Cognition, Conceptual Development, and Conceptual Change

Graduate Course, HBCSE, TIFR

2019-2020 – Semester 1

Monsoon 2019

Instructors: Sanjay Chandrasekharan, Sweta Anantharaman, Mashood K.K.

Credits: *4*
Duration: *16 weeks (9 August to 06 December); Saturday class will make up for any holidays*
Time and Location: *Monday 3-5 PM, Friday, 3-5 PM; Room 102/217, Main Building, HBCSE*
Important date*: Final paper due on December 16*

This course explores the research literature on the way concepts develop and change in children and adults, particularly from the perspective of developmental science and cognitive science.

The first part of the course seeks to provide a brief overview of three topics. First, some classical theories of learning are explored. Next, some cognitive psychology topics related to learning will be discussed. Finally, some developmental psychology papers related to mathematics and science learning will be discussed.

After this overview of some basic ideas related to cognition, we will discuss three prominent threads in science and math education research -- namely misconceptions, model based reasoning and conceptual change -- which have drawn from, and contributed to, cognitive science discussions about the nature of the mind. We will critically look into the models of the mind, and assumptions regarding human cognition, underlying these discussions.

Learning Objectives: The course seeks to establish basic concepts in cognition research, to help the student understand the ways in which the rich and complex literature in learning sciences and cognitive psychology relate to education. A second objective is developing the skills to ask critical questions about this research, particularly its application/relevance to education. A final objective is to have an idea of how cognitive science and theories of learning contribute to, and draw from, science and mathematics education research.

Reading Material

The course requires extensive reading (30-40 pages a week), based on the books and papers below.

1. Cognition Section: Smith, E. E. & Kosslyn, S. M. (2007). *Cognitive Psychology- Mind and Brain*. Pearson Education Inc., New Jersey.
2. Developmental Psychology Section: See table below
3. Conceptual Change: See table below

All readings will be provided as pdf files. The title for each week in the course plan below indicates the topic covered in that week.

Class Structure

The class will be participant-driven and discussion-based. Each week's readings would be presented by a team of two participants, possibly in two sections, and they will lead the discussion. This cycle will continue throughout the course. All participants are requested to read the text beforehand, so that there is a common base to discuss and critically analyse the issues raised by the papers.

All participants have to turn in a "Comments and Queries" (C&Q) document on Monday to the TA, focusing on the week's readings and focus questions. See Note 1 below for guidelines on what is expected in this document. The Comments and Queries could also be used to frame the discussion in the class. Participants who are presenting the material in a given week need not submit this document for that week, but generating these would be useful in guiding the discussion. The TA will provide feedback on your C&Q documents and the presentations. See Note 2 for guidelines on presentations.

You will work with the TAs to develop a concept map of the reading, integrating the various concepts covered in the reading, to generate a big picture. This activity will be done in class, for the modules where it is possible. The map will be built on the whiteboard by teams, and this activity will contribute to your class participation grades.

Assessment

Students taking the course for credit will be graded on the basis of two submissions. A final term paper (50%), the Comments and Queries document, Class Presentations and Class Participation (50%). Each C&Q/Class-Presentation carries 5 marks. Your C&Qs and Class Presentations together should total a minimum of 10 submissions.

The final term paper should preferably connect the student's interest in education with one of the topics covered in the course. A rough outline of the term paper should be submitted by November 15, and a clear outline (argument structure) of the paper developed in discussion with the instructor. See Note 3 on what is expected for the term paper.

Course Plan

Week	Date	Topic	Reference Chapter/ Paper
0	Aug 9	Introductions, scheduling, course orientation	
1	Aug 12,16	Piaget, Bandura	*H&O Chapter 11 & 13*
2	Aug 19, 23	Vygotsky	*Mind and Society Chapter 1,2,3,6,7*
3	Aug 26, 30	Representation and Knowledge in Long-Term Memory	*Smith and Kosslyn*
4	Sept 2, 6	Encoding and Retrieval from Long-Term Memory	*Smith and Kosslyn*
5	Sept 9, 13	Working Memory, Executive Processes	*Smith and Kosslyn*

6	Sept 16, 20	Core knowledge Flexible intuitions of Euclidean geometry in an Amazonian indigene group.	Spelke & Kinzler (2007) Izard V, Pica P, Spelke ES, Dehaene S.
7	Sept 23, 27	Reconstructing constructivisim Bayes and Blickets: Effects of Knowledge on Causal Induction in Children and Adults	Gopnik & Wellman (2012) Thomas L. Griffiths David M. Sobel Joshua B. Tenenbaum Alison Gopnik
8	Sept 30, Oct 4	The role of gesture in communication and thinking Gestures help learning	Goldin-Meadow (1999) Wakefield et al (2018)
Break	**Oct 7, 11**	**Dussehra**	
9	Oct 14, 18	Learning from Others: Children's Construction of Concepts Book chapter - Conceptual Development	Gelman (2009) Gelman & Kalish (2008)
10	Oct 21, 25	*A history of conceptual change research: Threads and fault lines.* *Misconceptions reconceived: A constructivist analysis of knowledge in transition.*	*DiSessa, A. A. (2014).* *Smith III, J. P., Disessa, A. A., & Roschelle, J. (1994). The journal of the learning sciences, 3(2), 115-163.*
11	Oct 28, Nov 1	*Misconceptions or p-prims: How may alternative perspectives of cognitive structure influence instructional perceptions and intentions.* *Conceptual change: A powerful framework for improving science teaching and learning.*	*Hammer, D. (1996). The Journal of the Learning Sciences, 5(2), 97-127.* *Duit, R., & Treagust, D. F. (2003). International journal of science education, 25(6), 671-688.*
12	Nov 4, 8	*How do scientists think?*	Nersessian, N. J. (1992).

		Capturing the dynamics of conceptual change in science. Capturing and modeling the process of conceptual change.	*Cognitive models of science*, *15*, 3-44. Vosniadou, S. (1994). *Learning and instruction*
13	Nov 11, 15	*What kind of explanation is a model?.* *Model based learning as a key research area for science education*	*Lehrer, R., & Schauble, L. (2010). In Instructional explanations in the disciplines (pp. 9-22). Springer, Boston, MA.* *Clement, J. (2000). International Journal of Science Education, 22(9), 1041-1053.*
14	Nov 18, 22	*Modeling theory for math and science education.* *Conceptual metaphor meets conceptual change.*	*Hestenes, D. (2010). In Modeling students' mathematical modeling competencies (pp. 13-41). Springer, Boston, MA.* *Amin, T. G. (2009). Human Development, 52(3), 165-197.*
15	Nov 25, 29	*Categorization and representation of physics problems by experts and novices. Cognitive science, 5(2), 121-152.* *Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In International handbook of research on conceptual change (pp. 89-110). Routledge.*	*Chi, M. T., Feltovich, P. J., & Glaser, R. (1981).* *Chi, M. T. (2009).*
16	Dec 2, 6	*Personal, deeply affective, and aesthetic engagement with science content. Converging*	*Levrini, O., Levin, M., & Fantini, P. (2018).*

		perspectives on conceptual change: Mapping an emerging paradigm in the learning sciences, 305-312. ***Reflection***	

Note 1: Comments & Queries

1) A summary of the papers is not expected. If summarising helps you in understanding the material, you should still do it. But don't submit this summary, keep that part as a separate file, and refer to the summaries when you run into problems or get stuck while conceptualizing/writing your final paper/proposal/thesis.

2) Queries with the following structure are not useful: "how can we use (say) mental imagery for education/design"? There is no clear answer to this question, because it is too general. It would be better if you turn such questions into something like: "in math/science education, there is this problem of XYZ, and the author's ideas seem to imply that strategy ABC would be useful/would not work, is this right?" or something along these lines. To do this, you will have to do some focused thinking about the author's ideas, and apply it to a problem you are familiar with. If you have a question like this, other people can contribute to the discussion, and maybe even help you solve a problem.

3) Comments along the lines of "this view is interesting", "the author has done a good job" etc. are not useful. Comments should show close engagement with the ideas in the papers. So something like "the author's position seems to contradict/support the position of (another) author X in the following way" or "the data seems to be showing X, but it does not seem to support the author's claims" or "the author argues for X, but it has the following implication, which is undesirable" etc.

4) Before writing your C&Q, try to think a little more deeply about the implications of the ideas presented by the authors, and also try to connect their ideas with other things you have read, in the class or outside. This would help you come up with C&Qs that are closer to the description above.

Note 2: Presentations

All presentations should follow the structure below:

1) What are the major findings/claims reported in the section?
2) What designs/data/arguments support these findings/claims?
3) How well does the design/data/argument support the findings/claims? What are the main problems?
4) What would be other better ways to support the findings/claims?

5) What implications/connections could follow from the findings/claims, particularly for education?
6) Any details you would like to highlight.

Using 1 slide for each of these questions would be the ideal format. Aim for a 15 minute presentation for each paper. Presentations for each day can be up to 30 minutes in total.

Note 3: Term Papers

The following points should be kept in mind while picking your topic for the term paper, and during writing of the paper.

*1) The paper should be around 15-25 pages, single space. Why is this an important point? Because you should choose a topic that *requires* that much space for discussion. If you choose a very broad topic, you will not be able to do justice to it in this amount of space. If you choose a very narrow topic, you will not have enough things to say to fill that amount of space. The size of the paper is a good way to "scope" your topic.*

2) The paper should have an argument. That is, it should have some clearly articulated premises, and a conclusion that follow from these, preferably with some discussion of data/results that support the conclusion. For instance, you can argue that neuroscience research is irrelevant for science education. Or you can argue that imagery research can inform physics learning. But you should give reasons for why you think this is the case. The requirement for an argument means the paper cannot be a literature review, a discussion of a new approach to science education, or an evaluation of a new technology. The argument structure makes the term paper similar to a miniature thesis, or a journal paper. If you write a few of these during your course work, you will be able to deal better with your research proposal and thesis.

3) The process of writing *the paper should make you think. This is sort of implicit in the previous point, as you cannot develop an argument without thinking. However, in academic writing, particularly in humanities and social sciences, apart from the thinking you do to develop the argument, you also think *through writing*. This involves being able to see counter examples and counter arguments as you develop your argument in text, and then finding ways of countering them. This process can take a life of its own, and might lead you into many tangents that prevent you from developing your core thesis, so part of the skill here is learning how to do this in a controlled fashion.*

4) Ideally, you should pick a topic that is related to a possible thesis topic you have in mind. This way, you can reuse the thinking you do for the term paper while developing your research proposal.

5) The paper should have an abstract (~150 words) that summarises its key points.

6)The term paper is due on December 15th midnight. This is a hard deadline, as I have to turn in the marks by the date specified by TIFR.

7) Two alternatives to term papers could be: 1)Developing and executing a new experiment, to test a new hypothesis; 2) Reviewing a book. Texts based on these would also need to follow the above structure. Further, you need to discuss ideas for these with the instructor beforehand, to develop a clear structure of what you will be doing.

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