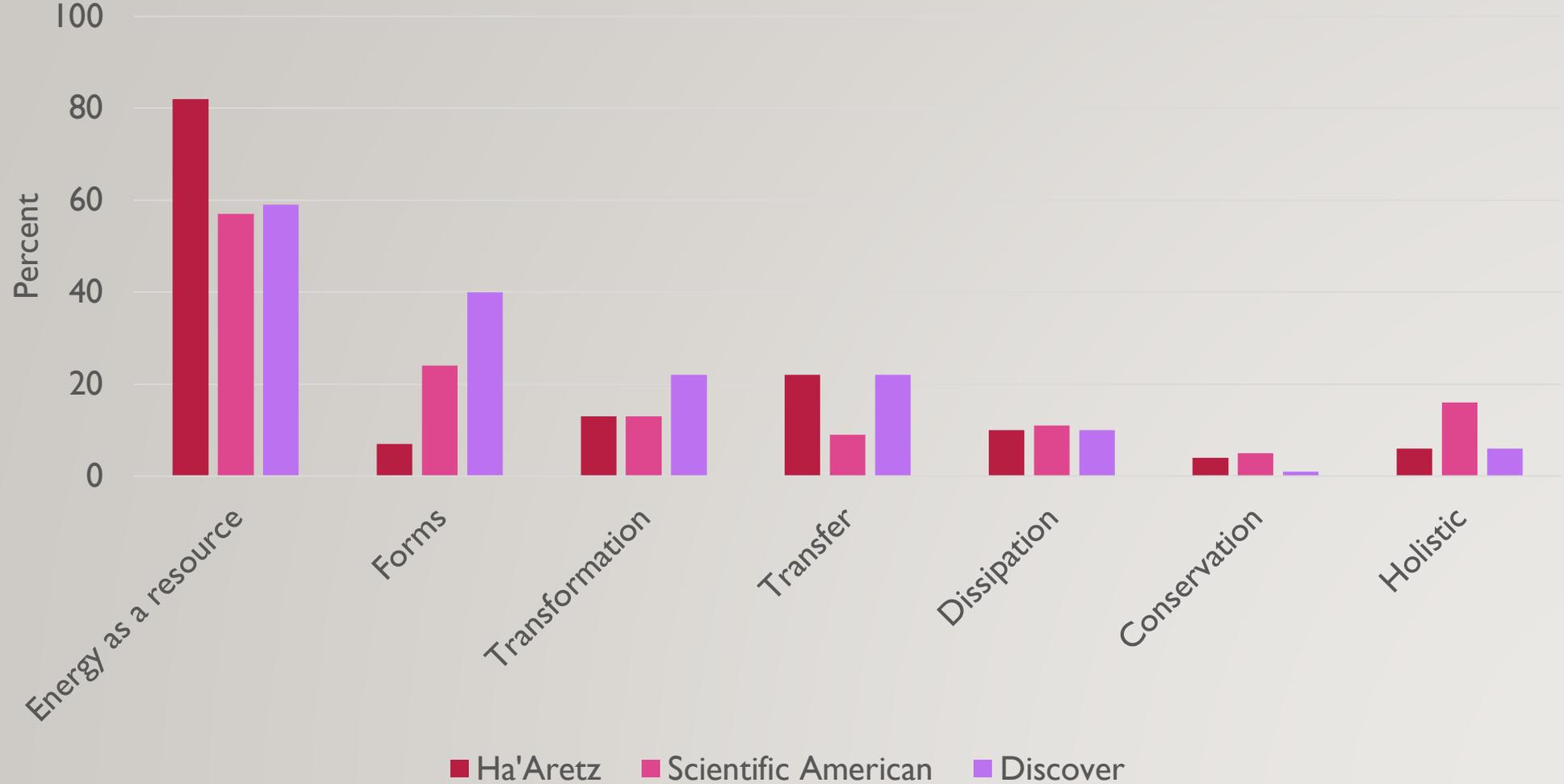


CODING – KEY ELEMENTS OF ENERGY

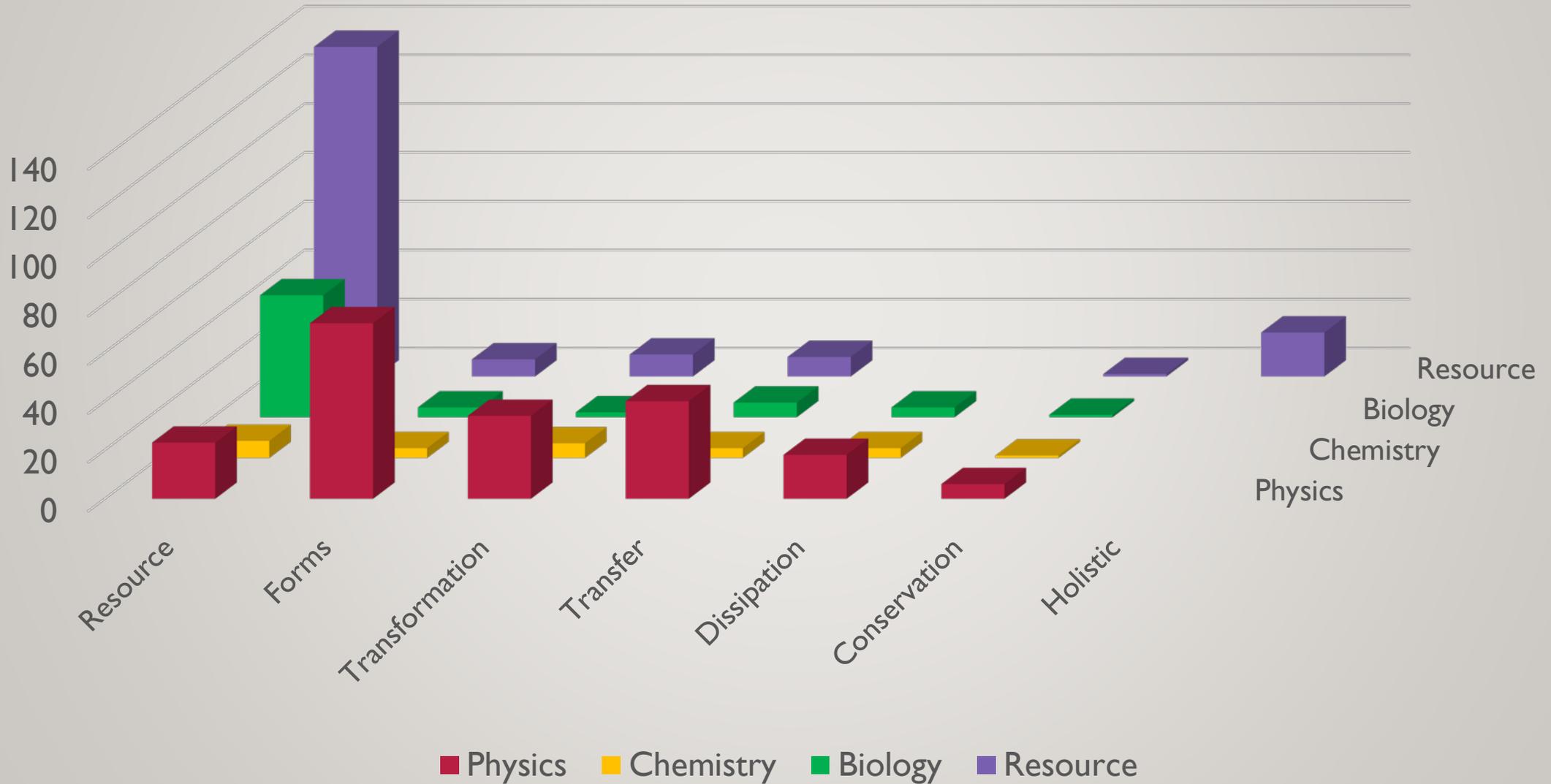
- Energy as a resource
- Forms
- Transformation
- Transfer
- Dissipation
- Conservation
- Holistic

RESULTS

Key Elements of Energy



RESULTS IN 3D



SUMMARY OF FINDINGS

- A clear majority of articles in the journals refer to energy as a resource. This conception of energy requires very little formal instruction.
- Energy is raised only very seldom in chemistry and Earth Science contexts.
- The key elements of energy are used almost only in physics contexts.
- Conservation is seldom used, even in physics contexts.
- Transfer and transformation are used with about the same frequency.

IMPLICATIONS

- Most use of the concept of energy in high-quality printed media aimed at the general educated public does not require any formal education.
- Existing instruction and NGSS-aligned instruction appears to be useful almost only in physics contexts.
- The holy-grail of energy, conservation, is almost never used.
- Why are we spending so much time to teach about energy to students who will not become scientists or engineers?
- Why are we so concerned that most students do not develop a deep understanding of energy conservation?

RECOMMENDATIONS – BREAKING THE RULES?

- Spend less time teaching about energy in junior high school (i.e., before students are tracked into science majors and non-science majors).
- Do not teach about energy conservation to JHS students.
- NGSS-aligned instruction is not likely to provide a better grounding in following the printed media.
- Examine whether energy is really a cross-cutting concept and is really as central to all science disciplines as is so often claimed.



מכון ויצמן למדע
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National Science Foundation
WHERE DISCOVERIES BEGIN



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