Searching as Learning

학습과정으로서의 정보검색: 미래의 정보검색시스템 관련 연구 현황과 전망

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2018년 10월4일

- Research areas: Web search behavior, information seeking behavior, credibility assessment, searching as learning, information literacy

- Faculty member in School of Information, University of Michigan (2002 -)

- Director of Master of Science in Information Program (2014-2017)

- Human Factors Research Engineer at Excite@Home, Redwood City, CA from 2000-2001

- Ph.D. in communication, information, and library studies from Rutgers University, USA

Information matters

Search as a core competency

Image credit:
http://neatoday.org/2014/11/25/deeper-learning-moving-students-beyond-memorization-2/

Outline

- Conceptual framework: Searching as learning

- Assessment of learning in web searching

- Toward searching to support critical thinking and creativity

Part I

Conceptual framework: Searching as learning

Contradictory Viewpoints on Students' Searching Behavior

Rieh, Kim, and Markey (2012)

- Why people do not make effort in searching, particularly in web searching

- College students put little effort into Web searching because of their high sense of self-efficacy in their searching ability and their perception of the easiness of the Web

Traditional Information Retrieval Framework

Searching as Finding

- Search effectively
- Search efficiently
- Search quickly
- Search easily

Research Problems

Traditionally, research on search technology tends to focus on improving the effectiveness of search results to match document with search queries

Search User Interfaces

https://searchuserinterfaces.com/ ▾ 이 페이지 번역하기

"This will be seen as a transformational book -- one that synthesized a new, coherent discipline of human information interaction out of literature and experience ...

Read It: Search User Interfaces

https://searchuserinterfaces.com/book/ ▾ 이 페이지 번역하기

1: Design of **Search User Interfaces**: introduces the ideas and practices surrounding search interface design, places modern design in a historical context, and ...

Search User Interfaces - ACM Digital Library - Association for ...

https://dl.acm.org/citation.cfm?id=1631268 - 이 페이지 번역하기

MA Hearst 저술 - 2009 - 752회 인용 - 관련 학술자료

This book focuses on the human users of search engines and the tool they use to interact with them: the **search user interface**. The truly worldwide reach of the ...

Abstract · Authors · Cited By

Search interface: 20 things to consider – UX Planet

https://uxplanet.org/search-interface-20-things-to-consider-4b146... ▾ 이 페이지 번역하기

2018. 5. 21. - What questions to ask **users**? What to consider while prototyping? And what are the best practices in **search interface** design? Depending on ...

Search User Interfaces: 9780521113793: Computer Science Books ...

https://www.amazon.com/Search-User-Interfaces.../0521113792 ▾ 이 페이지 번역하기

"Many people think designing a **search user interface** is as simple as copying what someone else

---

Search User Interfaces
마티 허스트의 책
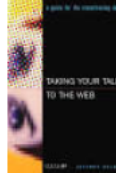
이 책이 마음에 드셨나요?   👍   👎

최초 발행일: 2009년

저자: 마티 허스트

함께 찾은 검색어   10개 이상 항목 더보기

Search Patterns: Design fo...
제프리 캘린더

Open Data Structures: An Introd...
팻 모린

Taking Your Talent to the Web
제프리 젤드먼

Problems on Algorithms
이안 파르베리

Think Complexity: Complexi...
알렌 B. 다우니

Current search systems are optimized for look-up tasks, not other kinds of search tasks such as learning, investigation, and discovery

Searching and Learning

- Search as a learning tool
  - Searching to learn
  - Learning to search
- Searching as a learning process

Search to Learn – Exploratory Search

- Searching to foster learning and investigation (Marchionini 2006)

- Search systems should help users explore, overcome uncertainty, and eventually learn (White and Drucker 2006)

White & Roth (2009)

Iterative Search / **Exploratory Search**

▲ Search target   Information space

◯ Result sets (larger = more results, intersection = overlap, # = iteration)

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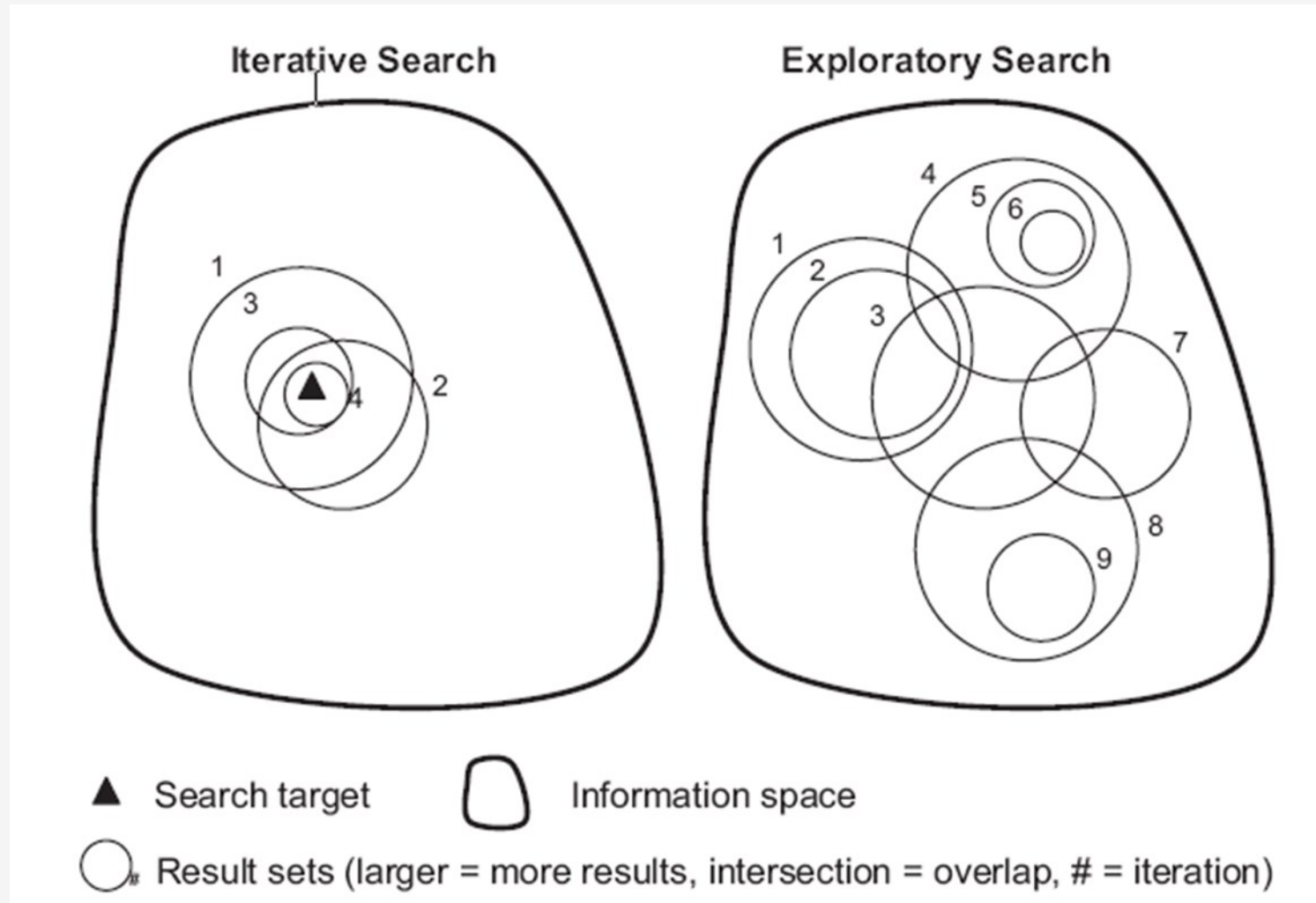
Learning to Search

- Information literacy
- Learning how to critically seek, evaluate, and use information
- Little integration of information literacy education with search systems

Searching as a Learning Process

- Searching is a process in which people engage various activities for learning
  - Critically analyzing information
  - Bringing pieces of information together to create something new
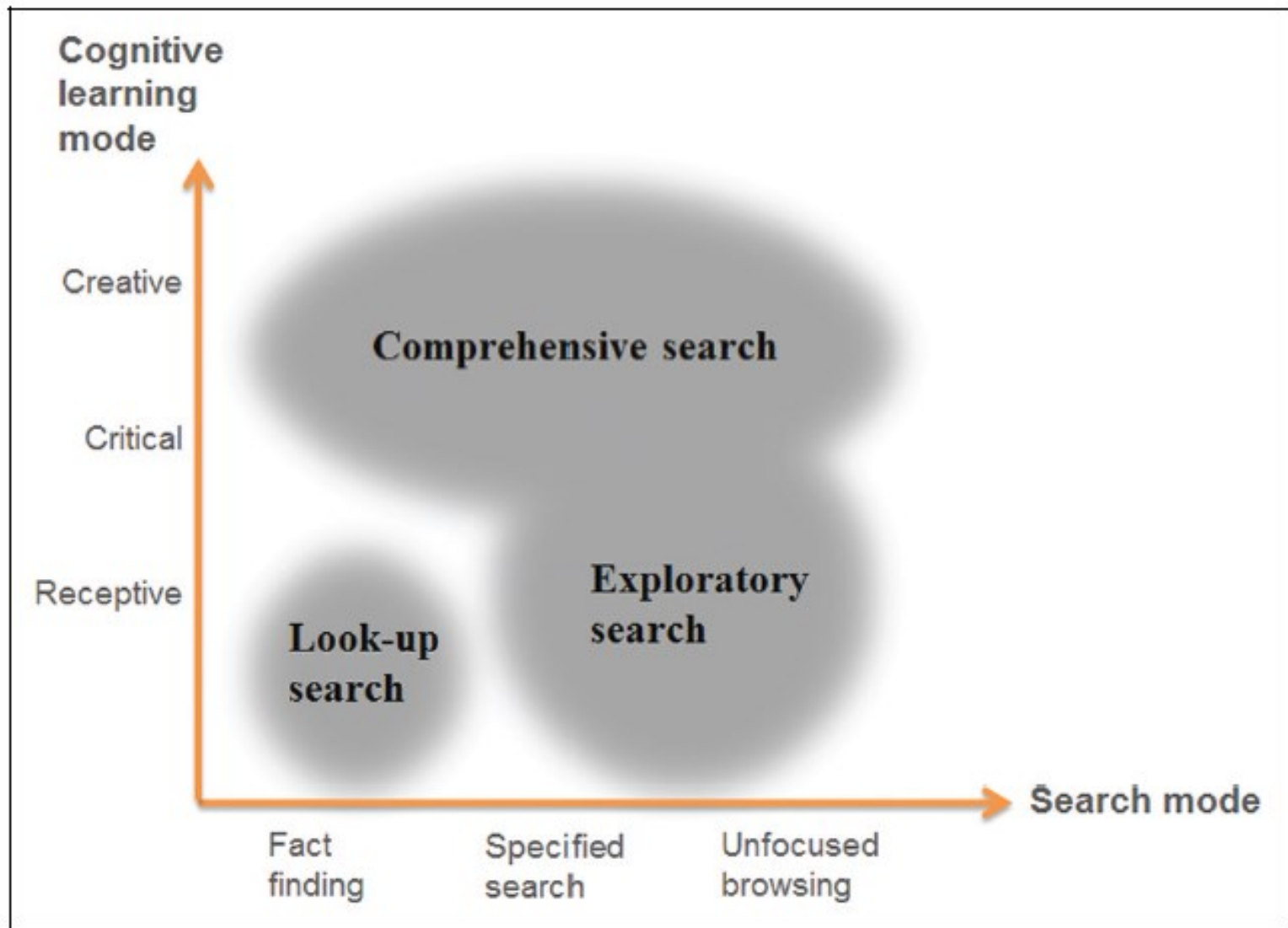
Search Behavior for Receptive Learning

- Receptive Learning
  - Known-item searching
  - Specifying
  - Modifying
  - Obtaining
  - Selecting
  - Acquiring
  - Judging relevance

Search Behavior for Critical and Creative Learning

- Evaluating usefulness
- Assessing credibility
- Comparing
- Extracting
- Differentiating
- Prioritizing
- Sense-making

Implications

- Does online activities make our brains worse at reading and thinking deeply?

- What competencies are required in today's digital society?
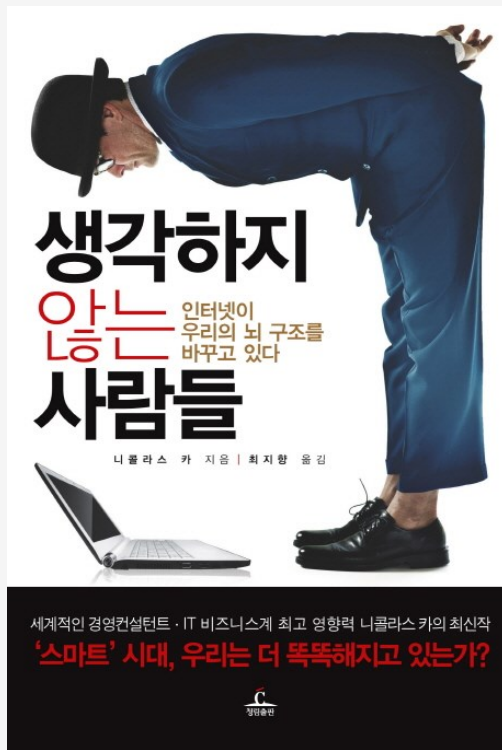
Reference

Rieh, S. Y., Collins-Thompson, K., Hansen, P., & Lee, H-J (2016). Toward searching as a learning process: A review of current perspectives and future directions. *Journal of Information Science, 42*(1), 19-24.

Part II
Assessment of Learning in Web Searching

Research Question 1

What kinds of measures and indicators can be developed to assess learning experiences and outcomes in search systems?

검색시스템에서의 학습경험과 성과를 평가하기 위하여 어떠한 측정지표가 개발될 수 있는가?

Research Question 2

What query strategies best support human learning experiences and outcomes in search systems?

검색시스템에서 학습경험과 성과를 지원하기 위해서는 어떠한 검색질의 방식이 더 효과적인가?

Research Design

- Lab study with users
  - Three query conditions (between-subjects)
  - Two learning tasks

  (within-subjects)

이용자 실험연구
- 세가지 다른 조건으로 연구대상자를 분배
- 모든 연구대상자에게 같은 검색과제가 주어짐

Assessment Methods

- Pre- and post-search questionnaires
- Coded analysis of written responses to prompts
- Interaction features from search log data
- 실험 전-후 설문지
- 연구대상자의 주관식 응답분석
- 검색로그 데이타 분석

General task instructions for study subjects

- You are preparing a term paper on the topic: collect and save all Web pages, publications, and other online sources that are helpful for you to write a paper.

- After your search is completed, you will be asked questions about this topic. Questions include writing an outline and completing a survey based on what you have learned from this search.

Task 1 description (Oil Spill)

- Suppose you are taking an introductory Environmental Science course this term. For your term paper, you have decided to write about *what chemicals can be used to clean up oil spills*. You also would like to learn *what environmental effects* oil spills have in the ocean and on shore.

Task 2 description (Open Data)

- For a course you are taking this term, you have decided to write a term paper about *government open data policy*. You know that it is about how government agencies manage information as an asset throughout the life cycle to promote openness.

Study Participants

- 44 study subjects (30 female, 14 male)

  → 42 due to technical problems with 2 user sessions

- Age: 19 to 38 years
- Education:

  – 36 graduate students

  – 7 undergraduate students

  – 1 alumnus

Users were assigned to one of three "query strategy" conditions

- Single query (SQ, N=12)
  - Select initial query
  - Use initial results for the rest of the session
- Multiple query (MQ, N=15)
  - Same user interface as SQ condition
  - Select initial query
  - May issue new queries
- Multiple query + Intrinsic diversity (ID, N=15)
  - Uses ID presentation to MQ condition
  - Select initial query
  - May issue new queries OR use ID suggestions

Single Query Condition and Multiple Query Condition

Search Result

Query: Open government policy

#	Results for Open government policy
1	**Open Government Policy	The White House** http://www.whitehouse.gov/open/about/policy The President's Memorandum on Transparency and Open Government The President's first executive action, the Open Government Memorandum calls for more transparent ...
2	**Open Government Initiative	The White House** http://www.whitehouse.gov/Open/ Official government site for open government, working to ensure the public trust and establish a system of transparency, public participation and collaboration.
3	**Open Government and Democracy Policy - Green Party of ...** https://home.greens.org.nz/policy/open-government-and-democracy-policy Read the Open Government Policy Summary Download the Open Government Policy as PDF. Spokesperson: James Shaw MP. Updated 16-Jan-2015. Vision. The Green Party ....
4	**The Government of India's new open source policy ...** http://opensource.com/government/15/8/india-adopts-open-source-policy The Government of India (GOI) has adopted a comprehensive and supportive open source policy. It builds on their earlier efforts to adopt open standards for procurement.

Multiple Query + Intrinsic Diversity

Search Result

Query: Open government policy

#	Results for Open government policy

1   **Open Government Initiative | The White House** `Open Government Data`
https://www.whitehouse.gov/open
Official government site for open government, working to ensure the public trust and establish a system of transparency, public participation and collaboration.

2   **Open Data Policy Guidelines - Sunlight Foundation** `Open Government Website`
http://sunlightfoundation.com/opendataguidelines/
The Sunlight Foundation created this living set of open data guidelines to address: what data should be public, how to make data public, and how to implement...

3   **Government policies - definition of Government policies by The Free ...** `Open Data Policy`
http://www.thefreedictionary.com/Government+policies
A plan or course of action, as of a government, political party, or business, intended to influence and determine decisions, actions, and other matters: American...

4   **Open Data Policy** `Open Government Website`
https://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-13.pdf
May 9, 2013 ... SUBJECT: Open Data Policy-Managing Information as an Asset ... readable and open formats, data standards, and common core and...

Pre-search questionnaire
4 Questions

P1: Subjects' prior knowledge level (1-5 scale)

P2: Interest in the topic (1-5 scale)

P3: Perceived difficulty of searching (1-5 scale)

P4: "Please write what you know about this topic"

Lower-level cognitive learning Questions:

Q1: Remembering

What are the kinds of materials…

Q2: Understanding

What are some factors that should be considered…

Q3: Applying

Why oil spills are important environment issues?

Higher-level cognitive learning Questions:

Q4: Analyzing

Write an outline for your paper

Q5: Evaluating

Write what you learned in 3-5 sentences

Q6: Creating

What questions do you have about the topic?

Learning assessment during search was based on Bloom's Taxonomy (revised)

Anderson, L. W. and Krathwohl, D. R. 2001. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman, New York.
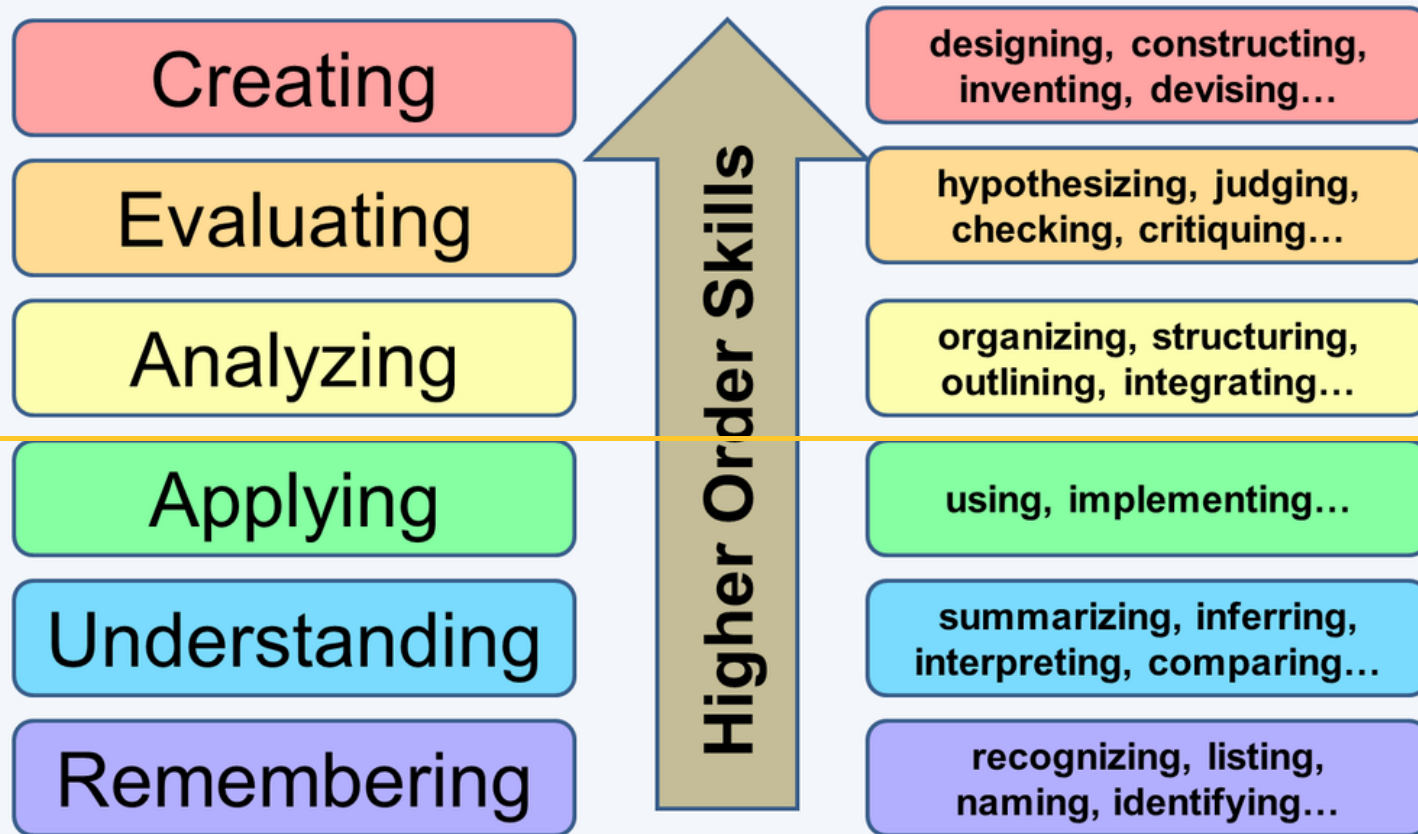
Post-search questionnaire Scale-based Questions

- Search Exploration (6 questions)

- User experience with the system (4 questions)

- Learner interest and motivation (5 questions)

- Perceived learning success

- Perceived searching success

RQ1: Measures for assessing learning in searching

- For the easier task (Oil Spill), there was more evidence of lower-level cognitive learning (M=7.21) than higher cognitive learning (M=5.88) in written summaries.

- For the more difficult task (Open Data), slightly more evidence of higher cognitive learning (M=5.31) than that of lower-level cognitive learning (M=4.55).

RQ1: Measures for assessing learning in searching

- We found a strong positive correlation between perceived learning outcomes and actual knowledge level gain in the "Intrinsic Diversity" condition, for both the Open Data (r=0.69) and Oil Spill (r=0.64) tasks.

Knowledge level gain	# Participants
+2 (none → conceptual)	10 (24%)
+1 (none → factual, factual → conceptual)	15 (35%)
+0	16 (38%)
-1 (conceptual → factual)	1 (3%)

RQ2: Knowledge Level Gain by Condition (Oil Spill Task)
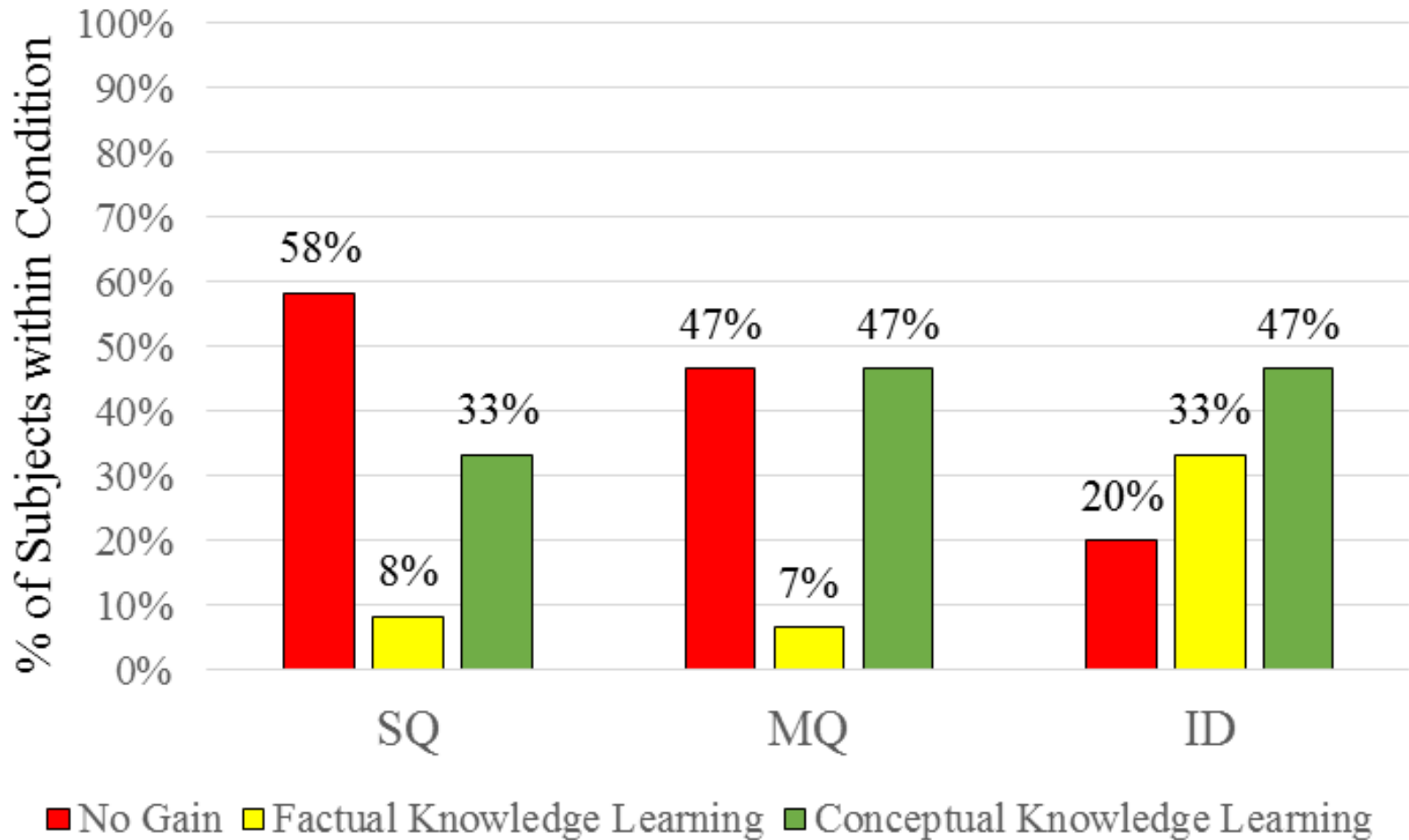
RQ2: Knowledge Level Gain by Condition (Open Data Task)
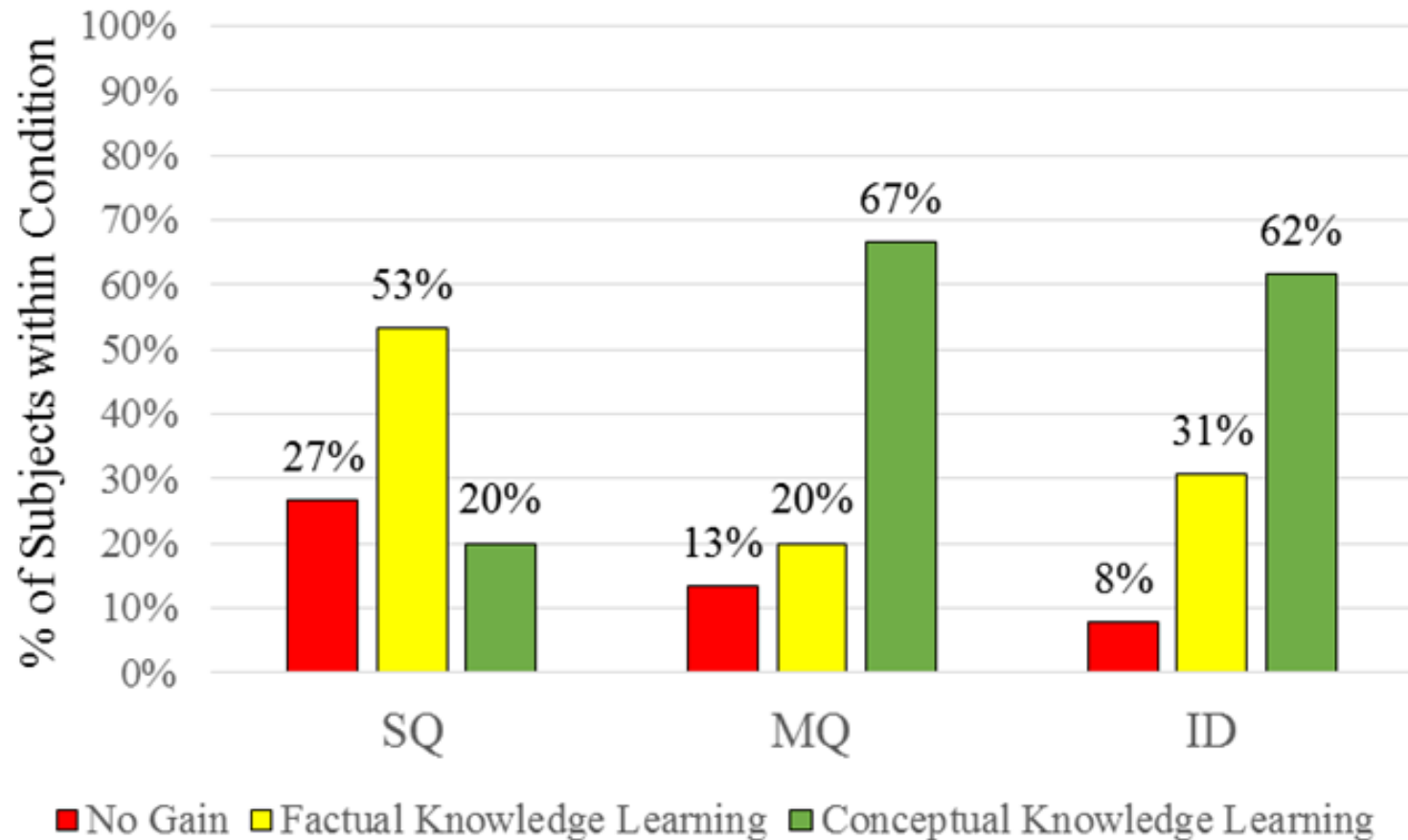
References

Collins-Thompson, K., Rieh, S. Y., Haynes, C. C., Syed, R. (2016). Assessing learning outcomes in web searching: A comparison of tasks and query strategies. *Proceedings of the ACM SIGIR Conference on Human Information Interaction and Retrieval* (CHIIR '16), 163-172.

Part III
Toward searching to support critical thinking and creativity

검색시스템이 비판적 사고력과 창의력을 지원하는 방향으로 발전하기 위해서는 무엇을 해야할까?

Research Problem 1

What types of learning can search systems support?

어떠한 종류의 학습을 검색 시스템이 지원할 수 있는가?

Research Problem 2

What functionalities and interventions on the search system interface level can foster learning?

검색시스템에서 학습을 조성하기 위해서는 무슨 기능이 추가될 수 있을까?

What is Critical Thinking?

Critical thinkers know how to reach reasonable arguments by utilizing information

Critical thinking is not just way of thinking but rather an active thinking process that uses multiple perspectives

Image from http://www.oxfordhumanists.org/?page_id=1841

How is it different from information literacy?

- Critical thinking research emphasizes the application of higher-order cognitive processes to discipline-specific knowledge

- Information literacy research empathizes locating, evaluating, and gathering information using both lower and higher-order cognitive processes

What is Creativity? How is it different from critical Thinking?

– "Inseparable, integrated, and unitary" thought processes (Paul and Elder, 2006)

  – Critical thinking focuses on the process of judging, assessing, and thinking critically

  – Creativity focuses on generating, making, or producing ideas as a result of critical thinking

Paul and Elder, Critical thinking: The nature of critical and creative thought, Journal of Development Education, 30, 2006.

Relationship between critical thinking and creativity

- Critical thinking without creativity – pessimism and skepticism

- Creativity without critical thinking – mere novelty

Paul and Elder, Critical thinking: The nature of critical and creative thought, Journal of Development Education, 30, 2006.

Four P Perspectives of Creativity (Mel Rhodes, 1961)

Image credit - https://www.cues.org/article/view/id/Put-Creativity-in-Concrete
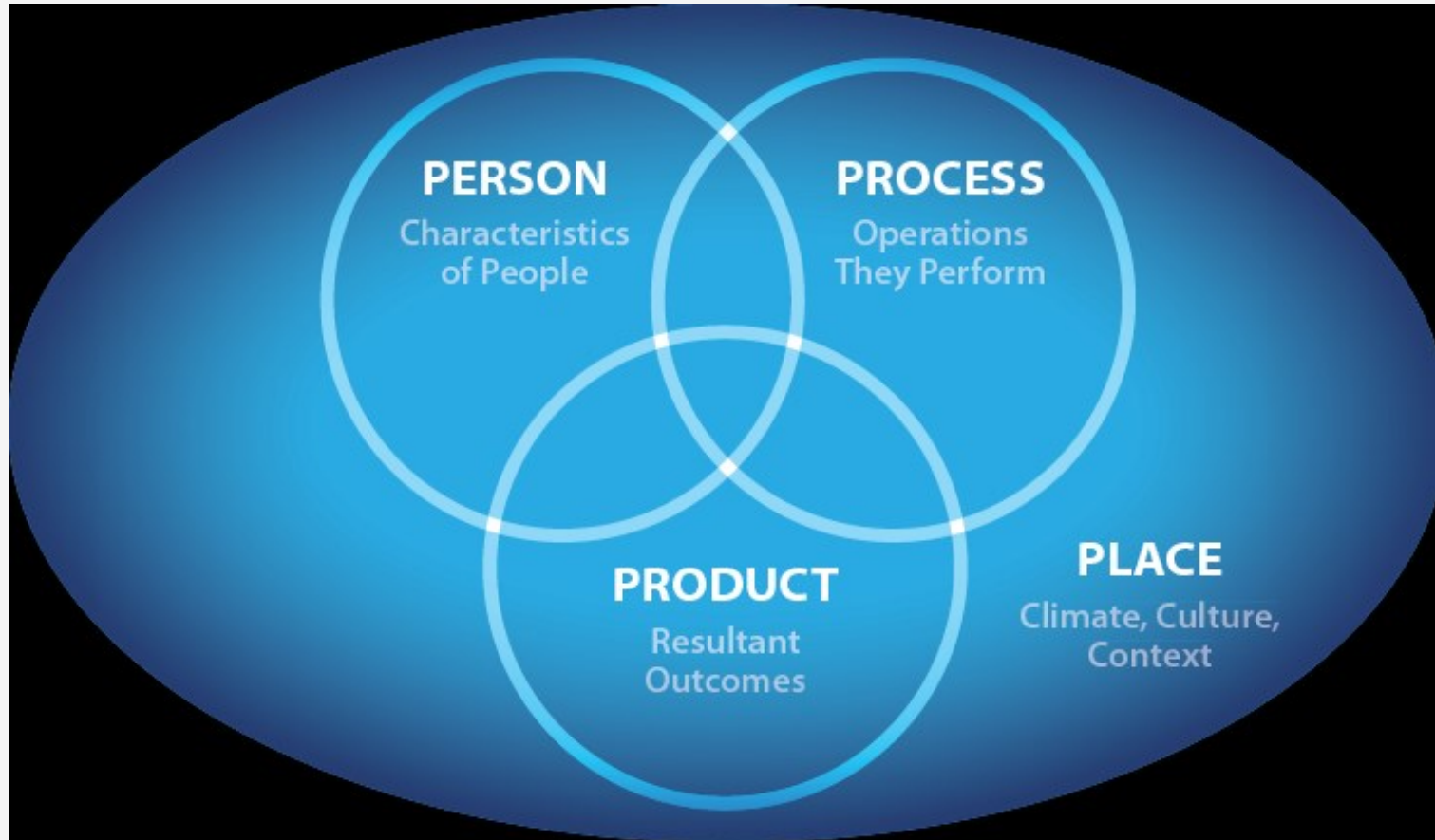
- Big-C
  - Creative genius
  - Big-time creativity used and enjoyed by generation
- Little-c
  - Development and demonstration of creative thinking in the layperson's everyday life
  - Characteristics of individuals – inquisitiveness, imagination, unconventionality, and freedom of thought

Stage 1: Find the Problem
Stage 2: Acquire Knowledge
Stage 3: Gather Related Information
Stage 4: Incubation
Stage 5: Generate Ideas
Stage 6: Combine Ideas
Stage 7: Select the Best Ideas
Stage 8: Externalize Ideas

Sawyer, K. 2012. Explaining creativity: The science of human innovation. 2nd Ed. Oxford University Press

Interpretation of Sawyer's Creativity Framework

Information Seeking Activities

Find the Problem

Acquire Knowledge

Gather Related Information

Incubation (Play)

Ideation Activities

Generate Ideas

Combine Ideas

Select Best Ideas

Externalize Ideas
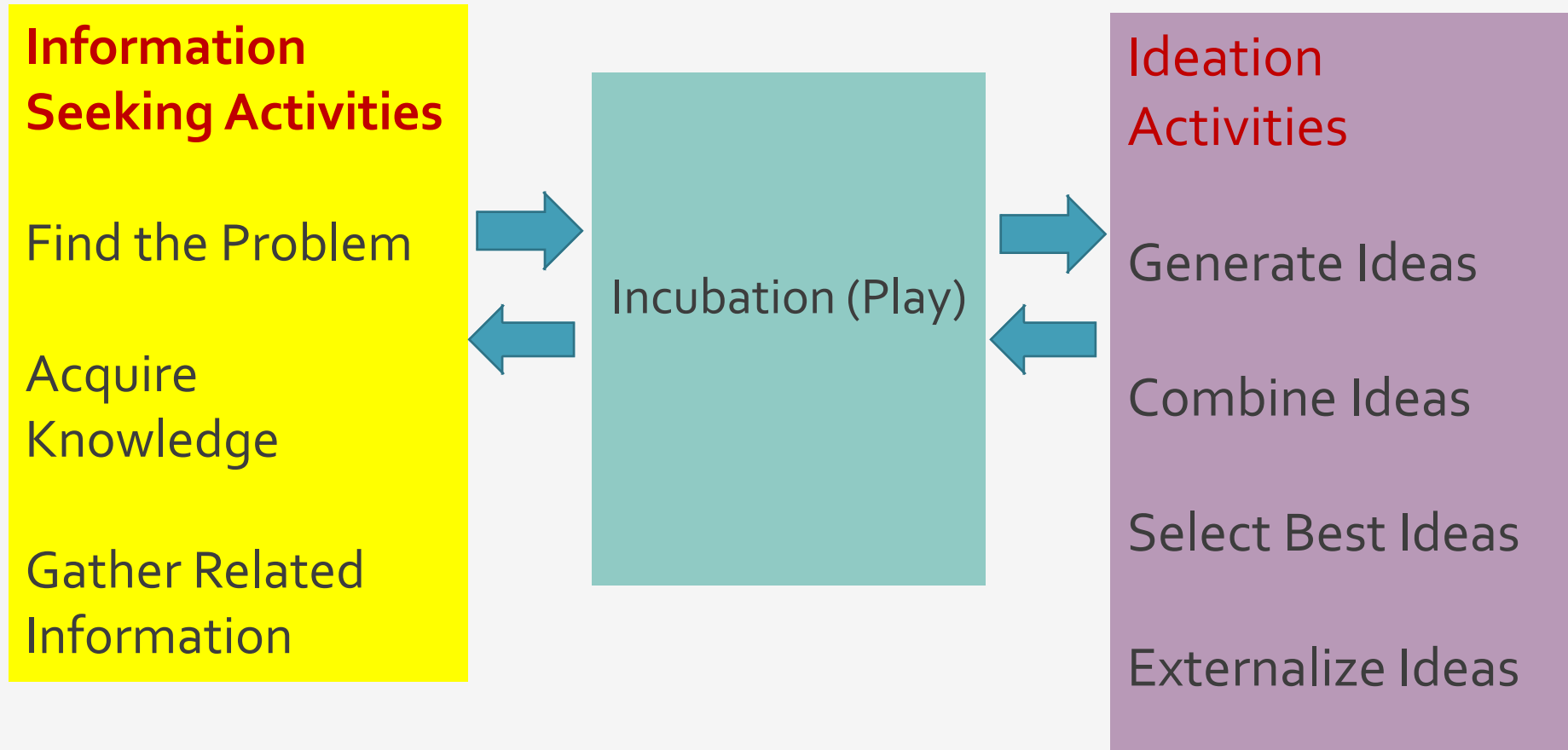
Future Search Systems Supporting Critical Thinking and Creativity

Three core constructs

- Divergent search

- Critical evaluation of information

- Creative ideation

Construct 1: Divergent Search

Intelligence:
Finding a single
correct answer

Creativity:
Discovering
multiple solutions

Vs.
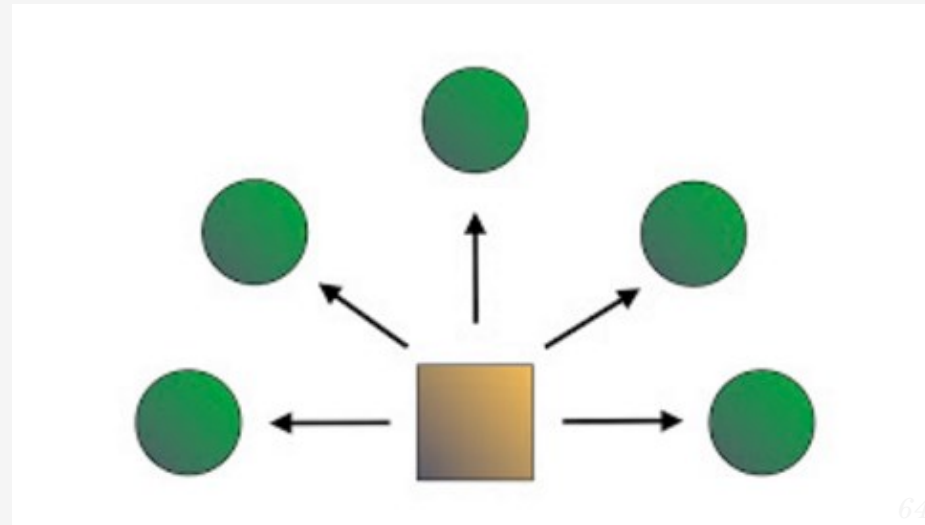
Construct 2: Critical Evaluation of Information

- Moving beyond the relevance/credibility judgment of a single document → judgment with respect to multiple search results

- Through critical information evaluation, identify the relations between multiple topics and connect the topics better

Construct 3: Creative Ideation

- Having a lot of information in hand does not guarantee the emergence of creative ideas

- Information seeking/searching → Idea generation

- Support the process of generating new and creative ideation

Creativity Support Search Systems Design Modules

Planning

Broadening the problem

Deepening topics

Combining and connecting

Externalize new ideas

Module 1: Planning the Application of Information

- Prompt users to plan what they want to learn and how they want to use information

- Provide meaning categories of user goals and intentions and ask people to select inquiry categories

What I want to learn:

I want to know how to clean up oil spills in ocean and shorelines. What chemicals are used? Are there environment effects?

How I want to use this information:

Write a research paper for coursework. ⌄

Start

Module 2: Broadening the Problem

- Broaden the problem by displaying search results from multiple perspectives

- Display diverse topics rather than listing relevant results related to a single topic

Search Result

Query: Open government policy

#	Results for Open government policy

1   **Open Government Initiative | The White House** `Open Government Data`
https://www.whitehouse.gov/open
Official government site for open government, working to ensure the public trust and establish a system of transparency, public participation and collaboration.

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A plan or course of action, as of a government, political party, or business, intended to influence and determine decisions, actions, and other matters: American...

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https://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-13.pdf
May 9, 2013 ... SUBJECT: Open Data Policy-Managing Information as an Asset ... readable and open formats, data standards, and common core and...

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Collins-Thompson, K., Rieh, S. Y., Haynes, C. C., Syed, R. (2016). Assessing learning outcomes in web searching: A comparison of tasks and query strategies. *Proceedings of the ACM SIGIR Conference on Human Information Interaction and Retrieval* (CHIIR '16), 163-172.

Module 3: Deepening Topics

- Search interface present the deep structure of search results

- Interface intervention to encourage user engagement to help them recognize inferential connections from multiple search results

title query   author query   item-to-area linking   scanning

expanding

initial book   books by same author   subject areas related to author   related material

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Thudt, A., Hinrichs, U., and Carpendale, S. 2015. A modular approach to promote creativity and inspiration in search. *Proceedings of Creativity and Cognition'15*. p. 250.

Module 4: Combining and Connecting

- Combine and connect multiple concepts

- People are encouraged to "play" active and critically with search results

- Interact with information iteratively to identify possible connections among topics

Shahaf, D., Guestrin, C. and Horvitz, E. 2012. Metro Maps of Science. *Proceedings of ACM SIGKDD'12*. 1122-1130.

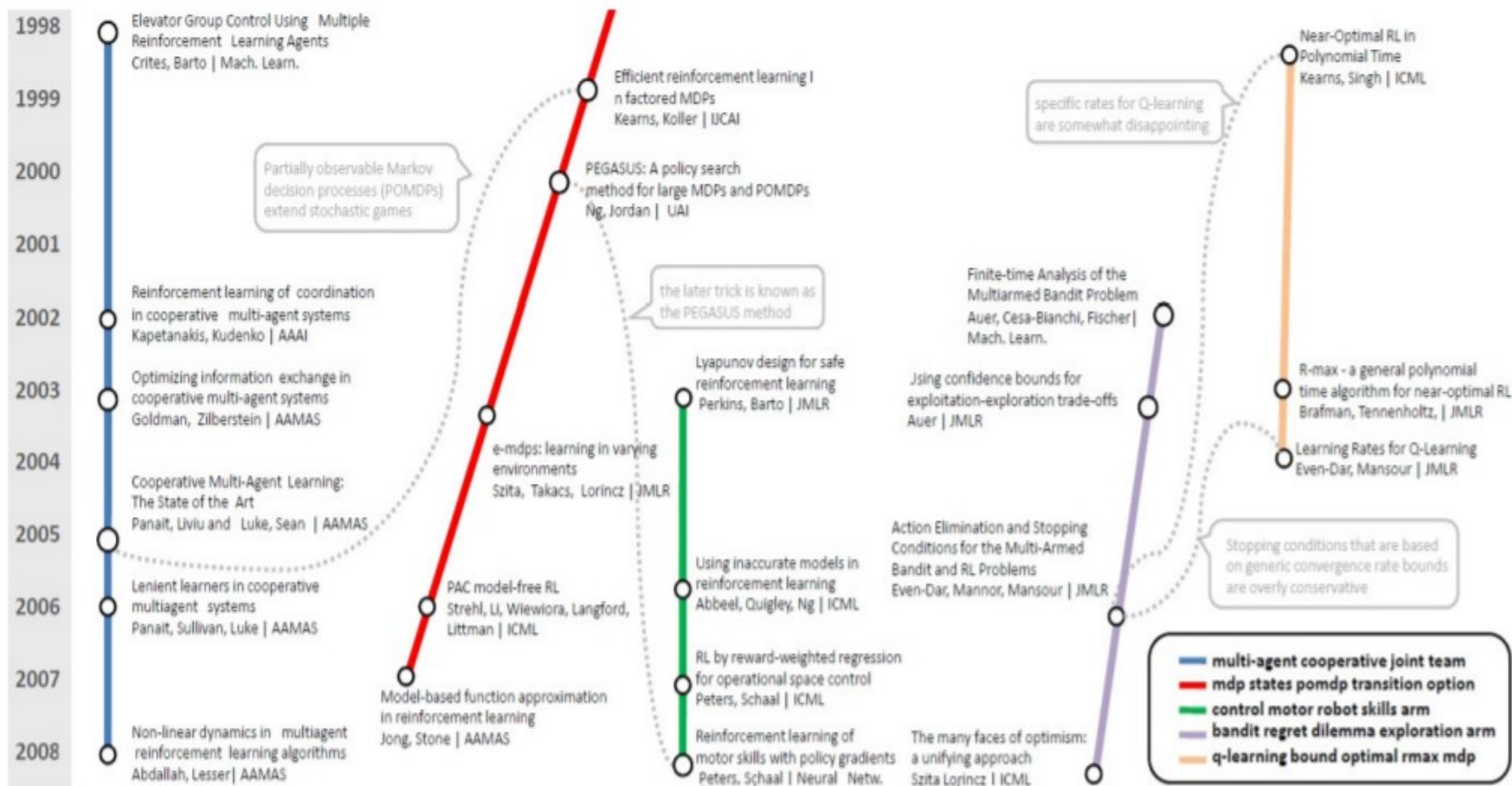| 1998 | Elevator Group Control Using Multiple Reinforcement Learning Agents Crites, Barto | Mach. Learn. | | | Near-Optimal RL in Polynomial Time Kearns, Singh | ICML |
1999		Efficient reinforcement learning in factored MDPs Kearns, Koller	IJCAI		specific rates for Q-learning are somewhat disappointing
2000	Partially observable Markov decision processes (POMDPs) extend stochastic games	PEGASUS: A policy search method for large MDPs and POMDPs Ng, Jordan	UAI	
2001			the later trick is known as the PEGASUS method	Finite-time Analysis of the Multiarmed Bandit Problem Auer, Cesa-Bianchi, Fischer	Mach. Learn.
2002	Reinforcement learning of coordination in cooperative multi-agent systems Kapetanakis, Kudenko	AAAI			
2003	Optimizing information exchange in cooperative multi-agent systems Goldman, Zilberstein	AAMAS	Lyapunov design for safe reinforcement learning Perkins, Barto	JMLR	Using confidence bounds for exploitation-exploration trade-offs Auer	JMLR	R-max - a general polynomial time algorithm for near-optimal RL Brafman, Tennenholtz,	JMLR
2004		e-mdps: learning in varying environments Szita, Takacs, Lorincz	JMLR		Learning Rates for Q-Learning Even-Dar, Mansour	JMLR
2005	Cooperative Multi-Agent Learning: The State of the Art Panait, Liviu and Luke, Sean	AAMAS		Action Elimination and Stopping Conditions for the Multi-Armed Bandit and RL Problems Even-Dar, Mannor, Mansour	JMLR	Stopping conditions that are based on generic convergence rate bounds are overly conservative
2006	Lenient learners in cooperative multiagent systems Panait, Sullivan, Luke	AAMAS	PAC model-free RL Strehl, Li, Wiewiora, Langford, Littman	ICML	Using inaccurate models in reinforcement learning Abbeel, Quigley, Ng	ICML	
2007		Model-based function approximation in reinforcement learning Jong, Stone	AAMAS	RL by reward-weighted regression for operational space control Peters, Schaal	ICML	
2008	Non-linear dynamics in multiagent reinforcement learning algorithms Abdallah, Lesser	AAMAS		Reinforcement learning of motor skills with policy gradients Peters, Schaal	Neural Netw.	The many faces of optimism: a unifying approach Szita Lorincz I ICML

Legend:
- **multi-agent cooperative joint team**
- **mdp states pomdp transition option**
- **control motor robot skills arm**
- **bandit regret dilemma exploration arm**
- **q-learning bound optimal rmax mdp**

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Shahaf, D., Guestrin, C. and Horvitz, E. 2012. Metro Maps of Science. *Proceedings of ACM SIGKDD'12*. 1122-1130.

Module 5: Externalizing New Ideas

- Develop an integrative system to support a whole critical and creative learning process

- Expand search systems to allow people to express their ideas

Kerne et al's research at Texas A&M demonstrates that connecting search results across text and image formats promotes the emergence of ideas (combinFormation system)

"Composition Space"

Andruid Kerne and Eunyee Koh (2008). combinFormation: Information Discovery through the Mixed-Initiative Composition Space. http://www.ieee-tcdl.org/Bulletin/v4n1/koh/koh.html

Next Steps

- Investigate future search systems as potential learning technology that could enhance human capability in learning

- Long way to go!

Takeaway

- Search systems as an everyday tool

- People tend to take things for granted in search systems

- Impact of information found in IR systems

- Contribution of searching to enhance human capabilities (e.g., decision-making, academic performance, work performance, creativity, etc.)

Thank you!

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