

Gamification of Smart Cities: Enhancing Engagement and Sustainable Behaviours

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<u>Abstract</u>: The convergence of smart cities and gamification presents a promising avenue for addressing urban challenges and enhancing the quality of life for citizens. Gamification, the application of game elements and mechanics in non-game contexts, offers opportunities to engage and motivate individuals in various activities related to smart city initiatives. This review paper explores the concept of gamification in the context of smart cities, aiming to understand its potential applications, benefits, and challenges. By reviewing existing literature, case studies, and examples, we examine how gamification has been employed in transportation, energy management, citizen engagement, waste management, and urban planning within smart cities. Additionally, we analyse the implications and effects of gamified systems on user behaviour, participation, and the overall urban environment. The paper also highlights the significance of evaluation methodologies for measuring the effectiveness and impact of gamification in smart city contexts.

Furthermore, future research directions and opportunities are identified to guide the development and implementation of gamification strategies in smart cities, considering emerging technologies and evolving citizen needs. The findings of this study contribute to a comprehensive understanding of the gamification of smart cities, offering insights for policymakers, urban planners, and researchers to leverage gamified approaches in creating sustainable, engaging, and inclusive urban environments.

Keywords: Gamification, Smart cities, Resource utilization, Information and communication technology (ICT), Energy management, Citizen engagement, Data-driven decision making, Disaster management, User adoption, Scalability, Inclusivity, Public health promotion, Disaster preparedness.

1.Introduction

A smart city is an urban environment that integrates advanced technologies and datadriven solutions to improve the quality of life for its residents, enhance sustainability, optimize resource utilization, and address urban challenges. It involves the integration of various domains, including information and communication technology (ICT), infrastructure, transportation, energy, healthcare, and governance to create a connected and efficient urban ecosystem. Smart cities are like cities that are good at taking care of people. They make things like buses and hospitals work better and make sure everyone is safe and happy. Smart cities are cities that try to take care of the Earth by using energy and resources wisely. They use things like solar power and make sure not to cause too much pollution. This helps to protect the environment and makes sure that we can continue to have a good future. Smart cities use special tools to make things work better. They have sensors and computers that can watch what's happening and make improvements. This helps with things like traffic, garbage, and electricity. It makes these things work smoother and use less energy.

Smart cities are cities that use technology and information to make life better for the people who live there. They help solve problems in the city and make it a nicer place to live. Smart cities are important because they can help make our future better and more connected.

1.1 Overview of gamification and its potential for promoting engagement and behaviour change

Gamification means adding fun game parts to things that aren't games to make people want to do them more. By using things like points, badges, and rewards, gamification makes people want to try harder and do things better. Gamification is like adding some fun game-like features to activities or tasks to make them more exciting and keep people interested as shown in [figure 1]. This can include things like tracking progress, earning rewards, and competing with others. It's a way to make things more fun and engaging, so people want to keep doing them. They can also play with other people, work together, or compete in a friendly way [1].

Gamification can be used in many different areas to help people change their behaviour. This includes things like being healthy, learning in school, taking care of the environment, being productive at work, and managing money. It is a fun way to get people interested and excited about doing the right things, and it helps them keep doing that for a long time[2].



Figure1: An AI-designed gamification interface displaying a roadmap in the application.

1.2Research Objectives of the paper

The primary objective of this research is to explore the gamification of smart cities and examine its implications.

- I. Investigate the concept of gamification in the context of smart cities and understand its underlying principles, components, and mechanisms.
- II. Explore potential applications of gamification in various areas within smart cities, such as transportation, energy management, civic participation, waste management, and urban planning.
- III. Investigate the effects and impact of gamified systems on user behaviour, participation, and overall urban environments.

- IV. Analyse the benefits and challenges associated with implementing gamification in smart cities, including aspects such as user adoption, privacy concerns, scalability, and long-term sustainability.
- V. Emphasise the importance of evaluation methods to measure the effectiveness and impact of gamification strategies in the context of smart cities.

This study wants to learn more about how games can be used to make cities better and more fun for everyone. It will collect information to help people who make decisions about cities, like government officials and planners, as well as researchers.

2. Gamification and its core elements

Gamification is like adding game elements to things that aren't games to make them more fun and exciting as shown in [figure 2]. It helps people stay interested and motivated, and it makes activities or tasks more enjoyable to do.

Points are like little rewards that you get when you do something good or complete a task. They show how well you are doing and make you feel proud of yourself. Badges or achievements are like stickers that you get when you do something cool or when you reach a special goal. They show that you did something great and make you feel proud. You can show them to other people and even compete with your friends to see who can get the most.



Figure 2: Elements involved in Gamification

Levels are like steps in a game. When you start playing, you begin at a lower level, and as you do well, you move up to higher levels. Each level comes with new and exciting things to do, like harder tasks, special rewards, or cool things you can do. Moving up to higher levels makes you feel proud and motivated to keep playing.

Leaderboards make people want to do better and beat their friends. Challenges are like special tasks that you can try to do. Some challenges have a time limit, some require certain skills, and some are about doing specific things. Challenges help you feel like you have a goal to work towards and make the game or activity more fun. They also give you a plan to follow and help you feel proud when you finish them.

Rewards are like prizes that people get when they do something good or finish a task. They can be things like special items or money in a game, or even real things like toys or treats. Rewards help make people happy and want to keep doing good things.

2.1 Frameworks or Models for designing gamified systems

There are ways to make non-game things more fun by adding game elements and mechanics. These ways are called frameworks, and they help people design these fun things. Some popular frameworks are:

(a) The Octalysis Framework:

It is a way for people who make games or other fun things to understand why people like them. It says eight things that make people want to play or do something fun. These things are divided into groups: things that make us feel good, things that make us feel like we accomplished something, things that let us be creative, things that make us feel like we belong to a group, things that make us feel important, things that make us feel like we are part of something important, and things that help us grow and learn as shown in [figure 3].

(b) Self-Determination Theory:

It is a way of thinking about how people feel motivated. It says that three important things make people want to do things on their own: being able to make their own choices, feeling like they're good at what they're doing, and having friends to do things with.



Figure 3: Infographic displaying stages in Octalysis Framework

When people make games or activities, they can use this theory to make them more fun and motivating by giving players choices, making challenges that are just right, and letting them play with others.

(c) The MDA Framework:

The MDA Framework is a way to design games by breaking them down into three parts. The first part is the mechanics, which are the basic rules of the game. The second part is the dynamics, which is how the player interacts with the rules to create fun and interesting gameplay. The third part is the aesthetics, which are the feelings and experiences the player has while playing the game. By thinking about all of these parts, game designers can create games that are more enjoyable and engaging for players.

2.2 Key motivations and psychological principles behind gamification:

Gamification is when people make games that make you want to do things, they want you to do by using things that make you happy and interested. Intrinsic motivation means doing something because it makes you happy or feels good, not because someone gives you a prize or reward. Gamification uses things like giving you choices, challenging tasks, and chances to play with other people to make you want to keep playing and get better at the game. It makes you feel like you have control, can do things well, and are part of a group.

Extrinsic motivation is when you do something because you want to get something in return, like a prize or a reward. In games, they use things like points, badges, and leaderboards to motivate you to do well and feel good about yourself. It's like getting a pat on the back for doing a good job! When you play games with other people, you might feel like you want to be part of a team and try to do better than everyone else.

Games use things like scoreboards and teamwork to make you feel like you're part of a group and motivate you to do your best. When we feel like we're making progress and achieving things, it makes us want to keep going.

Immediate Feedback means that when you are playing a game, it is important to know how well you are doing right away. You need to get information about what you are doing right and what you need to improve on. This information can come in different forms, like getting points or seeing a progress bar. It helps you understand how well you are doing and helps you get better at the game.

3 Challenges faced by smart cities and solutions

Sustainability means making cities cleaner and better for the environment. This helps stop climate change and use resources like water and energy more effectively. To do this, we need to use renewable energy sources, make sure we don't waste things like water, and plan cities in ways that are good for the environment. This will help us build better cities that are good for the earth. Getting around in cities can be difficult because there are a lot of cars and pollution, and it's not very easy to move around. To fix this, cities need to create transportation systems that focus on things like buses and trains, encourage people to ride bikes or walk, and find ways to make traffic flow better. Using smart technology for transportation, sharing rides with other people, and using electric cars can help make getting around cities easier and better for the environment as shown in [figure 4].

Resilience means being able to bounce back or recover from difficult situations. Cities, like where we live, need to get better at dealing with climate change and natural disasters. This means coming up with plans to adapt to climate change, making our buildings and roads stronger so they can handle really bad weather, and taking steps to keep people safe when disasters happen. Resilient cities also focus on using things like trees and parks to help with flooding and having systems in place to warn us when dangerous weather is coming. All of these things help us protect our city and the people who live here from the bad things that can happen because of climate change.

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Figure 4: *Roadmap indicating the potential* of *Gamification and its working model*.

4 Gamified Platforms for Citizen Feedback and Participation in Decision-Making Processes

Gamified platforms are like games that help people participate and give their thoughts and ideas about important things. They make it fun and exciting to take part, and everyone can join in. Some examples are websites where you can share your ideas and opinions.

Virtual simulations and planning games are like playing a game on a computer or tablet. In these games, you get to design your city and make decisions about things like roads, buildings, and how to make sure the city is good for the environment. It's a fun way to

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learn about how cities are planned and to use your imagination to create something cool as shown in [figure 5]. Mobile apps are like games that help people tell the government about problems in their neighbourhood, like holes in the road, broken streetlights, or garbage issues

Participatory budgeting is when people get to vote on how money from the government should be spent on different projects. Gamified platforms make this process more fun by including games and rewards for participating. Collaborative decision-making platforms are like games that help people work together to solve problems and make rules. Playing games can help people get more involved in their community.



Figure 5: Using Gamified application in urban area

4.1 Specific applications of gamification in different areas of smart cities

When people need a ride, they can use a fun game-like app that encourages them to share rides with others. This helps to reduce traffic and pollution. People who use the app can earn points, get discounts, or win prizes for sharing rides or using eco-friendly ways of getting around as shown in [figure 6].

Special garbage cans with sensors and fun games on them can give prizes to people who throw away their trash the right way. There can also be competitions to see who can recycle the most to encourage more people to do it. Urban planning can be made more fun and involve the people who live in a neighbourhood by using games. People can share their ideas and preferences for how they want their neighbourhood to look.



Figure 6: Infographic displaying all the different ventures for Gamification

Gamification is a way to make exercise and being healthy more fun. It's like playing a game while you're active. There are special apps that can track how much you move and set goals for you. When you reach those goals, you can earn rewards. You can also play games and compete with your friends to see who can be the most active and healthy. Gamified platforms are like games that can help keep people safe. For example, there can be a special app on a phone that encourages people to report things that might be dangerous or not normal. When people report these things, they can earn points or special prizes in the game. This makes people want to help keep their community safe and secure. By adding fun and game-like elements to different parts of smart cities, we can encourage people to get involved. do things that help the environment, and feel like they are part of a community.

5 Benefits and advantages of applying gamification in smart city contexts

Gamification is a way to make people want to do good things for the environment. It uses rewards, feedback, and showing how much progress they've made to help them want to make eco-friendly choices every day. These choices can include things like recycling, using public transportation, saving energy, and being part of community activities. By doing these things, it helps the environment and makes cities more sustainable.

Gamification is a fun way to get a lot of people involved in making cities better. It's cheap and easy to use on phones and computers, so we can reach lots of people without spending lots of money. It's also easy to make it bigger and get more people involved, which means we can make even more improvements!



Figure 7: Infographic displaying benefits of Gamification

Gamification can help people work together and become friends. By creating games and challenges that everyone can play, people can share ideas and work together to achieve the same goals. This makes people feel like they are part of a team and helps make the city a better place. Gamified systems provide feedback and show progress in a fun way. This helps people learn about how their actions affect the environment and make good decisions as shown in [figure 7]. Knowing more about how to be sustainable makes people feel responsible and want to help build a better future.

5.1 Limitations associated with implementing gamification strategies

We also need to make sure that the new things can work for a lot of people and keep working for a long time.

(a) User Recruitment:

User-centred design involves users in the design process and understand their needs, preferences, and potential barriers to adoption. Incorporate user feedback and iterate the gamification system accordingly.

(b) Clear communication:

Communicate the benefits of gamification and how it aligns with your users' interests and goals. Emphasise the positive impact on sustainability, convenience, and community participation.

(c) Training and Support:

Provide user his/her training and ongoing support to ensure individuals understand how to effectively work with gamified systems. A user-friendly interface, tutorials, and help resources facilitate adoption.

(d) Transparent data practises:

Communicate clearly to users how data is collected, stored, and used, ensuring their informed consent. Follow appropriate transparent practises and implement strong data security measures.

(e) Anonymous Data:

Collect and anonymize user data whenever possible to protect the privacy of individuals while maintaining data mining and analysis. rive for data minimization by collecting only the necessary information for the functioning of the gamification system.

(d) Scalability:

Scalability means making sure the gamification system can handle more and more people using it and storing more and more information. We need to test how well the system works when lots of people are using it to find and fix any problems.

We can work with other groups to share ideas and resources, and we need to plan for how we will keep the game going by making sure we have enough money and people to take care of it.

6 Examples where gamification has been successfully implemented in smart city projects

Present real-world case studies or examples where gamification has been successfully implemented are:

(a) Green City Game- Singapore:

In Singapore, they made a game to teach people about how to take care of the environment as shown in [figure 8]. People could make their own pretend cities and make choices about things like energy and recycling. If they did a good job, they could earn rewards and feel proud. Lots of people played the game and learned how to be more eco-friendly in real life.

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Figure 8: Green City game interface developed in Singapore

(b) Recycle Bank:

It is a fun recycling programme in the United States. When people recycle and do things that are good for the environment, they earn points. These points can be used to get rewards from local businesses. This programme has helped more people recycle, reduce waste, and get the community involved in taking care of the Earth.

(c) Citi. The city:

This is a fun game in Denmark where people can share their ideas for making their neighbourhoods better. They can earn points and work together with other players to make their ideas happen. This game helps everyone have a say in making their city a better place to live.

(d) Smart Road Sense:

It is a game in Italy as shown in [figure 9]where people use their phones to report bumpy roads and traffic problems. By doing this, they earn points and can compare their scores with others. The information they give helps the government decide which roads need fixing and make transportation better.



Figure 9: Road Sense is a gamified software developed in Italy

(e) Stockholm's Gamified Commuting:

In Stockholm, Sweden, there's a fun app that helps people make better choices when they travel. The app gives points and rewards to people who choose to walk, ride a bike, or take public transportation instead of driving a car. This helps to make the air cleaner, and there are fewer cars on the road, so it's not as crowded.

Gamification is like turning things into a fun game where you can earn points or prizes. Some smart cities have used this idea to encourage people to do things that help the environment, get involved in their community, and collect information. This has helped make cities better and more sustainable places to live.

6.1 The outcomes, impact, and lessons learned from these initiatives

"The Green City Game" in Singapore that helped people understand how their choices affect the environment. People played the game and made decisions about how to use energy, and water, and manage waste. They learned how to make sustainable choices. This game helped people become more aware of the environment and want to take care of it in real life. The game also taught us that making games about sustainability can be a fun way to encourage people to take better care of the environment.

Recycle bank is a programme in the United States that encourages people to recycle more and create less waste. They do this by giving people points for recycling, which they can then use to get rewards from local businesses. This helps the community work care more about together and the environment. Recycle bank has shown that making recycling fun and rewarding can help people be more responsible and work together to create a better world.

Citi. The city in Denmark helped people have a say in how their cities are planned and designed. They made it a fun game so everyone could share their ideas and preferences. This made sure that everyone's thoughts were considered and made the city better for everyone. People learned that planning cities is complicated, but their opinions are important. Because of this, more projects were made that focused on what people really needed and wanted. It also helped people feel like they belonged and were connected with others in their communities. The important lesson from Citi is that involving citizens in planning cities is important, and making it into a game can get more people involved and make sure their needs are met.

There was a project in Italy called Smart Road Sense that asked people to help collect information about the condition of roads and traffic. This information was then used by the government to decide which roads needed to be fixed and how to make transportation better. By using this data, the government was able to use its resources more efficiently and plan improvements to the roads. This project also showed that when people work together and share their information, it can help them make better decisions. One important thing they learned was that it is important to explain to people how their information will be kept safe and private so that they feel comfortable participating.

Stockholm's Gamified Commuting - Sweden: In Sweden, there is a game people can play on their phones to encourage them to use more eco-friendly ways of getting around the city instead of driving themselves in their cars. This has helped make the traffic better and the air cleaner! We learned that using games can make people want to use transportation in a better way and help the environment. We found that it's important to give people rewards, tell them how they're doing in real-time, and make them feel like they're part of a group to make them keep doing it for a long time[3].

6.2 Strategies to address privacy concerns and data security issues

To keep people's personal information safe when they play games, we can do things like make sure their information is only seen by the people who need to see it and make it hard for bad people to get it. When making a game, make sure to think about keeping people's personal information private right from the start. Build the game in a way that protects people's privacy and makes sure everyone using the game knows how to keep their information safe.

When we make a game, we only collect and keep the information we need. We also ask people if it's okay to collect their information, and we explain why we need it. We give people choices about how we use their information. When we have personal information about someone, we should try to make it so that no one can tell who that person is. We can do this by changing the information or keeping it a secret. This helps keep people's information safe and makes it hard for others to figure out who they are [4].

We need to keep the information we collect safe. This means we make sure no one can access it without permission. We also use special codes to protect it when we save it or send it to others. We check often to make sure everything is still safe, and we use special systems to store the information in a safe place. We work with trustworthy companies to help us keep everything secure.

7. Evaluation and Measurement of Gamified Smart City Systems

User Engagement Metrics are ways to measure how much people are playing and enjoying a game. This includes things like how many people are playing, how often they play, how long they play, and how like much they the game. These measurements help us see how well the game is keeping people interested and having fun. We can measure how well the gamified system is helping people change their behaviour. We look at things like how much people are using public transportation, how much energy they are using, and how much they are recycling. We also ask people how they feel about these behaviours. We can do surveys, and interviews, and watch people gather this information.

Performance metrics are like a report card for a game. They help us see how well the game is working and if there are any problems. We look at things like how fast the game responds, how often it has errors, and how well people like playing it. This helps us figure out if there are any things we need to fix or make better in the game. We want to see how the game affects people and their communities. We look at things like whether more people are getting involved in the community and working together, if people are becoming closer friends, and if people are learning more about problems in the city and how to make them better.

Economic metrics are ways to measure how the gamified system affects money. This includes things like how much money is saved, how much money is gained compared to how much is spent, and the benefits of using the system to encourage good habits. Looking at these numbers can help us understand if the gamification strategies are a good financial idea. We want to make sure that the game we created will be able to last for a long time and still be good. We will see how well the game can change and grow with more people playing it. We will look at the results to see if games make things more effective. When we test fun city systems, we need to pick ways to measure how well they work that match what we want to accomplish. We should use different ways to test them, like counting things and asking people questions, so we know if they are helping us like we want them to.

7.1 Identification of Emerging Trends and Opportunities in the Gamification of Smart Cities

Identifying emerging trends and opportunities in smart city gamification is critical to staying ahead of the curve and leveraging new developments to enhance the city experience. Below are some emerging trends and opportunities to consider:

AR and VR are cool technologies that can make cities more fun! They can put digital things in the real world and make it feel like you're in a different place. With AR, you can learn about cool stuff around you like old buildings or ways to help the environment. With VR, you can practise things like building cities or talking to other people in a different world.

Smartphones and wearable devices, like smartwatches, are really popular. They can be used to make fun games and activities that are about the city we live in. These games can help us learn about the city, use its resources and services, and do things that are good for the environment. Smartphones and wearable devices can keep track of what we do and give us rewards or prizes for doing good things. Playing games can help people prepare for emergencies and be safer in their community. These games can teach us how to handle dangerous situations and what to do to stay safe. They can also help us work together better when there is an emergency. By playing these games, we can learn how to take care of ourselves and our city.

Blockchain technology and cryptocurrencies can be used to create fun and fair systems in smart cities. They keep information safe, help with buying and selling things securely, and make it easy to trade digital items in games. Cryptocurrencies can be given as rewards for doing good things, like being environmentally friendly, which encourages people to keep doing those good things and helps the city be more eco-friendly.

Smart cities can use games to solve problems, help the environment, and make life better for people. People who plan cities need to learn about new ideas and work with technology companies to try out new ways to use games.

8 Conclusion

This paper talks about how to make cities more fun by using games. It explores different ideas and the challenges of doing this. It is found that using games can be a good way to improve cities. Smart cities are places where technology and information are problems used to solve in cities. Gamification is a way to make these solutions more fun and get people involved. Gamification is when we use things from games, like points, badges, and rewards, to make non-game things more fun and exciting. It's like turning something boring into a game to motivate and engage people.

To do this, we need to have clear goals, fun challenges, ways to know if we're doing well, and a feeling of moving forward. There are different ways to design games that are fun and engaging. Some of these ways include using frameworks like the Octalysis framework, the Self-Determination Theory, and the MDA framework. These frameworks help people create games that work well for specific parts of a smart city.

8.1 Suggestions for further research

In the future, there are many exciting things that researchers and inventors can still learn and create in the world of games for smart cities. Some of these include making games that are personalised just for you, helping people change their behaviour for a long time, making games that have a positive impact on society, creating games that use both real and virtual worlds, using data to make games better, finding ways to be ready for emergencies and tough times, finding ways to reuse and recycle things in cities, letting people have a say in how their cities are planned, thinking about what is right and wrong, and thinking about how games can affect people and communities.

People who make decisions about cities and technology can learn how to use games to make cities smarter and better by paying attention to some important information. Gamification can help make cities better by finding solutions to problems and making them more fun and enjoyable for people. It can also make cities more focused on the needs of the people who live there.

We want to learn about what different people like and what makes them excited, so we can make games that they will enjoy and want to play. We can make smart cities, even more, fun and interesting by combining games with cool new technologies like AR, VR, and MR. This will make people want to learn and do good things in the city even more. We need to study and understand the possible problems and fairness issues that could happen when we collect information, keep things private, and try to control people's behaviour. Then, we can make a plan with rules to make sure we use games fairly and responsibly. We want to use really smart computer programmes to make games even better for people. These programmes can look at how each person plays the game and give them personalised tips and challenges to help them get better.

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