Guidelines

for the

TIDeS Rubric for Curriculum Development

Revised version, June 2023

This document is intended to provide curriculum materials developers the information they need to be successful in developing materials for the TIDeS project that pass the rubric. The colors indicate different sections of the rubric; each criterion is further explained in the middle column and examples and references are given in the right-hand column. These guidelines are also available on the TIDeS website.

Guiding Principles

Criterion	What does this mean?	Examples and references
Courses engage students in scientific investigation and engineering design to deepen their understanding of core ideas.	● Through a holistic learning process, students will ask questions about a natural phenomenon or real-world engineering challenge, gather evidence to construct explanations or iteratively design engineering solutions, and communicate their reasoning to themselves and others. ● During experiences like these, students will make use of the science and engineering practices and crosscutting concepts in order to make sense of and deepen their understanding of core concepts and natural phenomena and to solve design challenges.	Courses provide substantial opportunities to engage in the complete cycle of investigation and design throughout the curriculum. For example during such a course, students could construct an initial model to explain a phenomenon, engage in learning activities that deepen their understanding of the phenomenon, revise their model, engage in activities to collect evidence for their revised model, and test their model with real-world data. ***Reference:*** *Chapters 4, 5, and 6 from Science and Engineering for Grades 6-12: Investigation and Design at the Center*
Materials cultivate an equitable learning environment where all students have equal access to learning and feel valued and supported in their learning.	● Multiple means of engagement, including multiple means of representing and expressing students' knowledge, are intentionally integrated, promoting equitable participation. ● Instruction builds on students' lived experiences, creating space to connect their experiences with core science or engineering topics. ● Instruction will have an emphasis on making meaning that includes students hearing and understanding the contributions of others, and communicating ideas in a common effort that builds understanding of natural phenomena or engineering solutions.	Instructional materials include citations and references to materials from diverse authors and perspectives that represent as many student backgrounds as possible. Students should engage in activities that investigate scientific phenomena and engineering design challenges that relate to different contexts (e.g., urban, rural, and other types of communities). Students have opportunities to voice their perspective and points of view utilizing supportive data and evidence. ***Reference:*** *Equity-focused principles, strategies, and resources from the Center for Research on Learning and Teaching at University of Michigan*
Materials engage students in addressing questions and solving problems that are relevant to their lives.	● Activities and materials connect phenomena and challenges in ways that cultivate student curiosity, build a sense of wonder, and allow students to make connections to their everyday experiences.	For example, students could investigate why a river floods. Activities could include materials (data, maps, visualizations, public records) related to a river that is regional to the classroom, allow for a field trip to a river (virtual or in-person), and provide an

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	● The phenomena and design challenges for students to investigate should be selected to be of interest to a wide variety of students as interest is proven to be a key catalyst for short- and long-term learning. ● Relevance can be established through personal interests, cultural contexts, real-world issues, and ongoing scientific questions, and the type of relevance should be varied throughout the course. ● Materials should highlight the ways instructors can adapt or modify the phenomena and challenges to their own settings where possible.	opportunity for students to practice their skills in investigation or design on a river of their choice.
Materials engage students in authentic and meaningful scenarios that make use of real data and models and reflect the actual practice of science and engineering.	● A key aspect of investigating a phenomenon or design challenge is making sense of it through the collection and analysis of evidence involving the use of real data and models and the tools used by scientists and engineers. ● Course design should provide the structure needed to support students in developing their data collection, analysis, and interpretation skills (including computational and visualization skills) to build usable knowledge. ● In selecting the data, models, and scenarios, instructors should consider differences in access to technology, tools, and preparation of students.This could include having students collect their own data over time or using available data repositories (e.g., USGS, NEON, NASA)	Students should use both tools for data collection and analysis—including spreadsheets, digital recording devices, etc…— and actual data that are used broadly by scientists and engineers in different fields. Examples of data-rich activities include *Project EDDIE*, *Tree-Ring Expeditions (TREX)*. Recognize the limitations of activities that can be useful but do not reflect the actual practices: for example, *mining a cupcake* provides a fun visualization of core sampling but does not reflect authentic practices and has the potential to introduce misconceptions.

Learning goals and objectives

Criterion	What does this mean?	Examples and references
Learning goals are expressed as performance expectations with practices as the verb *(e.g., develop models, analyze data, construct explanations)*. Goals that relate to the affective domain *(e.g., increasing self-efficacy, reflecting on an outcome, making connections about equity related to a phenomenon)* should be specific but may not be	● The materials should clearly communicate and describe intended module and course-level student learning outcomes. ● Goals and objectives should be stated in terms of what the student will be able to do when the work is completed, and be written as a statement that makes use of science and engineering practices and cross-cutting concepts to build understanding of disciplinary core ideas. ● Goals and objectives are substantial, measurable and achievable (or plausible in the case of affective domain goals) by students at	Goals will explicitly use concrete action verbs that correspond within various levels of Bloom's and Krathwohl's taxonomy for the cognitive, affective, and psychomotor domains. Example performance expectation: *Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.* (*NGSS HS-LS4-3*) Example affective domain outcome: *[Reflect on} the inequity of climate change and the need for climate resilience in*

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explicitly performance expectations.	the end of a unit or course (as opposed to a single class period).	*industrialized and developing countries. (Adapting to a changing world)* ***Reference:*** *Read more about Designing Measurable Learning Goals from InTeGrate*
Learning objectives are sequenced to build towards the learning goals/performance expectations.	● Learning objectives break down the learning goals into steps that are achievable in a single class period or activity. ● Scope, sequence, and how the objectives connect to the larger course goals should be evident. ● Each objective links to previous objectives and provides a need to engage in the current objective. For cognitive-domain objectives, this is often achieved by moving through the levels of Bloom's taxonomy.	Like course-level goals, objectives should be explicit and use action verbs, and affective-domain objectives may not be performance-driven. This unit on Soil Characteristics from InTeGrate is guided by a set of objectives that build in complexity to connect to module-level goals. By the end of this unit, students will be able to: ● Describe the soil properties of porosity and permeability. ● Characterize the porosity and permeability of a soil sample. ● Interpret and assess the effects of land use practices on the porosity, permeability, and erosivity of the soil. ● Make recommendations for sustainable agricultural practices in a hypothetical scenario.
Learning objectives and goals explicitly support student use of data as evidence in constructing explanations.	● Across the course, many learning objectives should address specific skills in using data as evidence in explaining natural phenomena and making design decisions in written and/or oral format. ● The data may be gathered from a reliable source or collected by students.	Examples come from GETSI, InTeGrate, and Project EDDIE: ● [By the end of this unit, students will] communicate the probability of risk of volcanic eruption based on geodetic data to a non-expert. (Yellowstone is active, but is it erupting?) ● Use collected data to produce a map of sensory experience that conveys social and physical concerns clearly and accurately. (Sensory Map Development) ● Students will use data to compare short-term and long-term discharge variability, and quantify climate change impacts on water quantity in their region. (Stream Discharge Module)
Learning objectives and goals are appropriate for the intended use of the materials.	The context for use section that accompanies the learning goals describes the intended audience, expected prior knowledge, and sets reasonable expectations using asset-focused language that emphasizes what students bring rather than what they lack.	Use asset-focused language to avoid labels such as "appropriate for majors or highly motivated students." Instead, for example: These learning objectives are appropriate for introductory environmental science, oceanography, or introductory geology or for a general introductory science course where the nature and methods of science are being investigated (Kortz & Smay).

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		Reference: *Read about [Asset-Based Pedagogy](#) at the Searle Center for Advancing Teaching and Learning at Northwestern.*
Learning objectives and goals are clearly stated in language suitable for the level of the students.	● Objectives and goals are intentional, concise, detailed, and presented in language that is understandable by the audience, while promoting science literacy and asset mindset that builds on the strengths students bring to the learning.	Units in the Water, Agriculture, and Sustainability module from InTeGrate provide information in the context for use section that further explains the expected student preparation. **For example:** Students can start the module with no shared preparation. Before each in-class activity of this first unit, each student will need to do the assigned readings, participate in the online discussions and (for unit 1.3) complete a homework assignment. This will give them the background necessary to analyze and critique the unit concepts and data. This unit can stand on its own, if desired. It is appropriate for college students at all levels and majors. It is of particular value in introducing Earth Science majors to the concept of sustainability and the roles of culture, politics, economics, and agriculture in the watery aspects of the Earth system.

Assessment and measurement

Criterion	What does this mean?	Examples and references
Assessments measure the learning objectives and goals.	● Formative assessments provide opportunities to elicit student thinking and need not be graded or have any stakes associated with them. They provide feedback that can be used to guide improvements in the teaching and learning setting to help students succeed in achieving the learning goals. ● Summative assessments provide logical tools to determine the extent to which students have met the learning objectives and goals, and should involve a substantial piece of student work.	The Climate change, after the storm unit from InTeGrate has examples of formative assessments and a substantial summative assessment. Formative assessments include collecting observations and questions on a chart, making concept maps, and discussing with peers. The summative assessment is a position paper in which students make an argument from evidence to address the question, "To what extent should we build or rebuild coastal communities? ***Reference:*** *Read more about Assessments that align with your learning goals from InTeGrate*
Assessments have rubrics, or answer keys, or anticipated student responses/what to listen for in oral responses.	● Assessments include a clear and meaningful list of criteria used to evaluate student work and participation, including the information students need to know about how a grade will be determined, proficiency expected, and the information another instructor would need to	The rubric for the position paper in Climate change, after the storm provides detailed levels of proficiency for elements of the paper. The VALUE rubrics from AACU are well-tested and established rubrics for intellectual and practical skills (including

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	know in order to assess to what extent students have met learning objectives. • Rubrics or Teaching tips for formative assessments may focus on "what to look/listen for" in student responses.	written and oral communication) as well as other skills such as civic engagement. Be aware that rubrics with vague or overly general criteria can promote unintended biases (see Quinn, 2020). ***Reference:*** *Read more about Teaching with rubrics from InTeGrate.*
Materials include multiple opportunities to elicit and interpret student thinking for formative assessment.	• Materials should give students awareness of their thinking and provide multiple, varied, and iterative opportunities to elicit students' emerging ideas about a phenomenon or engineering challenge through strategies that include opportunities for reflection, discussion, and synthesis. • Materials should provide means for students to assess their own thinking and confirm they are on the right track. • Materials should include instructional "tips" on what practices and discursive behaviors (e.g., in whole class or small group discussion) would be expected at that point in the investigation and design process.	The InTeGrate module Interactions between water, Earth's surface, and human activity, has a description of how to solicit students' initial ideas. Students can assess their own learning through metacognitive strategies such as think-pair-share and reflective prompts. Recognize group dynamics that limit inclusion and instead establish class norms and structured interactions) that create safe spaces for all to share ideas (see for example Grier-Reed & Williams-Wengerd, 2018). ***Reference:*** *Discussion strategies from the Center for Teaching and Learning at Washington University in St. Louis.*
Substantial student work is assessed that showcases students' evidence-based explanations of phenomena, solutions to design challenges, and their ability to apply their understanding to reason about novel phenomena and challenges.	• Materials and activities should promote deep learning about a phenomenon or engineering challenge where the results of the investigation and/or design process are assessed. • A capstone, summative, or final product of the process will provide a means for students to demonstrate and to assess their understanding of the causes of a phenomena, or solution to challenges using evidence, constructing explanations, and being able to communicate their reasoning clearly to others. • Effective summative assessments require a higher level of student thinking that synthesizes learning across concepts and/or domains.	A summative piece of student work can be used to evaluate student learning at the end of a unit or section of a course. The capstone project for the Earth's Thermostat module from InTeGrate provides an example, in which students develop and present a conceptual model exploring the possible climatic and societal effects of a Toba-scale volcanic eruption occurring in modern times.

Instructional strategies

Criterion	What does this mean?	Examples and references
Instructional strategies and activities support stated learning objectives and goals.	• Instructional strategies provide opportunities for students to build the skills and knowledge	Numerous evidence-based teaching strategies align well with investigation and design. Model-based inquiry describes an

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	that will allow them to meet the expectations outlined in the objectives and goals. ● Throughout the course, specific strategies are likely to change as students gain more experience and confidence and instructional scaffolds can be removed or altered. ● Instructional strategies are inclusive, student-centered, evidence-based, and facilitate students' engagement in the practices of science and engineering.	overarching framework for instructional strategies to plan for engagement, elicit student ideas, support students' changes in thinking, and pressing for evidence-based explanations. Strategies should involve supporting students in data collection, analysis, and interpretation. ***Reference:*** *Instructional Scaffolding to Improve Learning from the Center for Innovative Teaching and Learning at Northern Illinois University*
Instructional strategies and activities facilitate student engagement in science investigation to make sense of phenomena and engineering design to solve problems.	● Strategies should allow students to practice scientific methods and engineering design processes with iterations to solve real world problems. ● Opportunities provide students to take small bits of data and identify relationships to a larger, more encompassing set of ideas. This helps students make sense of phenomena or design challenge. ● ● Materials should highlight the ways instructors can adapt or modify the phenomena and challenges to their own settings where possible.	Chapter 5 How Teachers Support Investigation and Design describes specific strategies. Units can be designed so students explore first such as by observing patterns about a phenomenon as an opening activity, then introduced to concepts through discussion, video, or a virtual reality tour, followed by using data to analyze the phenomenon, incorporating their new learning and reflecting on it, as in the Arctic fieldwork unit from the MOSAIC project.
Instructional materials provide productive questions for instructors and opportunities for engaging students in discourse	● Materials are designed to allow students to be curious and encourage students to ask questions, debate, and practice decision-making as an individual and as a team member. ● Students should engage in productive science talk, providing exploration of ideas and use evidence to build and critique arguments, engage in peer collaboration, and communication, and feedback. Guidance for instructors in facilitating discourse is provided as needed.	The instructional strategy could have students collaborate in small groups as they together answer questions on an activity sheet that guide them to a more in-depth conceptual understanding and then ask them to share their understanding with the rest of class. Instructors support discourse by using talk moves (such as those shown in Table 5-2 of the chapter How Teachers Support Investigation and Design). ***Reference:*** *Discourse Primer from Ambitious Science Teaching*
Instructional activities provide opportunities for students to reflect on and communicate their learning.	● Activities include multiple opportunities for students to reflect on and represent their emerging understanding surrounding a phenomena or design challenge through metacognitive prompts, models, or other learning artifacts.	Units could include metacognitive prompts that promote student reflection of the learning process such as one-minute papers. Additionally, reflective learning opportunities could be embedded in an iterative process where students build models or another artifact that allows them to reflect and communicate their emergent understanding over time. ***Reference:*** *Read more about metacognition and self-regulated learning from InTeGrate*
Instructional activities provide opportunities for students to	● Activities allow students to obtain, evaluate, and communicate information to become	Different strategies encourage students to communicate, evaluate scientific

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practice communicating research findings and/or design ideas.	critical participants in the production and analysis of science. ● Such activities provide opportunities to express, clarify, justify, interpret, and represent their ideas and be open to peer and teacher feedback orally/and or in written form.	arguments, and consider equity implications. Units could include having students present stakeholder positions in a mock town hall or a wall walk for a discussion of a controversial scientific topic or writing a letter to a policy maker advocating for a particular design solution.
Instructional strategies make use of inclusive practices to cultivate students' sense of connection to and ability to see themselves as belonging in the course, community, or discipline.	● Instruction acknowledges students' different identities, experiences, strengths, and needs, and leverages student diversity as an asset for learning. ● Strategies help students connect their prior knowledge or skills to new learning and give them a sense of belonging.	When introducing a new topic, ask students to reflect on what they already know about the topic, or invite them to identify relevant skills they bring from different domains. Highlight diverse contributions to the field, and give students the opportunity to explore and discover assets within their own communities and/or identity groups. ***Reference:*** *Academic belonging from the Center for Research on Learning and Teaching at University of Michigan*

Resources and materials

Criterion	What does this mean?	Examples and references
Instructional materials link between and contribute to the stated learning goals and objectives	● Instructional resources and materials support instructors in helping students achieve the stated learning goals and objectives. Explicit descriptions help instructors see how resources link to specific goals and objectives.	Including instructor stories or teaching tips can describe how an activity could be adapted to engage students in a regional relevant example such as the adaptations for a Coastal Hazards Risk Management plan activity, or be augmented to strengthen students' conceptualization related to a learning objective such as through these teaching tips by reviewers of the Universities Space Research Association Catching a Heat Wave activity.
Instructional materials present multiple ways of knowing and recognize students' potential lived experiences.	● Science relies on empirical and experiential knowing; other ways of knowing are personal, aesthetic, cultural. Instructional materials should recognize these other ways of knowing where appropriate, highlighting the contributions of science without putting it conflict. ● Materials are culturally relevant or responsive to diverse learners, building on individual and cultural experiences and students' prior knowledge. Materials and instruction (such as teaching tips) recognize where students' experiences may enhance or limit their understanding (e.g., whether they have been exposed to certain types of natural environments).	Place-based education is one strategy for embedding other ways of knowing to understand physical features of landforms or ecosystems (see Semken et al., 2018) or ethnobotony or ethnogeology, scientific fields that examine a human culture's knowledge in relation to the given scientific field.

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Instructional materials cite contributions from diverse scientists and engineers with a range of identities, including how those have been historically valued differently.	• Materials should reflect contributions from individuals with different identities and backgrounds. How those contributions have been historically valued differently should be included where possible. • Materials should reflect that contributions may be complicated by the social and political time period of those contributions. •	Materials should acknowledge the specific contributions of members from multiple communities to scientific and engineering enterprises. Materials are justice-oriented and reflect the social context we're in now. Science and engineering topics should reflect current problems in engineering, but also reflect historical theories and principles when appropriate. **For example** GeoContext: A social and political context for geoscience education
Materials are current and are appropriately cited.	• Materials use data, resources, and questions/design challenges that are current and up-to-date at the time of publication. • Adherence to copyright permission should be explicitly practiced when using non-self-authored materials.	Case studies such as the Oso Landslide case study from GETSI provide opportunities to use up-to-date data and resources. Resources linked in this activity are attributed to their sources; many of the resources are in the public domain from the U.S. Geological Survey. Data are not subject to copyright, but the products produced from data, such as visualizations, are. ***Reference:*** *Copyright pointers for contributors to SERC-hosted sites*
Instructional materials, technology, and any software are widely available to instructors.	• Accessibility of materials for both instructors and students is equitable. • Images have alt- tags and uploaded documents follow accessibility standards.	Web sites, national data repositories, software, scholarly articles, and other external resources are accessible to students and teachers; if not, alternate resources are provided. When needed, downloadable software/programs are free and available with minimal computer specifications. ***Reference:*** *Universal Design for Learning (UDL) Guidelines from CAST*

Alignment

Criterion	Description	Examples
Teaching materials, assessments, resources and learning activities align with one another.	Each element of the curriculum within each section aligns with all other curricular elements (instructional strategies, activities, student materials, assessments) directly through the stated learning objectives and goals.	Alignment across all elements should make it clear that the guiding principles of science and engineering design, equitable learning, problems that are relevant to student lives, and authentic scenarios that use real data are pervasive throughout the course.
All aspects of the course are aligned	Curricular materials align directly with the stated course goals holistically across the entire curriculum.	Alignment should demonstrate the coherent structure of the course in addressing the course goals.

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