DEVELOPED FOR PHYSICALLY ACTIVE YOUTH

STUDENT INTERACTION GUIDE

Designing & Delivering STEM Lessons with Learners in Mind

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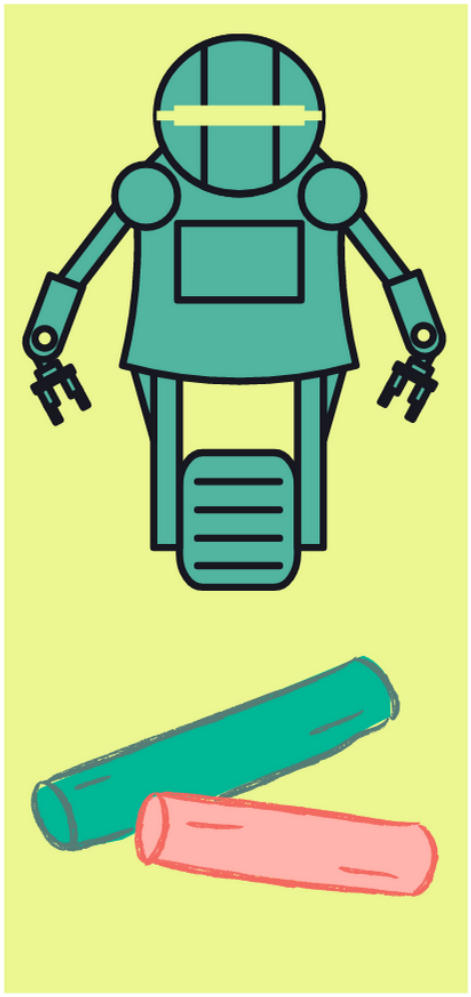
Introduction

This guide contains suggestions on how to improve a student's learning experience. The methods we discussed range from effectively managing the classroom to properly assessing each student's knowledge. In each of the different sections, we discussed specific skills and methods that will help a teacher continue to improve their presence in the classroom. We also share information about the implementation and usage of each skill or method into daily lessons.

This guide also contains an in depth discussion on gender and diversity and their place in the classroom. Through these sections, we state how instructors can promote diversity and inclusivity in their teaching methods to cater to everyone in the classroom. When instructors foster a diverse and inclusive learning environment, the students have the space to excel in technical fields. In this document we provide suggestions found through research and discussions with STEM educators and after school administrators.

CLASSROOM MANAGEMENT



STUDENT INTERACTION GUIDE

Classroom Management

Through our research we found nine different strategies that teachers consistently sighted as helping improve their classroom management. Effectively utilizing these skills will allow instructors to have more control of the classroom giving them more instruction time. The skills can be split into three separate categories: instructor-student relationships, time management, and enforcing rules.

The first set of skills are all designed to help instructors build a strong relationship with their students. A strong relationship with a student is more than the student simply liking the instructor, the student should respect the instructor and trust that they have their best interests in mind. There are many different methods for developing a strong relationship with each student and not every student is going to respond the same way to the same thing.

One recommendation to build a strong relationship with students is to greet them at the door at the start of a lesson. This establishes a positive tone for the rest of the lesson and can "boost academic engagement by 20 percentage points while reducing disruptive behavior by 9 percentage points"[1]. This slight change can add over four and a half minutes of instructional time to a one hour lesson. Another way an instructor can connect with the students more is by scheduling one-on-one meetings to get to know them better. Through these one-on-one meetings instructors can begin to understand the students' likes and dislikes, the things they enjoy and the ways they learn best. If the student feels that the instructor is actively trying to support them and know them, they are more likely to respond

[1]Terada, Youki. "8 Proactive Classroom Management Tips." *Edutopia*, 7 Aug. 2019, https://www.edutopia.org/article/8-proactive-classroom-management-tips.

more positively to directions and pay attention in class. Another method for instructors to foster strong relationships with their students is to acknowledge good behavior[2]. By highlighting the right thing to do, students are more likely to follow this course of action. If instructors go out of their way to recognize and value the skills and experiences the students bring to the classroom, the students often gain ownership in their work. Once students have ownership in their projects, they can build passion in the material and this could enhance their understanding of the material. Having a strong relationship with students allows for instructors to have more control over what happens in the classroom as students are more likely to follow instructions.

Managing time is another important skill for instructors to develop. Being able to control the amount of time spent on a particular topic or in the transitions between topics or activities allows instructors to spend more time teaching and less time trying to get the class focused. The first skill that will help any instructor manage time is to be prepared. Instructors need to be prepared for the lesson as well as to face any problems that may arise. Having a plan to redirect attention to the material when the students get distracted will allow class to resume more quickly as there are already steps in place to address the situation[3].

Another important time management skill is to have planned transitions from one activity to the next. This transition time is when students are the most likely to get distracted

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[2]Terada, Youki. "The Key to Effective Classroom Management." *Edutopia*, 27 Feb. 2019, https://www.edutopia.org/article/key-effective-classroom-management.

[3] "Classroom Management Techniques That Work In-Person and Online." *We Are Teachers*, 3 Aug. 2020, https://www.weareteachers.com/classroom-management-techniques/.

and derail a strong lesson plan. Having a plan on how to keep things moving quickly between activities gives students less of an opportunity to get distracted as they are already engaged with the next topic[4]. Also, planned transitions allow for instructors to develop a routine so that students know what to expect as the lesson progresses. By successfully managing time, instructors are able to deliver more of the material that is important and spend less time trying to get back on topic.

Developing rules is a critical part of managing a classroom. To assure the success of these rules, they need to be clearly established. One way an instructor can get the students to follow the rules is to get them involved in the rulemaking process. At the beginning of your program, allocate about an hour to establish the rules with the students, as this will give them ownership in what happens in the classroom. If the rules are not clearly established students may not understand expectations and are more likely to become distracted or misbehave[3]. When students do start to misbehave, addressing the issue before it becomes a big deal as making corrections to small issues is much easier than trying to fix something when the entire lesson has been derailed[5]. When rules have been established it is also important to enforce them fairly and consistently not showing favoritism or changing how rules are enforced[1].

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[4] Finley, Todd. "19 Big and Small Classroom Management Strategies." *Edutopia*, 6 June 2017, https://www.edutopia.org/blog/big-and-small-classroom-management-strategies-todd-finley.

[5] Kardamis, Linda. "30 Powerful Classroom Management Strategies You Can Implement Right Away." *Teach 4 The Heart*, https://teach4theheart.com/classroom-management-strategies/

Having effective classroom management skills will improve the success of lessons and make classes flow smoothly and efficiently. If an instructor can master all three of the parts of effective classroom management they will be able to become very successful.

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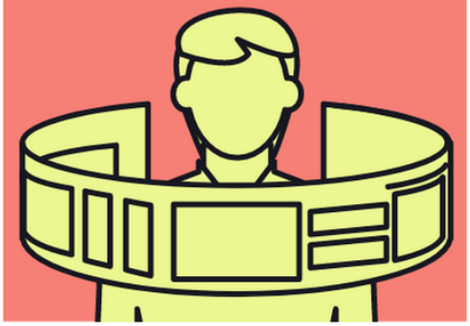
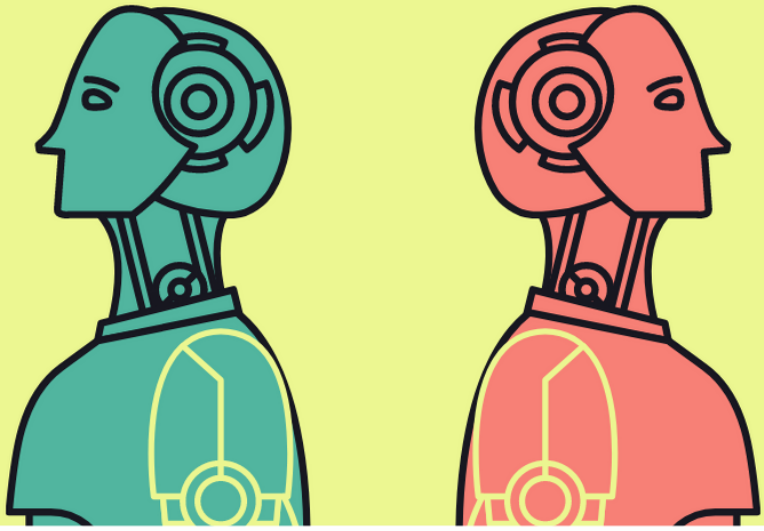
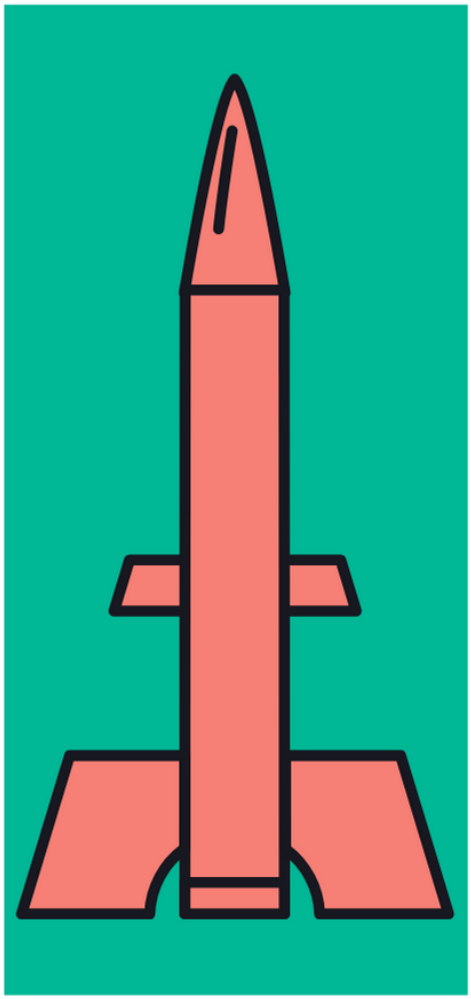
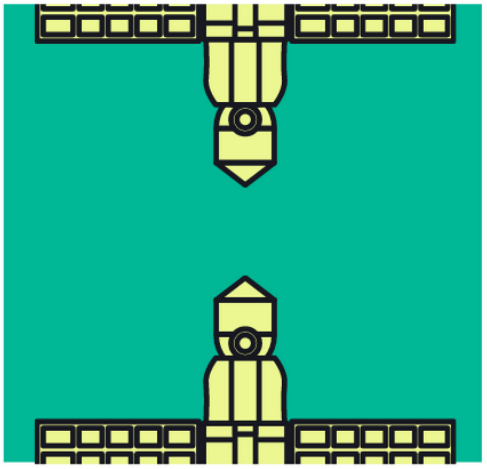


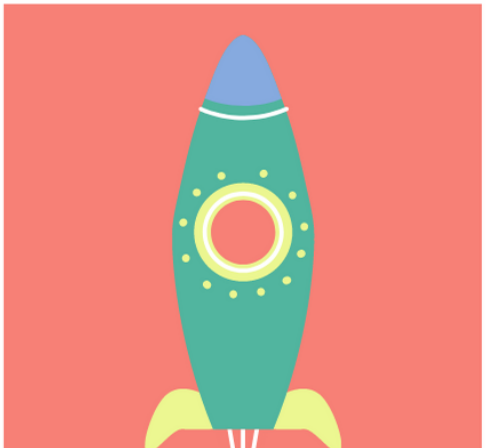
PROJECT BASED & ACTIVE LEARNING







STUDENT INTERACTION GUIDE



Project-Based & Active Learning

Through our research and interviews with the WPI STEM Education Center, we concluded that the students should receive the robotics lessons as a form of active learning, like project-based learning, to get the students involved in their understanding of the material.

Project-Based Learning

Project-based learning is a student-centered teaching method that allows the students to learn through the analysis and examination of engaging real-world problems. Project-based learning is a teaching method that provides students the opportunity to think critically, analyze problems, and find appropriate learning resources[6].

Project-based learning provides the students with a deeper understanding of the material that is being taught. It also provides them with real-world examples that equip them with the ability to see the applications of the material. Teaching a project-based curriculum allows for the students to be more in charge of their own learning. It also allows for them to work in groups, reflect on their work, distribute roles, and give presentations[7]. This prepares the students for the workforce, as many STEM fields are project oriented.

Since this teaching method is more student-centered, educators can step into the role of a project guide and advisor. They facilitate the information through projects to make

[6] R Pucher, A Mense and H Wahl,How to Motivate Students in Project Based Learning https://ieeexplore-ieee-org.ezpxy-web-p-u01.wpi.edu/stamp/stamp.jsp?tp=&arnumber=1146878&tag=1

[7] Dr. Shaban Aldabbus, PROJECT-BASED LEARNING: IMPLEMENTATION & CHALLENGES https://www.researchgate.net/profile/Shaban-Aldabbus/publication/328368222_PROJECT-BASED_LEARNING_IMPLEMENTATION_CHALLENGES/links/5bc8cd20a6fdcc03c79095e0/PROJECT-BASED-LEARNING-IMPLEMENTATION-CHALLENGES.pdf

learning interactive for the students and promote a fun and engaging environment for education. As shown in Figure 1, there are five stages to the process of project-based learning.

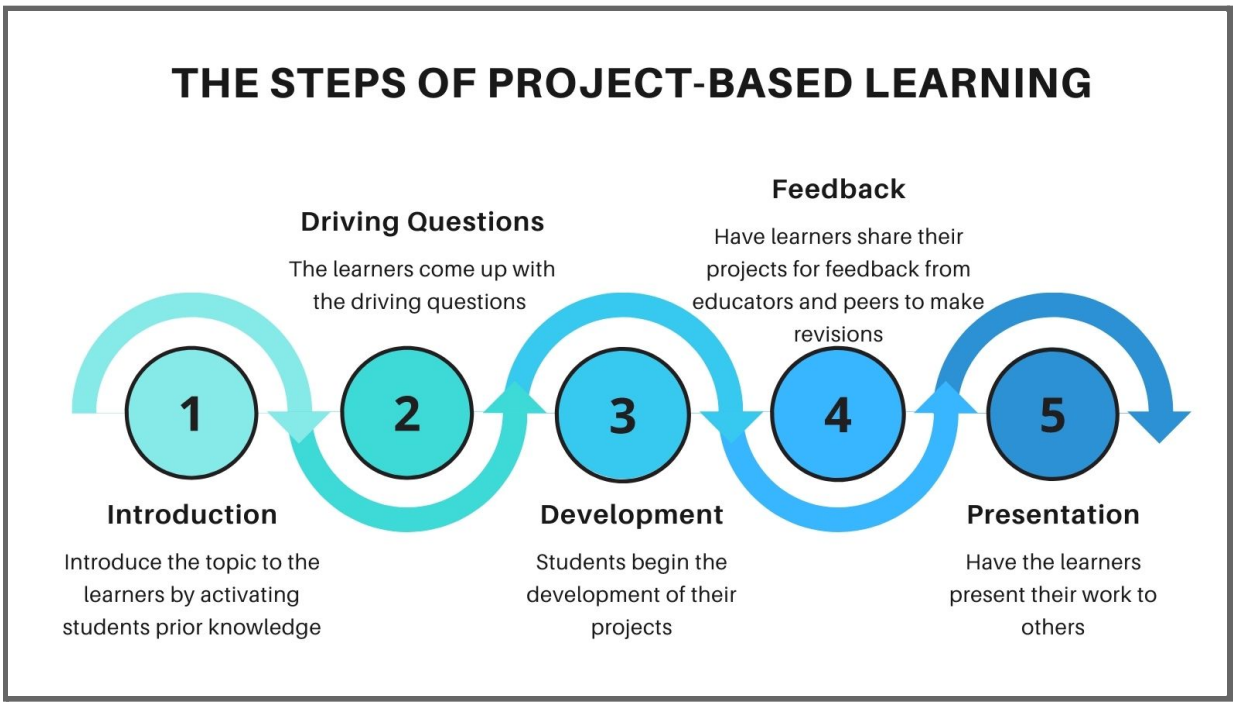


Figure 2: The Steps of Project-Based Learning

The first step is introducing the students to the topic. The learners should be introduced to topics by relating it to their prior knowledge and background. This will reinforce the knowledge and allow them a deeper understanding of the material. The learners should then come up with the driving questions for their project. These would be the main issues or issues that their projects would be addressing and can vary per project. After the students have come up with the driving issues for their project, the learners will move into the development of their projects. They should be in groups to promote communication and collaboration. While the students are working on their projects, they should go through the process of feedback. Learners will be able to learn from their educator's and peer's feedback and improve upon their projects and improve their circle thinking skills. Lastly the learners

should present their work. This will increase their communication skills as well as give them valuable practice for real world applications[8].

A simple example of project based learning that could be applied to a STEM curriculum is that of students building a bridge[9]. Students would start off by learning the engineering behind bridges such as the forces applied to them, loads, and different structural designs. They would then be split into groups and given materials to build a bridge. The lesson can be as complex or simple as needed. Students will then apply the knowledge learned from the bridge lesson to create one themselves. Throughout the building process they should be guided and supported when needed, but overall the project should be completed on their own. If a bridge fails, try asking the student what could have caused the failure to allow for them to assess their knowledge of bridges and learn from the mistakes. Once the bridges are complete students should present their projects. This can be done in a myriad of ways, such as a formal presentation or a competition. An example of a competition could be to apply weight to the bridges and the bridge that is able to hold the heaviest amount of weight would win. It is important for students to discuss why they made certain design choices as well to assure they are applying the knowledge learned in the classroom to the project.

[8] Dr. Shaban Aldabbus, PROJECT-BASED LEARNING: IMPLEMENTATION & CHALLENGES https://www.researchgate.net/profile/Shaban-Aldabbus/publication/328368222_PROJECT-BASED_LEARNING_IMPLEMENTATION_CHALLENGES/links/5bc8cd20a6fdcc03c79095e0/PROJECT-BASED-LEARNING-IMPLEMENTATION-CHALLENGES.pdf

[9] MATTHEW LYNCH, 7 EXAMPLES OF PROJECT-BASED LEARNING ACTIVITIES https://www.theedadvocate.org/7-examples-project-based-learning-activities/

Overall, when students are more active in their own learning process they tend to have a deep and more meaningful understanding of the material[10]. They are also able to take the material that they learned and apply it to real-world problems. This helps the students fully grasp the concept they are learning.

Active Learning

Active learning is much like that of project-based learning such that it promotes a deeper understanding of the material in a non-traditional sense. Active learning is another form of student-centered learning. It is a more passive type of student centered learning compared to project-based learning, but like project-based learning, it allows students to be more involved in the classroom. It is also a teaching method that engages students in the material, through activities that involve classroom discussions, problem solving, writing and reflecting. A study found that active learning can improve examination scores and students' understanding across all disciplines and in varying class sizes[11].

[10]Renata Holubova, Effective teaching methods—Project-based learning in physics https://files.eric.ed.gov/fulltext/ED504949.pdf

[11] Scott Freemana,1, Sarah L. Eddya, Miles McDonougha, Michelle K. Smithb, Nnadozie Okoroafora , Hannah Jordta , and Mary Pat Wenderotha, Active learning increases student performance in science, engineering, and mathematics, https://www.pnas.org/content/pnas/111/23/8410.full.pdf

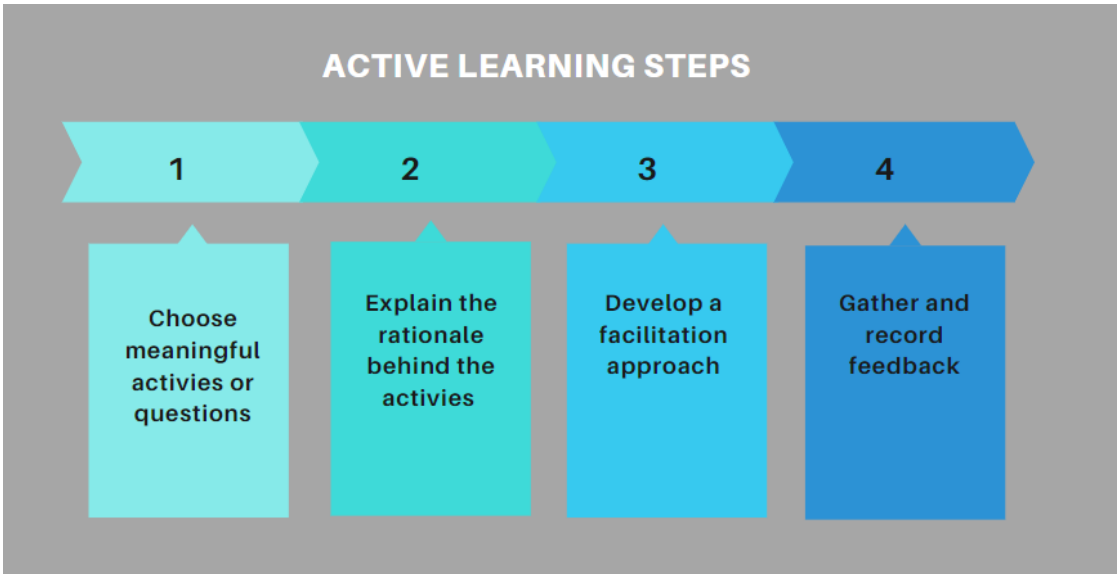


Figure 3: Active Learning Teaching Method Steps

As shown in Figure 3, there are four steps that aid in the successful implementation of an active learning style teaching method. The first step of this teaching method is to choose meaningful activities and questions[12]. The material is supposed to be engaging for the students and stimulate interest in the topic at hand. The focus of the material should be on the biggest takeaways that the learners should be getting from the lesson. Secondly, an explanation of why the learners are being provided the lesson in such a way will help them have a deeper understanding of why they are doing the activities. Third, the development of the facilitation approach should be completed by the educator. The facilitation of the activities and lessons can vary by topic and level. The main focus of the activities should be to aid the learners in the mastering of the topic at hand. Lastly, gathering and recording feedback will help with the improvement of the curriculum for future uses.

[12] Center for Educational Innovation, https://cei.umn.edu/active-learning

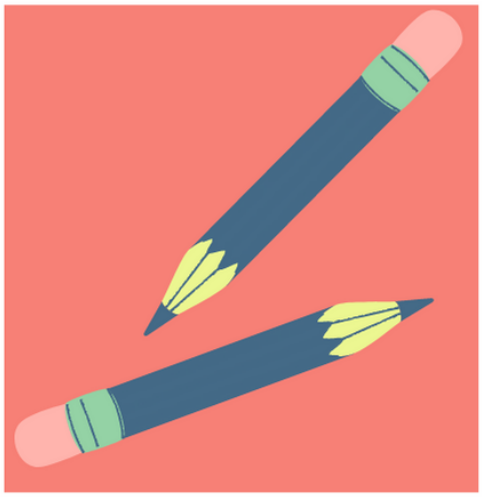
An example of an active learning lesson would be a think-pair-share activity[13]. Students could be given the topic of motors and the different applications for them. The students would then have a few minutes to write a response on the different applications of motors that they can think of. The students should then be paired up to discuss their responses. After this discussion individual students should be called upon to present their partner's findings. This activity allows students the opportunity to interact with the lesson as well as work collaboratively.

Active learning provided students the opportunity to apply the knowledge learned in the classroom to applicable activities. It is a less demanding learning style than project-based learning, providing a different type of learning outcome while still engaging learners with the topic of the lesson.

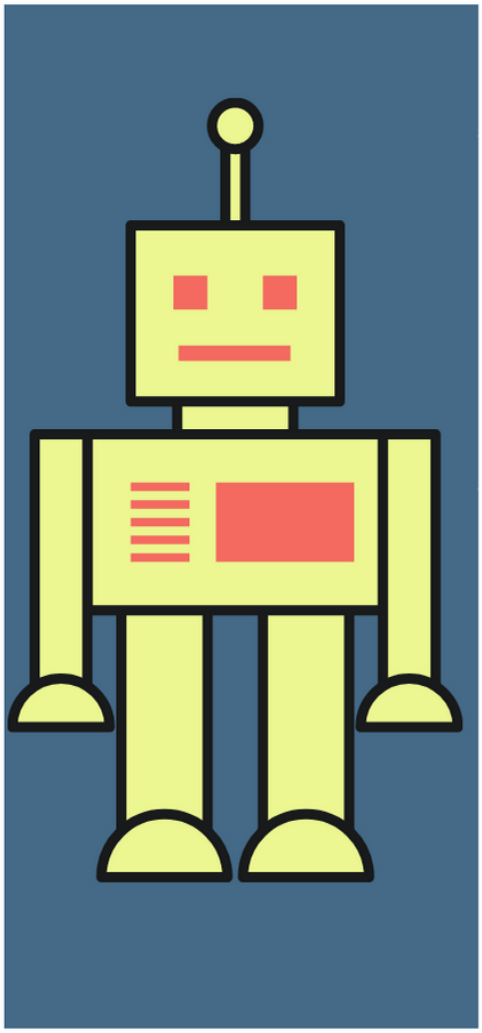
Making Projects Applicable

The projects and activities that the learners undertake should facilitate an active and engaging learning environment for them to build on their knowledge. Using their prior knowledge to introduce new topics reinforces their information as well as encourages interest in the newer topic. Projects should relate to not only the learners' prior knowledge but also their life experiences. This will promote a deeper interest and investment into the project.

[13] Active Learning Techniques for the Classroom, https://learninginnovation.duke.edu/resources/art-and-science-of-teaching/active-learning-techniques-classroom/



RECOMMENDATIONS FOR STEM EDUCATORS



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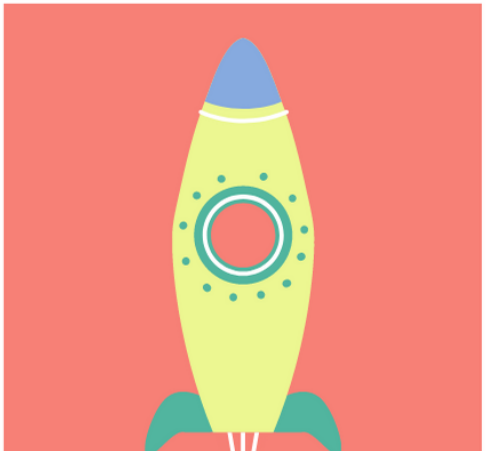

Recommendations for Delivering a STEM Education

After conducting a literature review and surveying educators in the greater Worcester, Massachusetts area, our team will provide the following recommendations on how instructors of all skill levels could present an effective STEM lesson:

1. Create interdisciplinary lessons that utilize the students' creativity and prior knowledge to solve problems that implicate them.
2. Focus all lessons with the students in mind.
    a. How will they perceive the lesson?
    b. How will they solve the problem?
    c. What will each student learn as a result of completing the lesson?
3. Target students with multiple different learning styles specifically experiential learning and transformative learning.
4. Present lessons with enthusiasm, confidence, and flexibility.

1. Interdisciplinary Lessons

One method that instructors can utilize to promote the engagement of the students is to develop interdisciplinary lessons. By definition, interdisciplinary studies involve the combination of two or more academic disciplines into one activity[14].

[14] What is interdisciplinary studies? | cbu online. (n.d.). Retrieved May 9, 2021, from https://www.cbuonline.edu/articles/what-is-interdisciplinary-studies#:~:text=The%20word%20%22interdisciplinary%22%20is%20defined,a%20breadth%20of%20understanding%20of

A principal strength of creating lessons that combine knowledge from multiple subjects is that students can make connections on prior knowledge and utilize those to solve problems in another discipline. STEM, in general, is interdisciplinary as it is a combination of Science, Technology, Engineering & Math. However, instructors can expand upon this by tying in humanities topics. For instance, instructors can give a historical context to a problem that can be solved with a robot like using a robot to pull up water from a well. Furthermore, robotics lessons can be expanded through an interdisciplinary perspective to utilize human-centered design[15] (Figure 4).

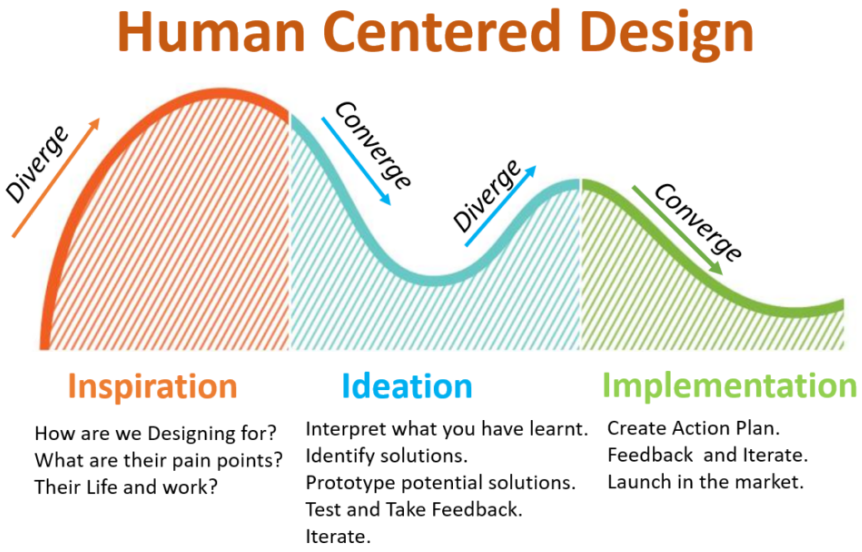

Figure 4: Human Centered Design[16]

[15] Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). Understanding k-12 stem education: A framework for developing stem literacy. Journal of Science Education and Technology, 29(3), 369–385. https://doi.org/10.1007/s10956-020-09823-x

[16] What is human centered design? (2019, November 13). Yukti. https://www.yukti.io/what-is-human-centered-design-and-why-it-works/

A human-centered design approach is a unique way to develop the students' problem solving skills. This method helps the students keep in mind the perspective of the people their designs would be aiding. We recommend that Physically Active Youth continue to expand their outreach to the city of Windhoek, and give the students the opportunity to design robots that will help people. The students could have the opportunity to interview the people who would be using their devices to comprehend the problems that their robot would be solving (Inspiration). From there, the instructor could support and help facilitate the different phases of design[17]: ask, research, imagine, plan, create, test (Ideation), and improve (Figure 5).

One instructor that we spoke to stated that a project that she facilitated had the students use design principles to create a design that gave them an advantage during a sports game. From there, the students had to pick a game, do research on the ways that people lose the game, imagine a solution to those issues, and then simply design a solution that helps them win the game. She stated that this sparked the students' interest as they had the opportunity to test and implement their devices for something that was fun and didn't feel like school. Students can design a robot that helps organize papers for a disabled instructor, or construct a robot that helps grab balls at the end of an outdoor activity. The opportunities are endless, all it takes is the right instructor to teach it.

[17] Engineering design process—Teachengineering. Org. (n.d.). Retrieved May 9, 2021, from https://www.teachengineering.org/design/designprocess

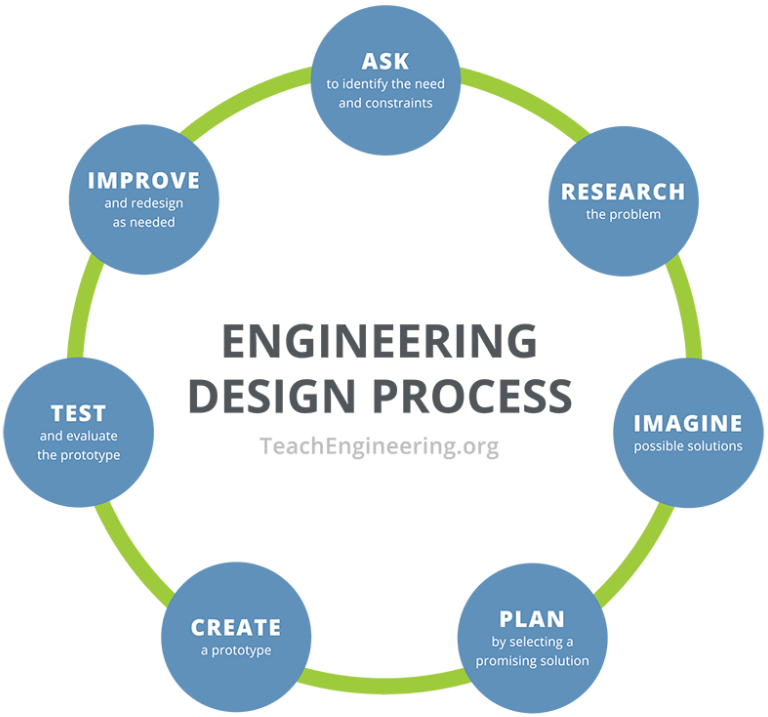

Figure 5: Engineering Design Process[18]

2. Student-Centered Learning

A benefit of utilizing a student-centered approach is that it helps students develop their critical thinking skills and shows them specific techniques for accessing information they are interested in.

One instructor we spoke to described student-centered learning as "anticipating the way students will perceive, understand, and question the materials we see". For example, instructors can do this by doing the lessons on their own, to see what could go wrong, and

[18] Engineering design process—Teachengineering.

how to troubleshoot any issues before they occur in the classroom. This would give the instructor the chance to think about how the students would go about solving a problem.

By prioritizing the preparation of lessons, instructors can prepare possible questions the students may have and become a greater resource to them. Student-centered learning should be designed with a very specific objective on what the students should obtain from the lesson[19]. By setting key objectives of what you want the students to learn at the end of the lesson, you can monitor their understanding and track if they are comprehending the material correctly. Furthermore, instructors should include the students' voice across all phases of both lesson design and delivery. The instructor should assure that the lessons focus on the students' experiences that can be meaningful and relevant to them. Finally, identifying and targeting each student's individual learning style is another way to promote the students' advancement in STEM topics.

3. Targeting Students with Different Learning Styles

One approach that an instructor can take to enhance the students' engagement in STEM topics is to cater to multiple learning styles. This can be done by using a mix of visual & auditory instruction, and by also having physical materials that the students can read and review at a later time. If the students are given a choice in how the material is presented to them, they may respond better to the instruction and be more engaged in the activities.

[19] What is student-centered learning and why is it important? (2020, August 25). Rethink Together. https://xqsuperschool.org/rethinktogether/what-is-student-centered-learning

Furthermore, instructors can create material that also targets students who learn best from experiential or transformative learning[20]. Experiential learning is a theory that states that true knowledge is "created using knowledge from one's experiences". Kolb's model of experiential learning includes four methods: do, observe, think & plan. This model helps students build skills like collaboration, communication, critical thinking, creativity, and problem-solving[21]. For teaching a STEM curriculum, experiential learning can be applied across various sectors of education like project-based learning or another version of active learning. Engineering design is a fantastic way to build the students' experience in experiential learning. Through the design process, most lessons that the students learn are from failure and by seeing what does and does not work. However, there are also other learning methods that can equally engage the students as well.

Additionally instructors can utilize transformative learning, a method that focuses on having a student alter their thinking based on new information. Jack Mezirow, the man who founded the theory, stated that "students had important teaching and learning opportunities connected to their past experiences" and later "found that critical reflection and critical review could lead to a transformation of their understanding[22]." Another application of this theory is lifelong learning and that "our world view is changed the more we learn, and that

[20] ElSayary, A. (2021). Using a reflective practice model to teach stem education in a blended learning environment. Eurasia Journal of Mathematics, Science and Technology Education, 17(2), em1942. https://doi.org/10.29333/ejmste/9699

[21] ElSayary, A. (2021). Using a reflective practice model to teach stem education in a blended learning environment

[22] ElSayary, A. (2021). Using a reflective practice model to teach stem education in a blended learning environment

helps us grasp new concepts and ideas.[23]" By incorporating lessons that not only build off of students' prior experience, but allow for a revelation of new understanding, students gain a greater understanding than they would in a traditional classroom setting. The final and most significant aspect that allows for the students' advancement is the enthusiasm, flexibility, and efficacy of the educator.

4. Attitude of the Educator

One of the most important aspects that lead to a successful delivery of instruction is the attitude and capability of the specific educator. In this case, capability will not be defined as technological knowledge, but moreover an understanding of instructional pedagogy.

Soft skills are a major aspect of comprehension of technical subjects for students but are also equally important for instructors as well. Taking the time to learn the best ways to present to a group of students with enthusiasm and care for the subject material goes a long way in helping the students learn the content. One researcher found that "there were signs that at times teachers were not confident in their implementation of the curriculum..." and "that affected what was accomplished in the class[24]."

Overall, we recommend that to advance the students' engagement and participation in STEM fields instructors should create interdisciplinary lessons, teach with the students in

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[23] What is transformative learning theory? (n.d.). Western Governors University. Retrieved May 9, 2021, from https://www.wgu.edu/blog/what-transformative-learning-theory2007.html

[24] Stohlmann, M., Moore, T., & Roehrig, G. (2012). Considerations for teaching integrated stem education. Journal of Pre-College Engineering Education Research, 2(1), 28–34. https://doi.org/10.5703/1288284314653

mind, target students with different learning styles, and maintain a positive attitude when interacting with the students. These steps will aid the students in understanding the robotics curricula and will help the teachers strengthen their pedagogy and ability to deliver STEM curricula.

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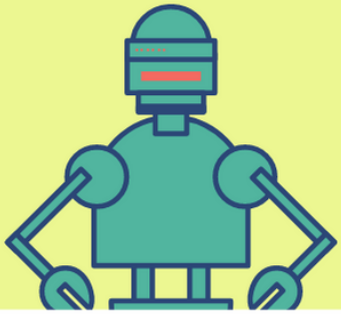
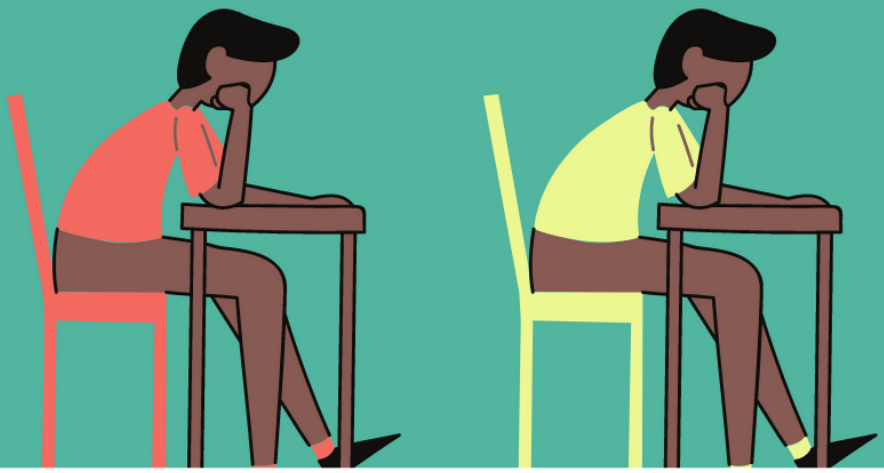
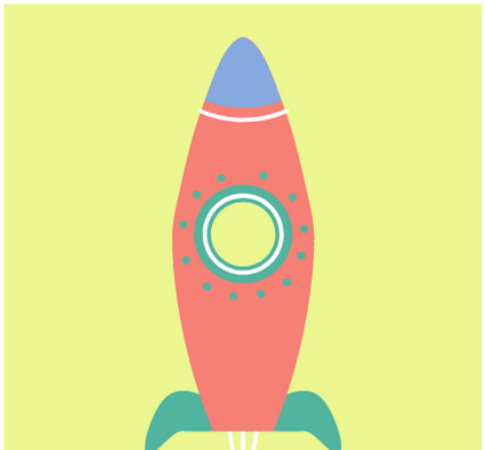


ASSESSING STUDENTS' KNOWLEDGE



STUDENT INTERACTION GUIDE



Assessing Students’ Knowledge

The assessment of learners' knowledge is an important process in the teaching process. At the beginning of the course, especially if a project-based learning teaching method is being implemented, students should be assessed on their prior knowledge. These assessments can be in the form of tests, activities, or a mixture. To decide what needs to be included in the assessment, it must first be decided what prior knowledge they may need for the course that is being taught.

It is also important to assess the students' understanding of the material throughout the process of the lesson. The assessments of the learners’ progress may present differently per teaching method. For project-based teaching methods, there are a collection of ways to assess the learners’ understanding of the material. These could include labs with lab reports, mini-projects, educator and peer reviews of projects, and other forms of assessment. For the active learning method these assessments can be done through written assignments, group activities, and tests.

At the end of the course, the learners should be assessed on the knowledge and progress throughout the course. This could be measured through successful projects, the completion of assignments, or final exams.

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HELPING STRUGGLING LEARNERS

STUDENT INTERACTION GUIDE

Helping Struggling Learners

While the goal is to instruct a lesson that does not leave any of the students behind as topics are discussed, inevitably, there will be some students who miss key points during instruction or have trouble comprehending at the level of the rest of the class. There are many strategies to engage these students, enabling them to catch back up to their peers.

Differentiated instruction is a method by which instructors can address the learning differences in their classroom. By setting goals on a per-student basis instead of only at the class level, students feel more efficacy, and take ownership of their learning[25]. When goals are tailored to the progress that each individual can be expected to make, it becomes easier to track a student's improvement, when compared to measuring the student against the rest of the class. A complete classroom running under differentiated instruction can be hard to maintain for a teacher working with many students, so coming up with one set of goals above and one below the average class level can allow for some differentiation, should it be needed.

A process which can work independently, or in conjunction with differentiated instruction, is high segmentation of the course content. Long lessons with many topics covered are difficult for some students to follow, but more importantly, they are harder to gauge progress on. Ideally, in a busy classroom with independent learners, multiple goals are set for the period, and learners may be able to choose the order for some or all of these targets. Again, increasing choice allows the student to gravitate towards the content that engages them. With this approach, an additional benefit arises. Students struggling with one

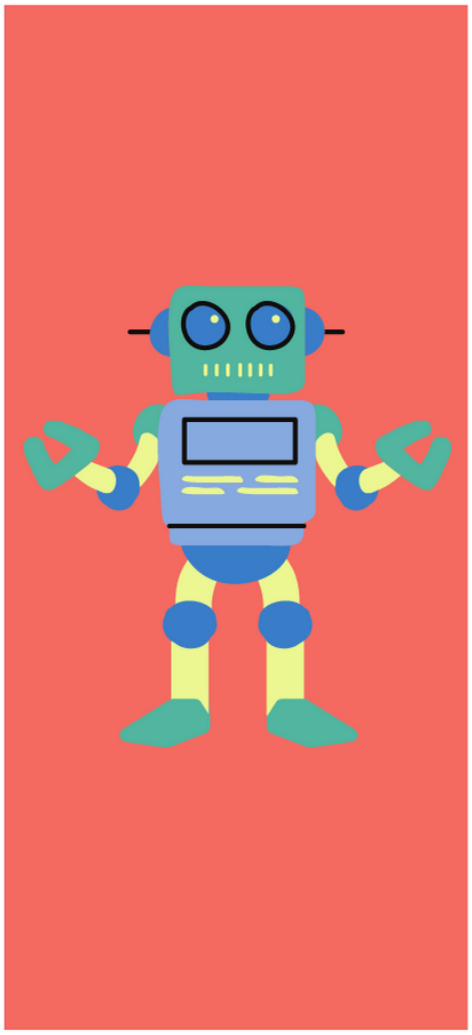
[25] Ginja, T., Chen, X. "Teacher Educators' Perspectives and Experiences towards Differentiated Instruction" https://files.eric.ed.gov/fulltext/EJ1270682.pdf

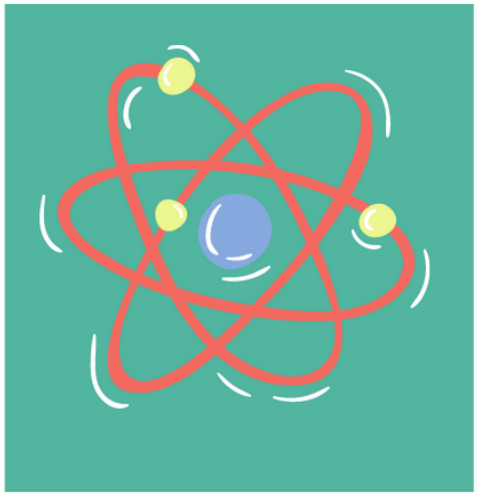
topic might focus on another goal until more of the class has an understanding with the difficult topic. After switching tasks, students can have more thoughtful questions and conversations, and be willing to ask their peers for help, knowing there are other students with at least a little more experience. It is important to have "stretch" goals that can be targets for students that are able to quickly complete the lesson. Differentiated goals do not necessarily have to be in the same field of instruction. In fact, some teachers find that activities like having students write a story about the work they did can promote deeper reflections for students that may have rushed through concepts, learning just enough to complete the lesson.

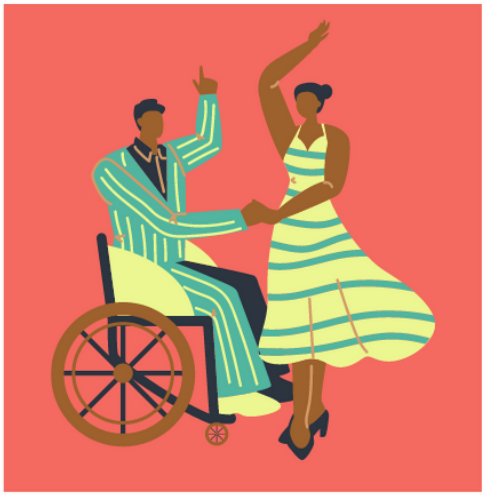
In order to best prepare for the questions, problems, and difficulties that some students will bring up, teachers should first do the full lesson on their own, taking note of their own struggles and points where the internet or other resources were used to get assistance with the activity. Especially in a project-based teaching environment, students may need varying attention and guidance, since they are creating, as opposed to memorization or recitation. Students who may excel at tasks where there is a "right answer" are often in need of extra guidance[26]. For these students, additional structure can aid in their ability to complete projects. By providing ways to break down the problem addressed by the project into smaller tasks, students overwhelmed by the many potential solutions to the problem can focus on just one at a time.

[26] Smith, E., Pastor, M. "Engage Me and I Learn" https://doi.org/10.1177/0031721716671905

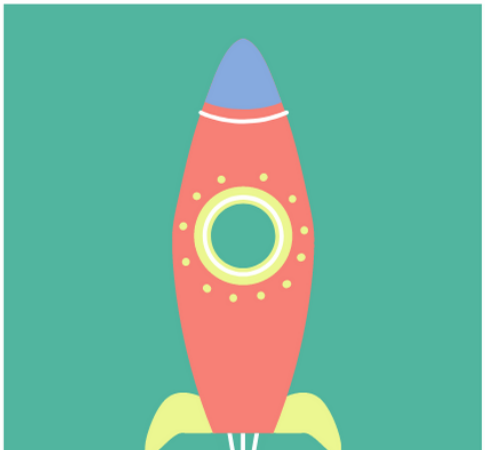
ROLE OF DIVERSITY & INCLUSION IN THE CLASSROOM







STUDENT INTERACTION GUIDE



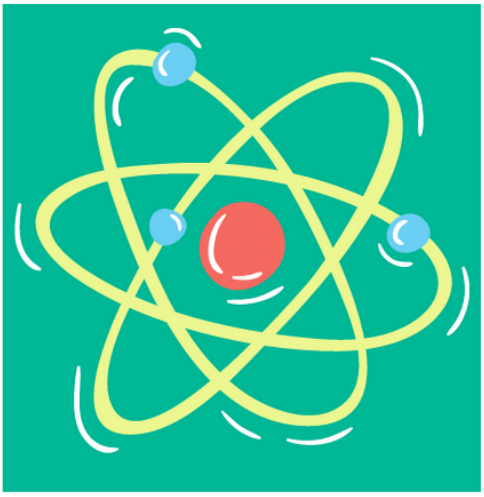
Role of Inclusion & Diversity in the Classroom

Some learners may be struggling because of exclusion in the classroom. While some forms of exclusion are obvious and can be mitigated by redesigning groups, many are more nuanced. Students may feel excluded from a project due to the context it is presented in as well. For this reason, it is very important to contextualize lessons and projects to the lived experience of one's students. In a classroom with students of various backgrounds and competencies, spending time to ensure groups of students work in an inclusive way is important, and should have class time devoted to this goal.

While cooperation between students may be enough to foster inclusion, teachers have an active role in the process, especially when a student is having many difficulties[27]. For students with learning disabilities especially, the teacher's involvement in group reflections leads to better understanding and pride in the work done for all involved. With inclusive learning strategies, students in out-groups or minorities in the classroom have a greater voice. Not only do typically excluded students get to participate in the learning activities of the "mainstream" students, teachers can work with these students to use the opportunity to share a differing perspective to more mainstream students. Exposing students to the diversity of their peers' life experience and decision-making processes helps to improve interpersonal skills and ultimately lead towards broader perspectives.

[27] Sormunen, K., Juuti, K. & Lavonen, J. *Maker-Centered Project-Based Learning in Inclusive Classes: Supporting Students' Active Participation with Teacher-Directed Reflective Discussions.* Int J of Sci and Math Educ 18, 691–712 (2020). https://doi.org/10.1007/s10763-019-09998-9

IMPLEMENTATION OF GENDER RESPONSIVE TRAINING



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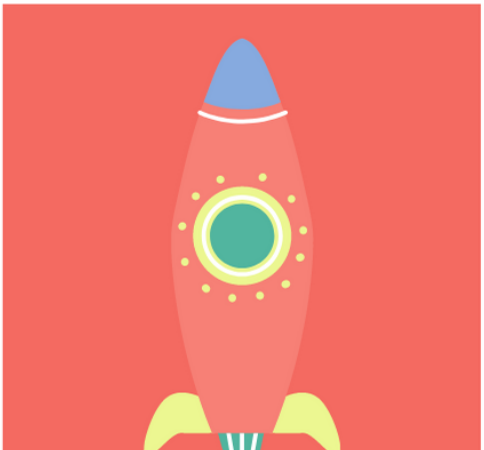

Implementation of Gender Responsive Training

One way to enhance engagement for women in technical fields is to employ gender responsive training. Gender responsive training refers to "teaching and learning processes that pay attention to the specific learning needs of girls and boys[28]." These learning needs will be described as the challenges that each gender faces in education and the goal of this training is to fully eliminate any gender bias in the classroom.

Through this document educators will gain proper training to unlearn stereotypes based around gender. In this section, gender responsive training will be described as the difference in learning styles of both genders and preferred modes of delivery & instruction.

1. Learning Styles

Outside of experiential and transformative learning, there are many other different learning styles that students may utilize when reviewing a STEM curriculum. One study explored two different continuums that describe one's learning style: the active experimentation-reflective observation dimension & concrete experience-abstract conceptualization dimension[29].

This study was done to see if there was a correlation between one's learning style and their gender. The active experimentation- reflective observation dimension deals with how an individual uses the information they are being taught. Learners who approach learning

[28] Training trainers on gender responsive pedagogy | unesco-iicba. (n.d.). Retrieved May 9, 2021, from http://www.iicba.unesco.org/?q=node/337

[29] Kulturel-Konak, S., D'Allegro, M. L., & Dickinson, S. (2011). Review of gender differences in learning styles: Suggestions for stem education. Contemporary Issues in Education Research (CIER), 4(3), 9–18. https://doi.org/10.19030/cier.v4i3.4116

with active experimentation, enjoy physically working with the material to best understand it[30]. The opposite are described as reflective observers, which are students that prefer to watch an individual and learn best from visual instruction (Figure 6).

The concrete experience-abstract conceptualization dimension focuses on how an individual perceives and understands direction[31]. This dimension probes the student to focus on the method in which they learn the material. Concrete experience learners are described as "feelers" meaning they base their understanding of the material by their intuition and their emotions. Abstract conceptualization learners are detailed to be "thinkers", meaning they utilize logic to comprehend new lessons[32].

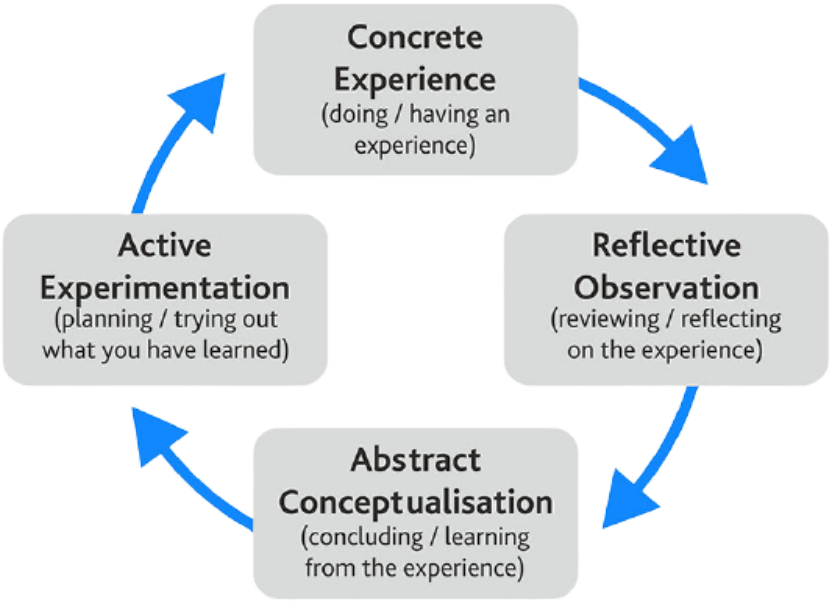

Figure 6: Domain[33]

[30] Ibib
[31] Ibib
[32] Ibib
[33] What are kolb's learning styles and what do they mean? (2019, November 13). Skillshub.com. https://www.skillshub.com/what-are-kolbs-learning-styles/

Those who prefer concrete experience & active experimentation are labeled as accommodators, meaning they are more practical, enjoy planning, and learn best through trial and error. The other side of the spectrum are assimilators who are more observational & and learn best through abstract conceptual styles. Those who have this style of learning use logic and reason to guide their decisions.

This study found that men most often identify as assimilators while women identify with this one the least[34]. Additionally, the study also suggested that females score higher in the concrete learning mode while males typically score best on the abstract conceptualization. Women with a concrete experience learning preference use hands-on experiences to learn and make decisions intuitively. Men who prefer abstract conceptualization tend to think logically. Overall, instructors can utilize this knowledge to best deliver a robotics curriculum through various avenues.

Instructors should present material first through an abstract open-ended problem that provides the students to build strategies and reason (assimilators/males), and from there give the students the opportunity to tinker and learn through trial and error (accommodator/females). If there is a disproportionate amount of students per gender in a classroom an educator can use their independent reasoning to determine how to teach each student in the best way.

[34] Kulturel-Konak, S., D'Allegro, M. L., & Dickinson, S. (2011). Review of gender differences in learning styles

Course Material & Methods of Learning

This same study also compared how gender influences one's preferred course material. In the survey students were told to choose between four different types of course material preferences: concrete material (data), creative thinking materials (brainstorming), abstract materials (concepts & theories), hands-on materials (experiments)[35].

The results truly illustrated how gender influences one's preferred course material. Primarily, both genders preferred concrete materials and hands-on material at about the same rate[36] (± 3%). The most significant conclusion made from this study is that 15.8% more women prefer brainstorming activities over men[37] (Figure 7). Therefore, when instructing women one could use brainstorming activities to engage females more in a STEM classroom.

Table 1: Course Material Preference for Males and Females

	Gender				Major			
	Male		Female		STEM		Non-STEM	
Preference	*n*	%	*n*	%	*n*	%	*n*	%
Concrete Material (i.e., facts, data)	48	34.3	52	30.6	55	33.1	43	30.9
Creative Thinking Materials (i.e., brainstorming)	33	23.6	67	39.4	34	20.5	63	45.3
Abstract Materials (i.e., concepts, theories)	16	11.4	10	5.9	14	8.4	11	7.9
Hands-on Materials (i.e., experiments)	43	24.1	41	27.1	63	38.0	22	15.8

Figure 7: Course Material Preference for Males & Females[38]

The next survey probed respondents on their desired methods of learning new content. The modes of delivery are preference facts, connection with related subjects, observe & reflect, test implications, focus on specific problems, work with others, do research, and

[35] Ibib
[36] Ibib
[37] Ibib
[38] Ibib

use experiments[39] (Figure 6). Overall, 15.8% more women preferred connection to related subjects (interdisciplinary than men) and 14.7% more men preferred testing implications over women. Finally, 14.1% more women observed & reflected to learn the lesson than men. Therefore, we recommend that instructors use interdisciplinary lessons to engage female students in a robotics education. Regarding testing implications, allow male students an opportunity to see how the robots they will build will affect the users, as this tends to allow them to be more engaged in the course material. Lastly, having a space for female students to reflect on their work after the course is done could give them a chance to finalize learning new material and put together more connections in the material.

Table 2: Methods of Learning New Content Preferences for Males and Females (Note that respondents could choose more than one method.)

	Gender				Major			
	Male		Female		STEM		Non-STEM	
	n	%	*n*	%	*n*	%	*n*	%
Preference Facts	60	25.8	92	29.7	74	24.3	61	20.9
Connections with Related Subjects	55	23.6	122	39.4	63	20.7	37	12.1
Observe and Reflect	78	11.4	79	25.5	96	31.5	71	23.3
Test Implications	95	24.1	29	9.4	114	37.4	116	38.0
Focus on Specific Problems	85	24.1	44	14.2	108	35.4	99	32.5
Work with Others	86	24.1	66	21.3	104	34.1	81	26.6
Do Research	96	24.1	42	13.5	114	37.4	106	34.8
Use Experiments	89	24.1	57	18.4	92	30.2	015	34.4

Figure 6: Methods of Learning New Content Gender Based[40]

Overall through this section, we provided recommendations to STEM instructors in ways that they can best engage different genders in technical studies. We believe that these techniques should be used in conjunction with one another to assure that students do not feel excluded in lessons.

[39] Ibib
[40] Ibib

Conclusion

Over the course of this guide, we discussed the different ways for educators to improve their classroom environment. Educators who are able to successfully implement these techniques are able to take their instruction to the next level, elevating the students' experience and learning throughout a lesson.

Classroom management skills allow instructors to have more control in the classroom, leading to more efficient teaching as less time is spent away from the lesson. Being able to implement project-based learning and other active learning techniques also allows for students to form stronger connections with the material ultimately giving them a better understanding of the material. Additionally, successfully assessing students' ability to grasp and understand the material will allow educators to know when they are able to move onto the next lesson and when they need to go back and reteach material from a previous section.

Being able to teach lessons such that the most students are able to understand it is vital for educators. As such, we made recommendations on how instructors can teach students with different learning styles.. While it is difficult to teach things only one way and have every student understand, it is possible to combine materials that cater to multiple different learning styles. Planning a lesson so that material is delivered several times, in multiple ways, allows for more students to grasp the concepts. If instructors want to learn more about the topics covered in this guide, all resources used when creating it are referenced for further reading.