TOWARDS A FRAMEWORK OF MEASURING EFFECTIVENESS OF ACTIVE LEARNING FOR COGNITIVE AND PROBLEM SOLUTION SKILLS.

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COGNITIVE SKILLS: DEFINITION

Quoting from the Summary of a Workshop* on ASSESSING 21ST CENTURY SKILLS:

- **Cognitive skills: <u>nonroutine problem solving, critical thinking, systems thinking</u>**
- *Interpersonal skills: complex communication, social skills, teamwork, cultural sensitivity, dealing with diversity*
- *Intrapersonal skills: self-management, time management, self development, self-regulation, adaptability, executive functioning*

http://www.national-academies.org/

NON-ROUTINE PROBLEM SOLVING: DEFINITION

A skilled problem solver uses expert thinking to examine a broad span of information, recognize patterns, and narrow the information to reach a diagnosis of the problem. Moving beyond diagnosis to a solution requires knowledge of how the information is linked conceptually and involves metacognition—the ability to reflect on whether a problem-solving strategy is working and to switch to another strategy if it is not working (Levy and Murnane, 2004). It includes creativity to generate new and innovative solutions, integrating seemingly unrelated information, and entertaining possibilities that others may miss (Houston, 2007).

SYSTEMS THINKING: DEFINITION

The ability to understand how an entire system works; how an action, change, or malfunction in one part of the system affects the rest of the system; adopting a "big picture" perspective on work (Houston, 2007). It includes judgment and decision making, systems analysis, and systems evaluation as well as abstract reasoning about how the different elements of a work process interact (Peterson et al., 1999).

CRITICAL THINKING: DEFINITION

There is no consensus! Just defined as an important component to both previously defined skills….. (Mayer, 1990)

CRITICAL THINKING: THREE DEFINITIONS

"[Critical thinking involves] cognitive skills or strategies that increase the probability of a desirable outcome—in the long run, critical thinkers will have more desirable outcomes than 'noncritical' thinkers. . . . Critical thinking is purposeful, reasoned, and goal-directed. It is the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions" (Halpern, 1998, pp. 450-451).

"Critical thinking is reflective and reasonable thinking that is focused on deciding what to believe or do" (Ennis, 1985, p. 45).

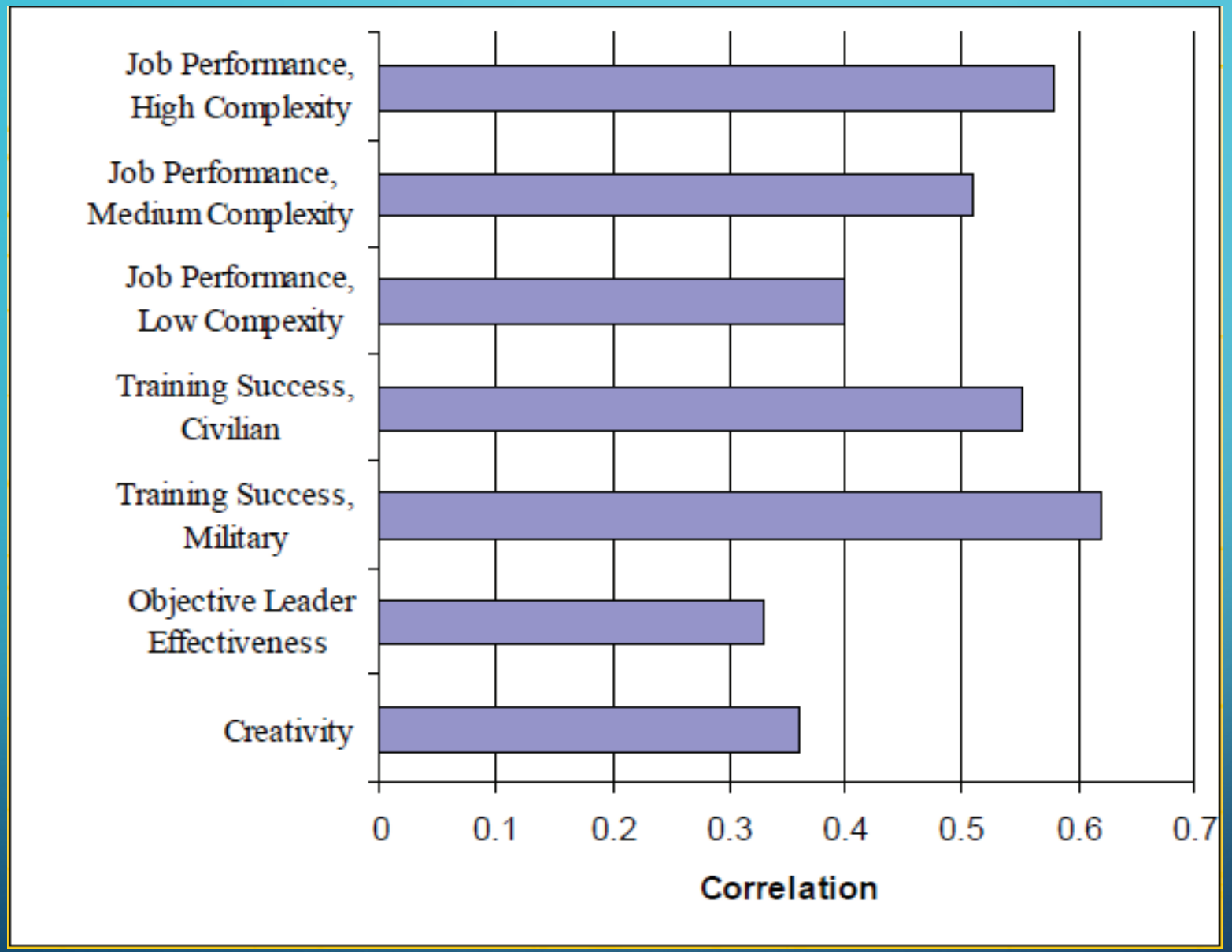
"Critical thinking [is] the ability and willingness to test the validity of propositions" (Bangert-Drowns and Bankert, 1990, p. 3).

RESEARCH QUESTION

HOW TO MEASURE OR ASSESS COGNITIVE SKILLS?

WHY IS THIS QUESTION IMPORTANT?

- There are relationships between measures of general cognitive ability (historically referred to as IQ) and job outcomes (Kuncel and Hezlett, 2010)
- There is evidence documenting that verbal and quantitative skills along with general cognitive ability are predictive of college and career performance.
- There is evidence for separation between domain-general and domain-specific.
- There is evidence of a correlation between cognitive skills testing and predicted graduate students' performance



Correlations between measures of cognitive ability and job performance.
SOURCE: Kuncel and Hezlett (2011). Copyright 2010 by Sage Publications. Reprinted with permission of Sage Publications.

OUR MOTIVATION AND INCENTIVES

- Measuring or assessing effectiveness of the teaching and learning approach by fostering domain-specific cognitive skills in higher education.
- Calibrating delivery of module contents while monitoring cognitive abilities.
- Put into context the numbers rising from NSS, SES and module pass rates in that fostering of cognitive skills becomes a first class citizen again in academic performance.

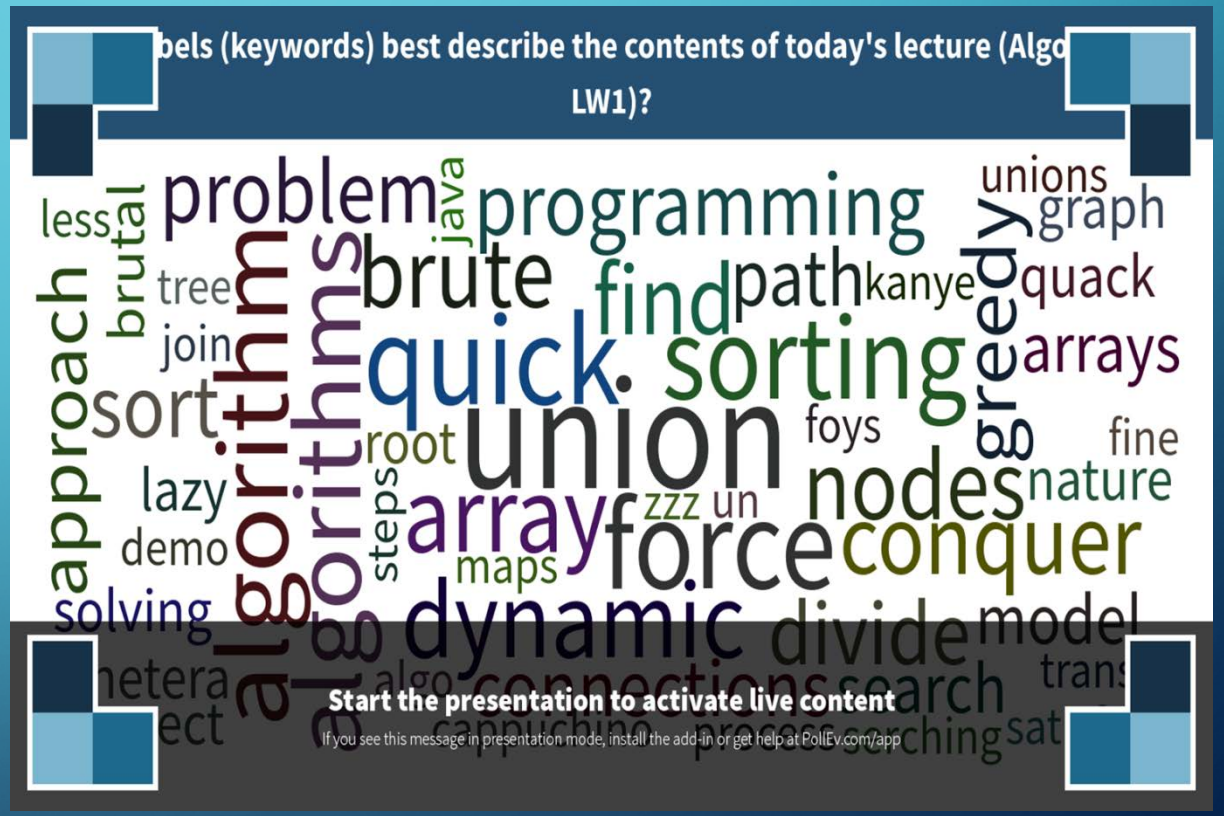
RESEARCH METHOD

- Define constructs to be measured: Two variables, *perception of lecture contents* and *perception of problem complexity*
- Qualitative research methodology: Students being asked to take part in Poll Everywhere specific questionnaires, decent amount of data gathered
- Case study:
  - Algorithms (Theory, Design and Implementation), UG Level 5
  - Web Intelligence, UG Level 6
- Data analysis: Graphs and first correlations among variables

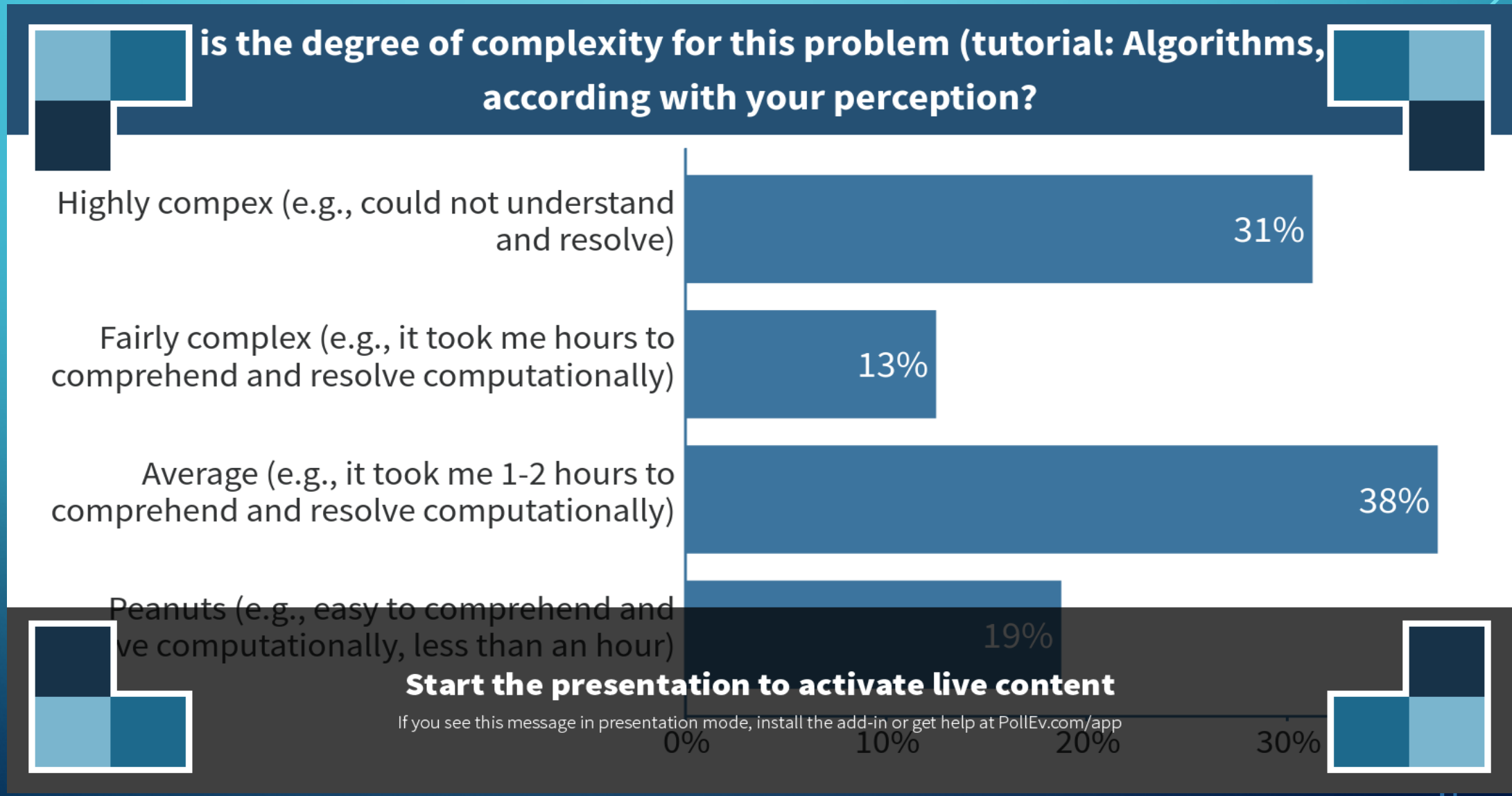
VARIABLE 1: PERCEPTION OF LECTURE CONTENTS

- What labels (keywords) best describe the contents of today's lecture (Algorithms: LW1)?

- A tag cloud (semantic annotation formed from up to **10 keywords per participant** to be entered….



VARIABLE 2: PERCEPTION OF PROBLEM COMPLEXITY



MOTIVATION FOR VARIABLE 1: TAG CLOUDS FOR PERCEPTION OF LECTURE CONTENTS

- There is evidence that tagging content is highly related with the way we perceive things and can be used as a metric in that:
  - Comparisons with the key vocabulary* (keywords, concepts) of a lecture can be made in order to measure whether all intended key concepts (keywords) have been received;
  - Comparisons among students' perceptions can be made on the same lecture or across the timeline of a module/course;
  - Comparisons between pre- and post-lecture perceptions
  - You can also compare the variety of vocabularies across different modules or levels
  - There is evidence that tagging helps in memorising contents easier

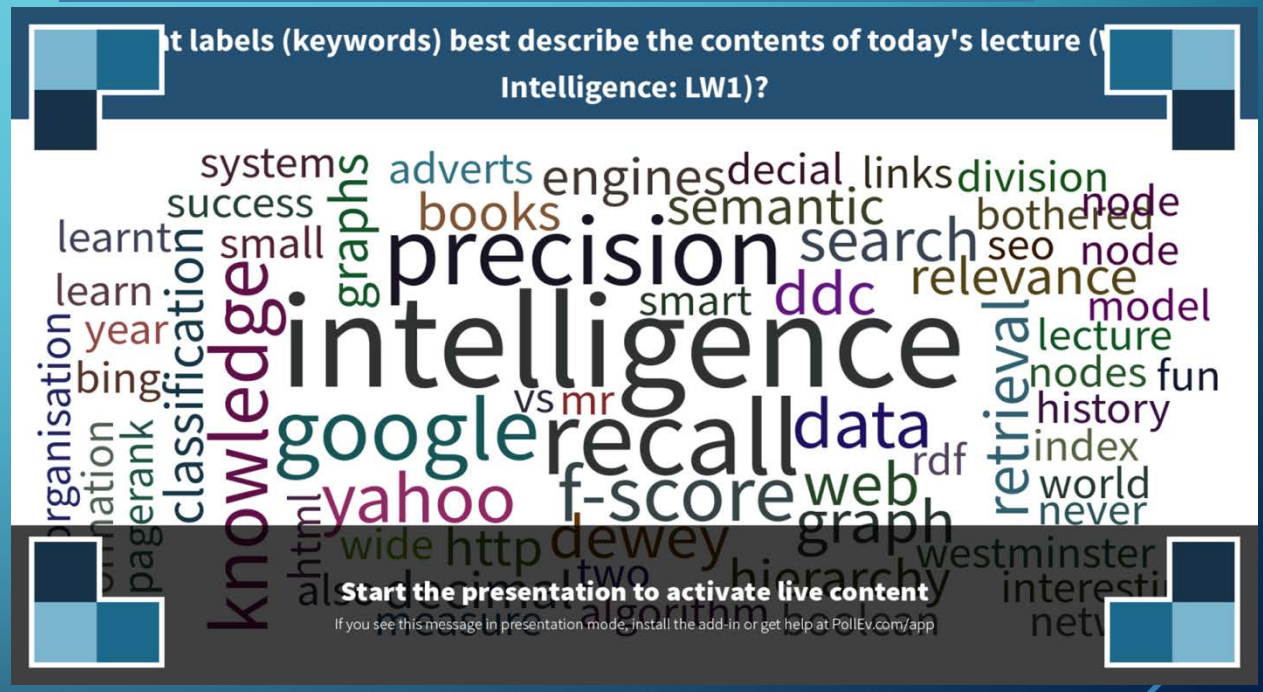
MOTIVATION FOR VARIABLE 2: PERCEPTION OF PROBLEM COMPLEXITY

- There is evidence that perception of problem complexity is highly related with problem solving skills in that we can
  - contrast perceived problem complexity among students with a well established one among professionals;
  - make comparisons between pre- and post-lecture perceived complexity;
  - make comparisons among different cohorts of students for the same problems and same or different learning and teaching approaches;
  - can monitor the distance between students' perceived complexity and professionals' one for different families of problem definitions.;
  - calibrate problem complexity and difficulty based on the distance between professionals' and students' perceptions.

PRELIMINARY DATA ANALYSIS AND EXEMPLARY FINDINGS: CAN YOU SEE THE DIFFERENCE?

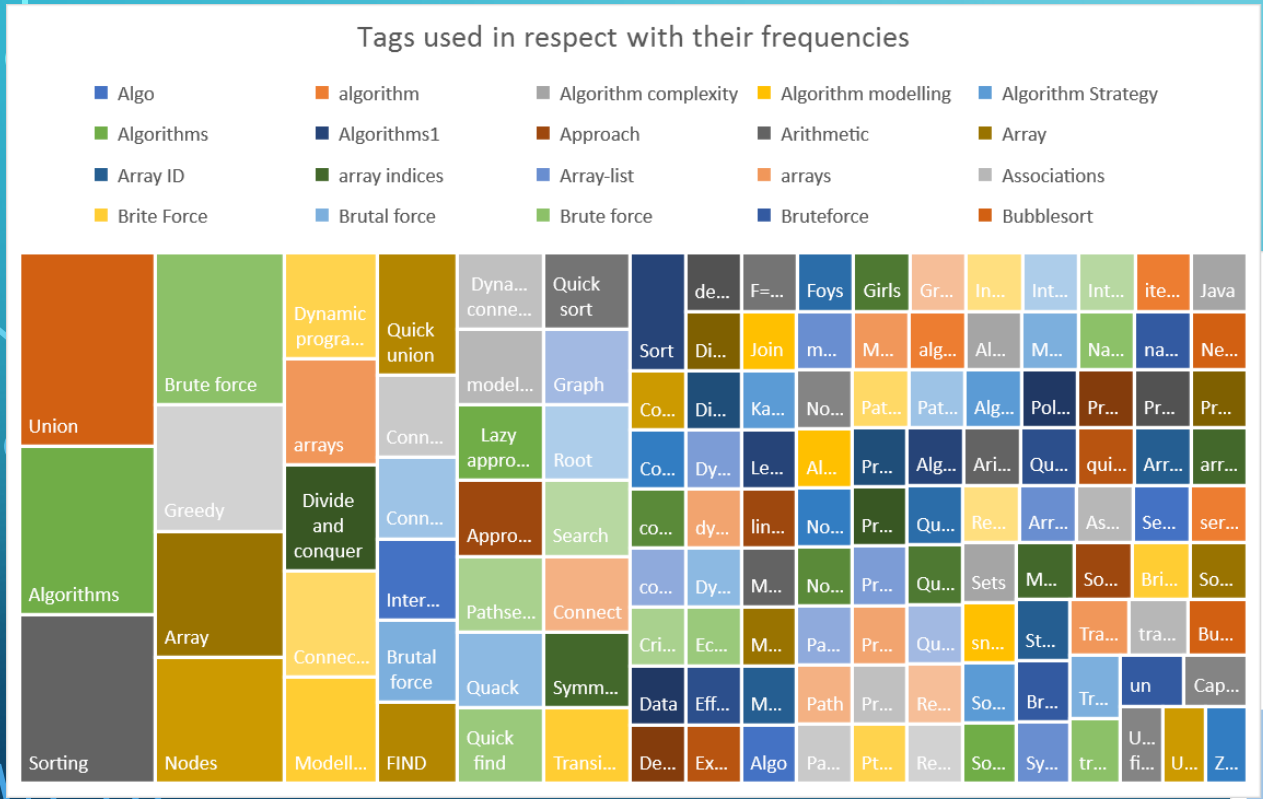
VOCABULARY OF STUDENTS AT LEVEL 5, FIRST LW

VOCABULARY OF STUDENTS AT LEVEL 6, FIRST LW

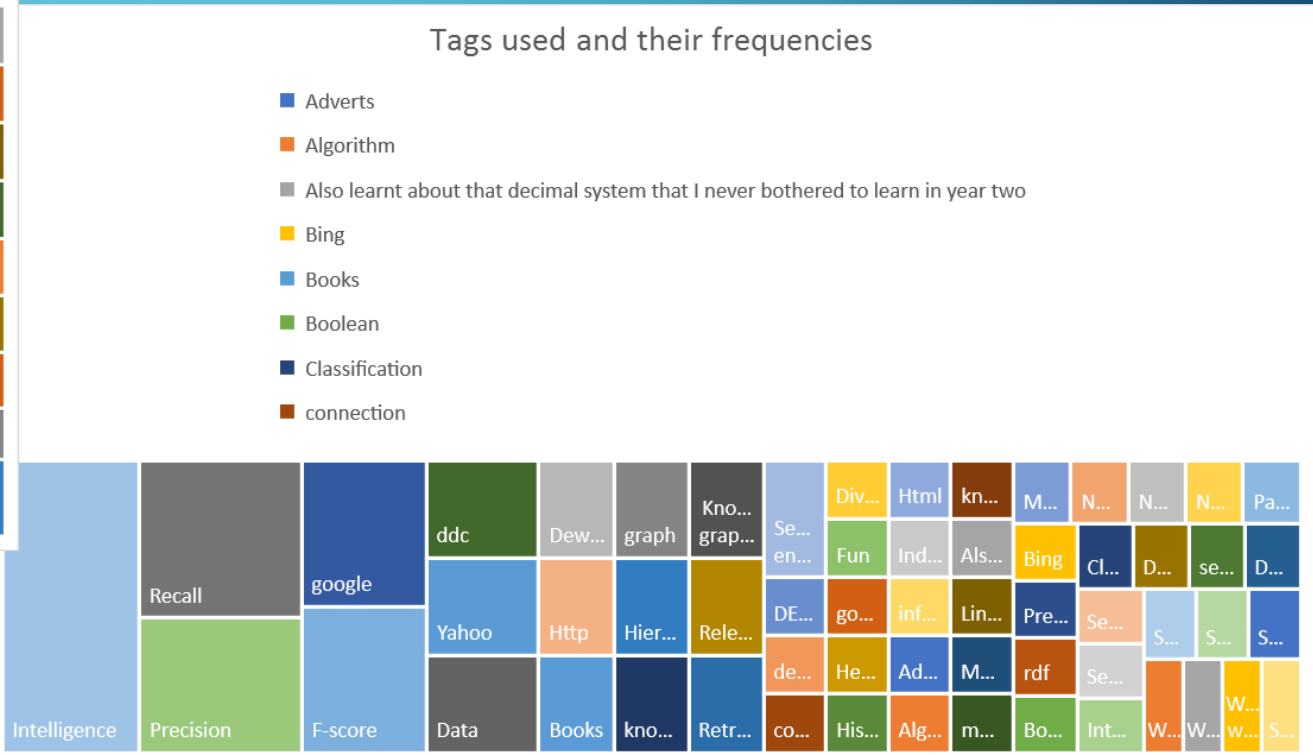


CAN YOU SEE THE DIFFERENCE NOW?

QUALITY OF LEVEL 5 VOCABULARY



QUALITY OF LEVEL 6 VOCABULARY



PRELIMINARY DATA ANALYSIS AND EXEMPLARY FINDINGS: CAN YOU SEE THE DIFFERENCE?

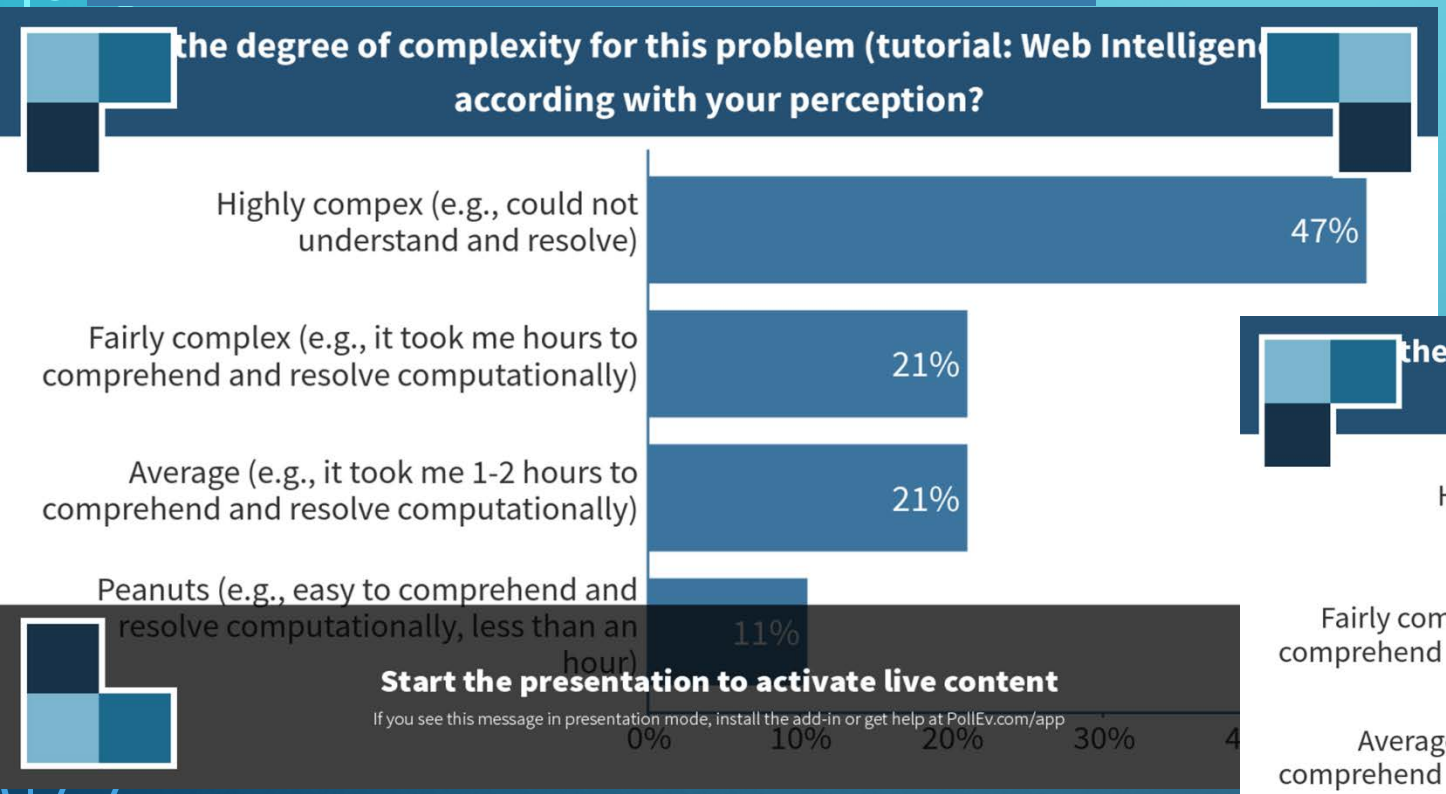
KEY WORDS FROM THE LEARNING OUTCOMES OR OBJECTIVES OF THE LECTURE

- In this week's lessons, you will learn how the vector space model works in detail, the major heuristics used in designing a retrieval function for ranking documents with respect to a query, and how to implement an information retrieval system (i.e., a search engine), including how to build an inverted index and how to score documents quickly for a query.

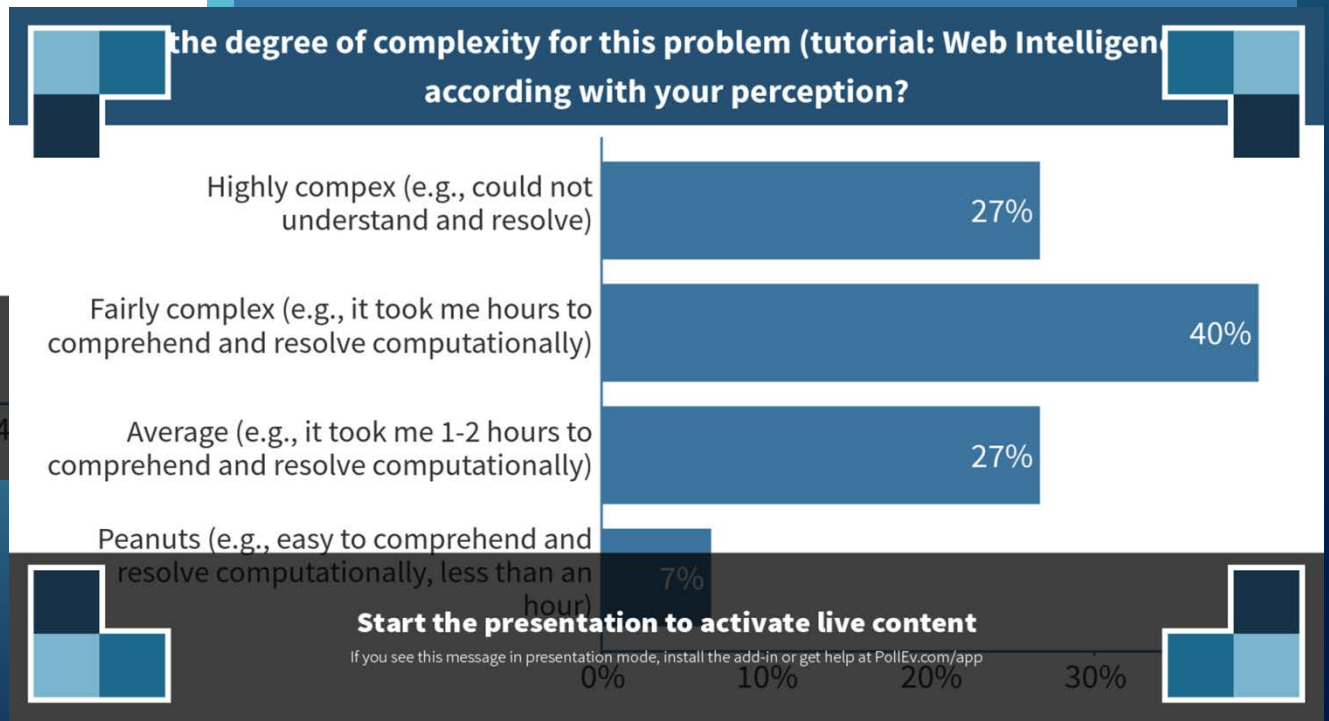
WHAT STUDENTS UNDERSTOOD

PRELIMINARY DATA ANALYSIS AND EXEMPLARY FINDINGS: HOW CAN I INTERPRET THESE FIGURES?

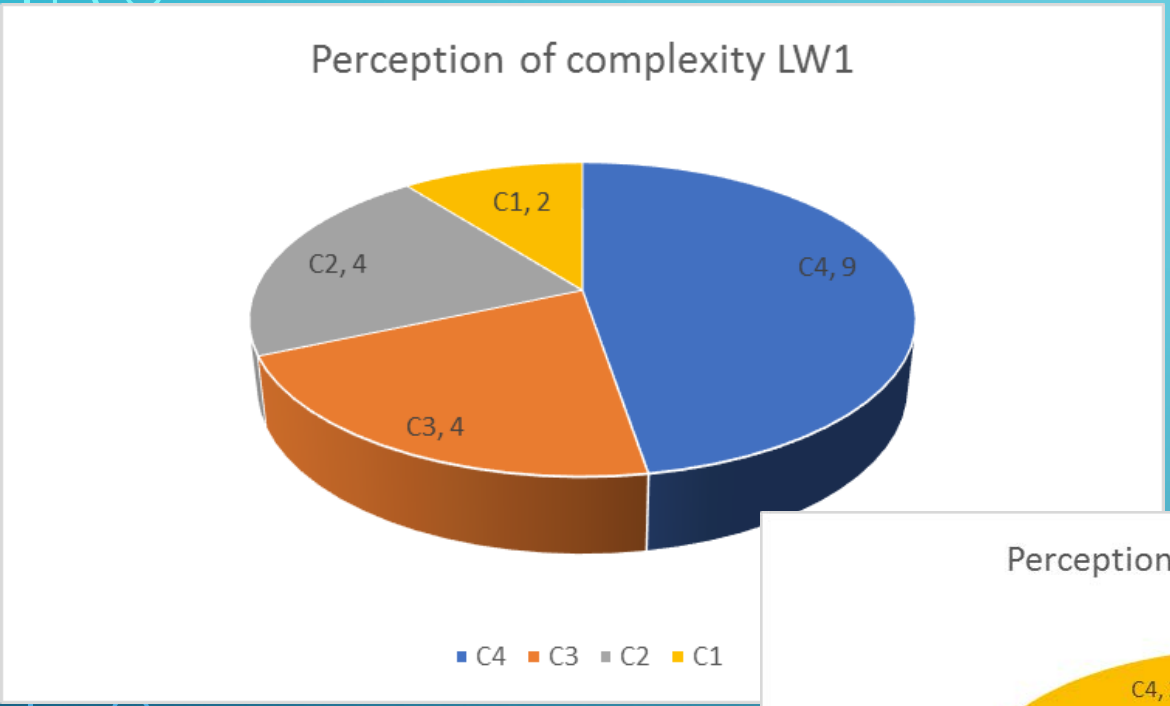
STUDENTS' PERCEPTION OF PROBLEM COMPLEXITY AT LEVEL 6, FIRST LW

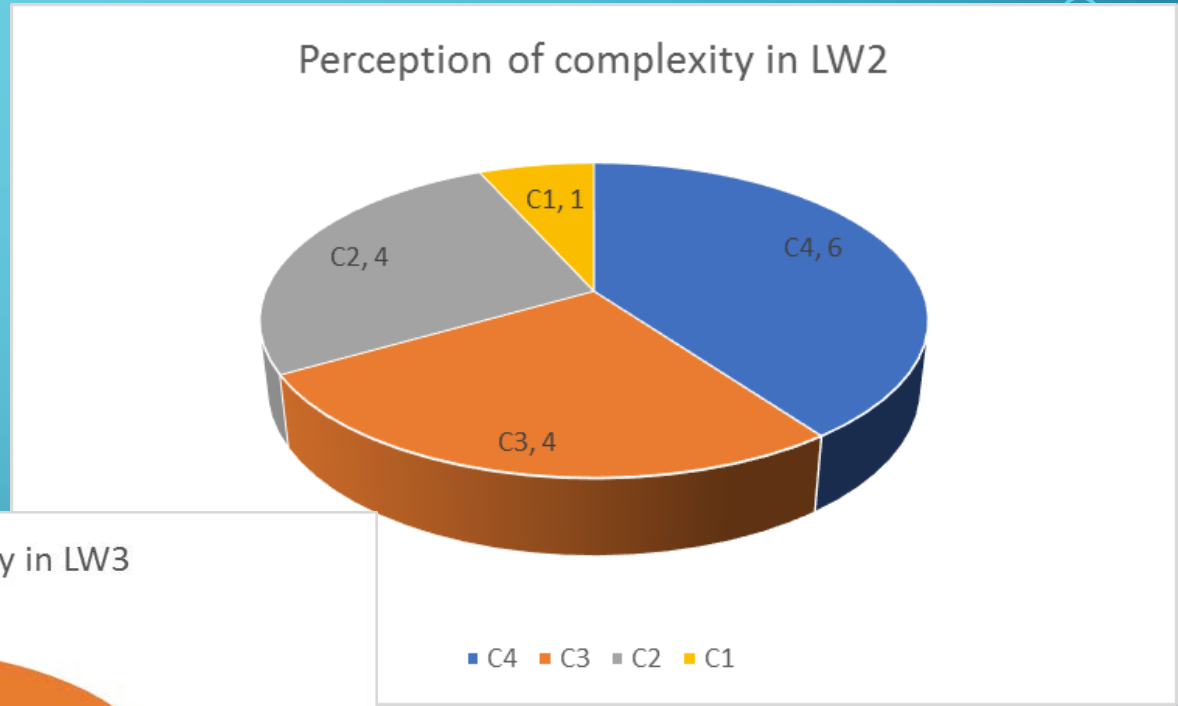


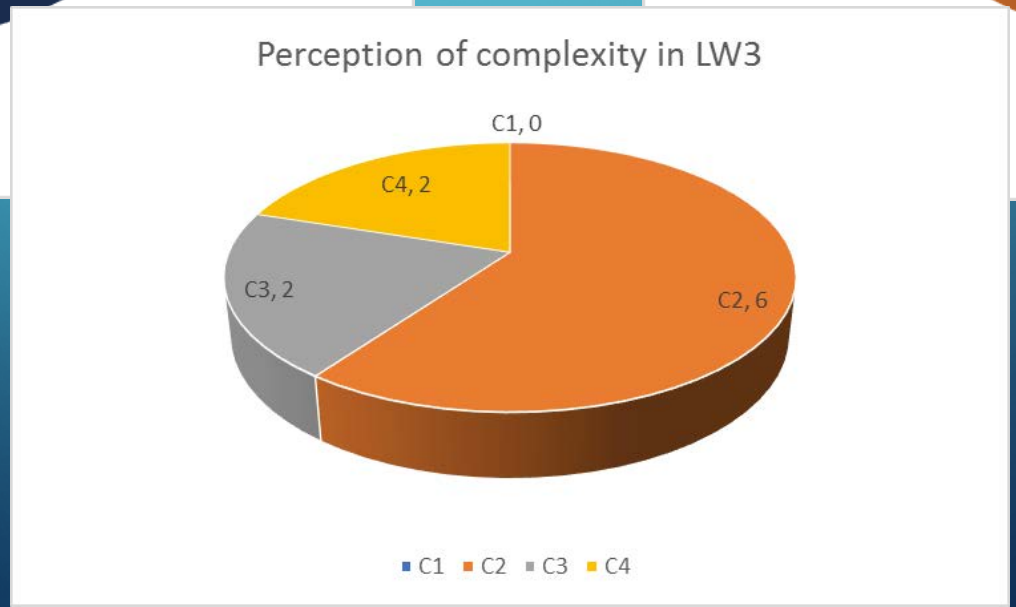
STUDENTS' PERCEPTION OF PROBLEM COMPLEXITY AT LEVEL 6, SECOND LW



TIMELINE OF PERCEIVED COMPLEXITY FOR PROBLEMS AS TUTORIAL EXERCISES: *WATCH C4 PORTION ON PIE CHARTS*

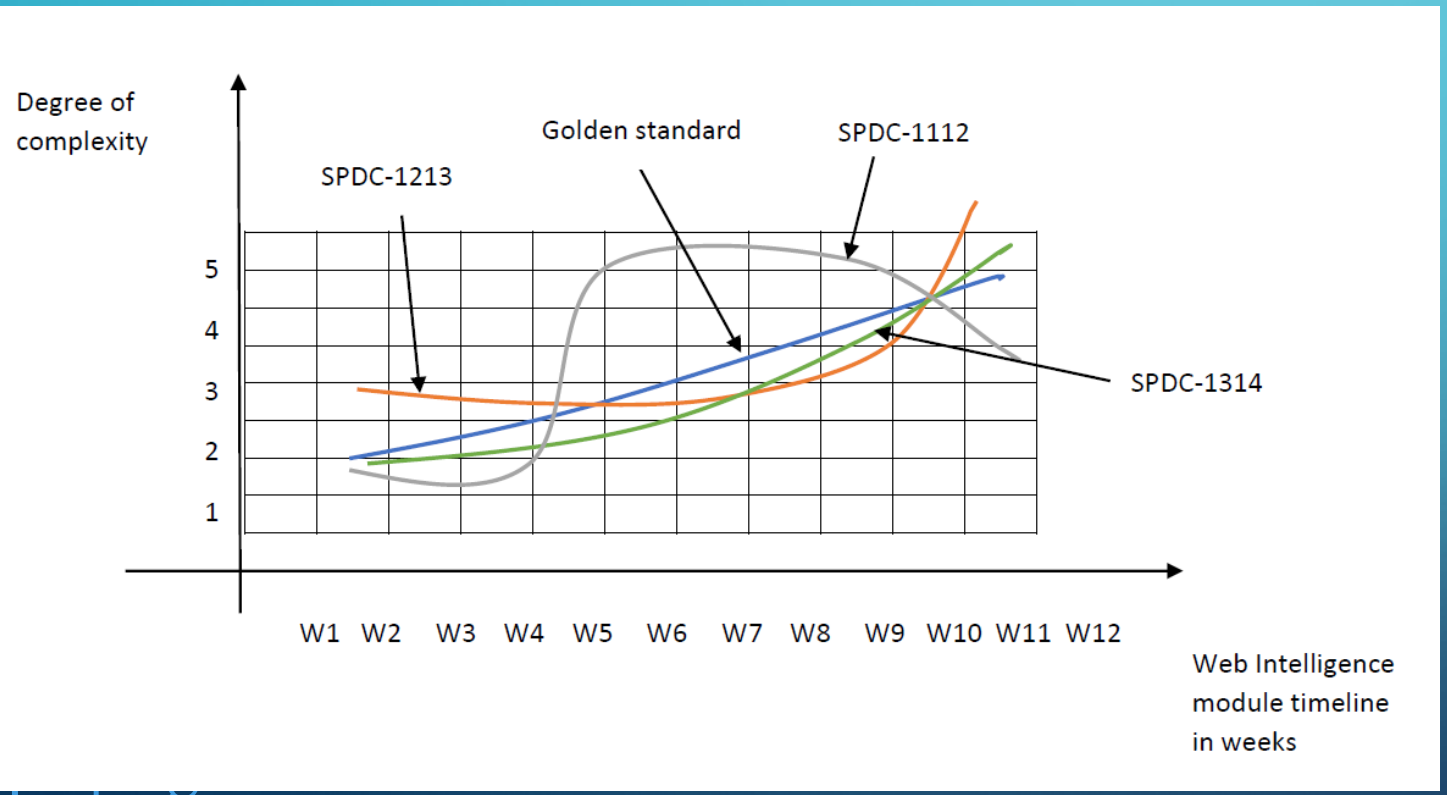






PRELIMINARY DATA ANALYSIS AND EXEMPLARY FINDINGS: HOW CAN I INTERPRET THESE FIGURES?

COMPARISONS AGAINST GOLDEN STANDARD FOR PERCEIVED PROBLEM COMPLEXITY



LEGEND:

- **SPDC-1314**: Average of students' perceived degree of complexity in academic year 2013/14
- **SPDC-1213**: Average of students' perceived degree of complexity in academic year 2012/13
- **SPDC-1112**: Average of students' perceived degree of complexity in academic year 2011/12
- **Golden standard**: Average of perceived degrees of complexity as informed by academic, scholar, research, CPD activities

INTERPRETATIONS OF STUDENTS' PERCEPTION OF PROBLEM COMPLEXITY…

- Possibly a much easier tutorial exercise, however, unlikely….
- Possibly a better explanation given to the first tutorial exercise in the lecture, however, unlikely…
- Possibly students filled up the knowledge gap quicker, however, unlikely…

Main hypothesis: *Possibly some indicator on improvement of problem solving skills to be attributed to the PBL approach as a representative of active learning?*

CONCLUSIONS AND KEY MESSAGES

- Although cognitive skills are acknowledged among the key personal skills of the 21st century, currently there is no well established evaluation framework for assessing effectiveness of (active) learning and teaching approaches for the advancement of domain-specific cognitive abilities after training on a course or a module.
- Currently available data reflecting on student satisfaction (e.g., NSS*, SES) and pass rates, do not adequately measure advancement of cognitive skills (problem solving, system thinking, critical thinking)

FUTURE OUTLOOK

- It is just a preliminary study, however,
- *We look into the further analysing the data reflecting perceptions of lecture contents and problem complexity;*
- *We look into correlations between these parameters and other data such as performance on assessments, online readings, attendance, learning and teaching approach (e.g., active with mobile devices, PBL vs. non-PBL)*
- *We look into expanding the portfolio of parameters and formalising our approach toward a multi-dimensional metric space model for assessing effectiveness of learning and teaching on the advancement of cognitive skills*
- *Gain a deeper understanding of effectiveness of learning and teaching approaches instead of (over-) reacting to students' comments and simplistically jump into conclusions…*

END OF PRESENTATION

FUTURE OUTLOOK II: MIDDLE / LONG TERM OBJECTIVES

- *Gain a deeper understanding of effectiveness of learning and teaching approaches instead of (over-) reacting to students' comments and simplistically jump into conclusions…*
- *Rethinking assessment by looking beyond the "memory based" assessment patterns…*
- *If we do not get to a holistic evaluation framework for domain-specific, or even more ambitious domain-generic cognitive skills, then we could, at least have a more holistic approach to assessing effectiveness and calibrating of learning and teaching approaches for module learning outcomes* and courses…*
- *Far reaching (science-fiction?):* Passive Brain Computer Interface (BCI) utilising spontaneously occurring brain signals to implicitly infer information about the cognitive or affective state of the user/student ☺

END OF PRESENTATION