

A means to foster STEM interest: A mystery room at Banksia Gardens Community Services



Abstract

Our project aimed to increase student engagement in science, technology, engineering, and math (STEM) by creating a mystery room for Banksia Gardens Community Services for its after-school program. Students in local schools are not pursuing careers in STEM, and this project provides the opportunity to increase their interest in these fields while providing a unique way to interact with the subjects. The mystery room made use of a theme, narrative, puzzles, actor, and immersive environment to engage participants. To complete this project, we researched learning styles and the mystery room design processes, built a room, and evaluated how engaging the experience was. We developed an iterative design-feedback process to create a mystery room that incorporated visual, auditory, and kinesthetic components while introducing STEM concepts to the participants. Our project resulted in a mystery room that engaged multiple learning types and presented fun and easy-to-learn science facts. Throughout our process, we learned that our mystery room required an actor and a linear flow of puzzles to be more effective as an educational tool.

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Throughout the world, a gap is forming between the increasing number of available jobs in science, technology, engineering and math (STEM) and the decreasing number of people to fill them. Therefore, it is important to motivate students to study STEM and seek careers in those areas. To facilitate this, teachers can employ unique teaching methods to engage students. Through learning STEM materials in new ways, students may find the motivation to investigate further into these crucial fields. This project sought to provide a new educational program in the form of a mystery room^a implemented at Banksia Gardens Community Services (Banksia) to increase STEM interest for its after school students. Banksia is a neighborhood community center located in the Broadmeadows suburb of Melbourne, Australia. Broadmeadows is an economically disadvantaged region, with a high population of refugees and non-English speakers. Due to these factors, many youth are behind in schooling compared to other Australians their age. Additionally, many are not encouraged to stay motivated and do well in their studies, and consequently do not ever reach Year 12. Banksia provides academic support through a homework study group and extracurricular educational pro-

^a The mystery room is an evolved escape room. An escape room is a game involving players solving puzzles in an attempt to “escape” from a locked room or enclosed space. We use the term “mystery room” to refer to a similar game experience involving puzzles, where the goal may not necessarily be to escape but instead to solve puzzles and challenges in a limited amount of time. Typically, a mystery room focuses more on a narrative and theme than an escape room does.

grams. The organization would like further its supportive efforts and thus has sponsored this project in hopes to more fully engage youth in STEM.

The objectives of this project were to 1) assess different learning styles, 2) to research the design process of a mystery room, 3) to construct a mystery room, 4) and to evaluate student engagement in the room. To implement the aforementioned objectives, we reviewed the literature on learning styles and STEM in the Australian Curriculum, observed Banksia youth, and created a STEM-related mystery room using an iterative design-feedback process. We determined that for the mystery room to be successful, it must accommodate for all learning types. The mystery room was built at Banksia, and featured several levels of difficulty to engage students from ages 5 to 16. Many Banksia youth are disengaged from STEM and only interact with the concepts through traditional schooling. By providing a completely new experience, this project sought to increase their interest in the STEM fields.

Mystery Rooms as a Means to Engage Students’ Diverse Learning Types

In this section we present our background research on STEM interest, STEM in the Australian Curriculum, student engagement, and learning styles (for Objective 1). We also review literature on game-based learning, educational escape rooms, and the escape room design process (Objective 2).

Engaging students in STEM: Strategies to meet the Australian Curriculum’s STEM goals

In 2009, Australia established a national academic curriculum, which included objectives for science and math, and in 2012, technology objectives were added.^{1,2} The curriculum stresses knowledge of core concepts and their applications to the real world. It also points out how important STEM skills are for future employment and global competitiveness, explaining that

to ensure international competitiveness, the Australian science curriculum must meet the needs of . . . students: who, as citizens in a global world, need to make personal decisions on the basis of a scientific view of the world; who will become the future research scientists and engineers; and who will become analysts and entrepreneurs in the diverse fields of business, technology and economics.¹

It also defines successful mathematics education as providing “a workforce that is appropriately educated in mathematics to contribute productively in an ever-changing global economy, with both rapid revolutions in technology and global and local social challenges.”² Despite the goals of the Australian Curriculum for Science, Mathematics, and Technologies, some studies show that students lose interest in these subjects between Years 4 and 7, and only 16% of Australian college graduates have a degree in STEM.^{3,4} How might educators increase interest in these subjects so that students are motivated to pursue advanced study and careers? The educational literature suggests “engagement” may be the key.

In an educational sense, “engagement” is defined as “the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught.”⁵ Additionally, engaged students spend more time on tasks, even if they do not realize it.⁶ Furthermore, there are three types of engagement that are defined under the term: behavioral engagement, emotional engagement, and cognitive engagement.⁷ Behavioral engagement relates to participation academically, socially, and extracurricularly.⁷ Emotional engagement relates to the reactions to instructors, peers, and work.⁷ Cognitive engagement relates to investment, thoughtfulness, and willingness to work.⁷ Together, these three types of engagement motivate students through the formation of bonds between the student and institution and the prevention of dropping out.

Sustained engagement can increase interest in a topic over time, and eventually that makes students more motivated to keep learning about it. Motivation is determined by how much a student values the subject matter, believes in his or her ability to succeed, feels accepted in the educational community, and feels a sense of control over learning activity.⁸ Educators can foster engagement when they 1) create tasks that feel “real” (authentic) to students, 2) when they pose problems or questions for students to solve (inquiry), and 3) when they ask students to work with others on a learning task (collaboration).⁸ These principles are easy to apply to escape room scenarios in that participants usually play the game in small groups and are given an urgent and realistic problem to solve in the context of a story or narrative. Teachers can also foster engagement when they adopt strategies for “transformative learning” over “conventional teaching.” Conventional teaching is a style that

gives learners a passive role, where they are meant to sit quietly and follow instructions. Contrarily, transformative learning puts students in an active role, where they don’t only memorize material but they also apply concepts to achieve a task. Conventional teaching focuses on a standardized teaching method; whereas transformative learning employs a variety of methods to engage a diverse group of students (see Table 1).⁹

Tailored teaching techniques for diverse learning styles

Teachers can engage students in STEM if they adopt principles of transformative learning. Bloom’s Taxonomy of Educational Objectives (see Supplemental Materials B) provides one productive method for developing practices and goals along these lines. An updated model of Bloom’s Taxonomy mixes the knowledge, skills, and affective goals together. Its six levels are organized according to increasing complexity: remembering, understanding, applying,

Table 1: Conventional and Transformative Learning Outcomes (adapted from Kozack and Elliott)

	Conventional Teaching	Transformative Learning
Goals for Learners	<ul style="list-style-type: none"> Knowing the right answers through recall 	<ul style="list-style-type: none"> Challenge information based on facts, evidence and examined values
Choice of Learning Pathways	<ul style="list-style-type: none"> Standardized Learner fits into school Few pathways are available 	<ul style="list-style-type: none"> Personalized School adapts to the needs and interests of the learner
Educator’s Role	<ul style="list-style-type: none"> Authoritative Command and control learning 	<ul style="list-style-type: none"> Coach, facilitator, co-learner
Learner’s Role	<ul style="list-style-type: none"> Predominately passive Sitting, listening, following instructions 	<ul style="list-style-type: none"> Active Seeking, interpreting, analyzing, judging, applying individually and with peers Knowing what to do when direction is not clear
Curriculum	<ul style="list-style-type: none"> Cover the curriculum through unit discovery 	<ul style="list-style-type: none"> Uncover the curriculum through learning projects and inquiries
Focus of Learning	<ul style="list-style-type: none"> Information transfer to the student 	<ul style="list-style-type: none"> Knowledge construction by the students

analyzing, evaluating, and creating. By developing assignments around these mixed objectives, teachers can provide a clear path for students to increase their involvement with the learning material (see Table 2).¹⁰

Educators should aim to incorporate activities related to the higher learning levels, such as create and evaluate, so that their students are more likely to be engaged, because lessons that include goals such as building and developing give students greater autonomy over the learning material. When students feel a sense of control over learning activity, their motivation to learn a topic is incited.

Students learn material in different ways, and recognizing and acknowledging these unique

learning styles creates an opportunity for engaging students. The way students learn material has been generalized into three learning styles: visual, auditory and kinesthetic. Naturally students cannot be pigeonholed into one type, but they do display a dominant style.¹¹ Visual learners best understand material through graphics and presentations. Auditory retain material best through listening and sound. Kinesthetic learners learn from doing activities. To promote student engagement, educators may use teaching techniques catered to students' different learning styles. Teaching practices that can provide multiple means to interact with material have greater success as more students may find the material accessible. The most prevalent model is the Visual, Auditory, Kines-

thetic Model (see Table 3).¹²

This model demonstrates that there are a few ways that students can understand material. Conventional teaching methods often only employ linguistic and logical tools to convey information, which fail to engage all learning types. These tools typically are auditory or visual, and do not provide a kinesthetic way to interact with the materials. On the other hand, transformative learning methods implement ways to interact with material that employs all of the senses. One approach to transformative learning is called game-based learning, which seeks to have students interact with subject material in an unconventional way. Through gameplay, students can interact with the learning material using different senses.

Table 2: How Bloom's Taxonomy works with learning objectives (adapted from The University of Arkansas)

Bloom's Level	Key Verbs	Example Learning Objective
Create	design, formulate, build, invent, create, compose, generate, derive, modify, develop.	<i>By the end of this lesson, the student will be able to design an original homework problem dealing with the principle of conservation of energy.</i>
Evaluate	choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.	<i>By the end of this lesson, the student will be able to determine whether using conservation of energy or conservation of momentum would be more appropriate for solving a dynamics problem.</i>
Analyze	classify, break down, categorize, analyze, diagram, illustrate, criticize, simplify, associate.	<i>By the end of this lesson, the student will be able to differentiate between potential and kinetic energy.</i>
Apply	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform.	<i>By the end of this lesson, the student will be able to calculate the kinetic energy of a projectile.</i>
Understand	describe, explain, paraphrase, restate, give original examples of, summarize, contrast, interpret, discuss.	<i>By the end of this lesson, the student will be able to describe Newton's three laws of motion to in her/his own words</i>
Remember	list, recite, outline, define, name, match, quote, recall, identify, label, recognize.	<i>By the end of this lesson, the student will be able to recite Newton's three laws of motion.</i>

Game-Based Learning as a means to engage multiple learning styles

Game-based learning (GBL) is a teaching tool that has been developed to promote the engagement of a diverse group of learners. GBL is game play with narratives, artificial conflict, and rules of play to make it interesting and engaging while promoting a learning objective.¹² Game-based learning theory features four main attributes that make it an effective teaching tool: motivation, engagement, adaptivity, and graceful failure. First, the motivational function of games drives students to participate for longer periods of time. Second, the three engagements (emotional, behavioral, and cognitive) are promoted; however, GBL must deeply incite cognitive engagement. If it fails to do this, GBL does not help the student learn subject material. Third, adaptivity in game-play allows for each participant to interact

Table 3: Visual, Auditory, Kinesthetic Learning Styles Model (adapted from Department of Education and Training)

	Visual	Auditory	Kinesthetic
Learning Style	Learn by seeing and looking	Learn by hearing and listening	Learn by touching and doing
Indicators	<ul style="list-style-type: none"> Take detailed notes rather than get involved in discussions Benefit from illustrations and presentations 	<ul style="list-style-type: none"> Acquire knowledge by reading aloud Enjoy discussions and talking things through and listening to others 	<ul style="list-style-type: none"> Learn through doing activities Remember what was done, but have difficulty with what was said or seen
Appropriate comments to prompt student inquiry	<ul style="list-style-type: none"> “How do you see the situation?” “Do you see what I am showing you?” 	<ul style="list-style-type: none"> “I hear you clearly.” “This sounds good.” “I’m wanting you to listen.” 	<ul style="list-style-type: none"> “How do you feel about this?” “Are you in touch with what I am saying?”

with the game with their specific learning style. Finally, graceful failure is promoted, where students are encouraged to take greater risks without the penalty of grading. GBL enables students to follow their own decision-making process, even if they make a mistake.

Game-based learning can be modeled in various ways; however, an all-encompassing model presents the attributes of challenge, response, and feedback. Challenge prompts the player to begin the game. Response promotes ways the player can interact with the game. Feedback provides the means for students to improve their understanding of the content or the skills required to play the game. The main foundation of the learning activities includes incentive systems, the game mechanics or rules of play, and the design of the learning system (Figure 1).¹³

The foundation of GBL lies at the intersection of the three attributes, as it would fail to be a teaching tool without each of them. The challenge is essential to the game aspect of GBL;

however, response and feedback are what elevate a traditional game into a teaching tool. Response and feedback tie standard teaching techniques into the game so that students have defined ways to interact and learn from their mistakes.

The use of escape rooms as an educational tool

One immersive implementation of game-based learning is an escape room, where players complete a goal through discovery and problem-solving in a limited environment with both physical space and time parameters.¹³ Despite the name implying that players are required to “escape” from a room, this is not true in all cases. Escape rooms are a recent phenomenon, although they have roots in game genres such as live-action role-playing, adventure games, treasure hunts, interactive theater, and game shows.¹⁴ Escape rooms have rapidly grown in popularity because the experience requires “a diverse set of skills and knowledge to play the game.”¹⁴ Therefore escape rooms appeal to companies and edu-

cational institutions as team-building exercises.¹⁵ Educational escape rooms aim “to improve cooperation and problem-solving skills” meaning one goal of them is to increase a student’s personal development.¹⁶ While STEM topics are not the primary focus, they can still be introduced to participants in subtle and fun ways. The major components of an escape room include: target group, theme and narrative, challenges and puzzles, and the physical space. In educational escape rooms, an additional component is the learning objectives. The target group is the intended set of participants whose age, background, competencies, and group size must be considered in the design. An escape room can have varying levels of theming and story-telling, ranging from themeless to complete integration of the puzzles into the narrative.¹⁷ Tight theming and narrative development increases player motivation through a compelling game experience.¹⁷



Figure 1: Model of Game-Based Learning (adapted from *Foundations of Game-Based Learning*)

For educational escape rooms, the narrative is not only “the flow of the game but also the structure upon which the learning process is relayed.”¹⁶ Learning objectives flow from the narrative and the design must accommodate for what the players already know, what their interests are, and what they can discover or learn through the experience. The puzzles and challenges are what the players interact with to continue through the game. Finally, the structure of the physical space is a major component to the game itself. Escape rooms can be a physical room, combination of rooms, virtual area, or set aside puzzle space on a table. Typically, there are also spaces to introduce the challenge and rules and to collect learning outcomes as well as a place to monitor from and offer hints.¹⁶

The escapED Framework

Escape rooms most often feature players participating in a “locked” area; however, this project will refer to the experience as a mystery room as the goal of the game is to complete as many of the puzzles possible rather than to exit the play area. An additional way of differentiating between entertaining escape rooms and educational mystery rooms is to use the escapED framework, which is presented in Figure 2.¹⁷

Identifying educational themes, learning

objectives (which encompass content and procedural knowledge, soft skills, and affective goals) and establishing an evaluation metric are the concepts that separate escapED from traditional escape rooms.¹⁷ The design of a mystery room is a complex process that requires consideration of all the above components and does not have to follow a set order. The design process is an iterative undertaking that relies on the continued and intertwined development of all components at each stage to be successful.

One step in the process is to identify the target **participants’** age, ability, learning style, and overall interest in potential themes for the mystery rooms. Participants need to be fully engaged and attentive in order to benefit from the mystery room, so catering to their interests and recognizing any limitations is essential to the design process. It is important to distinguish amongst the types of learning styles in this group and to attempt to incorporate puzzles that use these learning styles.

Another step in the design process involves identifying **learning objectives**. Educational mystery rooms are meant to expose participants to relevant topics in fun ways, as well as to let players exercise a variety of soft skills such as problem solving, teamwork, and communication. The use of these skills is more difficult to meas-

ure than content knowledge, but all are important to help them learn. The rooms can also engage them in procedural knowledge, such as procedures for STEM topics like science inquiry. Furthermore, the rooms can help participants recognize affective traits by introducing the concept of pass/fail (or win/lose), which has an emotive component. Establishing which learning objectives should be included requires a thorough understanding of the interests and existing skills of the participants.

Creating a mystery room also involves establishing a **narrative and theme**. This is more appropriately accomplished after establishing participant attributes and learning objectives. It is simpler to form a narrative and theme around these components rather than attempting to alter an existing narrative to fit them. The narrative is the overarching story or plot and the theme is the topic around which the narrative is based. For example, a theme could be space adventure travels and the narrative could be the artificial intelligence (AI) of the spaceship assisting the participants initially and later turning on them by killing them in the spaceship. While not necessary in an escape room, a strong theme and narrative are good indicators of a well-designed escape room. The narrative is often the driving force behind getting participants engaged.¹⁸ Unlike books or

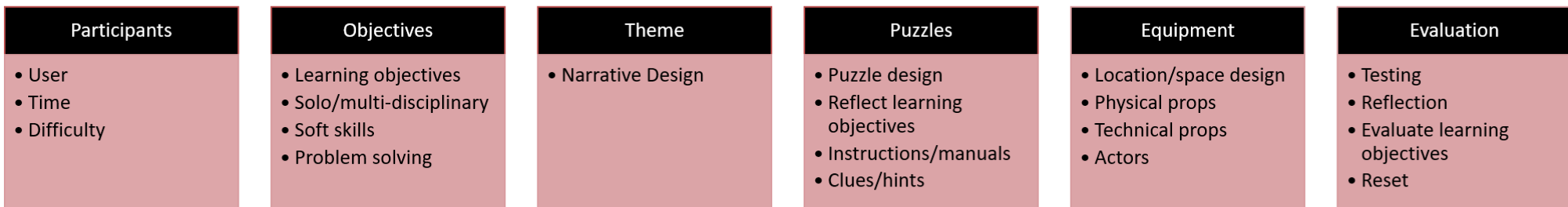


Figure 2: escapED Framework Components

movies, where narrative is recounted in a third or second person, in escape rooms the players are essentially the main characters of the story. They are immersed in the narrative and able to act it out in first person—as if they are actually living it. As such, a weak narrative or inconsistent theme is similar to reading a subpar book or watching a movie with a disorganized plot. The most common indicator of a weak narrative is boredom.¹⁹ This is why narrative is imperative in an educational escape room. Disengagement due to a substandard narrative causes a break in flow, and the participants might not put in as much effort as they would when fully engaged, which limits how much they learn. In addition, a strong narrative and theme should mask what the learning objectives are so that participants are engaged in what they believe to be a game, rather than thinking they're learning. Narratives can also vary in complexity. This is one way to create different experiences within the same narrative. Complexity is usually determined by how much the narrative varies based on player choices within the game. To follow the above example in a spaceship, the AI's responses vary based on what it is asked.

Puzzles, instructions, hints, and clues are supplementary to the narrative, so they are best chosen after completing the previous steps. If the narrative and theme are not already chosen, there will be little continuity amongst the puzzles, instructions, hints, and clues, resulting in a weak and disengaging scenario. Another consideration to make is to ensure that the puzzles convey the selected learning objectives—this is what distinguishes escape rooms for the purposes of entertainment and of education. Puzzles can range from figuring out the passcode to a lock to simply finding the key to lock in a hidden location. Be-

yond the puzzles themselves, the instructions given must be clear and concise. Revealing all the gameplay in the instructions is a common mistake; a good rule of thumb is to “show, not tell.” Giving too much instruction can lead to a feeling of being lectured, which takes away from a more interactive experience. For example, one method would be to instruct in the beginning of the game that the setting is a library in the Victorian era and the participants are here to find an old banned book. A different option would be convey that through the setting and puzzles within the room. The latter creates a far more immersive experience. Lastly, hints and clues are one of the most crucial components as almost always any puzzle created will be too difficult for someone else to solve. In the context of an escape room, a clue is usually found and requires effort to obtain whereas a hint is usually given by the game master or an actor. Hints are often given when the team is struggling and reaches a standstill and cannot further progress.¹⁹ Sometimes mystery rooms incorporate an actor (whose character is designed to align with the narrative) to give clues and hints. A clue would be finding a coded message in a book and a hint would be the actor telling the participants to search through the shelves to figure out how to break the code. Most escape rooms have manuals detailing when to give hints. It is important that hints and clues should direct the player towards a solution while “not breaking player immersion.”¹⁷

Equipment is required in the design of a mystery room for both transforming the physical space and creating puzzles. This includes the design of the layout of the room, props, and actors. All components should work together to increase player engagement rather than detract from enjoyment. The design should be spacious and

“comfortable to move around.”¹⁷ The props—which can be either physical puzzles and red herrings or technical props such as computers or GPS, should be foolproof in that they are sturdy and easily replaceable. A prop could be as simple as the chairs or tables in a room to as complex as a control panel on a spaceship to maneuver through the galaxies. Often times participants may try to break the equipment (such as a lock on a door) to move further in the game. As such, it is important to ensure that the props are easy to replace or not breakable at all. An issue that occurs with technical props is the tendency of them to crash or fail (fixing high-tech equipment also requires a special subset of knowledge that not everyone has). Finally, actors, if developed well, are a good way to increase player engagement, as well as deliver important information such as time remaining and clues.

Another step in designing a mystery room is **evaluation**. One important thing to evaluate is the functionality of the puzzles and equipment. Pilot testing the room is important because most escape rooms are completed in iterations and consecutive revisions to the design are made based on the evaluations of success of the previous escape room. In these evaluations, the escape room is tested in parts or in its entirety. This is normally done before the actual opening of the room—it can involve simply testing a couple of puzzles or asking for feedback on the setting of the room. Piloting reveals if the escape room has any points of confusion, the puzzles are not the right level of difficulty, or if the room is unintuitive or disengaging. Another type of evaluation involves testing for players' response to the actual experience and whether or not the experience engages students—this is done by directly observing players or having them reflect on how

their experiences were. Questions would include how long the participant believed they were in the room to see if they experience any time dilation, which would indicate the willingness to work on a task for a longer period of time, even if the student did not realize it. Other questions to ask include if they enjoyed certain aspects, or if they felt bored during the experience to gauge interest and optimism about the room. Furthermore, directly asking the players to suggest alterations uncovers recommendations for future game iterations.

Game-based learning programs, specifically mystery rooms, utilize an active environment that engages multiple learning styles. By including visual, auditory and kinesthetic components, students have a chance to learn material through different senses, which could increase their motivation to inquire further into the subject

matter. Incorporating creative education programs like mystery rooms into education establishes an opportunity to combat students' decreased involvement in STEM.

Building Banksia a Mystery Room: Our Process and Results

This project aimed to help Banksia incorporate a mystery room into its after-school programs. Proper mystery room development involves creating puzzles of all types to engage all types of learners and problem-solvers. The mystery room built at Banksia aimed to provide a wide set of challenges to meet the needs and interests of a diverse set of youth participants. Creating appropriate learning objectives and understanding the different learning styles were of high

importance in this project, so that we could engage a diverse set of youth.

In order to help Banksia construct an engaging mystery room that would increase student engagement in STEM, we established four objectives. They were to: (1) characterize and assess different learning types, (2) research the expert design process for creating a mystery room, (3) construct the mystery room, and (4) evaluate the effectiveness of the mystery room in terms of student engagement. We defined methods to use for each of these objectives, which were approved by WPI's Institutional Review Board (IRB) (see Supplemental Materials C-E). An overview of our methods are summarized in Figure 3. Each method and its results are discussed below.

Characterizing and assessing different learning types

We accomplished this objective by reviewing educational theory on learning objectives, principles of student engagement, and learning styles. The results of our literature review were discussed in the background section.

Additionally, we informally observed Banksia's after-school students to see the different learning styles in practice. We observed 21 students during Banksia's after-school programs over 11 days during our first three weeks on site. During this time, we helped students with their homework and made mental notes of our interactions. Shortly after the programs concluded each day, we recorded pertinent information about demographics and their interpersonal interaction and learning styles on a data sheet presented in Table 4.

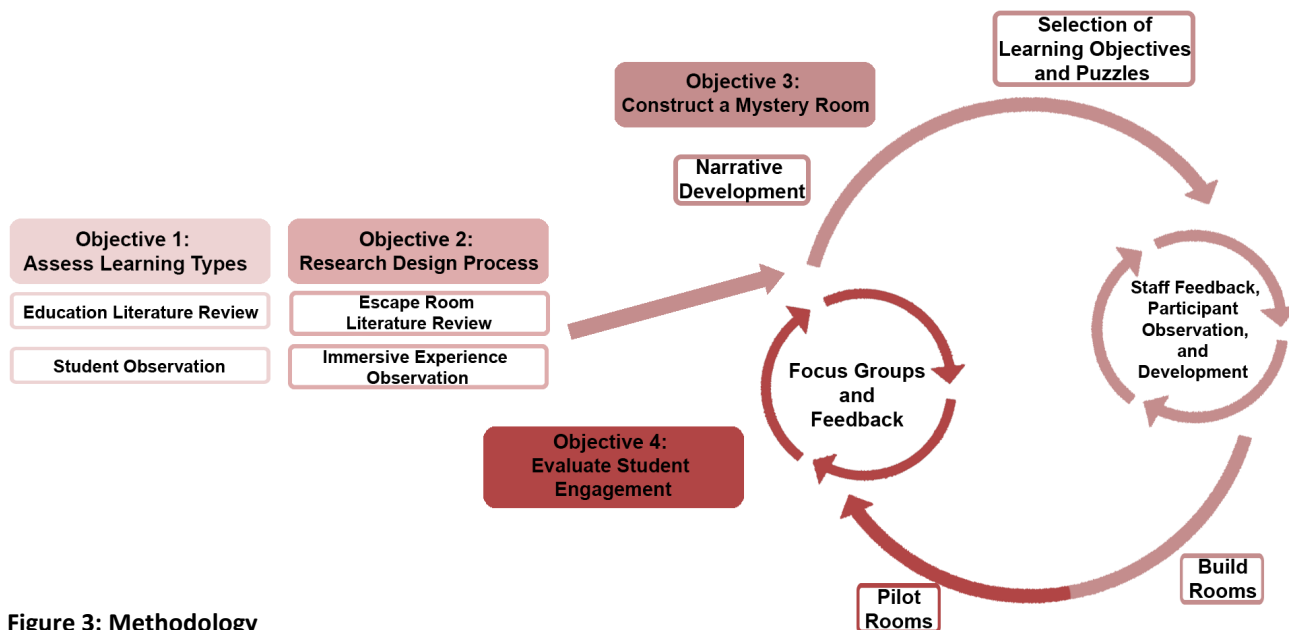


Figure 3: Methodology

Table 4: Student Observation Data Sheet

Observer	Age Group	Group Size	Interested By	Uninterested By	Triggers	Learning Style	Strengths	Weaknesses
Amelia								
Laurel								
Shreeja								

Our completed observations sheets can be found in Supplemental Materials F. We concluded from the observations that 1) the students are highly physically active, 2) have a mix of learning styles, and 3) have difficulty with literacy. We drew our first conclusion from witnessing fighting between the students and noticing that some were unable to sit still when trying to do work. Oftentimes, one student would get frustrated by his/her work and proceed to bother other students. Our second conclusion came from helping the children with their work. Some of them responded better to verbal explanation concept rather than written ones (auditory learners), whereas others seemed to benefit from watching us write (visual learners). We noticed some of the students were kinesthetic learners when they would ask us to get up and move around during their work. As a result, we decided that audio, visual, and tactile elements had to be incorporated evenly. We noticed difficulty with literacy when 8 to 10 year-old students were unable to read simple words on a worksheet. Some students also had difficulty with writing and would ask us how to spell words. With this in mind, we decided that our mystery room should not rely on the children having to read clues.

The students at Banksia come from diverse backgrounds. In addition to the observations of their educational background, we noted that many of them have experienced trauma

in their lives. Due to these experiences, we determined that the mystery room theming could not include scary or gruesome topics.

Researching the design process of a mystery room

To research the expert design process for creating a mystery room, we completed a literature review. We reviewed good design principles for constructing escape rooms, investigating the escapED framework (Figure 2). Results from this review were discussed in the previous section.

In addition, in order to gain more first-hand understanding, we took observations of actual escape rooms and immersive theatre experiences, noting effective features. We recorded our experiences on a data sheet presented in Table 5.

Using this information, we were able to create our own methodology for constructing the mystery room and became aware of what mistakes to avoid. We visited a deep-space themed

escape room and an Avengers themed immersive-theatre. In the escape room, we were woken up after a year of hyper sleep and were tasked with finding out why the spaceship had not gotten to the planned destination. From this experience, we observed that lighting and sound cues were es-

sential to immersion. We learned that carefully choosing challenges was important, as rooms could become traumatizing easily. In this experience, one player was locked away from the others which made the player very uncomfortable. The Avengers immersive theater experience aimed to have participants become an Avenger through training exercises. This experience was not very immersive, as it was set up with a series of museum-like exhibits. We determined that our mystery room had to make the participants feel “inside” of the story, rather than observing it. Role playing as the spaceship crew in the escape room was a much more engaging experience than the Avengers training. Both the escape room and the immersive theatre allowed us to first-hand understand what made them so engaging, what worked well, and what didn’t work well. These experiences allowed us to consider more deeply what the mystery room experience would be like for the participants. The complete observations can

Table 5: Immersive Experience Observation Data Sheet

Observer	Theme / Narrative	Puzzle Types	Hint Types	Duration	Physical Activity	Space Use	Things to Use	Things to Avoid
Amelia								
Laurel								
Shreeja								

be found in Supplemental Materials G. The key findings from our observations of the immersive experiences we attended were: a strong narrative is important, using the same parts and pieces in different places is an interesting concept, and while technologically-advanced equipment increases participant interest, the expense would not be feasible for Banksia.

Constructing our mystery room

Our method for designing mystery rooms was based on adaptation of the escapED framework, which was previously presented in Figure 2.

Our adapted, iterative design-feedback process is shown in more detail as the loop in Figure 4. In what follows, we describe each step in the process of our unfolding design, and how we received feedback and refined it along the way. Steps included narrative development, selection of learning objectives and puzzles, and building of the room. Selection of materials, budgeting, room design, and manufacturing of equipment occurred throughout the process.

The first room designed in this project was infection themed. This was a theme suggested by Banksia to connect learning concepts across age ranges. Biological sciences are listed in the Australian Curriculum for Science for all school

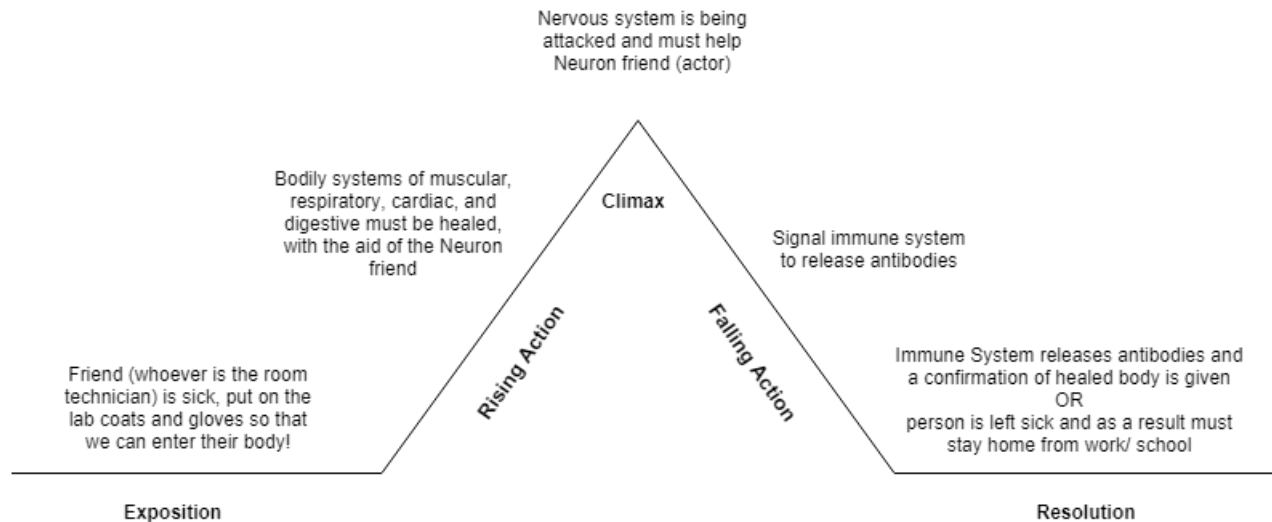


Figure 5: Infection Room Narrative Arc

years after Year 2. Although the topics listed encompass a wide range of biological objectives not related to human health, as students progress in school, they learn more and more about organisms, including cells and organ systems.

Narrative development was the first step in our process. We designed a narrative arc to map out the exposition, rising action, climax, falling action, and resolution of the story line, seen in Figure 5. After creating this narrative arc, we drafted a script, which can be found in Supple-

mental Materials H.2.

We also storyboarded the narrative to convey the script and characters more effectively, as it involved an outside actor. The storyboard can be found in Supplemental Materials H.1. At this point, we had a character workshop with the actor employed for this project. With her, we developed the personality and physical look of the lead doctor who would introduce the children to the room theme and the neuron who would accompany them once inside the room. The actor's role in narrative development is essential as actors often keep participants engaged and guide them throughout the mystery room experience.

The next step was selection of learning objectives and puzzles. Based upon the narrative, we selected learning objectives that tied into the story arc. These objectives were about the human body and some of its systems: muscular, digestive, circulatory, respiratory, nervous, and immune. One goal included in selecting learning objectives was to subtly reinforce material



Figure 4: Objective 3 Methods

previously taught to the students or present new material in an easy-to-understand way. After selecting learning objectives, we chose puzzles that were related in some manner. We also aimed to have the puzzles support the three learning types



Figure 6: Infection Room Puzzles

(audio, visual, kinesthetic). A collage of these puzzles is seen in Figure 6, and a table with their description and applicable learning type is presented in Table 6.

Solving the first four system puzzles resulted in a key, which were used to unlock the nervous system puzzle. Once the immune system safe was opened, white ping pong balls (white blood cells) spilled out, and the body was healed! The puzzle flowchart in Figure 7 further outlines the process. The first four puzzles could be solved separately or cooperatively, depending on what the participants decided to do.

We carried out testing with the Banksia staff, advisors, and the other team on this project. We gave them our puzzles to see how they interacted with them, and if they had any difficulties understanding the puzzle instructions. Our initial design for the Operation nervous system puzzle involved using the actual game pieces with the code written on them. During testing, we found

that it was too difficult to retrieve these pieces in a timely manner, which was frustrating to the participants. Therefore, we decided to modify the puzzle and use small, laminated pieces of paper, which were easier to grab. There were no difficulties with the other puzzles, which is what we expected. We intentionally made them simplistic given the time constraint of the room and what we assessed to be the abilities of our target participants.

Finally, the rooms went into the building phase. In this method, physical manufacturing of the room took place. The room was developed with several visual and audio cues for the participants. There was a hourglass timer projected on the wall to indicate the remaining time in the first pilot. It was not projected in the second pilot. We decided not to show the time in minutes so that we could evaluate time dilation for Objective 4. There was a map of the human body with stuck on bacteria at each organ system, and the students

Table 6 : Puzzle Descriptions and Applicable Learning Types

Puzzle	Description	Learning Type
Circulatory System	Manipulate tubes to direct water to a small bucket (with grate) so that a key floats up for retrieval (reused puzzle from other team)	Visual / Kinesthetic
Muscular System	A dance mat that plays music and shows lights to indicate what part of the mat players should tap	Audio / Kinesthetic
Digestive System	A sorting healthy from unhealthy foods activity where the healthy food will unlock a magnetic box	Kinesthetic
Respiratory System	Search through slime in the lungs to discover the hidden key	Kinesthetic
Nervous System (Box)	Use the keys obtained from previous puzzles to unlock a box	Visual / Kinesthetic
Nervous System (Electrical)	Operation-style game: pick out pieces of paper from the board that contain letters on one side, and numbers on the other for the immune system lockbox combination. Correctly spell BODY from the game to get the code (1928— the year penicillin was developed).	Visual / Audio / Kinesthetic
Immune System	Use the combination code obtained from the previous puzzle to unlock a lockbox	Visual / Audio / Kinesthetic

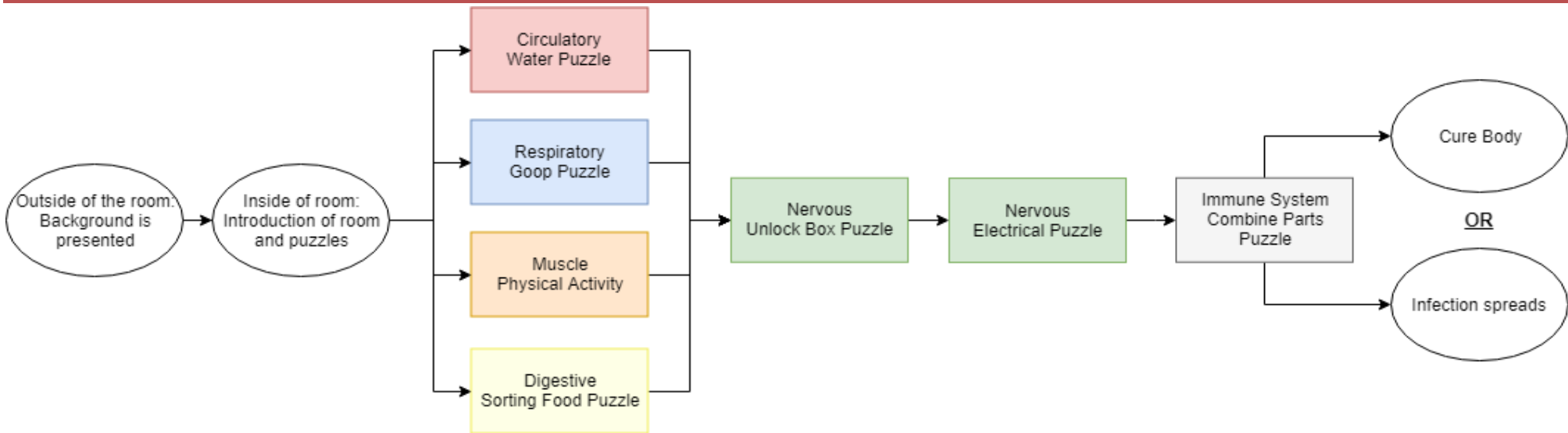


Figure 7: Puzzle Flowchart

were able to remove the bacteria after completing each puzzle. A thermometer poster was in the room and indicated the person's temperature. As gameplay commenced, the actor would decrease the temperature from a dangerous fever to a healthy level. Sound cues for this room included coughing and a heartbeat noise. The coughing would end after the students entered from the throat, and the heartbeat would decrease from rapid to steady once the circulatory puzzle was completed.

Our final room layout is presented in Figure 8 (and an earlier depiction of the room can be found in Supplemental Materials H.3). The room was a square tent, and we arranged the puzzles around the walls of the room and had them lead into the immune system puzzle at the center of the room. Pictures of the pilot day room setup are presented in Figure 9 (more pictures of the room can be found in Supplemental Materials I.1).

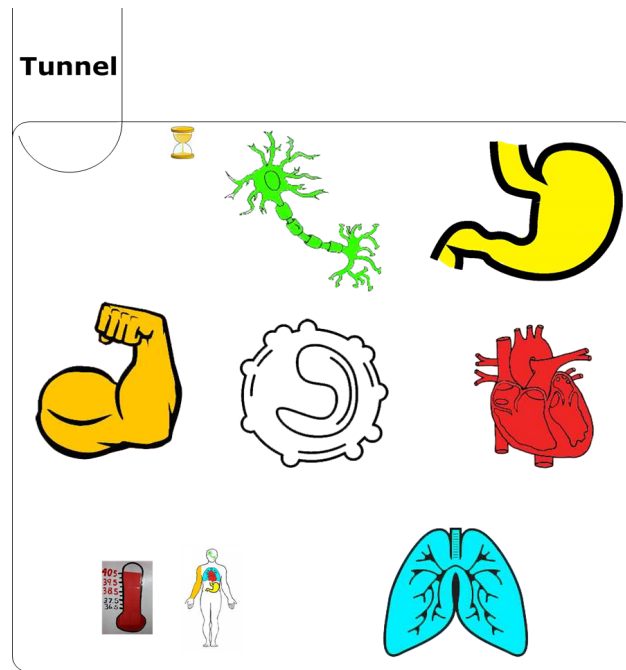


Figure 8: Puzzle Organization

We aimed to have the puzzles support the three learning types: audio, visual, kinesthetic.

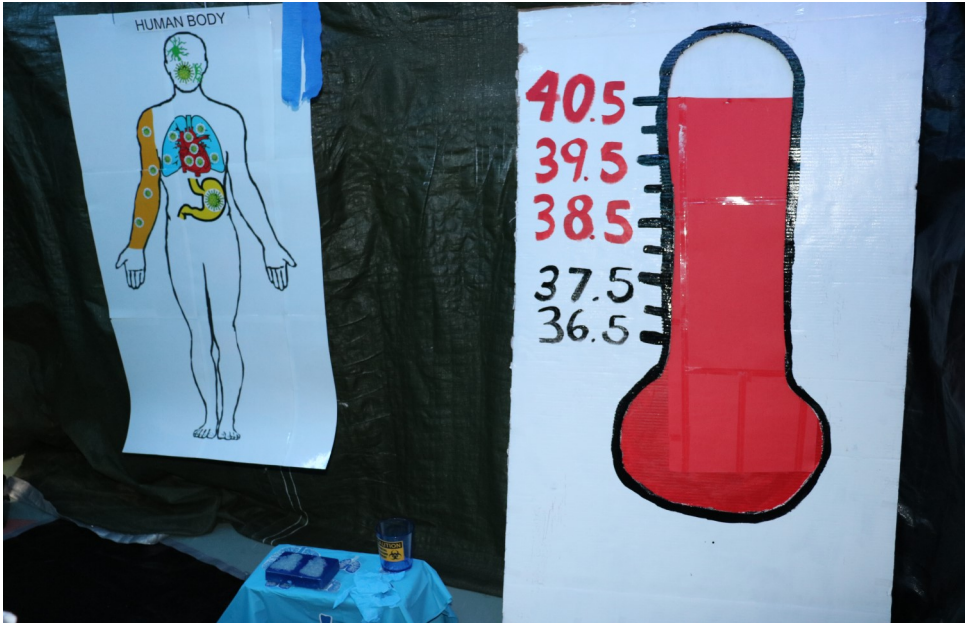


Figure 9. Pilot Day Room Setup

Evaluating the effectiveness of the mystery room

To evaluate the effectiveness of the mystery room and determine student **engagement**, we looked for behavioral, emotional, and cognitive signs of engagement, at students' sense of time (time compression suggests engagement and dilation the opposite) and at their immersion in the fantasy world. We gathered data on these things through direct observation and through focus groups during two pilot days for the room. The first pilot day consisted of three rounds, with three or four children in each. The second day consisted of two rounds, with four children each. During each round, a group of children went through the puzzles in the room and interacted with the actor. We observed the students while they participated in the room by listening through the tent. We were occasionally able to look through gaps in the curtains, but mostly relied on auditory observations, which we marked on the sheet presented in Figure 10. Our focus group

#1 General Notes:

Pinpointed Notes:

#2 Points of excitement:

#3 Points of distress:

#4 Points of confusion:

#5 Points of frustration:

#6 Points of trying to "hack the system" ("solve" puzzles in a way not intended- forcing them open, etc.):

#7 Any moments of conflict? If so, when?

Figure 10: In-observation Data Sheet

questions were:

1. What did you like about the room?
2. What was your favorite part?

Students put the picture of the puzzle they liked most (labeled with a heart) into the box (Figure 11)

3. What did you not like about the room?

Students put the picture of the puzzle they liked least (labeled with a X) into the box (Figure 11)

4. How much did you like the story?

Students put green card into the box if they really liked it, yellow if they liked it, orange if they disliked it, and red if they really disliked it (Figure 12)

5. What parts were hard?

6. Would you play this room again with new puzzles?

7. How long do you think you were in here?

We knew that focus group activities would be a better way of gathering information from the children rather than just asking them questions. The students are very active, and we had to keep their attention for the entirety of the focus group. Finally, the actor who was able to watch the children closely submitted her observation report to us after each pilot day (Supplemental Materials J.3 and K.3).

We also used these tools and our actor's reports from the pilots to gather data on **soft skill use** and **STEM learning**. Table 7 explains how we defined each of these dependent variables and it notes the particular activities,



Figure 11: Focus Group Tool for Evaluating Puzzles



Figure 12: Like to Dislike Scale

categories, and focus group questions we used to gather data on each.

Table 7: Research Tools for Engagement, Soft Skills, and Stem Learning

	Time Compression / Dilation	Behavioral Engagement	Emotional Engagement	Cognitive Engagement	Soft Skills	STEM Learning
Signs	<ul style="list-style-type: none"> Difference between actual time spent in room and student’s perceived time spent in the room 	<ul style="list-style-type: none"> Difference between behavior inside the room and outside the room (focused, listening, not distracted) Willingness to participate in the activity 	<ul style="list-style-type: none"> Interest and belief in the story (immersion) Emotional response to room and puzzles (excitement, interest, distress) 	<ul style="list-style-type: none"> Thinking about and questioning the material 	<ul style="list-style-type: none"> Teamwork 	<ul style="list-style-type: none"> Understanding of how an infection affects the body and the purpose of the immune system
Tools	<ul style="list-style-type: none"> Focus Group Question #7 	<ul style="list-style-type: none"> Actor Observations Observation Points #1 	<ul style="list-style-type: none"> Actor Observations Observation Points #1, 2, 3, 6 Focus Group Questions #1, 3, 4, 5, 6 	<ul style="list-style-type: none"> Actor Observations Observation Point #1 Informal Focus Group Conversation 	<ul style="list-style-type: none"> Actor Observations Observation Point #1, 7 	<ul style="list-style-type: none"> Actor Observations Observation Point #1 Informal Focus Group conversation about what was learned

Tables 8-13 summarize observations and focus group responses. The raw observation notes can be found in Supplemental Materials J.1, J.3, and K.1, and the raw focus group minutes can be found in Supplemental Materials J.2 and K.2.

Time Perception

As mentioned previously, overall student engagement in an activity can be determined by their perception of time. The phrase “time flies when you’re having fun” says a lot about engagement—students will not realize how much time they have invested into an activity if they are engaged. We looked to see if students experienced either time compression or time dilation. Time compression (students perceived the duration was shorter than it was) might indicate they had a higher interest and engagement in the activity. Time dilation (students perceived the duration was longer than it was) might indicate disinterest and disengagement. Table 8 compares the actual time for each session as compared to time of the session as perceived by the students. In the first pilot day, students all agreed upon a time together.

We adjusted the phrasing of the question in the second pilot day to get the individual responses. Green represents time compression, and red represents time dilation. Overall, eleven out of fifteen students that answered the question experienced time compression than time dilation.

In Pilot 2, the age range of the children varied considerably. Older students tended to experience time dilation, whereas younger students experienced time compression. This and comments from the students in the focus groups suggested that the room design may have been more suited for the younger children.

As shown in Table 8, there was a range of answers for how long students believed they were in the room. We observed in the first pilot day

that students became concerned with the amount of time they had left in the room. In the first pilot, we projected an hourglass to mark the amount of time left in the room, and students asked the actor about the hourglass running out of time; she assured them that it wasn’t an issue and they would be able to finish. We were not sure if the students thought the hour glass represented an actual hour, however, so we didn’t use it in the second pilot day. Their perceptions on that second day may have been less influenced by the hourglass image, and we consider them more reliable. It should be noted that the trials where the perceived time and the actual time spent in the room differed by a greater amount were done with younger age students.

Table 8: Time Compression or Dilation Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Focus Group #7	20, 20, 24, 25 minutes perceived (actual time 22 minutes)	Students did not answer this question	10, 10, 10, 10 minutes perceived (actual time 18 minutes)	5, 5, 10, 60 minutes perceived (actual time 32 minutes)	10, 13, 25, 60 minutes perceived (actual time 16 minutes)

Figure 11 shows the relationship between students' perceived duration and actual duration in the room for the second pilot day sessions, noting the age of each student. The greater amount of compression experienced by the younger participants could be because they believed the story more or had a greater interest with the puzzles or were not as familiar with the material and thus more engaged. The eight-year-old in the first

group did not like the experience, and was insistent on knowing more than the younger students, so she may have inflated the amount of time when answering. The fifteen-year-old in the second group was very noticeably disinterested, and even took a phone call during the experience.

Behavioral Engagement

This type of engagement is typically shown through students' participation in activities. Some of our in-room observations and the actor's commentary on the experience provided evidence that the students were behaviorally engaged.

Students showed signs of behavioral engagement through their desire to participate in the activities. Throughout the five sessions of piloting, the students exhibited a willingness to complete each of the puzzles and did not stop participating at any time during the experience. They were also attentive and listened to the Neuron's explanations. Although they needed considerable assistance from the actor on the puzzles, the youngest children still enjoyed being in the room. As previously mentioned, the children demonstrated a behavioral difference between their interactions outside the room and their interactions inside the room. Outside of the mystery room experience, the students are very rambunctious—they fidget, do not focus on their work, and often antagonize each other. However, in the mystery room, they did not demonstrate these typical behaviors. The students were calm, followed the Neuron's lead, and participated in the activity through its entirety.

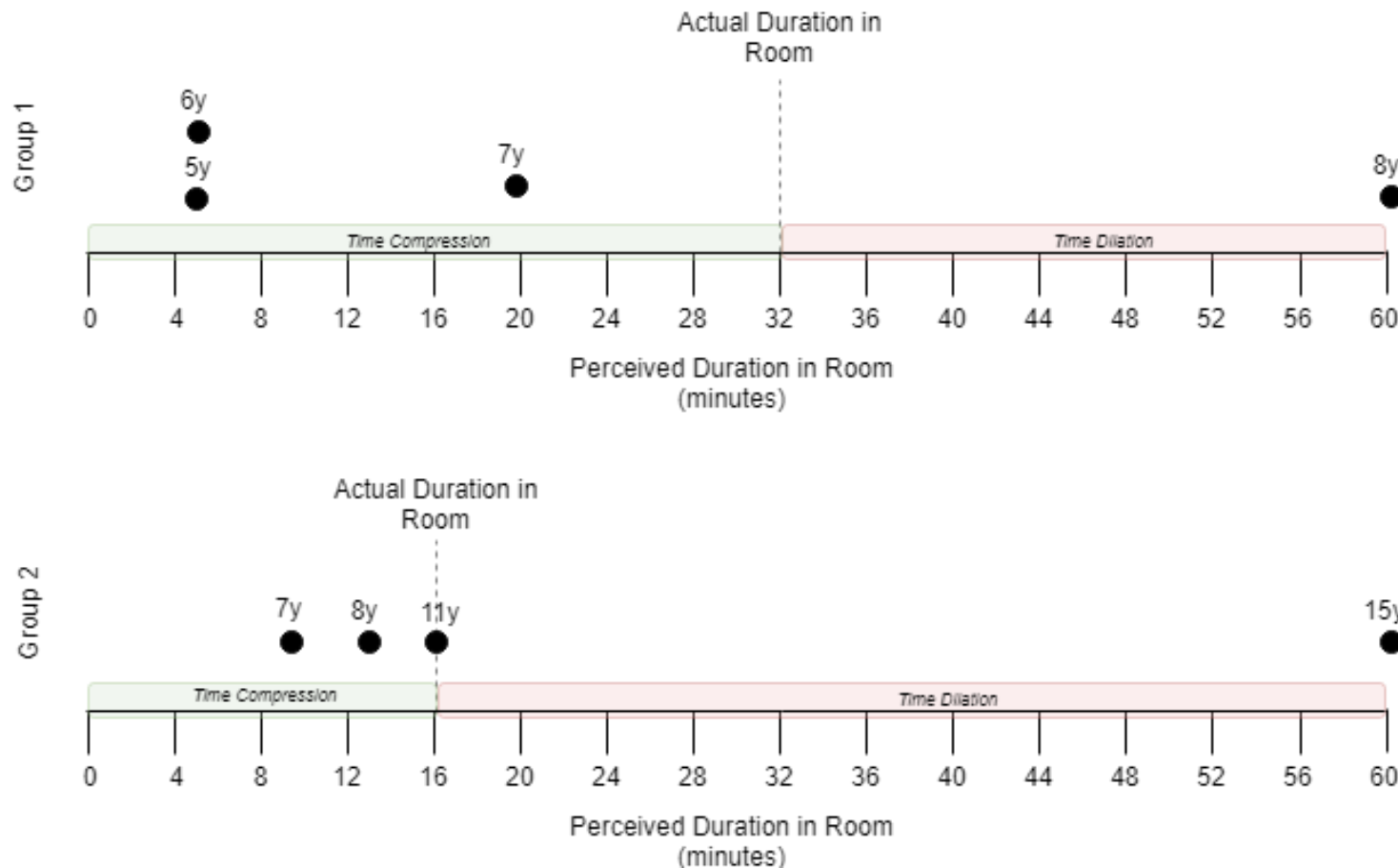


Figure 11: Students' Perceived Duration in Room (by age), versus Actual Duration in Room

Table 9: Behavioral Engagement Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Actor Observations		Student remembered the immune system code from testing and did not listen to the actor that the final puzzle couldn't be completed until the end			
Observation #1		Even though one student repeatedly entered the immune system code, the other students wanted to do the puzzles the correct way	Students (that we have worked with in study group who are generally hyperactive) were calm and focused throughout the experience		Oldest student did not participate except for when needed, took a phone call during the room

Emotional Engagement

This type of engagement is often represented through students' reactions to and interactions with instructions and the environment (other students, the actor, etc.). The actor's commentary, our in-room observations, and some of the focus group answers provide signs of emotional engagement.

Students exhibited qualities of emotional engagement through displaying interest or belief in the story. The students reacted positively to the presence of the Neuron and were intrigued by its explanations. Due to their immersion and belief, the students felt the need to help in this situation. Student immersion was determined from their responses to the room which were witnessed by both the observers and the actor. Many began to believe in the story line, and asked questions like "Are we really in the brain?" and "Is this real blood?" During the first pilot day, one student grew concerned when she hadn't put on gloves before touching the mucus in the respiratory system puzzle. She needed assurance from the Neuron that she wouldn't actually get sick. These comments and inquiries indicated that they were focused on the story presented from the actor and

were motivated to cure their sick friend. Additionally, when the hourglass timer was projected in the first pilot day, students expressed distress at the thought that they would not be able to help their friend in time. These subtle responses indicate they were forming an emotional bond to the characters.

Further, some students who participated in the first pilot day were upset to not participate again in the second pilot, even when told it would be the exact same experience. This demonstrates their eagerness to participate in the room. These students' enthusiasm spread to the other students who were participating in the after-school program, and there were many more students interested in going into the mystery room than time allowed for. The emotional reaction of the few was able to influence a larger group to become interested in what the mystery room program was.

The student's reactions to the puzzles also indicated emotional engagement. The mystery room was designed to have puzzles catered to the three learning styles (represented previously in Table 6). The immune system code box was favored among the students, and it utilizes all

three learning types. The students enjoyed the kinesthetic aspect of punching in the numbers and the response of the balls coming out once it had been opened. The second most-liked puzzle was the muscular system dance mat, which had auditory and kinesthetic components. The mat played music and made noises (auditory), but the students mostly enjoyed the physical (kinesthetic) aspect of stepping on the numbers. Our previous after-school observations confirmed that the students' tendency toward physical activity corresponds to kinesthetic learning.

Table 10: Emotional Engagement Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Actor Observations	Students were very set on “winning” (could’ve been because of the timer) and wanted to rush through the puzzles- but they were still very excited to be in the room.			Actor thought it was the shortest period (even though it was longest) and attributed this to how excited and willing the students were.	
Observation #1	They exclaimed over the mucus puzzle and the dance mat			Student exclaimed “it’s really flowing!” during the water puzzle Made “oohs” and “aahs” when opening the digestive puzzle Jumped up and down when opening the immune puzzle	Students appeared eager to enter the throat Student asked “why are there toys in the brain?”
Observation #2	Exclamations over dance mat puzzle		Excited to open the white blood cell (immune system) box		Lots of excited exclamation when white blood cells poured into the room
Observation #3	Lost one of the keys (actor made a point of holding onto the keys after this group)	We forgot to replace the circulatory puzzle key: distressed there was no key	Concerned the mucus was real and would become sick after touching it without gloves		
Observation #6	Mentioned they had already done the water puzzle and asked if the actor was the wizard		They spent a couple minutes trying to figure out if the actor had been in the other mystery room earlier in the day		
Focus Group #1	Liked everything, the blood	Liked the blood	Liked all of it		
Focus Group #2	Liked puzzles they did the most	Liked the blood	Liked the blood, liked the mystery of the immune system box	4 liked immune, and muscular, 3 digestive, 1 nervous box, and respiratory	4 liked immune, 2 nervous electrical and respiratory, 1 muscular
Focus Group #3	Disliked nothing	Disliked they couldn’t finish all the puzzles or hold the keys			
Focus Group #4	Story was good			All 4 rated green	2 green, 1 yellow, 1 orange
Focus Group #5	Disliked nervous system electrical puzzle			3 disliked nervous electrical, 2 circulatory and respiratory, 1 muscular	2 disliked circulatory. 1 muscular and nervous box
Focus Group #6	Yes—would play again		Yes—would play again	Yes—would play again	Yes—would play again

Cognitive Engagement

This type of engagement is exhibited when students think about material presented to them (can include asking questions), and later recite it in their own words.

Cognitive engagement was primarily demonstrated when students thought about and questioned the material presented to them. In one round, the actor forgot to lower the temperature presented on the thermometer, and the students were keen enough to remind her. They were putting together the idea that healing the body would decrease the fever. Their cognitive engagement was also indicated when they asked the Neuron questions or made connections between the puzzles and the STEM concepts. At one point the students asked the neuron if the heart puzzle was how blood actually flowed to the heart. The students asked so many specific biology questions during the first pilot day, that we learned the actor must have not only the script prepared, but supplementary background knowledge. The actor prepared for the second pilot day by reviewing about infections. We prepared by moving some more information into the introduction with the Doctor. After piloting, we created a background fact sheet to go with the actor materials (included as part of the Infection Room Manual, Supplemental Materials M).

Soft Skills

A common soft skill is teamwork, which is often something children develop through playing games with their peers. We hoped that our room would encourage the use of teamwork and the ability to distribute work. As we observed, the mystery room provided a fun outlet for children to practice these skills.

Students demonstrated a few soft skills while in the room. The students exhibited teamwork skills throughout the entire experience. The mystery room was designed so that the first four puzzles could be done in parallel, with each student doing one puzzle. However, we observed in the first pilot day the students in each round worked together for all puzzles. Unprompted by the actor, they offered to share parts of puzzles with one another and distributed aspects of them like hitting the numbers on the dance mat and taking turns entering the immune system lock box code. In the third session of the first pilot day, one student asked another if he wanted to finish pouring the water to solve the circulatory puzzle. The anomaly was during the second session of the first pilot when one student who knew the final code ignored the other students and puzzles and kept trying to “win” by entering the number into the immune system box. The other students in this session tried the other puzzles together;

however, the actor sent them out after the student refused to participate with the rest of the group.

In the second pilot day, we had the Neuron follow a set order of puzzles for the students. During this day, students did not question or try and break away to do their own puzzle. Students focused on what the Neuron presented them with and responded. Interestingly, in one round during the first pilot day, two students helped each other within the room, only to exit the room and fight. This was an extreme example of the general response to the room: students were boisterous out of the room, but were calm and demonstrated focus in the room. During the pilots, we had to block off the room since students were fighting each other to enter the mystery room first. However, once the same students were unruly in the hallway entered the mystery room, their demeanor changed, and they collaborated with each other.

This suggested the mystery room was effective in encouraging the participants in soft skills such as teamwork and distribution of work. We suspect the students chose this collaborative approach so that they could each experience all of the puzzles rather than trying to rush through them in a divided effort. To us, this indicates that they were genuinely interested in the room and wanted to experience all it had to offer.

Table 11: Cognitive Engagement Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Actor Observations	Students were asking questions about what the Neuron was/does - thinks it would be good to have the Doctor present some content before students enter the room				
Observation #1	Answering multiplication questions correctly (dance mat failed to work properly - so actor improvised)	Ability to remember the immune system code from a couple days before		Kept asking the Neuron what it was When led to the digestive puzzle, student exclaims “That’s where the stomach is!”	Students asked many questions about the science aspects throughout the room

Table 12: Soft Skills Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Actor Observations			Students shared and divided up parts to do without any prompting		
Observation #1	Students took turns with the nervous system Operation puzzle and entering the final code		Teamwork with the circulatory puzzle—one student offered to take turns with another	Students took turns with both the nervous system Operation puzzle and entering the final code	
Observation #7	Fought over deciding which food was healthy		Fighting over who would put in the final immune system code	Had minor conflict over taking turns with the nervous puzzle	Had difficulty taking turns when entering the final immune system code

STEM Learning

In Objective 3, part of the process to design the mystery room was the selection of learning objectives and puzzles (Figure 4). Our overarching learning objective for the Infection Room was how an infection affects the body across organ systems. We did not create a clear metric to evaluate what students had learned or remembered from school lessons but our general obser-

vations and conversations with the students are presented in Table 13.

Students displayed STEM Learning through correctly answering some of the Neuron’s inquiries relating to what the organs were and what they do inside the body during the mystery room experience. During the debrief after the experience, students were able to express that the infection was going away through examples like

eating healthy food and the recognizing the immune system’s response. To better evaluate STEM Learning in the future, the actor suggested having a post-experience worksheet that would tie pictures of the room with questions about what happens at each of the organ systems. This would give students a more structured time to reflect about what they’ve learned.

Table 13: STEM Learning Results

	Pilot Day 1 Session 1	Pilot Day 1 Session 2	Pilot Day 1 Session 3	Pilot Day 2 Session 1	Pilot Day 2 Session 2
Actor Observations	Need a set order of the puzzles so that the Neuron can convey all of the STEM concepts, worked when teamwork was strong, but when a student broke away to do their own puzzles and made this more difficult			Having all students participate in puzzles together worked better for talking about concepts	
Observation #1	Neuron asked what organs were in the systems and students knew circulatory		One child mentioned something about using a “lolly” when the Neuron prompted how to heal a sore throat	Neuron asked what they were looking for to fight the disease and students responded white blood cells	
Informal Focus Group conversation				“white blood” is what protects the body	Communicated that immune system heals body

Reflecting Back and Looking Ahead: Lessons Learned and the Implications for the Future of the Mystery Room Program

In this section, we present what we have learned through our process of building a mystery room, how the program could improve, and a design for a future mystery room at Banksia.

Our room compared to the escapED framework

The escapED framework highlights six components: participants, objectives, theme, puzzles, equipment, and evaluation. We found all of these factors important in the design of our mystery room. One striking difference between escapED and our design process was the incorporation of an actor. While the use of an actor is only a suggestion in escapED, we found it to be essential. This is likely due to the fact that in our mystery room, the children aren't "escaping" from the room. In escapED, the idea of escaping from the room provides a factor of motivation, which is often enough for the students to go through the room on their own. However, for our mystery room, the students need some sort of guidance through the narrative and STEM concepts, which is what the actor provides. The concept of a mystery room would not exist without the narrative, and therefore also needs an actor to implement it.

One of the components of escapED is evaluation, which involves understanding what the students learned and gained from the experience. In order to evaluate our mystery room, we

used reflective focus groups and asked the children questions about their experience. We also asked them questions about the STEM topics they were exposed to in the room.

The escapED framework places emphasis on theme as one of its factors, but through our design process (and other expert design sources) we learned that theme and narrative are equally important. Narrative is valuable because it tells a story that engages the students, which is an essential aspect to our mystery room. We speculate escapED places more focus on theme because players are "escaping" from a room, and in that case, theme would be more relevant. In the case of our mystery room, when adding STEM concepts, the narrative is important because it allows for dialogue related to the material.

Our room compared to traditional escape rooms

Our mystery room design process diverged from the typical approach that professional escape room designers use. This was unsurprising, as the escapED framework reveals that educational escape rooms must focus on educational themes, learning objectives, and reflection, which are not included in entertainment escape rooms. One aspect that was not revealed in the literature was the different puzzle structure that our mystery room required. Escape rooms typically follow a parallel puzzle scheme where several puzzles can be completed at once. The advantage is that multiple players can interact with puzzles instead of all hovering around one.¹⁴

Our designs initially incorporated this parallel structure as we believed that the students would each work on a puzzle at the same time.

Instead, the students all worked together, which surprised us during the first pilot day. The actor also noted that having all of the students together created a better experience educationally: it was easier to convey the STEM concepts, and students did not distract each other (which occurred when one student broke away from the group to solve a puzzle on their own). For the second pilot day, we had the Neuron follow a set order of puzzles. We have kept the parallel structure in visuals so that it is clear that the puzzles can be done in any order; however, it is strongly encouraged for the puzzles to be completed sequentially. The linear organization benefits the Banksia students, who are highly physically active and unfocused. When provided a series of set tasks, they were able to complete the mystery room activity while interacting with actor for the entire time.

Our recommendations for running the mystery room in the future

Through comparing our design process to escapED and traditional escape rooms, we have been able to identify several areas both internal and external to the mystery room that need to be considered for the future success of the program at Banksia. These areas are: puzzle and actor use, student disengagement, frequency of program offering, and the debriefing (or reflection) period.

Using the iterative design process outlined in the previous section of the book resulted in an effective preliminary mystery room. Although it was not an explicitly stated part of the design processes, we tried to reduce the cost of the room by recycling puzzles and puzzle materials in other designs. In the Infection Room, we reused the water puzzle designed by the other team in this

project. This puzzle proved to be a great opportunity to reuse a puzzle, as it fit nicely into the narrative.

However, on the first pilot day, students' immersion was broken during one of the sessions because they had already seen the puzzle in the other team's mystery room. To avoid students being confused by solving the same puzzle again, several measures must be taken. If the puzzle is to be reused in its entirety, it must be redecorated (which we did by turning the water into red blood and decorating with hearts), and students must have a longer period between seeing the puzzle. If parts of puzzles are to be reused, they must use different game mechanics or have a different look. In the Baking Room (presented at the end of this section), we suggest reusing two of the lock boxes from the Infection Room. However, students will not be solving these puzzles in the same way. For the magnetic locking box, the Infection Room had students sort through possible keys, whereas the Baking Room will have students search for a key using a clue. For the lock box, the Infection Room had students decode a number and letter puzzle, whereas the Baking Room will have students sort through possible keys. By changing how students interact with the puzzle elements, the same physical materials offer endless mystery room opportunities.

We recognize that Banksia has a limited budget to spend on the mystery room, so in the future we think it would be possible to have one of the Banksia employees fill in as an actor for the room, rather than paying for one each time. Our design has a simple script that would not take much time to memorize and mostly contains common knowledge about the body. We think the presence of an actor is more essential when the

participants are younger, so it might be possible to leave out the actor when older students (about Year 8-12) are in the room. It might even be possible to leave out the actor for Years 4-7, but only after they've done at least one or two mystery rooms with the actor already there. If there isn't an actor, the puzzle flow of the room should be more parallel rather than strictly linear. Lastly, technology can be used to fill in for the role of actor. One of our mystery room experiences made use of an artificial intelligence system that we were able to talk to and ask questions. Incorporating some sort of programmable voice technology (for example, Google Home) into the room would be a fun and interesting way to eliminate the need for an actor.

Through our pilot days, we learned that disengaged students detract from the mystery room experience for others. One of the older students brought a cell phone into the mystery room and answered a phone call during the experience. This briefly distracted the other students and also reduced the older student's immersion. Therefore, we suggest making sure students do not bring their cell phones or any other distractions (toys, etc.) into the room with them.

We witnessed one instance of a student trying to "hack" the room. Prior to the first pilot day, we tested some of our puzzles on students who we believed would not go through the mystery room. However, when the pilot day occurred, one of the puzzle testers went through the room and remembered the immune system lockbox code. This student then proceeded to repeatedly enter the code and distracted other students from completing the room properly. As a result, this was the only group of students that did not complete the room successfully and did not give the

room positive reviews.

When we first piloted the Infection and Dragon rooms, we found that running two different rooms in the same day was not effective because after the first time, the novelty of the experience wore off. Additionally, with the time and effort it takes to set up and take down a mystery room within the same day, our recommended frequency of the mystery rooms is once every two weeks. This also provides an adequate time between rooms that may be reusing the same puzzles.

Careful consideration should be given regarding the location of the debriefing period. It must be in an isolated room with no distractions (such as computers, loud noises, toys, or other humans). It is important for the children to reflect on their experience in a calm environment. They will likely be excited after leaving the mystery room, and need a chance to settle down and think about what occurred. There should be a table and enough chairs for participants and debrief leader to sit down and ask them about their experiences and what they learned. If it is an interactive debriefing period with different parts such as stickers and coloring, it is important there be two adults in the room. One should lead the debriefing period and the other should distribute supplies.

Our recommendations for the improvement of the Infection Room

Through our results, we determined that the current puzzles in the Infection Room are most appropriate for students aged 8-10 years old. We observed younger students express interest in the puzzles, but they required considerable guidance from the Neuron to complete them. We also saw older students become disinterested in the

room. Because of this we suggest creating different levels of puzzles for the younger and older students with similar learning objectives.

We also suggest adjusting certain components of the room so that they can be enjoyed by all students. For example, we initially placed the body map too high, and some students were unable to remove the bacteria from it. Additionally, the water puzzle is too tall for some of the shorter students, but this is more difficult to fix. Therefore, we suggest allowing the Neuron to pour the water into the pipes in cases where the students are not quite tall enough. This still allows the students to both manipulate the faucets and retrieve the key once it floats to the top.

We found that the tunnel provided a fun way to get students immersed in the room, but it was difficult to prevent others who weren't participating from going through it. Therefore, we advise starting the tunnel from a location that can only be accessed by the current participants. For the Infection Room, this would require starting the tunnel from the room where the Doctor is explaining information rather than in the middle of the hallway.

Our design for a future room

We developed a second mystery room narrative and puzzles. The theme of this room is baking, which was chosen because Banksia puts a strong emphasis on the relationship students have with their food. Using this theme, procedural STEM knowledge such as measuring and weighing was also easy to incorporate into the overall narrative.

In this narrative, a renown baker, Claude Croissant, has been sabotaged by a competitor before the world baking competition. He has invited the students into his kitchen to help unlock

the chocolate chip cookie ingredients that have been hidden away from him. The narrative arc for this room is presented in Figure 12. The script for this narrative can be found in Supplemental Materials L.

Three main puzzles were designed for this room: a radio puzzle, a measurement puzzle, and a scale puzzle. One level of puzzles was developed for this room. Once the puzzles are tested with the students, the appropriate age range can be determined. From there, easier or harder sets of puzzles can be developed and switched in for this room. Puzzle descriptions are listed in Table 14. A flowchart of the puzzles is presented in Figure 13. The puzzles are presented in parallel, not because students should necessarily complete them individually, but because they can be done in any order at any time. The completion of the three puzzles then leads into a narrative-based conclu-

sion of the experience where the baker has them mix the cookie ingredients together and bake the world famous chocolate chip cookies.

Our suggested room layout is in the Figure 14. The colored areas on the layout correspond to the colors in Figure 13. The room will include play kitchen furniture to set the scene, as well as projected bakery images. Sounds of a French bakery will be played to also help immersion. For this mystery room, the story begins with the students in the mystery room itself. There is no outside instruction or lead-in to the room. We decided this would be a more effective way of running future mystery rooms after seeing how much of a challenge having the tunnel was during the second pilot day.

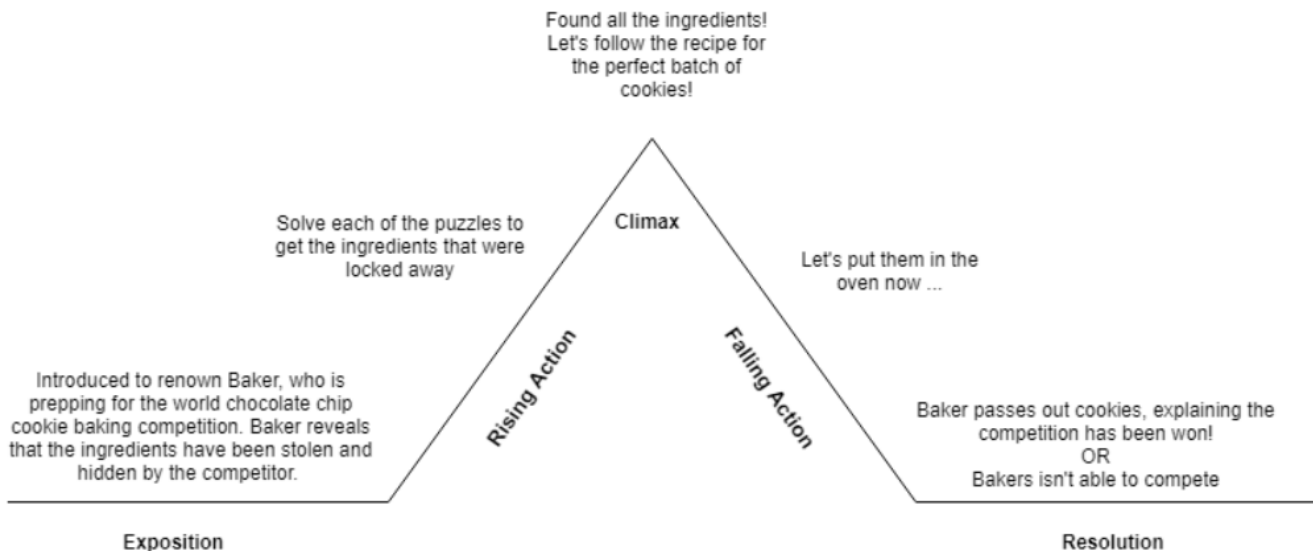


Figure 12: Baking Theme Narrative Arc

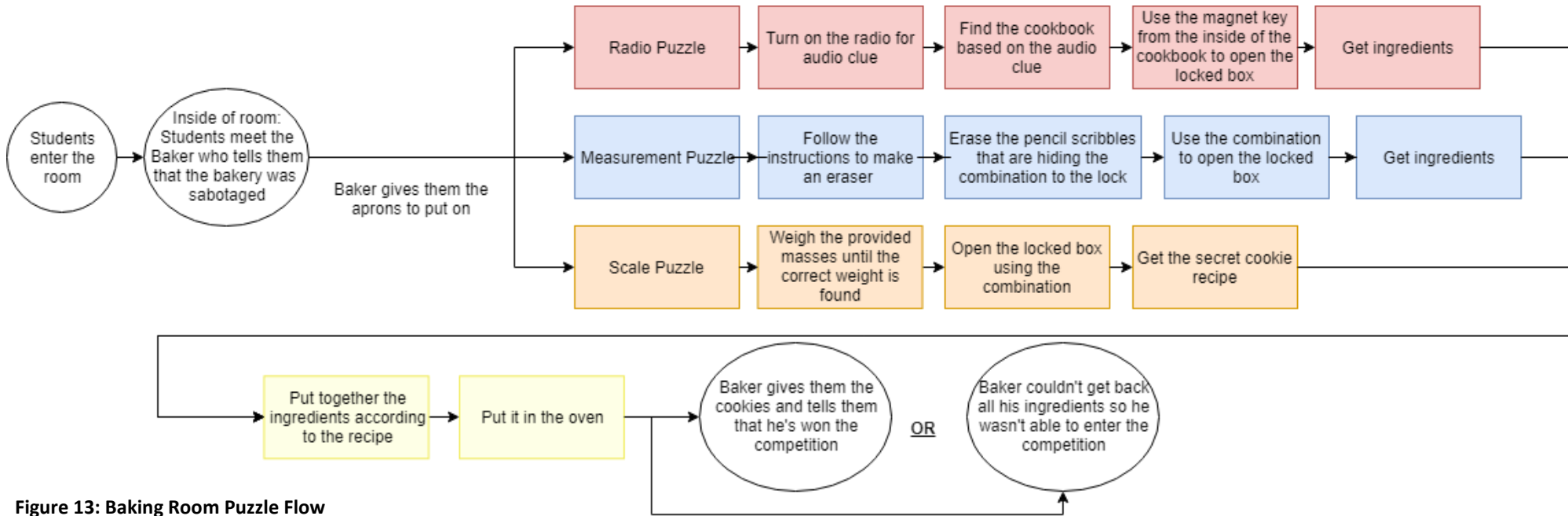


Figure 13: Baking Room Puzzle Flow

Table 14: Baking Room Puzzle Descriptions

Puzzle	How to Solve It	STEM Concepts	Learning Style
Radio Puzzle	<ol style="list-style-type: none"> 1. Turn on radio for which cookbook to look in 2. Find the cookbook and open for the magnetic key 3. Open the magnetic lock box 		Audio
Measurement Puzzle	<ol style="list-style-type: none"> 1. Mix 3:1 ratio of talcum powder and silicon into an eraser 2. Use the eraser to remove pencil markings hiding the combination 3. Open the locked box 	<ul style="list-style-type: none"> • Using a ratio to measure ingredients • Concept of friction and how erasers work 	Kinesthetic
Scale Puzzle	<ol style="list-style-type: none"> 1. Try each of the masses until each one matches the number marked on the scale 2. Use the combination on this scale to open the safe 	<ul style="list-style-type: none"> • Using a scale to measure masses 	Kinesthetic

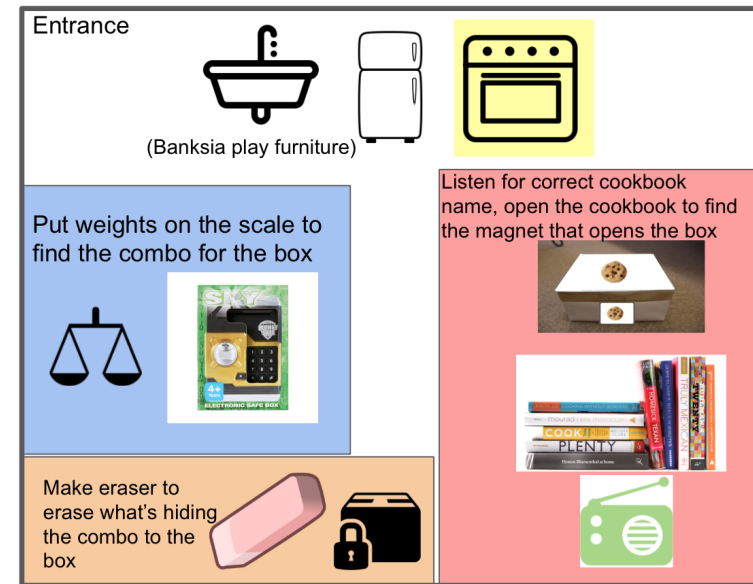


Figure 14: Baking Room Floor Plan

Deliverables

To document the mystery rooms we designed, we have produced two manuals, one for each room, that include materials for the actors and room technicians. Additionally, the manuals

contain more focused STEM questions to ask the participants during the debriefing period to determine what they learned in the room and to allow them to reflect on the experience. Excerpts of the manuals are presented in Figure 15 (and can be found in Supplemental Materials M.1 and M.2).

Conclusions

We think that mystery rooms have the potential to be implemented as a powerful tool to engage students across all learning types. So many traditional school programs only offer the appropriate engagement tactics for visual and auditory learners. This is at no fault to schools, as the easiest ways to share information are either verbally through lectures or visually through presentations. The mystery room experience enabled kinesthetic learners to have a hands-on experience with the learning objectives. We hope that this unique educational experience incites STEM interest among the participants.

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Manual to set up and run the Infection (Flu) Mystery Room



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How to set up and run the Baking Mystery Room




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Script

- Background
 - Doctor
 - "You're here on a mission. Your friend is sick and needs your help to get better!!"
 - They've been infected with a virus because they caught the flu. Do any of you know what a virus is?
 - "To stay safe from the virus, I need to check if everyone is healthy enough to enter the body. Let me check your throat and ears."
 - Checks throat and ears
 - "What's important to keep in mind when people are sick?"
 - Eventually get on topic of sanitary practices
 - "Sanitize your hands, put on the gloves and the coat. Then you will be ready to enter the throat!"
 - Have kids use toy sink (and hand sanitizer), put on costumes

Script

- Introduction
 - "Hi, I'm Claude Croissant, world renowned baker. I'm so glad you're here, today is the day of a huge baking competition! Unfortunately, my award-winning cookie recipe has been hidden from me! I suspect that one of my competitors, Belot Beignet, came in here and tried to sabotage me. We'll have to figure out where he hid the ingredients and my recipe...then hurry to make the cookies!"
 - "Ah, but of course, what sort of bakers would you be without an apron and hat! We also need to make sure our hands are clean before we handle the ingredients."
 - Give aprons and hats, use hand sanitizer
 - Sound cues: French bakery noises

Figure 15: Excerpts from the Mystery Room Manuals

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Supplemental Materials for this project may be found at wp.wpi.edu/Melbourne.