Teaching Engineering Information Literacy with INCLUSIVE ADDIE

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Teaching Engineering Literacy Using the INCLUSIVE ADDIE Instruction Model

Abstract

Instructional design models provide organized guidelines to achieve educational goals. One example is the well-known ADDIE instructional model. ADDIE is an acronym for Analyze, Design, Develop, Implement, and Evaluate, all of which are steps within the learning development process. ADDIE has a proven record of accomplishment in both in-person and virtual education. This popular teaching method has been used in numerous educational settings, from primary schools to colleges, and is taught to students in education programs across the continent. However, critics of the model point out that it can miss cultural cues from students in underrepresented and marginalized groups and that it does not work well in diverse classroom spaces.

This paper will introduce a recent upgrade to ADDIE known as INCLUSIVE ADDIE, which is intended to fill in those diversity, equity, and inclusion gaps present within the current ADDIE model. INCLUSIVE is an acronym for Introspection, Needs, Context, Lessons, Understanding, Supporting Structures, Interactions, Value, and Evolution. These additional inclusions function as substages within the instructional model to support instructors in fostering a sense of belonging within their learning environments and to allow all students to feel valued and welcome. Each of the substages are mapped directly into ADDIE – this is not a replacement of the model, but an enhancement. The enhancements expand the idea of classroom inclusion to consider both socio-economic factors and the physical abilities of every student. Engineering programs are increasingly more diverse and incorporating this model acknowledges this fact, giving instructors an opportunity to better support all their students. In addition to the new INCLUSIVE ADDIE model introduction for librarians, the authors provide examples and limitations for its use within the science and engineering library classroom.

Introduction

Diversity in engineering is of great importance to everyone. Frequently, the best solutions to a problem are those that consider the widest variety of ideas and viewpoints. However, not all groups have had equal access or opportunities to become engineers and have a place at that problem-solving table. Even worse, they have often not been welcomed. Many of the problems that exist today are due to not bringing in these voices when dealing with previous issues. Therefore, it is extremely important that creating an inclusive environment for all students to have the best possible learning experiences is implemented in the process of instructional design.

In 2021, only 24.3% of students in the United States who graduated with a bachelor's degree in engineering identified as women. Meanwhile, African American, Hispanic, and Native American students who graduated with a bachelor's degree in any STEM field comprised about 27.8% of total graduates, even though members of these groups account for almost 35% of all college students [1], [2]. Although all these percentages are higher than they were in 2012, there is still a long road to travel before full equity in these fields is reached.

Inclusivity in Instruction

Inclusivity can be defined as “an intentional practice of recognizing and working to mitigate biases that lead to marginalization or exclusion of some people” [3]. Students’ social identities do have effects on how they learn and whether they stay the course in their major through graduation [4]. Unfortunately, many students from backgrounds underrepresented in STEM can feel alone or unwelcomed and eventually change their major to one where they believe they will be better supported or even drop out of school entirely [1], [5]. However, research has shown different ways instructors can mitigate implicit biases and create welcoming, inclusive learning environments for everyone [4]. Two traits that instructors can develop to assist them in this process are self-awareness and empathy.

To better understand where our students come from, we must first understand our own experiences and voices [3]. Knowing our own identities is an important element of incorporating inclusive design in our instruction [3], [6]. Many instructors have experienced obstacles along the path they have chosen, however, many have also benefitted from different privileges that have helped them obtain their positions [4].

A self-aware instructor will be willing to develop an empathic relationship with their students. Learners in higher educational environments have the agency to choose their own programs and the support structures/tools that they will need to be successful. Librarians can become an important part of that support structure if they are willing to empathize with the students. Each student is unique, and although they may be classified into various demographic categories, these categories have a tendency to “mask” this uniqueness [3].

One way where inclusivity can be introduced into the classroom is by incorporating it directly into the design of the instructional product. Although there are several well-known instructional design models currently in use by teachers and designers, none of the most popular incorporate inclusivity as a major component. Therefore, before going into detail about a new, inclusive variation to one of these models, it makes sense to discuss two major ones in detail: ADDIE and Universal Design for Learning.

ADDIE

One of the most popular instructional design models in use today is ADDIE. ADDIE stands for Analyze, Design, Develop, Implement, and Evaluate [7].

- Analyze: Determine instructional goals, the intended audience, and resources needed
- Design: Create performance objectives and testing strategies
- Develop: Generate content and supporting materials, guidance for both teachers and students, and revise if necessary
- Implement: Conduct the actual class
- Evaluate: Assess the quality of the instruction

When each step is followed in order, the model provides support for any instructor to create meaningful, well-designed learning environments. ADDIE works best as an iterative process, much like the research skills that librarians are teaching students in information literacy sessions.

One advantage of ADDIE is that it can be extremely flexible – instructors can use it in a wide range of situations [8]. As a systems-focused design process, it allows for the integration of the Association of College and Research Libraries' Framework for Information Literacy for Higher Education [9] and can be easily replicated from library to library and even across disciplines. However, ADDIE in this original form does not allow for cultural introspection [10] and lacks the support necessary for the inclusive classroom of the twenty-first century [11].

Universal Design for Learning (UDL)

Universal Design for Learning (UDL) is another frequently referenced instructional design model, especially amongst librarians. It is useful in both online and in-person learning environments and guides the instructor into taking a proactive approach to accommodating students from a wide variety of backgrounds and abilities [12]. There are three guidelines to UDL [13], [14]:

- Develop multiple ways of engaging students.
- Provide multiple ways of representing content to students.
- Provide multiple ways for students to express their learning.

UDL allows students to learn on their own, at their own pace, and in an engaging manner [13], [15]. This focus on the learner and the less-regimented process are the two major differences from ADDIE. In fact, some instructors have even occasionally combined the two models in an attempt to take advantage of both [16]. UDL, however, lacks the step-by-step process of ADDIE and can be more difficult for newer instructors to use without support [16]

What is INCLUSIVE ADDIE?

As shown above, the ADDIE instruction model, Analyze, Design, Develop, Implement, and Evaluate, has been used by instructors and instructional designers for decades. INCLUSIVE ADDIE builds on this model by aligning action-oriented INCLUSIVE steps to the original ADDIE framework. This model was first developed by instructional designers at the Pennsylvania State University to help ADDIE support diversity, equity, and inclusion in the classroom [11]. In a way, it combines ADDIE with UDL while maintaining the easy-to-follow process of course design.

In the following descriptions below, the individual developing the lesson or course is referred to as the designer. The designer may also be the instructor of that course.

Breaking Down Each Letter

Analyze - The designer defines the problem and establishes learning outcomes. The designer also assesses the existing knowledge and skills of learners, as well as the learning environment.

- **Introspection** - The designer reflects on their personal and professional identity and worldview, considers classroom power dynamics, and their own current capabilities.

- **Needs** - The designer considers the identities and needs of students, as well as their professional goals. This may be more difficult as a librarian primarily teaching one-short instruction, as you may not have the opportunity to get to know the students or the field as well as the instructor.
- **Context** - The designer investigates the context of subject matter and learning objectives, as well as the broader field or institution.

Design - The designer further develops and clarifies learning objectives. During this phase, they also begin to identify assessments, content, and exercises for the instruction.

- **Lessons** - The designer explores and considers strategies for instruction, with a specific focus on equitable instruction built on diverse representation.
- **Understanding** - The designer identifies what can be assessed in learning objectives and considers formative and summative tools to evaluate learning.

Develop - The designer brings together the ideas from the design to create a coherent lesson plan.

- **Supporting Structures** - The designer critically examines the policies and supports that shape how the course is run. This may involve examining library policies as well, to consider how they do or do not support learners.

Implement - The designer develops the training for learners or for facilitators.

- **Interactions** - The designer examines the way that they facilitate course-required student interactions.

Evaluate - The designer assesses the objectives that they identified during the analysis phase.

- **Value** - When considering value, the designer uses multiple methods to assess the efficacy of their teaching. This can be difficult with one shot instruction, but this feedback can be insightful in designing future instruction.
- **Evolution** - The designer can look beyond student assessments and consider their own reflections as they seek to improve the course. Writing a short reflection after you teach, especially if you try something new, may be valuable in helping you to reflect and improve.

Three Examples of INCLUSIVE ADDIE in Information Literacy Instruction in the STEM Classroom

Engineering First-Year Seminar Library Session (In-Person, online, or hybrid)

This lesson plan is for first year students and is applicable to both in person, online, and hybrid classes. At the end of the session, students will be able to identify resources offered by the library, use beginner database search strategies to find articles and ebooks, and know how to access additional library support. The lesson emphasizes the following aspects of the INCLUSIVE ADDIE framework:

- **Needs** - models and encourages discovery, student led-learning, and communicating findings.

- **Context** - when used by the authors of this paper, the students have an upcoming assignment in their class where they need to find an article.
- **Lessons** – lesson uses both technology and human interaction.
- **Interactions** – students interact individually and can choose to type or speak; they also work in groups and communicate back to the class.

The following lesson plan is designed for a 50-minute class session. Times and activities can be adjusted to meet your needs.

Do ahead: If in-person or hybrid, ask instructor to ask students to bring laptops to class OR ensure students will have access to computers in classroom.

Materials: Online slides, laptop, internet access.

Lesson Outline:

0-7 minutes: Introductions
- Introduce yourself and set expectations.
  - Can they interrupt with questions, or would you prefer them to wait?
  - If online, will you be monitoring the chat the whole time?
- As you do this, invite students to join the presentation and answer questions featured on a slide. Remind them that it is anonymous.
  - Instructor can use both a serious and a fun question, like "Where do you go to start your research?" and "What is your favorite study snack?" This ensures they are familiar with editing the document, gets them thinking about searching for resources, and the fun question will give the instructor something fun to return to throughout the session.
- Review student answers to the questions.

7-17 minutes: Library Resources Overview
- The Library Website
  - How to get there
  - Basic website features
  - If appropriate, subject LibGuides
- Catalog
  - Introduce finding and accessing books.
  - Course Reserves
  - If appropriate, mention Interlibrary Loan
- Databases
  - How to get to databases

17-30 minutes: Jigsaw: Group Searching
- Place students in four or five groups and assign each group a database to learn to use. Instruct students to take notes on the slide for their database so the whole class can return to these notes if needed. At the start of the activity, tell students to be prepared to share their findings with the rest of the class. Ensure groups have at least ten minutes to search.

- Choose 4-5 databases (one per group) that are relevant to the class. If in doubt, ask the instructor!
- Activity can be a true jigsaw, where the number of students in each group equals the number of groups so that during the sharing activity, one student from each group comes together to form a new group and each member of this new group then instructs their group about their database. However, class sizes do not always work out and this can be complicated with hybrid or online classes, so this version tends to be easier to plan for.
- During their exploration time, visit each group and talk to them about what they are finding. Mention any database features that you want them to notice.

30-45 minutes: Jigsaw: Sharing

- Either in new groups (see above) or with the larger class, each group has 2-3 minutes to share how to use their database.
    - When sharing with the whole class, you could ask the students to use the computer at the front or, if time is short, have them talk from their seats while you click and type.

45-50 minutes: Wrap Up

- Ask students how they will use something they learned today.
- Ask students to fill out feedback survey, if using
- Remind students they will continue to have access to slides and make plans to share them with the instructor.
- Final questions

Engineering Upper-Level Course (In-Person, online, or hybrid)

This lesson plan is for engineering students in upper-level capstone courses and is applicable to both in person, online, and hybrid classes. At the end of the session, students will be able to understand how different types of engineering literature can be used to discover the background and current trends in a topic of choice, learn how to find relevant standards, technical reports, and patents in their field using both library and real-world resources, and how to properly cite what they find in their own final reports. Students will have already been through the first-year seminar session and will be expected to already know the topics that were discussed then. The lesson emphasizes the following aspects of the INCLUSIVE ADDIE framework:

- **Needs** – models and encourages discovery, student led-learning, and communicating findings.
- **Context** – the capstone-level course revolves around completing a project (either in groups or as individuals) that focuses on a real-world issue which can be solved through the application of science and technology.
- **Lessons** – lesson uses both technology and human interaction, with
- **Interactions** – students interact individually and can choose to type or speak; they also work in groups and communicate back to the class. For asynchronous and hybrid learning environments, any videos used will include both closed captioning and transcripts.

- **Value –** students will be able to complete an online survey built into the course which will allow them to provide feedback to the instructor on what worked, what did not, and ideas for improvement.

The following lesson plan is designed for a 50-minute class session. Times and activities can be adjusted to meet your needs.

Do ahead: If in-person or hybrid, ask instructor to ask students to bring laptops, tablets, or any other device that can access the internet to class OR ensure students will have access to computers in classroom. A slideshow with all relevant information will be sent to the regular course instructor at the beginning of the semester to give students plenty of time to become familiar with the material before the day of class.

Materials: Online slides, laptop, internet access.

Lesson Outline:

0-5 minutes: Introductions

- Introduce yourself and set expectations.
  - Can they interrupt with questions, or would you prefer them to wait?
  - If online, will you be monitoring the chat the whole time?
- As you do this, invite students to join the presentation and answer questions featured on a slide. Remind them that it is anonymous.
  - Begin by asking how often the students use the library. Since they are all third- and fourth-year students, many will have had some interaction with either us or our space by this point. For those that have frequented the library, they are asked what resource they use the most. End the introduction by asking "Why do you think engineering students need to learn research skills?"
- Review student answers to the questions.

5-8 minutes: Review of Engineering Library

- Where we are physically located
  - Current hours of operation
  - Any upcoming changes that they may need to know about
- Current Services and Resources
  - What they can find and use in our physical space
  - The services provided at the front desk.
- Circulation policies
  - Number of materials they can have checked out.
  - Length of loans
  - Where they can return library materials when they are done with them.
- Students will have the opportunity to ask questions at the end of this section.

8-40 minutes: Using the Library's Resources to Find the Information You Need

- The instructor will demonstrate how to find several types of engineering literature by using the relevant subject guide for the course (in the case of this example, mechanical

engineering). Then, students will conduct searches on their own for information on their topics for their final project. This section is broken down into three main parts:

- A demonstration on how to find a certain resource:
  - ASME Digital Library and SAE Mobilus
  - Knovel
  - Espacenet
- Students will then work within their previously assigned teams (unless doing a solo project) to find information on their topic:
  - ASME Digital Library or SAE Mobilus, depending on which is more relevant to them.
  - Knovel
  - Espacenet or Google Patents (their choice)
- Once students find a standard, technical report, conference proceeding, article, or patent (depending on the activity) that they believe will be useful for their research, they will share it on a virtual anonymous corkboard with the rest of the class, using proper citation (which will depend on the requirements of the course).

- This activity is completed three times, with the ASME Digital Library/SAE Mobilus first (demonstration, search activity, sharing with class), then Knovel, then Espacnet/Google Patents.

40-45 minutes: Assessment of Learning

- Students will be given a ten-question gamified quiz within the Nearpod app which will touch on the important points that they should have learned in this class.

45-50 minutes: Wrap Up

- Remind students of the Ask-A-Librarian Chat Service and other ways to find help when they need it.
- Ask students how they will use something they learned today.
- Have students fill out feedback survey.
- Tell students they will continue to have access to the slides posted on the course's page on the learning management system (LMS).
- Final questions

Chemistry Upper-Level Course on Patents (in-person, online, or hybrid)

This lesson plan is for upper-level STEM students and is applicable to both in person, online, and hybrid classes. At the end of the session, students will be able to identify patents, understand the parts of a patent, use open access database search strategies to find patents, and know how to access additional library support. Students in the class are mostly chemistry and chemical engineering majors looking to understand chemical literature. Some students are interested in a career path with the United State Patent and Trademark Office, and they frequently ask questions regarding this pathway. The lesson emphasizes the following aspects of the INCLUSIVE ADDIE framework:

- **Needs** – The course models and encourages student discovery, engages in student led-learning, and allows students to communicate their findings.

- **Context** – This class falls during the patent portion of the course. Following this class, students have a homework assignment related to the lesson plan.
- **Lessons** – The lesson uses both technology and human interaction.
- **Interactions** – Students interact individually and can choose to type or speak; they also work in groups and communicate back to the class. For asynchronous and hybrid learning environments, any videos used will include both closed captioning and transcripts.
- **Evolution** – Students partake in course activities using tools that collect real-time feedback for analysis by the instructor on what worked, what did not, and ideas for improvement. The instructor can then use these evaluations, along with their own personal reflection, to create iterative updates to the presentation.

The following lesson plan is designed for a 50-minute class session. Times and activities can be adjusted to meet your needs.

Do ahead: If in-person or hybrid, ask the instructor to ask students to bring laptops to class OR ensure students will have access to computers in their learning space.

Materials: Online slides, laptop, internet access.

Lesson Outline:

0-5 minutes: Introductions
- Introduce yourself.
  - Tell students about your background.
  - Introduce your pronouns and invite students to introduce themselves with their pronouns.
- Set expectations.
  - Can they interrupt with clarifying questions, or would you prefer them to wait?
  - If online or hybrid, will you be monitoring the chat the whole time?
- Introduce the outline for the class.
  - Share what we will cover during the class.

5-20 minutes: Learn about Patents and Patent Trivia
- What are patents?
  - Define what a patent is.
  - Share the goals of today's patent system.
  - Share the first United State Patent
- Patent Trivia #1
  - Ask students a trivia question related to patents.
  - Students are encouraged to answer questions anonymously on virtual corkboard, such as through Padlet.
- Explore the types of patents.
  - Explain the similarities and differences between utility, design, and plant patents.
  - Pay special attention to the utility patents which include chemical patents.
  - Share what cannot be patented.

    - Encourage students to think about the difference between a copyright and a patent.
- Give a brief overview of the patent parts.
    - Patent numbers
    - Patent titles
        - Explain that titles can be vague.
    - Patent dates
        - Share differences in application date and date of issue.
- Check in to see if there are any questions that have not been asked and/or answered so far.

20-30 minutes: Patent Names Activity

- This activity utilizes AhaSlides for an interactive and fun way to teach patent titles. The instructor can say that patent titles are written by lawyers and that patent titles do not include product names, but this activity allows students to experience this firsthand. AhaSlides has a free account and paid account options. One author uses the educational small account which is currently priced at $3/month for up to 25 students per game [17]. This allows for data to be exported to Excel files after classes for review during the Evaluation stage of INCLUSIVE ADDIE.
- Five patent titles, usually based on a theme chosen by the instructor, are placed into a slide deck. Students will each have the chance to anonymously choose the correct product from a list of popular products that the patent is related to. After each slide, students are scored. The instructor then talks about why a patent may have a title that seems obscure or vague for a given product.
    - Example: Method of Treating Foodstuffs is a patent for a Microwave
- By the end of the game, students have a better understanding of patent titles.
- Check in to see if there are any questions that have not been asked and/or answered so far.

30-40 minutes: Patent Searching Introduction

- Talk about the challenges of patent searching.
    - Reiterate what just learned about patent names.
    - Not a true form of scientific literature
    - Patents are written by lawyers.
- Use link to transfer to the Libraries' homepage to introduce the patent searching research guide.
    - Show how to navigate from the Libraries' homepage to the Patents & Trademarks Research Guide
    - Introduce three popular patent databases for chemical patent searching specifically requested for this course: SciFinder-n, Lens.org, Esp@cenet.
        - Talk about how to search.
        - Talk about unique features.
        - Explain Patent Families

40-45 minutes: Student Searching Exploration

- Allow students the opportunity to explore a new patent database and find a patent related to a chemistry/chemical engineering topic that interests them.
- Check in to see if there are any questions that have not been asked and/or answered so far.

45-50 minutes: Wrap Up

- Patent Trivia #2
  - Ask students a trivia question related to patents relevant to the day's activities.
  - Students are encouraged to answer questions anonymously on virtual corkboard, such as through Padlet.
- Remind students how to contact you for follow-up questions.
- Tell students they will continue to have access to the slides posted on the course's page on the learning management system (LMS).
- Share a final word that you are not a lawyer and cannot give legal advice related to patents.

Limitations

INCLUSIVE ADDIE is a very new model of instruction and designed for courses that last an entire semester or longer. Some portions of the model do not have a good fit with one-shot instruction sessions, which, unfortunately, are still the standard for most librarians. This requires most librarians to modify the model for their own needs, which may limit the efficacy of the model.

Topics for Future Research

The authors are currently using INCLUSIVE ADDIE as a model for a Basic Engineering Information Literacy Badge that they are creating in collaboration with the Leonhard Center for Engineering Education at Penn State's College of Engineering. The badge will be embedded into the cornerstone engineering design course required for entrance to all engineering majors at the institution. This will enable librarians to asynchronously teach over 1200 students per semester, giving students the basic research tools they will need to complete the required projects in the course as well as any assignments in future courses.

Because this model is still very new, assessing its effectiveness will be extremely important, both for the authors and for anyone else who is interested in adopting it into their own learning environments. Follow-on research will be required to determine the model's strengths and weaknesses, as well as ways to improve it and allow for true inclusiveness in instruction.

Conclusion

INCLUSIVE ADDIE is an enhancement of the ADDIE instructional model that allows for the creation of an accepting learning environment for all students. As engineering fields welcome more students from diverse backgrounds into their ranks, librarians who can maintain an inclusive classroom, along with the use of instructional activities that engage every learner, will

help those students believe that they belong and can succeed as future engineers. The result will hopefully be new engineers unafraid to apply innovative solutions to the problems they face.

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