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AUDISANKARA COLLEGE OF ENGINEERING & TECHNOLOGY
(AUTONOMOUS)
Gudur, Nellore Dist, A.P (India)

AUDISANKARA COLLEGE OF ENGINEERING & TECHNOLOGY Date 14/11 GUDUR - 524 101 SPSR Nellore Dt.

The Program of Computer Science and Engineering
Metacognitive Direct Assessment Tool for Program and Program-specific Outcomes (POs & PSOs)

(V2.0 Designed by Dr. J. Raja Murugadoss, 2024, an upgraded version of 2023 V1.0)

Preamble: The metacognitive knowledge dimension tool is developed enabling the learners to understand their mastery on the one's own learning process specifically problem-solving and providing sustainable solution for a given problem statement or specific task involving various stakeholders. Additionally, it allows assessors to evaluate the mastery or calibre of learners' thought processes. This tool is implemented in courses such as capstone projects or semester-long internship programs, where learners demonstrate the theoretical knowledge acquired during the initial years of their B. Tech. program. In the mentioned courses, learners are required to clearly express the learning outcomes corresponding to each Program Outcome (PO) and Program Specific Outcome (PSO) by the end of the course. While the assessment of learning outcomes primarily relies on the project outcomes, this dedicated section allows the system to directly evaluate students' articulation in relation to all POs and PSOs over and above the regular assessment tools.

Table 1 Meta-cognitive assessment tool for POs and PSOs

No.	POs & PSOs	Strongly Agree (4)	Agree (3)	Developing (2)	Disagree (1)	Score
1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems **(Engineering Knowledge)**	Consistently demonstrates a comprehensive understanding of mathematics, science, engineering fundamentals, and their engineering specialization, effectively applying this knowledge to devise innovative solutions for complex engineering problems. Their solutions exhibit a high level of precision, creativity, and alignment with established engineering principles.	Demonstrates a solid grasp of mathematics, science, engineering fundamentals, and their engineering specialization, consistently applying this knowledge to address complex engineering problems. Their solutions are generally effective, showcasing a good understanding of the problem's context and relevant principles.	Shows progress in applying the knowledge of mathematics, science, engineering fundamentals, and their engineering specialization to tackle complex engineering problems. While efforts are made to address the challenges, there is a need for further refinement in understanding and application, with occasional gaps or inaccuracies in solution approaches.	Struggles to effectively apply the knowledge of mathematics, science, engineering fundamentals, and their engineering specialization to solve complex engineering problems. Solutions lack coherence, and there are significant inaccuracies or misunderstandings of fundamental principles, hindering the ability to devise appropriate solutions	
2	Ability to identify, formulate, review research literature, and analyze complex engineering	Regularly showcases an outstanding proficiency in recognizing, articulating, and critically examining intricate	Demonstrates a solid proficiency in identifying, formulating, and analyzing complex engineering	Shows progress in identifying, formulating, and analyzing complex engineering problems using first	Faces challenges in proficiently identifying, formulating, and analyzing intricate engineering problems utilizing	

	problems using first principles **(Problem Analysis)**	engineering issues, leveraging foundational principles of mathematics, natural sciences, and engineering sciences. Their analyses are exhaustive, meticulously researched, and bolstered by a thorough examination of pertinent literature, culminating in well-supported conclusions that make substantial contributions to the discipline.	problems by applying first principles of mathematics, natural sciences, and engineering sciences. Their analyses are generally well-supported by a review of research literature, leading to substantiated conclusions that contribute effectively to problem resolution.	principles of mathematics, natural sciences, and engineering sciences. While efforts are made to conduct problem analysis and review relevant literature, there is a need for further refinement in synthesizing information and drawing substantiated conclusions.	foundational principles of mathematics, natural sciences, and engineering sciences. Analyses exhibit deficiencies in depth and coherence, and conclusions frequently lack substantiation or may diverge from established principles, highlighting notable deficiencies in problem analysis capabilities.	
3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	Demonstrates an exemplary ability at all times and assist other peer groups to design solutions for complex engineering problems, incorporating system components or processes that effectively meet specified needs while prioritizing public health and safety, and considering cultural, societal, and environmental factors comprehensively. Their designs exhibit innovation, robustness, and meticulous attention to detail, setting high standards in engineering practice	Exhibits competent skills in designing solutions for complex engineering challenges, integrating system components or processes that meet specified requirements while appropriately considering public health and safety, as well as cultural, societal, and environmental aspects. Their designs typically meet essential criteria and demonstrate awareness of pertinent factors, reflecting a solid understanding of the design process.	Shows progress in designing solutions for complex engineering problems, incorporating system components or processes that partially meet specified needs while beginning to consider public health and safety, as well as cultural, societal, and environmental factors. However, there is a need for further refinement in design approaches and consideration of diverse factors to enhance overall effectiveness.	Struggles to effectively design solutions for complex engineering problems, often failing to incorporate system components or processes that adequately meet specified needs. Consideration for public health and safety, as well as cultural, societal, and environmental factors, is minimal or absent, indicating significant shortcomings in the design process.	
4	Use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions. **(Conduct Investigations of Complex Engineering Problems)**	Regularly showcases outstanding proficiency in employing research-based knowledge and methodologies, encompassing experiment design, meticulous data analysis and interpretation, and information synthesis, to undertake comprehensive investigations into complex engineering issues. Their conclusions exhibit robustness, strong support, and make	Demonstrates a proficient ability to utilize research-based knowledge and methods, including the design of experiments, analysis and interpretation of data, and synthesis of information, to conduct investigations of complex engineering problems effectively. Their conclusions are generally valid, supported by rigorous analysis, and contribute to	Shows progress in utilizing research-based knowledge and methods to conduct investigations of complex engineering problems, including the design of experiments, analysis and interpretation of data, and synthesis of information. While efforts are made to draw valid conclusions, there is a need for further refinement in methodology and interpretation to enhance the reliability and depth of investigations.	Faces challenges in effectively applying research-based knowledge and methodologies to conduct investigations of complex engineering problems. The design of experiments, analysis, and interpretation of data, as well as information synthesis, lack thoroughness, leading to conclusions that frequently lack substantiation or may deviate from established principles. These shortcomings	

		substantial contributions to advancing the understanding within the field.	expanding knowledge within the discipline.		suggest notable deficiencies in investigative skills.	
5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. **(Modern Tools)**	Consistently demonstrates an exceptional ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to address complex engineering activities. They exhibit a deep understanding of the limitations of these tools and effectively navigate them to achieve optimal outcomes, showcasing a mastery of technological integration in engineering practice.	Demonstrates proficient skills in creating, selecting, and applying appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to tackle complex engineering activities. They exhibit a good understanding of the limitations associated with these tools and utilize them effectively to achieve desired objectives, contributing effectively to engineering endeavors.	Shows progress in creating, selecting, and applying appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to engage in complex engineering activities. While efforts are made to understand the limitations of these tools, further development is needed to enhance proficiency in their application and to navigate their constraints effectively.	Struggles to effectively create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to address complex engineering activities. Limited understanding of the limitations of these tools hinders their application, leading to suboptimal outcomes and indicating significant deficiencies in technological integration skills.	
6	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. **(The Engineer & World)**	Regularly exhibits outstanding proficiency in applying contextual knowledge to assess societal, health, safety, legal, and cultural issues, alongside the corresponding responsibilities relevant to professional engineering practice. They possess a thorough grasp of the intricate relationship between engineering decisions and wider societal ramifications, consistently making well-informed and ethically sound judgments that adhere to professional standards.	Demonstrates proficient skills in applying reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues, along with the associated responsibilities relevant to professional engineering practice. They exhibit a good understanding of how engineering decisions impact various stakeholders and consistently consider ethical, legal, and cultural dimensions in their professional practice.	Demonstrates advancement in employing reasoning informed by contextual knowledge to evaluate societal, health, safety, legal, and cultural issues, along with the corresponding responsibilities pertinent to professional engineering practice. Although they make efforts to contemplate these factors, there is a requirement for further growth in comprehending the broader implications of engineering decisions and in consistently integrating ethical and cultural considerations into professional practice.	Encounters difficulty in adeptly applying reasoning informed by contextual knowledge to evaluate societal, health, safety, legal, and cultural issues, as well as the associated responsibilities within professional engineering practice. A restricted grasp of the broader societal implications and ethical obligations leads to decisions that could neglect crucial considerations, highlighting notable shortcomings in professional judgment and ethical awareness.	
7	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Consistently exemplifies a steadfast commitment to ethical principles and demonstrates unwavering adherence to professional ethics and responsibilities in	Demonstrates a strong commitment to ethical principles and consistently upholds professional ethics and responsibilities in engineering	Demonstrates advancement in applying ethical principles and maintaining a commitment to professional ethics and	Encounters challenges in applying ethical principles effectively and showcasing a commitment to professional ethics and	

	(Ethics)	engineering practice. Their actions consistently align with the highest standards of integrity, transparency, and accountability, setting a commendable example for others in the profession.	practice. They exhibit a clear understanding of ethical standards and regularly integrate them into their decision-making processes, contributing to a culture of integrity and trust within the profession.	responsibilities within engineering practice. While strides are taken to adhere to ethical standards, there is a requirement for further growth in consistently integrating ethical considerations into decision-making processes and exhibiting a deeper comprehension of professional responsibilities.	responsibilities in engineering practice. Actions frequently diverge from established ethical standards, signaling notable deficiencies in understanding and prioritizing professional responsibilities and ethical considerations within the field.	
8	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. **(Individual and Teamwork)**	Consistently exhibits remarkable proficiency in operating effectively both independently and within varied teams and multidisciplinary contexts. They demonstrate exceptional skills in communication, collaboration, and leadership, fostering a sense of synergy among team members and contributing significantly to the attainment of common goals	Demonstrates proficient ability to function effectively as both an individual and as a member or leader in diverse teams and multidisciplinary settings. They exhibit good communication and collaboration skills, actively contributing to team objectives while demonstrating adaptability and flexibility in various roles and settings.	Shows mild progress in developing the ability to function effectively both as an individual and as a member or leader in diverse teams and multidisciplinary settings. While efforts are made to contribute to team dynamics, there is a need for further development in communication, collaboration, and adaptability to enhance overall effectiveness in team environments.	Struggles to effectively function both as an individual and as a member or leader in diverse teams and multidisciplinary settings. Limited communication, collaboration, and leadership skills hinder their ability to contribute meaningfully to team objectives, indicating significant deficiencies in adapting to various roles and settings within teams.	
9	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. **(Communication)**	The student consistently comprehends complex engineering activities and effectively communicates ideas through clear and concise reports and design documentation, demonstrating mastery in written communication in addition to presentation skills, clarity and engagement with engineering community and society.	The student generally engages with the engineering community and society through effective communication of engineering activities, with occasional opportunities for deeper involvement and broader impact through enhanced collaboration efforts.	The student often struggles to provide clear instructions or comprehend instructions accurately, leading to misunderstandings and inefficiencies in engineering tasks. The student's engagement with the engineering community and society is limited, and their communication of engineering activities lacks depth or broader societal context, indicating the need for significant efforts to foster greater participation and contribution.	The student frequently fails to comprehend complex engineering activities and struggles to communicate effectively through written reports and design documentation, resulting in significant misunderstanding. The student's presentations often lack coherence and fail to engage the audience, resulting in limited understanding and retention of complex engineering content. The student's instructions are frequently unclear or misunderstood, resulting in significant errors and	

					disruptions in task execution in engineering contexts.	
10	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change. (**Life Long Learning**)	The student consistently demonstrates a proactive attitude towards independent and lifelong learning, actively seeking out opportunities to expand their knowledge and skills in response to technological advancements, and effectively applying acquired knowledge to adapt to evolving contexts.	The student generally recognizes the importance of independent and lifelong learning, displaying a willingness to engage in self-directed learning activities and demonstrating the ability to adapt to technological change through continuous skill development and knowledge acquisition.	The student shows some awareness of the need for independent and lifelong learning, but may struggle to consistently engage in self-directed learning activities or demonstrate effective adaptation to technological change, requiring further development in their ability to take initiative and pursue continuous learning opportunities.	The student lacks recognition of the importance of independent and lifelong learning, demonstrating minimal engagement in self-directed learning activities and displaying resistance to adapting to technological change, indicating a significant gap in their readiness to embrace lifelong learning in the context of technological advancements.	
11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments **(Finance and Management)**	The student consistently demonstrates a comprehensive understanding of engineering and management principles, effectively applying them to their own work and taking on leadership roles within teams. They adeptly manage projects and thrive in multidisciplinary environments, showcasing advanced proficiency in integrating engineering and management concepts to achieve project goals.	The student generally exhibits a solid grasp of engineering and management principles, applying them effectively to their work and contributing positively as a member of a team. They demonstrate proficiency in project management and display adaptability in multidisciplinary settings, contributing to the achievement of project objectives with competence and reliability.	The student shows some understanding of engineering and management principles but may struggle to consistently apply them in their own work or take on leadership roles within teams. They display moderate proficiency in project management and may encounter challenges in navigating multidisciplinary environments, indicating a need for further development in integrating engineering and management concepts.	The student lacks a fundamental understanding of engineering and management principles, resulting in ineffective application to their work and minimal contribution as a member of a team. They demonstrate limited proficiency in project management and exhibit difficulty in adapting to multidisciplinary environments, highlighting significant deficiencies in their ability to integrate engineering and management concepts effectively.	
PSO #1	Graduates will demonstrate a strong understanding of mathematical and computational principles, including differential equations, linear algebra, complex variables, and discrete mathematics, enabling them to analyze complex engineering	Demonstrates limited or minimal understanding of key mathematical principles. Struggles significantly to apply concepts to engineering problems, with frequent errors and little to no clear reasoning. Decision-making lacks a solid foundation in data or mathematical reasoning.	Demonstrates a partial understanding of mathematical principles, but struggles with applying concepts effectively to engineering problems. Often requires guidance to solve problems, and may make occasional errors in application. Decision-	Demonstrates solid understanding of core mathematical principles and applies them to solve engineering problems accurately. Can use most concepts with minimal errors. Makes generally sound, data-driven decisions, though some minor	Demonstrates a comprehensive and deep understanding of all core mathematical principles (differential equations, linear algebra, complex variables, and discrete mathematics). Applies concepts effectively to solve complex engineering problems independently and efficiently. Shows	

	problems and make informed, data-driven decisions.		making is sometimes inconsistent or lacks full data integration.	inconsistencies in the application of concepts may be present.	exceptional ability to make informed, data-driven decisions with clear logical reasoning.	
PSO #2	Graduates will possess the skills necessary to design, construct, and evaluate software systems, applying best practices in software design, development, and security principles to create robust applications that meet user needs and industry standards.	Demonstrates limited understanding of software design, development, and security principles. Struggles to apply best practices in software construction, and systems may be poorly designed, incomplete, or insecure. Security vulnerabilities may be overlooked, and user needs may not be fully addressed. Documentation, testing, and evaluation are minimal or absent.	Demonstrates an understanding of software design and development principles but has difficulty applying them consistently. The software systems are functional but may lack robustness, scalability, or security features. Some industry standards are met, but documentation, testing, or security measures may be incomplete or inconsistent. Requires guidance in addressing more complex challenges or security vulnerabilities.	Demonstrates strong ability to design and build functional software systems using best practices in design, development, and security. Systems are generally well-constructed, meet user needs, and comply with industry standards, though minor areas for improvement in code quality or security may exist. Documentation and testing are adequate, and security considerations are well integrated.	Demonstrates exceptional ability to design, construct, and evaluate software systems. Consistently applies best practices in software design, development, and security principles to create robust, scalable, and user-centric applications. Systems are well-documented, thoroughly tested, and secure, meeting or exceeding industry standards. Can identify and address potential issues proactively and suggest innovative solutions.	
PSO #3	Graduates will exhibit strong ethical and moral values while collaborating effectively in multidisciplinary teams, demonstrating continuous learning and effective communication skills. They will also be prepared to pursue higher studies and develop careers in the software industry.	Demonstrates limited understanding or application of ethical principles in professional or team contexts. Struggles to collaborate effectively in multidisciplinary teams and may have difficulty communicating clearly. Shows limited initiative for continuous learning and lacks clear preparedness for higher studies or a career in the software industry.	Demonstrates an understanding of ethical principles but may struggle to consistently apply them in all situations. Works with others in multidisciplinary teams but may require guidance to collaborate effectively or manage conflict. Communication is generally clear but may lack confidence or depth in more complex situations. Shows some commitment to learning but may need more direction in preparing for future academic or professional goals.	Demonstrates a solid understanding of ethical and moral responsibilities in professional contexts. Collaborates well with others in multidisciplinary teams and communicates effectively, though there may be occasional room for improvement in clarity or persuasion. Actively seeks opportunities for learning and shows strong potential for pursuing higher studies or entering the software industry with appropriate preparation.	Consistently demonstrates strong ethical and moral values in all professional settings. Effectively collaborates in multidisciplinary teams, contributing actively and respecting diverse perspectives. Communicates clearly and persuasively, both in writing and verbally, with stakeholders at all levels. Shows a proactive commitment to continuous learning and growth, with clear evidence of preparation for higher studies or a career in the software industry.	