Cognition, Conceptual Development, and Conceptual Change

Graduate Course, HBCSE, TIFR

2022-2023 – Semester 1

Monsoon 2022

Instructors: Sanjay Chandrasekharan, Sweta Anantharaman

TAs: Pranshi Upadhyay, Joseph Salve

Course Title: *Cognition, Conceptual Development, and Conceptual Change*

Course Code: *SCE106.2*

Credits: *Four*

Duration: 17 *August to 14 December*

Time and Location: *Monday 3-5 PM, Wednesday, 10-12 AM; Room 217, Main Building, HBCSE*

Contact hours: 64 hrs, 32 sessions, 15 weeks, *(17 August to 14 December)*

Instructors: *Sanjay Chandrasekharan, Sweta Anantharaman*

Time and Location: *Monday 3-5 PM, Wednesday, 10-12 AM; Room 217 or 102, Main Building, HBCSE*

Important date*: Final paper due on December 25*

Learning Objectives

- *Understand how learning sciences and cognitive psychology relate to education*
- *Establish the basic constructs related to cognition-oriented education research*
- *Critically evaluate cognition research, particularly to see how it applies to education*
- *Explore how recent theories and technologies related to cognition and interaction contribute to, and draw from, science and mathematics education research*

About the course

This is a survey course, introducing cognition-oriented education research, particularly from the perspective of developmental science and cognitive science. It presents studies and analyses of the way learning and concepts develop, and change, in children and adults.

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 concept learning will be discussed.

After this overview of some older constructs related to cognition, we will discuss three theoretical approaches focusing on science and mathematics education research -- namely conceptual change, transfer, and model-based reasoning – and how they draw from, and contribute to, cognitive science discussions about the nature of the mind.

The final segment of the course introduces some recent analyses and studies based on embodied interaction theories, and also the emerging field of teacher cognition.

Across the course, the discussions will critically examine the models of the mind, and assumptions regarding human cognition, underlying these education discussions.

Learning Objectives: This survey course seeks to familiarise students with some basic constructs developed by cognition-oriented science education research. It will help students understand the ways in which cognitive psychology and the sciences of learning relate to education. A related objective is developing the skills to ask critical questions about this research, particularly its application/relevance to education. A final objective is to briefly introduce the way in which recent theories and technologies related to cognition and interaction 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. Classical Theories of Learning: *See table below*
2. Cognitive Psychology: *Smith, E. E. & Kosslyn, S. M. (2007). Cognitive Psychology- Mind and Brain. Pearson Education Inc., New Jersey*
3. Developmental Psychology: *See table below*
4. Conceptual Change: *See table below*
5. Technology and Embodied Cognition: *See table below*
6. Teacher Cognition: *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 by Sunday 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.

Apart from the C&Qs, students will need to work with the TA to develop a concept map of the readings in each section, integrating the various concepts covered in the readings, 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 the following. A final term paper (20%), the Comments and Queries document (40%), Class Presentations (20%) and Participation in the concept mapping excercise and class discussions (20%). Each C&Q/Class-Presentation carries 6 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.

Important Note: As there have been a few instances of plagiarism in past term paper submissions, students are now required to generate a plagiarism report using Urkund, the plagiarism checking software used by TIFR. Please contact Ravindra for details on using this software.

Course Plan

Week	***Date***	***Topic***	***Reference Chapter/ Paper***
0	Aug 17	Introductions, scheduling, course orientation, LSR	
		Classical Theories of Learning	
1	Aug 22, 24	Folk pedagogy A short history of learning theories, Models of the Learner	*Bruner 1996* *Bruner 2004, 1985*
2	Aug 29, 31	Piaget Bandura	*H&O Chapter 11, 13*
3	Sept 5, 7	Vygotsky 1,2,3 Vygotsky 6,7	*Mind and Society Chapter 1,2,3,6,7*
		The Cognitive Turn: Memory, Categorisation, and Executive Control	
4	Sept 12, 14	Representation and Knowledge in Long-Term Memory	*Smith and Kosslyn*
5	Sept 19, 21	Encoding and Retrieval from Long-Term Memory	*Smith and Kosslyn*

6	Sept 26, 28	Working Memory, Executive Processes	*Smith and Kosslyn*
Break	**Oct 3, 5**	**Dussehra**	
		The Developmental Psychology Perspective	
7	Oct 10, 12	Core knowledge Reconstructing constructivisim	Spelke & Kinzler (2007) Gopnik & Wellman (2012)
8	Oct 17, 19	Learning from Others: Children's Construction of Concepts The role of gesture in communication and thinking Gestures help learning	Gelman (2009) *Goldin-Meadow (1999)* *Wakefield et al (2018)*
Break	**Oct 24, 26**	**Diwali**	
		The conceptual change perspective	
9	Oct 31, Nov 2	A history of conceptual change research: Threads and fault lines. Conceptual change: A powerful framework for improving science teaching and learning.	*DiSessa, A. A. (2014).* *Duit, R., & Treagust, D. F. (2003). International journal of science education, 25(6), 671-688.*
10	Nov 7, 9	Rethinking transfer: A simple proposal with multiple implications. Dynamic transfer and innovation	*Bransford, J. D., & Schwartz, D. L. (1999). Review of research in education, 24(1), 61-100.* *Schwartz, D. L., Varma, S., & Martin, L. (2008). International handbook of research on conceptual change, 479-506.*
11	Nov 14, 16	How do scientists think? Capturing the dynamics of conceptual change in science.	Nersessian, N. J. (1992). *Cognitive models of science, 15,* 3-44.

		Capturing and modeling the process of conceptual change.	Vosniadou, S. (1994). *Learning and instruction*
12	Nov 21, 23	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.*
		The Embodied Interaction Perspective	
13	Nov 28, 30	Restructurations: Reformulating Knowledge Disciplines through New Representational Forms Constructing liminal blends in a collaborative augmented-reality learning environment	*Uri Wilensky, Seymour Papert 2010* *Noel Enyedy & Joshua A. Danish & David DeLiema, 2015*
14	Dec 5, 7	Shuttling Between Depictive Models and Abstract Rules: Induction and Fallback. Mechanical reasoning by mental simulation Embodied Learning in Makerspaces.	*Schwartz, D. L., & Black, J. B. (1996). Cognitive Science, 4(20), 457-497.* *Hegarty 2004* *Sinha, R., Date, G., Chandrasekharan, S. (2021)*
		Teacher Cognition and Academic Language	
15	Dec 12,14	The narrative construction of reality Teacher enaction: modeling how teachers build new mechanism concepts in students' minds. Making mechanisms: how academic language mediates the formation of dynamic concepts. ***Reflection***	*Bruner 1991* *Upadhyay, P., Salve,J., Mashood, K.K., Chandrasekharan, S. (2021).* *Salve, J., Upadhyay, P., Mashood, K.K., Chandrasekharan, S.(2021)*

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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