

# Ingress Rooms: Sustainable and Scalable Games for Learning

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**Abstract:** This paper introduces Ingress Room as a more scalable and sustainable hybrid game solution for education environments while still accessing the engaging benefits of Escape Rooms. A key challenge for institutions wanting to use escape rooms within an education environment is the highly controlled and physically restricted but safe space that is required to deploy the game. The Ingress Room reverses this situation by using the entire campus (or city) space as the platform for the game with the specific goal of locating and gaining access to a room in an unknown location. The challenges for the game are at specific locations but are only visible and have context through access to a website/app. Each game sets the participants off on a trail of puzzles that converge on an ingress room. Success is confirmed by entering a code displayed within the Ingress Room. As with Escape Rooms hints and tips are provided after unsuccessful attempts through the website/app. These tips are increasingly specific to avoid frustration among participants. The opportunities for learning are diverse and customisable depending on the skills level and the knowledge domain of the participants. There are opportunities to orient participants in their physical location, to encourage specific Inquiry Based Learning activities and to test existing knowledge. The game encourages generic skills including teamworking, communications and problem solving as well as domain specific understanding through tests of knowledge.

**Keywords:** Escape Rooms, Higher Education, Games in Education, Inquiry based learning

## 1. Inspiration for Ingress Rooms

The concept of Ingress Rooms developed out of a need to deliver engaging, innovative and collaborative student experiences at university-level that are also massively scalable and highly changeable. These requirements pointed to a core set of criteria that would shape any potential solution. The solution would need to be technology based, it would have to break out of the classroom and it would need to have game-like elements that would encourage repeat usage through – at least - some healthy competition between teams.

Having previously worked on street-oriented games for student classes, induction activities and the 2018 ESRC Festival of Social Science with a game engine developed by the author called “Lookup” a location-based technology solution appeared to deliver many of the necessary elements to suit the brief. However, all these previous deployments had also exhibited shortcomings in relation to the specific requirements of the brief. This paper describes the conceptualisation, specification and initial development of a new games engine that undertakes to provide engaging, scalable, safe and customisable games appropriate to a variety of subjects areas at a university education level. The game engine is currently being coded with limited beta testing planned for late 2019 as a part of university induction activities around specific subject areas. Wider implementation is expected to occur throughout 2020.

The street games that had been deployed previously, by the the author through “Lookup”, required students to find ‘virtual’ markers in a campus or city-wide location using a mobile device. After finding a marker the participants then answered a multi-choice question based on the theme of the game and their specific current location. Points were awarded based on the speed that participant’s could find seven of the many hidden markers. Further points were awarded if the participant provided a correct answer. Points were deducted for leaving a pre-defined ‘safe’ area that participants could see on their device. The safe area was a necessary precaution to avoid busy roads and the simple temptation of stepping into traffic while distracted by a phone or tablet.

The general inspiration for the game design of “Lookup” came from the early location-based game “Uncle Roy All Around You” (<https://www.blasttheory.co.uk/projects/uncle-roy-all-around-you/>) produced by Blast Theory in 2003 and 2004 that was enabled through the use PDAs (personal digital assistants) in a period before

ubiquitous GPS. Further inspirations were found with the popularity of the app-based *Pokemon Go* game that was enjoying considerable success after its launch in the Summer of 2016 and the more mundane school playground game mechanics of "Capture the Flag". The relationship to *Pokemon Go* was particularly inspiring in terms of relating location-based gaming to a university curriculum. Warner's (2016) thoughts for the 5-18 curriculum were relevant but the work of my own colleagues with the same game added further insight. Despite some critical headlines from the mainstream media in 2016 (Hughes 2016; Mail Online 2016), the rationale for using the game was sound, achieved the student engagement it sought and is still being used in the same degree (in October 2019) supported by the robust *Pokemon Go* related syllabus that is curated through Google Docs (<https://docs.google.com/document/d/1xYuoZfkON-RVZQkr7d1qLPJrCRqN8TkzeDySM-3pzeA/edit>).

A key shortcoming of the earlier "Lookup" street game and its underlying engine was that participants tended to work on finding the markers independently and then guessing the answers rather than working collaboratively to find and utilise locational clues or to eliminate the most unlikely responses. The gameplay was effectively encouraging participants to put their heads down into the device, the exact behaviour that engaging social learning seeks to avoid. Some participants also tended to share the locations of the markers with other participants making it easier to find seven markers quickly and achieving high scores without exhibiting any knowledge whatsoever. Upon reflection, the cited initial inspirations for the development of the street game's engine had produced a trajectory that lead to individualised action and a pedagogic philosophy that at best was loosely didactic and momentary – asking of a string of simple and unordered questions to which only one response could be correct.

Modifications were made to the "Lookup" game engine that made the markers appear randomly. This single change rendered any intelligence received from other participants already in the field as far less useful and improved the repeatability and challenge of the game. However, the more important feature of creating and improving collaboration between participants still remains problematic with the Lookup game engine. It was at this point that the concept of Ingress Rooms emerged.

## 2. What is an Ingress Room?

An Ingress Room take the concept of Escape Rooms - most particularly the need for collaborative inquiry and problem-solving - and flips the venue outside. The overall challenge of each game then becomes one of finding a way into a room (gaining ingress) rather than attempting to escape from a room. Shifting the venue of the Escape Room into the outside does have significant consequences for how and what can be done within the game environment. There are benefits too. The Ingress Room is massively scalable and highly changeable in ways that Escape Rooms cannot be.

The Ingress Rooms engine offers a backend for lecturers and teachers that enables them to customise puzzles to suit their own curriculum needs. Customisation is also important to ensure that the game functions within a defined 'safe' space such as a campus, parkland or the pedestrianized parts of a town centre. Further development is planned around integration of the Ingress Room engine with existing virtual learning environments. This integration will enable automated capturing of participation for potential summative assessment as well as the tighter association of Ingress Room activities with other related learning materials to ensure reinforcement and the ongoing debate of topics raised by the games.

The primary means for delivering an Ingress Room experience is through the use of participant's own mobile devices. This does not itself limit the opportunities for collaborative game dynamics although it does admittedly remove the use of more tactile experiences and the use of other senses such as taste, smell or touch. Using Pederson's (2016) categorisation of Escape Room puzzles shows that the restriction of senses is not itself a significantly limiting feature (Table 1).

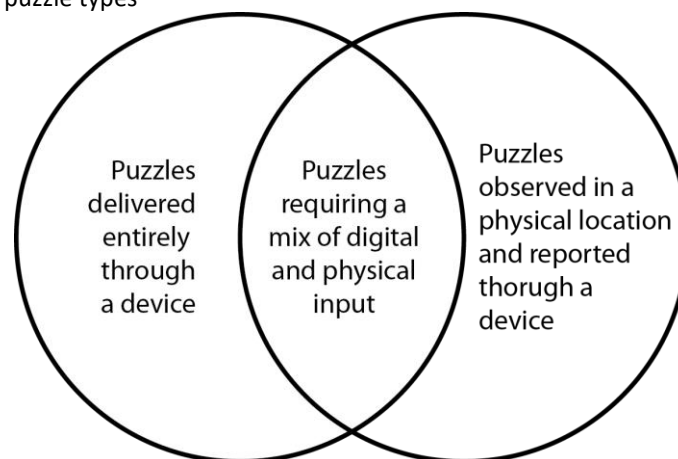
**Table 1:** Pederson's Categorisation of Escape Room Puzzles (virtualisable puzzles are italicised)

Suitable for Ingress Rooms	Estimated Worldwide Usage %	Unsuitable For Ingress Rooms	Estimated Worldwide Usage %
<i>Team Communications</i>	58	Hidden Objects	78

<i>Counting</i>	53	Light	54
Noting something obvious	49	Using something in an unusual way	47
<i>Symbol substitution with a key</i>	47	Assembly of a physical object	40
<i>Searching for objects in an image</i>	43	Ropes or chains	16
<i>Algebra and other mathematics</i>	39	Physical agility	13
<i>Pattern identification</i>	38	Touch	12
<i>Riddles</i>	37	Liquids	9
<i>Ciphers without a key</i>	35	Smell	3
<i>Mirrors/mirroring</i>	26	Taste	1
<i>Abstract logic</i>	22	Temperature	<1
<i>Sound</i>	26		
<i>Research using information sources</i>	20		
<i>Strategic thinking</i>	20		
<i>Hand/Eye coordination</i>	17		
<i>Traditional word puzzles</i>	14		
<i>Mazes</i>	14		
<i>Knowledge of facts not provided in the room</i>	11		
<i>Shape identification</i>	11		
<i>Social interaction with actors</i>	7		
Physical interactions with actors	4		

The list of usable Ingress Room puzzles that remains after filtering Pederson’s Escape Room categories highlights the extent to which mobile devices can be used wholly or in part to deliver the Ingress Room experience. By drawing on permanent fixtures in the location – ranging from the most obvious items such as street signs, through the abstract including identification of the shape of a piece of street furniture view from the ‘top down’ – there is potential to create mixed reality puzzles that requires observation and interpretation of the physical environment in combination with interactions that are achieved through one or more device. This classification of puzzles leads to a further three-way classification of Ingress Room puzzles that further assists in defining and developing the overall gameplay (Figure 1).

**Figure 1:** Ingress Room puzzle types



This categorisation of puzzles does highlight that an Ingress Room must use puzzles that do not require any type of manually reset. This is a result of being unable to guarantee that members of the public will not tamper with the puzzles and the fact that in order to be a scalable game all puzzles must be immediately and continuously available. Table 1 indicates that only two categories of puzzle suitable for Ingress Rooms that cannot in some way be delivered solely virtually through one or more of the team’s devices and one of these, “Noting something obvious” does not require physical resetting. “Noting something obvious” is also the primary candidate for the type of puzzle identified in Figure 1 as “Puzzles observed in a physical location”. The other category, “Physical interactions with actors” is only rarely used by Escape Rooms and could also be

deployed with a well-resourced Ingress Room setup that was operated with clear time boundaries and that could queue teams undertaking this type of puzzle in order to avoid one interaction overrunning into another. Such interactions could be as simple as an actor handing a team member a piece of paper containing a clue or an actor holding a sign at a specific location containing a puzzle, a clue or a direction. More sophisticated interactions could involve conversations or discussions in which a 'successful' outcome was the actor offering the team a spoken word or printed note that enabled them to progress on to the next puzzle.

Other than the categories and types of puzzles for Ingress Rooms there is a further pedagogic classification of the puzzles. Some puzzles are more suited for developing generic key skills in the participants with "Strategic thinking" being the most self-evident of this category. Other categories of puzzles are better suited for supporting the development of domain knowledge such as "Research using information sources". A well-designed Ingress room will deliver a mix of these two pedagogic classes of engagement including puzzles that blend the two classes together. An acknowledged limitation with the previous location-based Lookup game engine was the comparative lack of this mixture of pedagogic classes of puzzles.

The final puzzle in all Ingress Room games delivers an unlock code for a door. In a more sophisticated variant the lock is computer controlled and the unlock code itself will be generated within the game and be customised for each team. Inside the room the participants find a device with a single button and a small LED screen all powered by a networked Raspberry Pi device. Pushing the button will display a number on the LED screen. Members of the team must then input the generated number into their own device within 30 seconds. If this final group action is done in time the game will be completed and each device will confirm the team's completion and indicate their reward (if it is virtual) or how to obtain their award (if it is physical). The Ingress Room itself is the only challenge in the game that involves direct interaction with physical objects other than each participants own mobile device.

### **3. Game delivery**

The underlying engine for creating Ingress Rooms is created on a common web-based development platform of HTML and Javascript for the user interface combined with backend PHP code and a MySQL database. This enables the game engine to be accessible to the widest possible audience without requiring downloads from an App store. This approach is consistent with the previous location-based game engine, Lookup and as a result well-tested and robust.

Pointing the web browser on a mobile device to a URL starts each game. The first person chooses to start a game and this then generates a QR code that appears on their screen. Other participants go to the same URL and instead of choosing the option of starting a game they select to join a game and use the QR scanner that pops up to scan the QR code on the other participant's device. This joining mechanism ensures that the participants are standing in close proximity and that they are already collaborating. Once the team has joined the team leader – the person with the QR code on their screen chooses the commence option and all the mobile devices are drawn into the game.

In the background the game identifies the current location of the participants and determines if there is a nearby Ingress Room that is accessible to them. Some rooms may be restricted to specific participants or groups of participants who must authenticate themselves against an institutional identity management system or through an available OAuth sign-in system such as Twitter or Google. The game then randomly identifies specific locations that the participants must visit for the delivery of puzzles. Individual games can be configured to deliver a specific proportion of categories, types and pedagogic classes of puzzles. A further specification will be the domain specific focus for the pedagogically specific puzzles that are delivered. In this way it is possible for multiple teams of participants to be attempting to find a Ingress Room at the same time and in the same location but with a different domain of knowledge and different intended learning outcomes. This aspect of the Ingress Room requires curation by domain experts with consideration to levels, purpose and the outcomes they are seeking. Games must also be curated for safety. Entirely randomly generated locations for a specific team could result in encouraging them to move into restricted, private or dangerous places – or entirely inaccessible locations.

All the mobile devices of participants continuously update their location by making use of the What3Words system. What3Words is a system that divides the entire globe into 3m x 3m squares and enables precise

location of participants without drilling down to the point specific location provided by the longitude and latitude that direct GPS provides. What3Words also labels each grid square with a convenient three word address – a type of postcode system for the entire globe. As well as enabling Ingress Rooms to be deployed across the globe, this method of determining location enables a range of opportunities for the game play itself. The three word label for the location of a puzzle can be incorporated into the puzzle itself as part of its solution or as the outcome of a puzzle that is then applied to determine the location of the next puzzle.

Puzzles are delivered across all of the devices in the team. This will look different for the different categories of puzzles. For example a maze type puzzle may partially appear on all but one of the participant's devices. The first challenge would then be to place the devices together in the reveals the entire puzzle. Once these devices are combined the remaining device would be the input device for the answer. Other puzzles may reveal parts of an entire sentence or paragraph on each device. Only by placing the devices in the right order can the solution be discovered. At even the simplest level – and learning from the earlier Lookup engine development – multiple-choice questions that test domain knowledge may show the question on one device and then distribute the possible answers across all the other devices. Only by working in combination as a team can the answer be determined. Unlike the earlier Lookup engine providing an incorrect answer would not enable the team to progress and rather reset itself with a new question. A correct solution to all puzzles is required to progress.

Taking some of the learning from Escape Rooms. If the team struggles to correctly solve a puzzle different types of prompts are delivered to one or more of the participant's devices. Further incorrect responses will offer more hints to avoid team frustration but in a measured way in order to maintain a sense of urgency and dramatic tension.

Once a puzzle is solved the participant's devices guide the team to the next location. Aspects of the next location may be revealed through the solution to a problem but other directions will be required and these will be delivered – in parts – to all of the devices of the participants. In this way moving between each puzzle itself requires collaboration, conversation and continuous problem solving. There is no option for team members to split up and solve each of the puzzles in parallel.

In contrast to Lookup where the scoring tension between encouraging the speed of completion and the correctness of the answers created an uneven experience, Ingress Rooms entirely rely on the time taken to complete the entire game as a comparative measure of success between teams and for the same team repeating the experience. The configuration of the game ensures that the same number of puzzles are delivered with each new game and that the total distance that needs to be covered between the puzzles are all comparable. This general structural similarity of any Ingress Room experience also enables a more consistent basis for comparison between locations than the star ratings or difficulty levels that are sometimes applied to different Escape Rooms. The opportunity to create cross-institutional and international competitions and leagues then becomes possible with Ingress Rooms. The use of mobile devices to deliver the game play also ensures that the level of support or input that a team receives between rooms is consistent and does not bring in external human input that might influence the reported completion times.

#### **4. Ingress Room puzzles**

In developing puzzles for Ingress Rooms a matrix of categories and pedagogic classes was used to ensure that a variable mix of activities makes any single delivery of an Ingress Room experience sufficiently different, would continue to represent a challenge for returning participants and can suitably engage the participants with the intended learning outcomes.

The work of Brandeth and Truran (1987) and Brandeth (1981) provided useful inspiration for the development of Ingress Room puzzles. Although their books were originally intended for a popular audience both works describe a spectrum of challenges suitable to be adapted for delivery through mobile devices. By splitting aspects of the puzzles between participant's devices and having a further separate device to input the answer ensures that all of the puzzles in some way require collaboration between the participants even if this is only to vocalise their part of a solution. This means that all of the puzzles will fall into the second most popular category of puzzles as 'Team Communications'. Table 2 describes some examples of Ingress Room puzzles, their category of puzzle and the pedagogic class into which they will generally fall. The larger matrix of puzzles

covering the full range of categories prevents repetition of an Ingress Game experience and further encourages repeated usage.

**Table 2:** Example Ingress Room Puzzles

Puzzle	Category	Pedagogic class	Example Puzzle Descriptions
Odd one out	Abstract Logic	Domain	The team is confronted with a list of word or images that are domain-related on their devices and potentially in the location. They must determine the one word or image that is 'odd' in order to answer the puzzle. The 'oddness' will be based on a domain based logic or concept. (e.g. the components of a information system may be presented with a single 'intruder' which must be identified)
All together	Searching for objects in an image / Noting something obvious	Domain / Key skills	Parts of an image will appear on each device. The devices must be oriented together to reveal an image that is contained within the combined image. Clues may be present in the current location. (e.g. the image may contain an image of a reserved word such as a shopping 'list' in a programming language that must be identified)
Next symbol	Pattern identification	Domain / Key skills	Using symbols from a domain (e.g. the Periodic Table) the team must identify the next symbol in the sequence (with the each of options displayed across multiple devices) or perform a more sophisticated combination (e.g. combinations of elements to create a compound)
Outlines	Riddles	Domain	Using outlines or silhouettes of domain specific object the team must correctly identify what they are seeing (e.g. Human anatomy in a reverse version of the popular Nurse's Anatomy and Physiology Colouring Book)
Missing words	Research using information sources / Knowledge of facts not provided in the room	Domain	Using sentences or paragraphs key domain-specific text with key words missing the team must fill in the blanks. As a further challenge although the text will remain the same on the participant's devices in some cases the blanks will vary. This means that the solution can be developed through team conversations (however there will always be at least one entirely missing word) (e.g. this could be a significant quote from a politician or thinker that has sparked subsequent debate).
How many	Shape identification	Key skills	The team is asked the total number of items or shapes that are displayed on their devices as well as can be identified in their immediate location (with sufficiently explained scope). The answer is a single number.
Jeopardy	Research using information sources / Knowledge of facts not provided in the room	Domain	Domain specific definitions are shown – in some situations parts of the definition are displayed on each screen. The answer to the puzzle is the word or phrase that describes the concept (e.g. Jeopardy can be applied to any domain based on the key knowledge expected at the current level)
Unusual locks	Symbol substitution with a key / Mazes	Key skills	The team are given an image containing a grid of symbols. The other devices in the team each contain a key to one of the symbols. The team must navigate the image using the decoded symbols to find the end point solution. The symbols could connect to the "Outlines" and "How Many" puzzles to reinforce current subject knowledge.
Anagrams	Knowledge of facts not provided in the room	Domain	Each participant's device contains an anagram of a key domain concept. The puzzle is successfully completed when each anagram is solved.

## 5. The Inquiry Based Learning perspective

It is an unexpected ordering for an academic paper to present its core reference literature after it describes the problem and the solution that has been developed. In the case of Ingress Rooms this reflects its technical development from an earlier and less pedagogically robust game engine. The core of the game's design existed in experimental form before its pedagogic rationale was developed. However, once the pedagogic rationale had been clarified it clearly supported the design of the individual puzzles as well as the overall structure of the game. In this sense the game found its *raison d'être* after the development of its predecessor and particularly after many of the shortcomings to the game's design and its gameplay became evident through its delivery. Ingress Rooms are, in this way, arguably a product of their own Inquiry Based Learning cycle. Research into some of issues faced by the earlier Lookup game engine highlighted that these challenges were not unique and had already been tackled in a range of ways. For example, Hossain et al (2017) highlight the issues with scaling interactive and innovative pedagogic activities, Song & Wen (2018) consider the challenges faced with the integration of a learner's own mobile device in a learning activity and Suarez et al (2018) document the types of activities currently used in mobile Inquiry Based Learning. Each of these papers supported some of the thinking that assisted in shaping the development of the Ingress Rooms game engine. This influence makes a strong argument for the benefits of theoried technical development over more ad hoc or user-interface oriented design perspectives that can be identified in many game available through App stores. In contrast the academic literature regarding Escape Rooms offered somewhat less value to the development of the Ingress Room concept as the focus in this literature tends to be upon making the Escape Room concept work for a specific location or in a particular disciplinary context.

It is through this development route that the pedagogic inspiration for Ingress Rooms so clearly draws from Inquiry Based Learning. Savery's definition, set out in response to distinguishing Inquiry Based Learning from problem-based learning, is comprehensive, "Inquiry-based learning is a student centred active learning approach focused on questioning, critical thinking and problem solving. Inquiry-based learning activities begin with a question followed by investigating solutions, creating new knowledge as information is gathered and understood, discussing discoveries and experience, and reflecting on new found knowledge." (Savery 2015, 11). In almost all cases the participants in an Ingress Room game are working on puzzles where they either do not have all of the facts in front of them or the answer to the puzzle is distributed between multiple participants in such a way that they must work together to apply their domain knowledge and problem solving skills. In this way Ingress Rooms are testing and challenging a further set of higher-level skills relating to identifying and interpreting findings to produce an answer. While some of the puzzles require the recall of domain knowledge the solution is not solely based on the memorising of facts but requires further contextualisation or application in order to derive a solution. The absence of complete details, facts or context in some of the puzzles requires problem-solving skills and is not solely about remembering key facts.

Inquiry Based Learning is not only about solving problems with Pedaste et al (2015) emphasising that it "emphasizes active participation." This describes a key feature of any game-based learning environment but particularly one that requires all members of the teams to continuously engage in varying roles in order to progress past each challenge. Pedaste et al (2015) also critique the notion that the learning cycle in Inquiry Based Learning is either linear or fixed. This thinking is echoed in Ingress Rooms through the delivery of different puzzle in varying order and locations. Students cannot 'rote' learn the sequence of the puzzles or their solutions as they will vary with each delivery. This type of approach to puzzles and their relationship to the overall game play encourages deeper learning and exploration of the many different ways in which the investigation stage of Inquiry Based Learning can be experienced.

## 6. A future for Ingress Rooms

The development of Ingress Rooms addresses the initial brief to create a game engine that is engaging, innovative, collaborative, safe, scalable and changeable. The approach taken also learns from, and overcomes, the limitations of the previous "Lookup" game engine as well as other physical location-based quiz games. The Ingress Room experience is challenging and brings a genuine game-like competitiveness to learning while still encouraging active peer learning. The flexibility of the Ingress Room engine also offers opportunities for delivery beyond being an alternative classroom experience. Versions of the game with less emphasis on specific domain knowledge can be used for open days, induction and for public engagement events.

The customised Ingress Rooms set up for individual university modules are part of the conversation. By getting students outside and thinking about their subject in a problem-based way the purpose of Ingress Rooms is to get conversations started and to support the momentum of other parts of the module delivery throughout a term or semester.

Ingress Rooms have wider applications including a commercial context. The end of an Ingress Room game may be the beginning of an Escape Room experience, it may be found in a space such as a Visitor Information Centre where the experience has focused on domain knowledge of the local area or the Ingress Room may be discovered in a commercial outlet where successful completion is rewarded with commercial offers.

Real opportunities also exist for a global network of Ingress Room experiences and competitions.

The Ingress Room engine is still in its earliest development phases but initial testing of the key components described here confirms the strength of a theorised approach to games development. Inquiry Based Learning will continue to inform Ingress Rooms as they developed through beta testing and into full production deployment – initially in Salford and Manchester but then the potential opportunities are vast.

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