Mapping the Terrain: Developing Content & Pedagogy meta-data categories for learning resources

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Teachers need to search for learning objects and make use of them in their teaching

- To support inquiry learning
- Pressure to integrate technology
- Personalize learning trajectories
- Interactive e-textbooks are coming of age

- Remillard, J. T. (2016). Keeping an Eye on the Teacher in the Digital Curriculum Race. In M. Bates, & Z. Usiskin, (Eds.), *Digital Curricula in School Mathematics*. Greenwich, CT: Information Age Publishing.
- Chazan, D., & Yerushalmy, M. (2014). The Future of Mathematics Textbooks: Ramifications of Technological Change. *Media and Education in the Digital Age: A Critical Introduction. New York: Peter Lang*.
- Pepin, B., Gueudet, G., Yerushalmy, M., Trouche, L., & Chazan, D. (2015). e-textbooks in/for teaching and learning mathematics: A disruptive and potentially transformative educational technology. Handbook of International Research in Mathematics Education. Third edition., 636-661.

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The common available technology

The web is not "semantic"

- Google and its like do not support "surgical" searching --- the search results are based on popularity
- HTML does not usually include pedagogical meta-data
- No standard semantics for pedagogical meta-data for learning objects

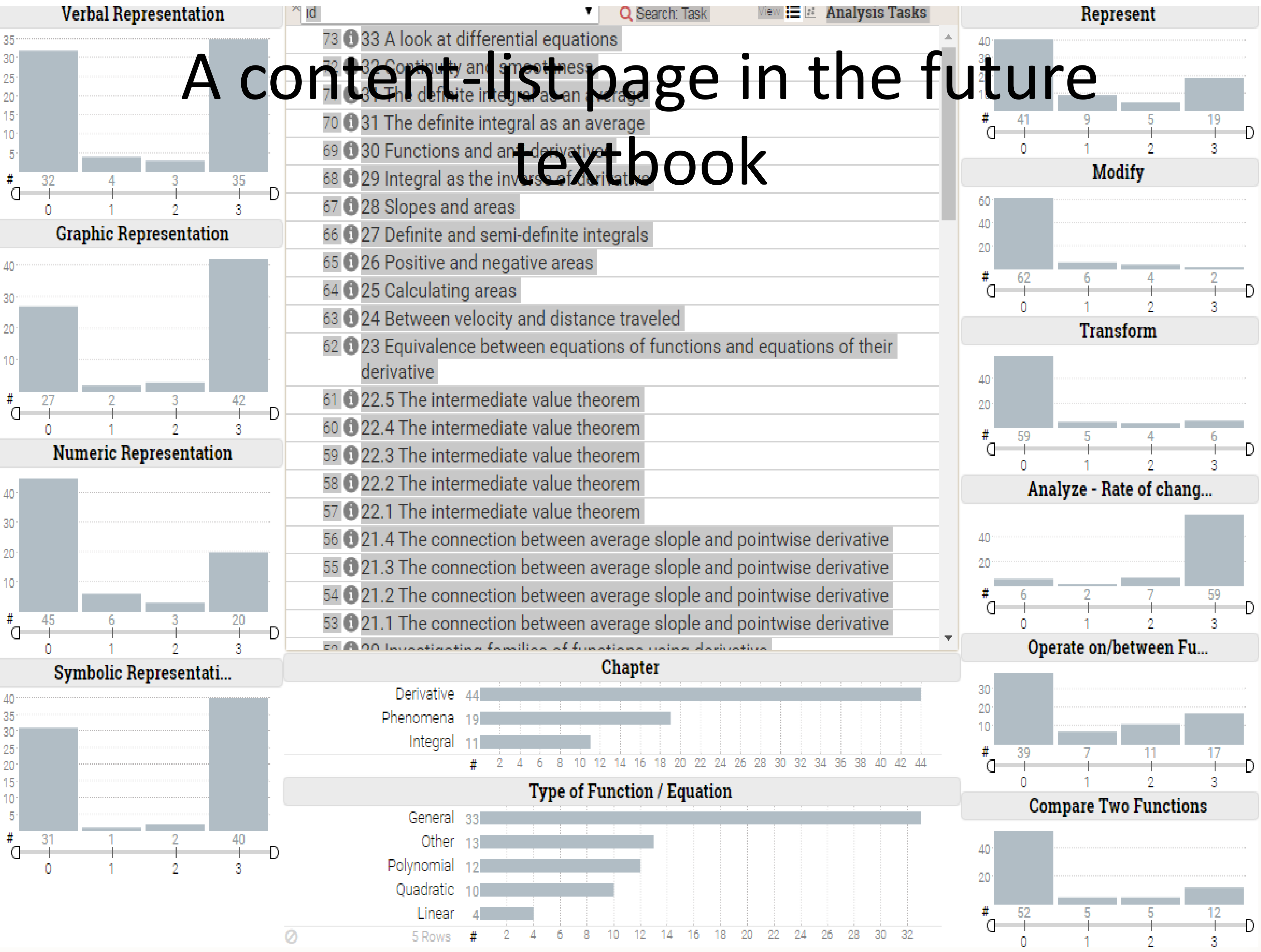
As a result teachers compromise:

- authoring their own learning objects

-make decisions on use without any "reflecting feedback"

Our solution: Coupled pair of tools for tagging/searching learning objects on the internet

A content-list page in the future textbook



Design dilemmas

- What meta-data should be tagged?
  - Research perspective
  - Practical perspective
- How should tagged database be displayed (organized for navigation)?
- Who should tag ? Designers? Users? Regulators?
- Scope of tagged database: Personal? Universal? Well defined communities?

The Edumap challenge: Two discourses

Represented by blue balloon

Descriptive –

As if it is not tied to specific context

so that tasks may be found suitable for a variety of contexts.

- Research-based frameworks
  - Balanced Assessment[1] (object × organization of curriculum)
  - Semiotics, including pedagogical nature of Interactive Diagrams[2]
  - Curricular specificity / mathematical expressivity[3]

[1] Balanced Assessment, 1995, Assessing Mathematical Understanding and Skills Effectively - AMUSE http://hgse.balancedassessment.org/amuse.doc

[2] Naftaliev, E., & Yerushalmy, M. (2017). Engagement with Interactive Diagrams: The Role Played by Resources and Constraints. In *Digital Technologies in Designing Mathematics Education Tasks* (pp. 153–173). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-3-319-43423-0_8

[3] Sinclair, N., and Jackiw, N. (2005). Understanding and projecting ICT trends in mathematics education. In S. Johnston-Wilder and D. Pimm (eds), *Teaching Secondary Mathematics with ICT* (pp. 235-251). Maidenhead: Open University Press

The Edumap challenge: Two discourses

Envisioned Usage (pragmatic categories)

Teachers were likely to expect this kind of tagging:

- Mathematical topic
- Pedagogical role (homework, assessment, etc)
- Class arrangement

Represented by green balloon

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Edumap cycles of Design:

- A light hand with research-based categories of meta-data

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Mathematical Domain

Domain — Pattern / Function ▾

> Balanced Assessment: Mathematical domain

Mathematical Actions

	0	1	2	3
Modeling / Formulating	○	○	◉	○
Transforming / Manipulating	○	○	◉	○
Inferring / Drawing Conclusions	○	◉	○	○
Using Technology	○	○	○	◉

> Balanced Assessment: Actions

Mathematical Topic

Pattern / Function — Equations ▾

> Envisioned usage: Topic

Mathematical Object

Type of Equation — Quadratic ▾

> Balanced Assessment: Mathematical Object

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Operations

	0	1	2	3
Represent	○	○	●	○
Modify	○	○	○	○
Transform - build a family	○	○	○	●
Analyze	○	○	○	○
Operate with/on	○	○	○	○
Compare	○	○	○	○
Other	○	○	○	○

Balanced Assessment: Operations on objects

Representation

	0	1	2	3
Verbal	○	○	●	○
Graphic	○	○	○	●
Numeric	○	○	○	○
Symbolic	○	○	○	●

Mathematical Representation

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Type of Resource

Text	0	1 (selected)	2	3
Video	0	1	2	3
Mathematical Aid	0	1	2	3
Dynamic Sketch	0	1	2	3 (selected)
Other	0	1	2	3

Type of resource

Type of Diagram

Type of Diagram: Evolving

Semiotic:
Nature of interactive diagram

Nature of Resource

Relvant for curriculum	0	1	2	3 (selected)
Relevant for variety of mathematical topics	0	1	2 (selected)	3

Curricular alignment

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Edumap cycles of Design:

- A light hand with research-based categories of metadata
- A separate section for "Resource Usage"

Resource Usage

Role: Practice

Class Arrangement: Individual

Envisioned usage of task

Additional Technology

Numeric Manipulation (Excel): ○ No ○ Yes

Graphic Representation (Graphing Calculator): ○ No ◉ Yes

Symbolic Manipulation (CAS): ○ No ○ Yes

Acceptable explanation of reasoning: An explanation that re

Envisioned usage of technology

Note

Save ✚

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Edumap cycles of Design:

- A light hand with research-based categories of metadata
- A separate section for “Resource Usage”
- None of the fields are compulsory

Edumap / Keshif experiment: Method & Finding

- **Short professional development** with pre-service teacher candidates at University of Haifa
- **Structure of experiment**
  - 23 pre-service participants
  - Pre-task (submitted online): ***Select three tasks from Visual Math to serve as 1. Opening the topic; 2. Practice; 3. Assessment. Explain your selections – what guided you in choosing a task for each of the teaching stages?***
  - Introduction to Edumap (version 2)
  - Experiment task: ***Repeat pre-task using Keshif browser, present to peers.***
- **Research questions:**
  - How will the teachers make use of the meta-data categories in designing teaching sequences?
  - How will teachers' curricular discourse be different compared to the pre-task?

INSTRUMENTAL GENESIS OF KESHIF

case 1 (opening task): Disappointment with “envisioned usage”

- *At first we tried to actually select the tasks [that were tagged as]* ***opening tasks****, and we saw that they weren’t necessarily the opening tasks that we were looking for. <u>So we started to think together what we want in opening tasks</u>…* ***graphical representation****… and then we asked for a pair activity, and that the* ***explanation*** *should be* ***not only technological****… we were left with two tasks, and we decided to look at them.*

Case 2 (practice task): First descriptive, then usage

- *In practice [task], it was important for us that the representation be **verbal**…*
  *Then we went to tasks [that were tagged as] **practice**… and also that it should be **individual activity.***

Case 3 (assessment task): Descriptive/usage/descriptive, think!

- *For assessment we first did* ***drawing conclusions****. Then we selected individual activity. Then graphical representation. We were left with many tasks, and then* <u>*we started to think what else is important for us*</u>*.*

Research questions & preliminary answers

1. How will the teachers make use of the meta-data categories in designing teaching sequences?
   - A blend of descriptive and usage categories
   - When a few tasks remain – personal preference
2. How will teachers' curricular discourse be different compared to the pre-task?
   - Enriched criteria (*I didn't think about that at home*)
   - A priori search criteria, opposed to a postriori justification (*we started to think what's important*)
   - Evidence of multiple "obligations":
     - *you know your students* (personal obligation to students)
     - *what kind of lesson you want* (institutional obligations)

Preliminary conclusion

- Challenge of resolving relevance between communities encourages each community to critically evaluate what is important
  - Researchers: Which research-based categories are crucial for curricular design?
  - Teachers:
    - » Which categories of usage are searchable
    - » Which social contexts share meanings for metadata

Further questions

- Could it be "universal"?
  Supporting communities that have common grounds for common tagging
- Should tagging be automatic?

Interacting with digital textbooks

- Who?
- How?
- What can we learn from this?

Tangible representations of digital textbook contents

- Teachers: use it creating learning sequences
- Designers: reflect the big ideas in a digital textbook
- Policy makers: choosing textbooks among many

Creating the data

- Tagged learning objects:
  - Different taggers on a large corpus
  - Many taggers on the same topic
  - [Automatic tagging]
- Result: tagged database
- Let's represent it in a tangible, accessible way

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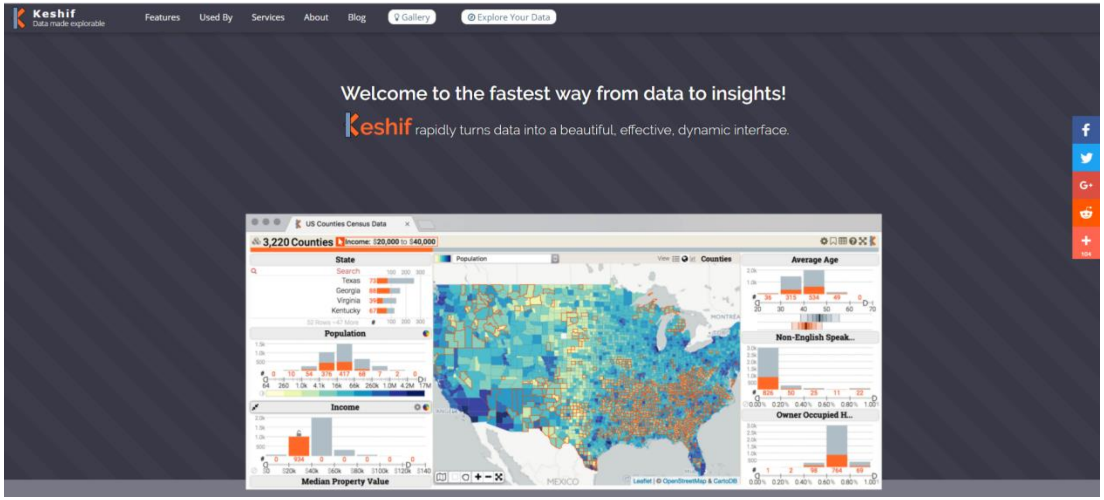
Chosen tool: Keshif Browser

- Visual
- Dynamic
- Partial solution (not suitable for sequence representation)
- Available for use at www.keshif.me

Yalcin, M. A., Elmqvist, N., & Bederson, B. B. (2016), Keshif: Out-of-the-Box Visual and Interactive Data Exploration Environment, Proc. of IEEE VIS 2016 Workshop on Visualization in Practice: Open Source Visualization and Visual Analytics Software.



Goal

- Can we use this visual representation to gain insight about:
  - A. The tagged data
  - B. The taggers
- Today we will demonstrate a proof of concept on A - a methodology to gain insight on the tagged data

Specifics

- 9 practitioners (teachers, graduate students, mathematics education researchers)
- 74 tasks in Analysis from 3 chapters of the Visual Math textbook of Analysis – Computer supported inquiry activities for higher school (Yerushalmy et. al, 1996).
- Tagging fields were predefined by researchers (for more details you can attend Yerushalmy's presentation later during this conf.)
- Visual representation created with Keshif

What did we try to do?

- Exploring the representations to gain insights about the textbook chapters
- Check the alignments of these insights with the designers intention to define:
  - Intentional correlation: The insights reflect the designers intension.
  - Tacit correlation: The insights exist, but the designers did not intend knowingly to incorporate them(implicit or unintentional)
  - Not relevant: The insights are not relevant to the designers intentions.

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Let's try it out

- Go to the following website:

  https://goo.gl/dxjwmV

- Try to gain 3 *insights* on the given data base
- Example.
- (this was created using keshif – www.keshif.me)

Method cont'd

- Initial analysis reveled insights (17) regarding the tagged data set
- The identified insights were presented to the designer in an interview to comment on
- According to the analysis of the reply, insights were categorized into the 3 categories presented earlier

Results

- Intentional correlation: The insights reflect the designers intension.
- Insight: The tasks that were designed for opening a topic were without symbolic representation almost in all cases.

- Designers reaction:
  - “This is the definition, generally speaking, of an opening task – to reach the symbolic - from sensing, complex problems which one can think about, non-mathematical information etc.“

Results – cont'd

- Tacit correlation: The insights exist, but the designers did not intend knowingly to incorporate them
- Insight: Non-technological justifications are not so common in the "derivative" chapter.

- Designers reaction:
  - "This is a logic conclusion from two other conclusions: derivative has a lot of symbolic work, and when working symbolically you cannot rely solely on technology."

Results – cont'd

- Not relevant: The insights are not relevant to the designers intentions.
- Insight: Symbolic representation is especially common in drawing conclusions tasks".

- Designers reaction:
  - "I am not clear why this phenomenon is shown in the data."
  - "Maybe this testifies on the type of conclusions they aspire to. For example – how does drawing a conclusion from a graphic representation without symbolic representation looks like? That is probably not reflected in this collection."

Limitations and pitfalls

- Tagger and designers might not be aligned
- Tagging performed by multiple taggers
  - Contradicting tagging for the same object
  - Tagging of different objects by different taggers
- Insights are dependent on user of Keshif

Summary and Conclusion

- Visual dynamic representation could assist in revealing different characteristics of datasets of curricular materials
- "Objectively" gained insights could be presented to designers (teachers?) in order to conduct a productive discussion
- Characteristics are restricted by the tagging (what you don't tag you can't represent)
- Automatic tagging is key
- Accessible terminology (common discourse) is important

Thank you.

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