Centre for Educational Research and Teaching Excellence (CERTEX)

IIT Kanpur

REPORT ON WORKSHOP ON INSTITUTE CORE COURSES

Held on: 01-03-2025

INTRODUCTION

CERTEX (Centre for Educational Research and Teaching Excellence)) is mandated to advance research-driven pedagogy, analyze the efficacy of emerging learning technologies, and address diverse student needs. Through such initiatives, IIT Kanpur seeks to consolidate its position as a pioneer in innovative education.

The first formal workshop of CERTEX was held against the backdrop of the new pedagogic challenges in undergraduate STEM (Science, Technology, Engineering, and Mathematics) education. It is a rapidly evolving domain, with new knowledge seeking to displace classical topics. There is a continuing debate on what essential knowledge in undergraduate education at IIT Kanpur should be.

This workshop focused on refining **Institute Core Courses (ICCs)**, which form the foundational backbone of undergraduate education at IIT Kanpur. ICCs aim to impart skills and knowledge in diverse fields required for a strong scientific temper, basic technical skills, and a world-view that makes them responsible citizens. Balancing classical knowledge with emerging innovations remains a critical challenge as STEM disciplines evolve rapidly. ICCs must adapt dynamically to equip students with scientific rigor, technical proficiency, and a global perspective, fostering responsible citizenship.

CORE COURSE FRAMEWORK AT IIT KANPUR

ICCs, spanning the first two years of undergraduate studies, are categorized into four sub-domains:

1. **Basic Sciences**
2. **SCHEME (Social Sciences, Communication, Humanities, Economics, Management, and Environment)**
3. **Technical Arts**
4. **Engineering Sciences**

While these domains represent essential pillars of knowledge, their content, pedagogical focus, and delivery must evolve alongside advancements in tools, technologies, and industry demands. The proliferation of new undergraduate programs — tailored to emerging technical disciplines — further necessitates agile curriculum design.

WORKSHOP OBJECTIVES

The workshop addressed two primary themes:

1. **Role and Expectations of ICCs**: Aligning core courses with departmental, industrial, and student aspirations.

2. **Effective Pedagogy**: Strategies for enhancing teaching efficacy amid expanding student cohorts and evolving academic priorities.

METHODOLOGY

Insights were gathered through structured exercises:

1. **Departmental Presentations**: Faculty outlined expectations from ICCs, emphasizing course delivery, evaluation practices, and observed challenges.

2. **Panel Discussion**: Distinguished faculty deliberated on pedagogical philosophies, curriculum design, and interdisciplinary coherence.

CONCLUSION AND KEY RECOMMENDATIONS

Core courses are integral to undergraduate education at IIT Kanpur, fostering interdisciplinary knowledge, scientific rigor, and a humanistic perspective essential for holistic student development. These courses cultivate creative thinking, technical proficiency, and a sense of responsible citizenship, preparing students for both specialized and broader professional challenges. As such, core courses should continue to be an essential part of the IIT Kanpur educational experience, evolving concurrently to meet their goals.

CERTEX recommendations in this regard are given below, organised into four subsections:

A. CURRICULUM DESIGN & COLLABORATION

1. **Basket of courses**: Allow students/department to take core-courses from a basket of courses. An example of this is the basket of four courses offered by the Department of Physics, out of which two are taken by any department.
2. **Stakeholder involvement:** All departments contributing to ICCs must co-design curricula, also taking feedback from those departments whose students take these courses.
3. **Faculty Engagement**: All participating departments should contribute tutors and instructors to maintain diverse expertise in course delivery.
4. **Flexible Learning Pathways**: Allow students to pursue additional core courses later in their UG program, as and when deemed necessary, to align with their evolving professional aspirations.

5. **Balance Theory and Application**: Prioritize conceptual depth alongside hands-on implementation, ensuring a blend of foundational principles and real-world problem-solving.
6. **Eliminate Redundancy**: Audit courses institute-wide to remove overlapping content and streamline syllabi.
7. **Dynamic Content Updates**: Refresh course material more frequently than the current ten-year period. This refresh can take place through dedicated faculty workshops and inter-departmental collaboration.

B. PEDAGOGICAL ENHANCEMENT

8. **Industry-Academia Integration**: Incorporate regular industry feedback and guest lectures to align core knowledge with practical demands.
9. **Standardized Evaluation**: Ensure uniformity in content delivery and assessment methods across semesters.
10. **Faculty & TA Training**: Conduct annual workshops to train tutors, teaching assistants, and lab staff in innovative pedagogy and course-specific methodologies.
11. **Optimized Class Sizes**: Reduce tutorial and lecture section sizes, particularly for HSS courses that require interactive discussions.

C. STUDENT ENGAGEMENT & COMMUNICATION

12. **Emphasize Syllabus Depth**: Clarify the advanced nature of first-year courses to dispel misconceptions stemming from the superficial JEE syllabus overlaps. With the background of the JEE preparation, the students often miss out on appreciating the depth of the new syllabus and its importance in their education at IIT Kanpur.
13. **Raise Awareness**: Highlight the significance of core courses through departmental video clips, student brochures, and dedicated sections in orientation materials, in addition to updates on education at IITK.
14. **Enhance Communication Skills**: A critical concern in core courses is first-year students' underdeveloped communication skills, mainly writing—a gap exacerbated by intensive JEE preparation. Core courses need to integrate communication skill enhancement. For instance, students could be encouraged to make short audio/video presentations of snippets of key concepts taught. These exercises will help improve communication skills and make the student an active learner through peer validation.

D. INSTITUTIONAL SUPPORT

15. **Departmental Oversight**: Establish departmental committees to monitor and maintain coherence in course content and its delivery, and evaluation standards.

16. **Resource Repository**: Develop a centralized digital repository for syllabi, teaching materials, and case studies to facilitate resource sharing.

Detailed departmental presentations and panel discussions are appended (**Appendix A and B**).

CERTEX ACTION PLAN

1. **Stakeholder Surveys**: Conduct biennial surveys among alums, industry experts, students, and faculty to evaluate core course impact.
2. **Promotional Content**: Collaborate with departments to create explanatory documents and multimedia resources for core courses.
3. **Workshop Facilitation**: Organize biannual curriculum-update workshops and annual instructor training sessions.
4. **Resource Management**: Develop and maintain a digital repository for core course materials accessible to all stakeholders.

Acknowledgments

The committee extends its gratitude to the speakers, panelists, attendees, and all other associates for their insights and contributions towards shaping the future of undergraduate education at IIT Kanpur. The committee explicitly thanks Professor Pradip Sinha for the editing and final structuring of the report. The synergy created in this process of thinking together is warmly cherished by all members.

(Ritika Gautam) (Manoj K. Harbola) (Aditya K. Jagannatham) (Aditya H. Kelkar)

(Amit S. Kuber) (Santosh K Misra) (Satyaki Roy) (Ushasi Roy)

(Vineet Sahu) (Chandra Shekhar Upadhyay) (Ark Verma)

Enclosed Appendix I and II

APPENDIX-A:

PRESENTATION BY THE DEPARTMENTS

THE SPEAKERS:

1) *Dr. Anna Thottapilly (Economics)*
2) *Dr. Rajat Mittal (CSE)*
3) *Dr. Vipul Arora (EE)*
4) *Dr. Pritam Chakraborty (AE)*
5) *Dr. Suchitra Mathur (HSS)*
6) *Dr. Sudeep Bhattacharjee (Physics)*
7) *Dr. Sumit Basu (ME)*

The speakers belonged to diverse departments –users and teachers of several core courses. Each department had distinct observations about the current core courses, their structure and content, and how they are taught. They shared their valuable insights. These can be grouped under the following heads:

1. The teaching of physics and other introductory science courses.
2. Teaching of Engineering Computations
3. Teaching of Electronics and Electrical Circuits
4. General teaching of ESO courses
5. Teaching of Technical Arts 111
6. Teaching of Economics
7. Teaching of Humanities and Social Sciences
8. General observations

The salient points from the presentations and the ensuing discussions are listed below.

1. **Views of the Department of Economics on teaching core Economics courses:**

(1) The course exposes the initially reticent student to economics, society, and public policy.

(2) The course sensitizes the student on the role of economics in their evolution as decision-makers.

(3) New paradigms in pedagogy involve linking the course to daily life and experience.

(4) Open new perspectives concerning the world around us, like the role of wars, inflation, and the age of start-ups.

(5) Emphasize the importance and beauty of data through live experiments in class using mobile apps. Bring modern concepts like game theory through daily experiences – e.g., climate change.

2. **Views of the Department of Computer Science and Engineering:**

Core is viewed in three parts: (a) Core by CSE, (b) Core for CSE, and (c) Teaching core effectively.

Core by CSE:

They teach introduction to programming, data structures, and algorithms. The teaching experience is based on this. Further experiences are with their students taking other core courses:

(1) Programming language is a philosophy – learn fundamentals and apply them anywhere.
(2) Should the flipped or unflipped mode of teaching be used?
(3) Should old content be replaced with new, or course modernization is required? E.g., LLM, code completion, python, or C.
(4) Diversity in pre-knowledge in the classroom is a problem.
(5) Algorithms are fundamental; programming language is secondary.
(6) Emphasis on algorithms aligns well with industry expectations.
(7) Core in ML was debated, and opinions were divided.
(8) It can offer a general ML core, but load distribution across departments is required through collaborative teaching.

Core for CSE students:

(9) Chemistry and Life sciences core are not essential for CSE students.
10) Need flexibility in science basket (e.g., physics options for CSE students).
11) The department would like room in the curriculum to introduce CSE courses in the first year.
12) The ethics course is not working and has to be reviewed.

Teaching core effectively:

13) Student tutors have not been effective, and review reports are consistently poor. I need to revert to faculty tutors. Collaboration from other departments is required to take care of human resource requirements.

3. Views of the Department of Electrical Engineering:

The EE department teaches ESC201 (Introduction to Electronics). The opinion on teaching core is primarily based on this experience.

(1) The course is too heavy, with all topics not necessarily relevant to non-EE students. Need to review and streamline content.
(2) Large class size (600+ students) is a significant constraint – limited interaction constrained laboratory spaces.
(3) Need content overhaul – should be application-oriented with substantial input from other departments (e.g., use of sensors, bio-medical electronics, etc.), remove redundancies, and make laboratories interactive and engaging.
(4) Need to upgrade infrastructure and laboratories.
(5) We need to inculcate a sense of ownership amongst the instructors for this course. There should be a dedicated team of faculty who run the course and supervise the laboratories.
(6) Better coordination is needed among instructors and tutors to make tutorials effective.
(7) Training of new instructors is essential.
(8) Training for tutors and laboratory staff is also needed.

(9) Collaboration in teaching and removing duplication (in courses across departments) is required.
10) I need to revisit the Quantum Mechanics course taught by physics. Better coordination can help streamline the content of this course.
11) Due to timetable clashes, EE students have trouble registering for data structures and algorithms courses. Timetabling has to be better coordinated.

4. Views of the Department of Aerospace Engineering:

The department teaches and participates in core courses on Fluid Mechanics, Solid Mechanics, Thermodynamics, and Engineering Drawing (TA111).

(1) The department emphasized the need to review program objectives (of each department) and learning outcomes for undergraduate students. Course refinement (type, content, and style) must be done accordingly.
(2) The core template should be seen as the common overlap of basic knowledge essential for the student to mature as a technologist/engineer/scientist and provide basic life, social, and STEM skills.
(3) Share core teaching and learning loads to optimize resource utilization.
(4) Create a pool of experts (from across departments) who teach and update specific core courses' content.
(5) Maintain a repository of legacy lectures, especially for reference of future generations of teachers. Simultaneously, the content should be revised, refined, and updated while incorporating modern teaching best practices.
(6) Institutional and departmental goals of undergraduate education should be clear to the faculty – with a balance between theory and hands-on experience.
(7) Create a set of (evolving) non-core job-related courses to be offered in the summer (could include courses on AI, ML, Engineering Computations, Advanced Manufacturing, Robotics, etc.).
(8) Remove redundancy across departments.
(9) Involve industry in core course design. Understand the expectations of employers in the core sector.
10) Create mechanisms for guest lectures from domain and industry experts.

5. Views of the Department of Humanities and Social Sciences:

They offer several HSS -electives, which are mandatory for undergraduate students.

(1) Functional core teaching should focus on why and how.
(2) Develop critical thinking in the students.
(3) A discussion mode of teaching is required to sensitize the student to society. Thus, a small class size is essential – something we have failed to maintain.
(4) Sow seeds of responsible citizenship by developing empathy and responsibility.
(5) Level I courses are introductory and inculcate new ways of seeing and producing knowledge. Level II courses go into specialized topics.

(6) English language teaching has to be handled by English Cell (and not HSS), and communication skills cannot be treated as an HSS course.
(7) Allotment of HSS courses is lottery-based and is not liked by students or faculty.
(8) HSS faculty is heavily loaded, as each has to offer one HSS elective every semester.
(9) Students find it challenging to take HSS electives, as departmental and open electives also fill their designated slots.

10) Suggestion: Have a Philosophy of Science and Analytical Philosophy course.

11) Suggestion: Find an alternative to the lottery system.

12) Suggestion: Make HSS courses modular, with more tutorials.

13) Suggestion to have multiple sections for a course instead of large lecture classes followed by tutorials.

14) Suggestion: Bring environment and sustainability into the courses.

6. Views of the Department of Physics:

The department offers a basket of courses for the core physics curriculum. Departments choose specific courses from this basket for their students.

(1) Physics offers four courses, and departments choose two out of them. Gives choices to departments.
(2) The goal of core teaching is the development of scientific temper, employing general techniques for problem-solving.
(3) Content should be reasonable and presentation lucid.
(4) Develop the student's capability for rational arguments and use of tools for analysis and experimentation to comprehend and analyze data.
(5) Use technology to augment pedagogy – give different perspectives of problem interpretation and solution, use live demonstrations with working models, and use multimedia to simplify understanding.
(6) Update yourself as a teacher, using concepts from pedagogical journals.
(7) Challenge the gifted student.
(8) Request that CERTEX develop a repository of experiments, demonstration models, and videos to help with teaching.
(9) We need to develop a laboratory to support experimental demonstrations.

10) Encourage students to develop experiments or devices.

11) Course management support systems need to be streamlined, such as printing booklets and question papers and training PhD students to assist in the conduct of tutorials and grading.

12) Suggestion: Unclutter the courses; lecture-wise plan and fine-tuning of lecture to deliver enough; gauge effectiveness of learning.

13) Suggestion: Encourage using current knowledge to innovate in the laboratory.

14)Suggestion: To overcome disparities in learning, send out notes and use HelloIITK effectively.

15) Use CERTEX to plan blue-sky experiments for students.

7. Views of the Department of Mechanical Engineering:

The department participates in teaching several core courses, like Fluid mechanics, Solid mechanics, Dynamics, Thermodynamics, and Technical Arts.

(1) Engineering graphics (TA111) has to be revisited and reworked.
(2) The goal of the course should be clear – whether to develop an understanding of engineering drawing or to acquire the skill of making CAD drawings using software.
(3) The course is focused on (often) instructors who do not work with graphics or CAD. We need to train the instructor also.
(4) Suggestion: A specialized CAD cell should be set up to run the course; upgrade infra-structure (CAD stations, software support); use machine grading; decide on essential content that needs lectures and the part that CAD can handle.
(5) Student tutors are untrained, have shallow understanding, make mistakes in grading, and manage classes poorly. We need to figure out whether faculty tutors are essential or whether we need to train student tutors well to aid in the conduct of the course.
(6) Suggestion: Do away with drawing and introduce a design course.
(7) Suggestion: Make the course modular – Projections and CAD as separate modules.
(8) Suggestion: CERTEX can conduct training programs for graphics and CAD instructors and tutors.

Some key points on core pedagogy processes and effectiveness emanating from the discussions:

ECONOMICS

1) Experiential learning – live examples (audio-video-hardware), use apps and online tools for in-class demos, link to daily experiences, societal and world-view.
2) Continuous evaluation – In-class data handling, participative learning (group experiments and break-out sessions), impromptu in-class examinations.

CSE

3) There is too much diversity in class – expert programmers to strugglers.
4) How do we keep everyone excited and engaged? How do you teach effectively?
5) Attendance is abysmal.
6) Course offerings should be homogeneous across semesters. There seems to be a lot of variation from one instructor to the next. Attendance, grading policy, and syllabus should be similar across semesters.
7) Resources needed—for example, availability of notes for all students to see and use.
8) Language is a means to build logical reasoning.
9) I need to go back to faculty tutors as feedback from student tutors is terrible.
10) First, and second-year core content should be decided by departments and enforced. We should have clarity while designing the program syllabus rather than try to please students.
11) Flipped classroom mode has to be appropriately implemented and monitored. Due to callousness, several instructors do not follow the three contact hours per week. We need to

enforce policies from the top. The flipped mode of teaching is debatable and not uniformly accepted by all.

EE

(1) Large class size (600+ students) is a significant constraint – limited interaction constrained laboratory spaces.
(2) Need content overhaul – should be application-oriented with substantial input from other departments, remove redundancies, and make laboratories interactive and engaging.
(3) Need to upgrade infrastructure and laboratories.
(4) Better coordination is needed among instructors and tutors to make tutorials effective.
(5) Training of new instructors is essential.
(6) Training for tutors and laboratory staff is also needed.
(7) Collaborative and consultative development of core course content is required.

AE

(1) Have clear departmental program objectives and learning outcomes.
(2) Periodically review core structure to reflect common overlaps and essentials across departments.
(3) Have a group of expert teachers handling each core course – from teaching to curriculum review. Encourage collaborative content development and teaching.
(4) Create a repository of lecture notes, question-bank, learning aids, legacy lectures, etc.
(5) Remove redundancy.
(6) Involve the industry in program design.

HSS

(1) Small class sizes encourage discussion.
(2) Modular content with more tutorials.
(3) We need more classrooms.
(4) Adopt a model of multiple sections for a course instead of large lecture classes with several tutorial sections.
(5) Collaborative development of content to connect it with STEM education.

Physics

(1) Unclutter the lectures, plan the content of each, and give a lecture plan.
(2) Introduce experiential laboratory through the design of experiment devices.
(3) Train PhD students to aid in running the course and grading.
(4) Create a central repository of teaching material, demonstrative experiments, etc.
(5) Effectively use multimedia and the learning management system (e.g., HelloIITK).
(6) Inculcate scientific temper in students.

ME

(1) The engineering drawing course needs a relook – content can be made modular.
(2) Set up specialized CAD cells to assist in teaching CAD.
(3) Student tutors have performed below par, and a training program is required for both the instructor and the tutor.

APPENDIX-B:

OUTCOME OF PANEL DISCUSSION ON CORE EDUCATION

PANEL MEMBERS:

Drs. Neeraj Misra, Ashish Garg, Sudhir Mishra, Sandeep Sangal, Kumar Ravi Priya, Raj Chhabra, and Aloke Dutta.

Questions were encouraged by the audience to initiate discussions. Several questions were posed to the panel. These questions and the significant outcomes of the follow-up discussions are listed below.

Q1: Learning objectives and effect on future professional learning.

(1) Strengthen the foundation, and HSS is central to it.
(2) Develop perspective in the student.
(3) Be sensitive to the times – today is the age of biology, materials, and information. Incorporate them into your curriculum.
(4) STEM education should look beyond the current. Programs have to be future-oriented.
(5) The curriculum explains the scientific premise of technology and its benefit to society.
(6) Some of the intense practices of the past have to be revived, e.g., faculty tutors and collaborative teaching, where the tutor attends lectures and comments on them.

Q2: How do you strengthen reading habits?

(1) Strengthen the waning habits of listening, grasping, and processing concepts learned.
(2) Students do not read much, and this is a concern that has to be addressed.
(3) With the internet, information is readily available. Educators must be aware of this and align with it rather than resist it.
(4) Teach students to read codes, regulations, and design manuals. Engineering is practiced.
(5) Prepare the student for the last job, not just the first.
(6) The curriculum is increasingly unconnected to industry. Revive industrial visits.

Q3: Rigor and depth

(1) Review core courses frequently. They should evolve and refine continuously.
(2) Curriculums should not be static and should be reformed continuously. Sensitization to current threats (like climate change) is essential to make the next generation think of solutions.
(3) Core has to evolve dynamically. The baskets have to become more frequent.
(4) We need to revive departments' participation in evolving and teaching core content.
(5) Teach according to the audience and not at your convenience (e.g., mathematics for engineers should not become a course on pure mathematics).
(6) Encourage group activities and pose open-ended challenge problems.
(7) Spice the lectures with stories of persons or accidental discoveries.

(8) The curriculum should be well thought out and not be based on popular demand. What you learn today will become useful later.

Q5: Should attendance in lectures and tutorials be compulsory?

(1) There were varied opinions on attendance, and enforcement of mandatory attendance was generally not favored.
(2) For any course, declare your expectations.
(3) The instructor should be a performer in class and control the audience, not vice-versa.
(4) Concern was expressed about the instructors' interest, dedication, and honesty of effort.

Q6: Should there be uniform evaluation and conduct for the core?

(1) Evaluation cannot be uniform, and the freedom to decide on the evaluation mode should be left to the instructor. However, some pointed to the need for a guiding grading policy.
(2) Instructors have freedom but also are responsible for their classes.

Q7: Communication skills and fluency in English affect learning. How do we address it?

(1) It is difficult to enforce anything. Hand Holding is not possible. The student has to make the effort.
(2) Do diagnostics and have language courses for deficient students.
(3) Communication skills have to be good.

Q8: Role of size of tutorials.

(1) For that matter, the tutorial size for any course should be less than thirty for a practical discussion-based session.
(2) Tutorials complement lectures.
(3) These sessions allow students to clear doubts and the instructor to bond with the group.
(4) The current infrastructure has to improve to handle more miniature tutorials.

Q9: Enforce core template in first two years.

(1) It is the student's responsibility to take care of this.
(2) Departmental DUGCs should enforce the policies strictly.
(3) Need a mechanism to handle failure in "dreaded" courses. Student counseling, help sessions, and topical lectures could be options.

Q10: How do you add/expand the core?

(1) Relook, review, and refine the core more frequently – 10 years is too long.
(2) We have grown (in terms of departments) and are almost a university now. The engineer of today is multi-faceted.
(3) Expand the core basket to account for new essential knowledge or skills.
(4) The core should be relatively unaffected by departmental content.
(5) The core should evolve collaboratively, with participation from all stakeholder departments.