Cheat Sheet for ASTR 205: Introduction to Astronomical Teaching
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Section 0: Introduction

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This was one of my first courses at UC Santa Cruz. The lectures were all (but one) in-person, with Madelyn Broome primarily using Google Slides projected onto a whiteboard. We used Canvas and Gradescope for assignment submissions, for her to share notes, and to work through modules. Our primary means of communication were email.

I really appreciated her lecture style which allowed for lots of awkward silences to think about a prompt. I particularly enjoyed the final presentation that gave me the chance to practice boardwork. From this course, I became much more comfortable with understanding what makes an impactful instructor / teaching assistant (TA). It really formalized what I thought to be good practices by learning the vernacular used in the learning community.

The goal of this cheat sheet is to have a document I can reference to make sure I'm not being a bad TA. I want something I can easily look over and understand what I should be thinking about when designing an instructor section. I also would like to be open with my future students about what I'm practicing, and this should hold the words that students can easily search to learn how they're learning. I plan to keep this a lively document where I can refine my teaching abilities, including teaching my future self.

To create this cheat sheet, I referenced my own lecture notes, Google Slides shared from Maddy, and many helpful resources she provided. I became much more comfortable through many discussions during and outside class time, so many thanks to my first-year cohort: Pedro-Jesus Quiñonez, Malik Bossett, Mika Lambert, Anna Gagnebin, Lordrick Kahinga, and Courtney Carreira. I am also grateful for Professor Graeme Smith who supervised the course and provided insightful discussions on the development of astronomical teaching over the last $\sim$2 decades.

Section 1: Learning Theory

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Note: *LATEX format adapted from template for lecture notes from CS 267, Applications of Parallel Computing, UC Berkeley EECS department.*

1.1 Perspectives

1.1.1 Universal Design Learning

Universal Design Learning (UDL) is the cornerstone to become a great instructor for all students. It provides a framework to teach to any student and reinforces practices that create accessibility as a foundation of learning goals, rather than an after thought. The goal is not to lower the standard, but to provide many avenues of learning that keeps those accessibility issues in mind. A key outcome of these principles allows for a more efficient mode of teaching, and lowers the need to provide additional accommodations after the fact.

The general guidelines to UDL thinking are:

- Allow flexibility

- Work with the students

- Use the students' modes of communication

- Make the overall learning goals clear

- Reinforce idea that primary goal of the instructor is all student success

- Provide the resources available to help learn

To achieve these general guidelines, UDL has three design principles for which instructors should provide multiple pathways for

1. **Engagement**: Provide purposeful motivation and stimulate different interests for a topic. Tackles the "Why" of learning

2. **Representation**: Provide different representations of information and content. Tackles the "What" of learning

3. **Action & Expression**: Provide avenues for different ways of expression and their knowledge on a topic and be creative. Tackles the "How" of learning

In order to provide accessibility to as many students as possible, the key is diversity. Not all students learn, understand, process, or can be assessed in the same manner. Some guiding questions when creating instructing sessions:

- Are there different ways for students to engage with material?

- Are there different ways that the instructor conveys the information?

- Are there different ways to assess understanding?

Not only does this thinking of providing a guided buffet of learning opportunities grab all students, but it can also expose them to other ways of thinking. It helps let students tackle a learning goal from many ways and reinforces the learning goals. A student who may have not been exposed to learning from Canvas interactive modules may work better for them than pre-recorded videos.

The key to providing these options is making them *guided*. Communicate with students about the goals of a particular learning assignment, and why it will benefit them to interact with other learning methods they may have less exposure to. Providing that level of ownership over their learning is tricky because it asks for quite a bit of buy-in from students. Communicating, being transparent, and being purposeful about what is being provided to students helps overcome that barrier. Purposeful reflection on sections of how the UDL principles are being implemented helps catch any pitfalls. Even if they cannot help the current students, feedback and communication can help future students.

An example of practicing UDL is by providing a clear syllabus to the students, with time for them to review and ask questions. The syllabus should have clear font for everyone (e.g. Arial) and provide resources that they can take advantage of.

1.1.2   Mindsets

Mindset (as it relates to learning) is a perspective on somebody's learning potential. Instructor mindset is the view that instructors have on their students about their potential.

Deficit Mindset is the thinking that a person's learning potential is capped and are unable to reach the standards of success.

Growth Mindset is the thinking that a person's learning potential is flexible and are capable of reaching the standards of success *with the proper support*.

Instructors need to 1) believe that a student is capable of greatness and 2) communicate that capability to the students. Deficit and Growth mindsets are practices that need to be communicated to students, but also **need to be practiced by the instructors**.

In order to practice these mindsets, the standards of success must be clearly defined and established. Only then can the proper support be identified and shared with students. Without clear goals in mind, students are just swimming around with no direction.

Something impactful that I learned was that an instructor, with the goal of accommodating a student, shouldn't lower the standards of success because it sends the message that the student is not able to reach that level of success. It can show that they are not *capable* of reaching the ladder rung that others are able to. Providing this mindset can form a negative relationship with the learning material, which is why these mindsets are not limited to the students. Furthermore, a deficit mindset can create more anxiety around the learning material, as they're just waiting to make the next mistake and be corrected rather than being comfortable exploring and being wrong.

Instructors should be mindful to **identify, share, and practice growth mindset by providing targeted and encouraging feedback to students**.

Good growth mindset practices need to be properly guided. Self-compassion has to be practiced by students, which means that an instructor needs to show how to create these practices. **Instructors should communicate how to identify burn-out and the ability to recover**. A common practice is to self-reflect

throughout the course. Have students question whether their studying techniques are actually working, and provide alternative methods of interacting with the learning material (see the connection to UDL?). Instructors should present the down-sides of simply "pushing through" and how it does not *necessarily* produce better results that lead to a higher standard of success. Encourage students to touch grass and re-evaluate their goals and values.

1.1.3 Positionality

Positionality is how an instructor's many different aspects of their identity is formed and how it may pervade onto their teaching. An aspect of somebody's identity can include (but isn't limited to)

- socioeconomic status / upbringing

- race

- gender

- sexuality

- ability

When interacting students and trying to provide multiple pathways of learning, it is important to keep these in mind in order to...

1. create a safe and inviting environment and

2. tailor your teaching style to empower everybody

Past simply identity, an instructor's past experience and training can be important when interacting with students. The setting and culture of past places have an impact on an instructor professionally, and they could positively or negatively impact students from marginalized communities.

For example, I don't have much explicit experience (as an undergrad student and undergrad TA) interacting with students who are hard of hearing. If I have a student that identifies with that community, I know I have not developed any tools to accommodate for that student. When planning an instructor section or setting classroom norms, I should think about my positionality, which includes being able to hear others easily.

I should ask myself what communities I identify with that may represent some privilege or marginalization. How could that identity compare with my students and could I be further marginalizing or discouraging students? What are some backstops that I can place to 1) not let them get left behind and 2) promote student success for all students? (see the connections with UDL?)

For example, I have had access to my own personal computer laptop and reliable internet access since high school. Being interested in computers, I have learned how to use a computer, navigate the terminal, manage my files, and general computer literacy. I should think about how I can help uplift those who have not had that sort of exposure to computers. Since plenty of astronomy is dealing with computers, general computer literacy is something I am familiar with and I know is part of the astronomical community. Not all classes require a computer to interact with, but most resources I know of are online. If a class is computer focused, I also need to be aware that I am mostly familiar with Unix-based operating software.

The goal of positionality is to **be aware of who I am and how it may impact others as an instructor**, not to change my identity.

1.1.4   Stereotype Threat, Microaggressions, Implicit Bias

The goal of an instructor to practice UDL techniques should be to create a safe and welcoming environment for everybody to participate. While this does include some level of discomfort and uneasiness with the learning material (create some struggle with the topics at hand), this should have no basis on a student's identity so as to marginalize and discourage a population of students from participating. To that end, instructors should be aware of and attempt to mitigate...

- **Stereotype threat**: concern about conforming to stereotypes about a group someone belongs to contributes to cognitive load that impairs learning and contributes to achievement and opportunity gaps. Providing a stressor related to stereotype threat can make students perform worse (Aronson et al., 1999).

- **Microaggressions**: verbal or nonverbal (subtle and sometimes unintentional) prejudice directed towards a marginalized group. These can reinforce a deficit mindset for students

- **Implicit Bias**: prejudice or bias which one is not consciously aware.

1.2   Interactions

1.2.1   Learning Goals

When creating learning goals, they should be **clear, direct, and meaningful**. They help in the process of lesson planning and serve as a guide for "alignment" on assignments, commonly referred to as construct relevance. In the context of teaching, it means to question whether something is serving the learning goals. Are you testing what you think you're testing?

Well written learning goals will make the goal and motivation for a lesson plan and/or activity transparent to students. They should include not simply the *what* but also the *how* of expectations. The standards of success should be easy to understand. While it can be taxing to do, it can help be a guide for the instructor and the student.

A helpful guide in creating these learning goals is "Bloom's Taxonomy", with a helpful diagram in Figure 1.1 (Anderson & Krathwohl, 2001). The structure of learning goals should follow the form

Students will [action verb] [specific topic or skill] by [assessment].

For example: "Students will estimate the temperature of a star using Planck's Law and identify its type". The goal is to be specific, not vague, with all three bracketed terms.

1.2.2   Backward Design

Traditionally, assignments are first created and the outcome of the assignment are defined after the fact (usually to save some time). The goal of backward design is to work *from* the learning goals *to* the assignments to ensure construct relevance. Sidenote: "backward" is not the best term, but it serves as a dichotomy to the traditional pathway of lesson construction.

There are three helpful guideposts to ensure backward design is done in a proper manner (Bowen, 1999)
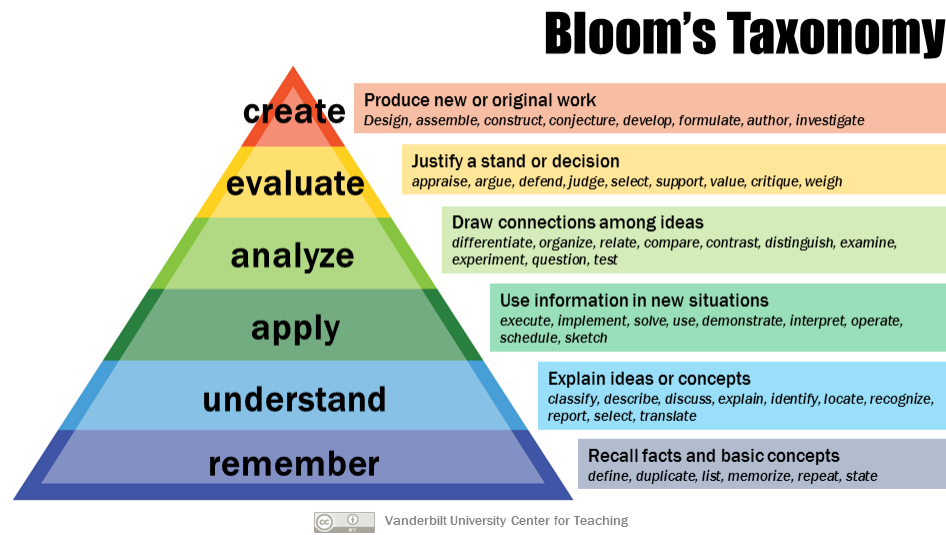
Figure 1.1: Bloom's Taxonomy

1. Identify the results. Think about the big ideas and skills

2. Determine acceptable evidence. Culminate the assessments and tasks

3. Plan learning experiences and instruction. Create the learning events.

It is helpful to constantly reevaluate what works and what doesn't so that any missteps are found early on.

1.2.3   Taxonomy for Significant Learning

Fink (2003) created a helpful framework to create learning goals that are based on six areas of learning going beyond "knowing" and "doing". Rather than a hierarchical framework, it is something that's relational to one another, where each piece works with the other.

The six pillars are

1. **Foundational Knowledge**: Understand and remember fundamental concepts, ideas, and information

2. **Application**: Learn how to use and apply the foundational knowledge

3. **Integration**: Seeing how a concept can relate to other concepts

4. **Human Dimension**: Identify and assesss the personal and social implications of the concept

5. **Caring**: Further develop previously set values, beliefs, feelings, and interests to define value of concept

6. **Learning how to learn**: Develop intuition for self-directed learning and continuation of a concept after a course

To implement this taxonomy, any piece works best when combined with some of others.

1.2.4   Metacognition and Wise Feedback

Metacognition is the thinking about thinking. To practice this, a person needs to be aware of and understand different ways of thinking (see how UDL connects?). Having some form of pre and post assessment lets people see the growth that occurs from the learning. For students, this is always done in the context of learning goals.

For a student to practice mindful metacognition, it requires a growth mindset of believing growth is possible. Instructors have the ability to demonstrate and model different ways of metacognition and its impacts outside of learning in a classroom. This can be particularly useful for pattern recognition and analyzing points of least comprehension. Metacognition is also useful for "ignorant learning", where instructors are clear about the boundaries and identifying specific ignorances ("ignore air resistance") that a concept revolves around (Tan & Koh, 2023). Solidifying how a person is thinking helps in making connections to other ways of thinking as well.

Slightly related to metacognition is the idea that learning should be served in bite-sized chunks that are stacked on top of one another, or **scaffolded**. This guided version of learning takes off the training wheels to let the students explore and build confidence on what they have learned ("take into account air resistance").

An important aspect of metacognition and scaffolding is to provide "wise" feedback to students that builds trust between the instructor and the student as well as trust between the concepts and the student. The student becomes much more comfortable with and trustworthy in the concepts with good feedback. Yeager et al. (2014) identifies the structure to "wise" feedback includes

1. Communicate high expectations and standards
2. Communicate belief in student's abilities to meet expectations
3. Provide specific feedback for student to improve upon

Furthermore, feedback should be ...

- Goal-oriented
- Tangible & transparent
- Actionable
- Appropriate level
- **Timely** (within 24 - 48 hours if possible)
- Ongoing
- Consistent

It is very important for feedback to be timely, so that it provides the student the ability to practice metacognition and self-reflection. Students shouldn't be receiving feedback, say for instance, only twice throughout the quarter with one of them being right after the final and the final grade of the course being delayed to the middle of the following quarter.

1.3 Astronomy Learning

1.3.1 Teaching Problem Solving

Teaching how to problem solve is difficult. Stice (1987) describes different methods on how to teach, and its Section 4 has a lively discussion on different methods and highlights mathematician George Polya's 4 step method with additions from engineer Donald Woods:

1. **Define**: Identify the problem

2. **Think**: Ponder about the problem including its attributes, necessary prerequisite information, and the field it stands in

3. **Plan**: Create a game plan with alternatives if there are any hiccups, and try describing the plan in different ways

4. **Carry out plan**: Execute the game plan

5. **Look back**: Make sure the solution solves the initially defined problem, check for reasonableness, identify potential applications, develop approximation techniques, and clearly communicate results

Students should be practicing these problem solving techniques with constant feedback from the instructor as guidance.

1.3.2 Passion Tax

Communicate with students the common potential pitfalls of being emotionally involved with the concepts. Practicing the self-compassion that's needed for a growth mindset requires being aware of the passion tax, which is well summarized by the common phrase

> If you really love science/astronomy, then you should ...

Being passionate about a subject, while it may provide extra motivation and connection, shouldn't come at the expense of the agency a person has over the subject. These common phrases can lead to exploitative practices and make it harder to set boundaries. It is good practice to share with students early on that, especially in academia, it is easy to get overcommitted on passion projects. Instructors should encourage conversations and model healthy practices.

Section 2: Learning Practice

Contributors: *Diego Garza*

2.1 Setting Environment

2.1.1 Teaching Assistant Ethics

Ethics of a teaching assistant is a broad topic that covers legal concepts that I am not qualified to speak on which include Title IX responsibilities. However, I would like to highlight some important considerations instructors should keep in mind so as to encourage UDL principles and create a safe, welcoming environment for everybody. This is slightly an extension of the Instructor/Educator mindset discussed earlier, as well as discussing the positionality and power dynamic that an instructor has over students.

Robert Filback and Alan Green, of the University of Southern California, created a framework to monitor educator mindsets and their consequences, which was adapted from Pollock (2008), Milner (2020), Hancock (2011), Bartolomé (2007)

1. **Student Demographics**: Instructors should have an AWARE mindset where they recognize differences and roles of demographics, not be BLIND (race-blind)

2. **Culture, Language, Ethnic Heritage**: Instructors should have a multicultural, strength-based, inquirical view that sees these traits as ASSETS instead of DEFICITS (assimilationist)

3. **Socioeconomic Status, Education Level, Career Path**: Instructors should have an EQUITY based mindset in order to be aware of systemic injustices and be open to exceptions to pure meritocracy to achieve more equal outcomes, rather than offering EQUALITY with pure meritocracy and individual agency

4. **Local Contexts**: Instructors should incorporate a SOCIOCULTURAL learning perspective rather than abstracting away and being A-CONTEXTUAL of real life implications

5. **Cultural Identification and Group Membership**: Instructors should have a multiconceptual and dynamic view of groups through the lens of INTERSECTIONALITY as opposed to placing students in individual buckets in a CATEGORICAL manner

Instructors should also properly role-model the practices in general astronomy, including citing works on presentation slides and resources. Also, the manner of communication should reflect what is expected from the students. The level of formality in conduct and language is seen and reflected by students. Professionalism should be practiced with students outside of class time as well. Most importantly (personally) is to communicate and demonstrate that it is okay to

1. Be unsure

2. Ask questions

3. Be wrong

2.1.2 Classroom Norms

To create a safe and welcoming environment for students to interact and learn in, there should be a common foundation for everybody to participate. That foundation is set by creating classroom norms with the students through dialogue. Creating classroom norms helps emphasize student's agency over their learning. Making a student comfortable, yet challenged, helps instill UDL principles to all students. Furthermore, inclusion is being perpetrated at the forefront of an activity, rather than as an afterthought.

In a shared document, students can make comments and propose new norms that can better elevate others's experience in the classroom. It is important to return to those norms and bring it up during classroom discussions to show students that the agency the instructor is given onto the students is being seen and valued.

2.1.3 Classroom Management

Communicating and being transparent about a concept's goals incorporating UDL principles is most of the challenge in managing a classroom. With clear and direct communication of an instructor's goals and establishing classroom norms, instructors just need to treat students like human beings, allow them the space to grow, and be flexible when things aren't working.

When dealing with questions, let the opportunity help everybody by ...

- **Paraphrase/Repeat** the question to ensure everybody heard the question and the question is well understood

- **Encourage/Commend** the question to help build an inquisitive environment and to demonstrate a student's agency in their learning

- **Honesty** is the best policy, and not knowing the answer to the question is not the end of the world

Make sure to communicate and model the structure of a **meaningful question** when paraphrasing. Essentially, a question is only "bad" if 1) it has the goal of putting others down , 2) it has the primary goal of making the student sound smarter, or 3) irrelevant to the conversation at hand to the point of being a distraction. To help construct a meaningful question, a general guideline is for a student to ask themselves

1. What is the goal of the question?

2. What context is needed for the instructor to answer the question?

3. Is the time/place appropriate for the question?

When an instructor asks a question to the class, allow for awkward silences to build up and let students think about it.

2.1.4 Hidden Curriculum

The "hidden curriculum" is **unspoken rules, expectations, and skills that students utilize to navigate college**. It is important to illuminate these "hidden" things and shine a light to them for all students, especially for those who come from a first-generation, low-income background. Sharing and discussing

the objective of resources is an easy way to uncover these hidden aspects. To help develop student buy-in, clear examples, directions, and outcomes should be accompanied by those resources. For example, "65% of the class attends office hours and those who attended had an average score 5% higher than those who didn't" demonstrates that there are other students who go to office hours and there are material benefits for students to reap.

Without helping illuminate these usually hidden resources, students may feel distracted, at a disadvantage, and have less agency over their learning. Outcomes of a concept are more likely up to luck and whether a student "gets it" rather than taking advantage of resources that could help them. Raising the blanket to the hidden curriculum ranges from defining common terms in class to being aware of the implicit skills and tools used, which all promote a growth mindset.

2.2 Useful Tools

2.2.1 Lesson Planning

To construct a lesson plan, instructors need to put all of the previous ideas into one basket. The general structure includes

1. Timing

2. Concepts / Topics / Skills covered

3. Learning goals

4. Agenda

5. Lecture / Problem solving

6. Active learning activity (which aligns with learning goals)

7. Assessment for understanding (with clear rubric)

8. Opportunity for feedback to students

9. Opportunity for students to provide feedback

10. UDL principles representation

2.2.2 Active Learning Techniques

Active learning is broadly defined as activities that promote learning where a student is actively doing something and they are thinking about what they are doing. Active learning provides students with a method of learning that asks them to become an active participant in the topic at hand. As opposed to passive learning, like lectures, **active learning gives students the chance to problem solve, struggle with, and practice the learning topic**. The focus is instead shifted from information retention to skill development.

Some examples of collaborative learning techniques, from Elizabeth F. Barkley (2014), include

1. **Dyadic Essays**: individually write an essay and a model answer, then exchange

2. **Test-Taking Teams**: prepare for an exam as a group, take it individually, discuss as a group

3. **Fishbowl Discussion**: smaller, more high-level discussion of students sitting in a circle surrounded by larger, more big-picture student discussions

4. **Analytic Teams**: divide roles and assign specific tasks to different students on an assignment

5. **Send-a-Problem**: group receives a problem, attempts a solution, then passes both to a nearby group

6. **Think-Aloud Pair Problem Solving**: student pairs solve problems with alternating roles of listener and problem-solver

7. **Think - Pair - Share**: Students think about a prompt, pair with a classmate, and share their results

2.2.3 Assessments

UDL ON CAMPUS - Universal Design for Learning in Higher Education highlights that instructors assess students for one of three broad reasons

1. **Accountability**: pair the student's success with respect to job preparation, prerequisites, and school goals

2. **Student Progress**: monitor how a student's performance changes over time as a result of instruction (assessment *of* learning)

3. **Instruction**: optimize course of learning by probing student response to instruction (assessment *for* learning)

Assessments should always be paired with a learning goal to provide motivation.

There are two forms of assessments:

- **Summative**: at a certain point of the semester/quarter (midterms, finals)

- **Formative**: along the way, identifies misconceptions, struggles, and learning gaps, and how to close those gaps

Summative assessments aren't necessarily the end of the world, but they shouldn't be relied upon solely. Instructors should use a combination of both to work synergistically with one another.

2.2.4 Flipped Classrooms

Flipped classrooms are learning environments where the student is expected to complete the more passive types of learning (lectures, readings) on their own time, and spend class time working on active learning activities with instructor feedback. With the ability to upload and share resources on the internet with hyperlinks, this can open the doors to new ways of learning to students. However, it should be used cautiously, as flipped classrooms require buy-in from students and trust in the system instructors ask them to adopt. If done correctly, it can allow students to process information at their own pace, and create shared learning experiences during class.

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