# Unlocking the Next Level of Crime Prevention: Development of a Game Prototype to Teach the Conjunction of Criminal Opportunity

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***Key Words:*** *Serious game; rapid prototyping; formative evaluation; conjunction of criminal opportiunity.*

***Abstract.*** *This paper reports on a case study of using rapid prototyping to develop a serious game about crime prevention. Five small-scale formative evaluations (with a total of 17 participants) were used to guide the collect user requirements and formative feedback. Early formative results are positive and provided early signals on what needs to be changed in the game design and what could be kept. Evaluations also provided valuable feedback for the underlying subject matter theory. The process used in this research could possibly be transferred and adopted in other serious game development projects, resulting in low-cost development and early feedback on game design ideas.*

## 1. Introduction

There is a growing interest in serious games (games designed with an educational objective in mind), but there has been little discussion of the cost involved in developing a successful serious game. Freitas and Jarvis [1] state that the focus of development must be on target users of the games, and recommend a series of user studies like semi-structured interviews and workshop activities. At a workshop in 2009 at the Game Developer Conference three emerging trends for serious games were identified. Among those were the broader use of early prototyping and new market demands, notably pressure for lowering costs. This trend can be seen as a response to the fact that commissioned projects usually require multi-million-pound budgets and diverse teams working over years to deliver [2].

Despite that a review of fifty serious games [3] found out that the developers of less than half of those report to have used established educational theories or principles. Possibly related to that to date there is only weak empirical evidence of the learning benefits of serious games [4].

In this paper, we report work in progress to develop a low-cost game in the domain of crime prevention. The intention is to provide a case study of how rapid prototyping could be used to develop serious games and how such a development approach impacts the collection of user requirements and formative feedback.

## 2. Background

The game under development is intended to support practitioners when they learn to use a new framework for crime prevention – the Conjunction of Criminal Opportunity. CCO, as the framework is commonly abbreviated, comes at the price of greater (but necessary) complexity relative to widely used frameworks. Paradoxically this equips practitioners to better handle the complex reality of crime [5]. A diagram capturing the dimensions of CCO is provided in *figure 1*. CCO has two aspects – 1) supporting analysis of the immediate causes of criminal events, shown here; and 2) supporting systematic consideration of an array of principles for preventive intervention, each principle in effect blocking, weakening or diverting one of the causes.

The design of a serious game needs to take user motivation and learning into account – both have been the subjects of long-term research.

The term gamification – shorthand for the idea that people generally like seeing tangible and comparable outcomes of their effort – has recently gained popularity. When receiving feedback in terms of numerical values (such as points and scores), users get an opportunity to compare their performance with others. This was acknowledged by Richard Bartle [6], who in 1996 designed one of the first taxonomies of approaches towards playing networked games. In his taxonomy, people driven by performance scores are called *achievers*. There are three further types: *explorers*, *socializers* and *killers*. Subsequently, Andreasen and Downey [6] developed a survey to classify people according to this taxonomy.

Starting with this survey Yee [7] conducted a more extensive investigation, using factor analysis on more than two thousand players in massive multiplayer games. Yee concluded that the motivational types identified by Bartle are not exclusive to one another. As a result of his research he rearranged motivational factors into three groups: *achievement*, *immersion* and *social motivations*. Each of these factors are the aggregation of loosely related subsidiary factors. *Social motivation* unites the needs for socialization, relationship building and teamwork. *Achievement motivation* represents the needs to make progress, to compete and to understand underlying rules. *Immersion motivation* combines together discovery, role-play, customization

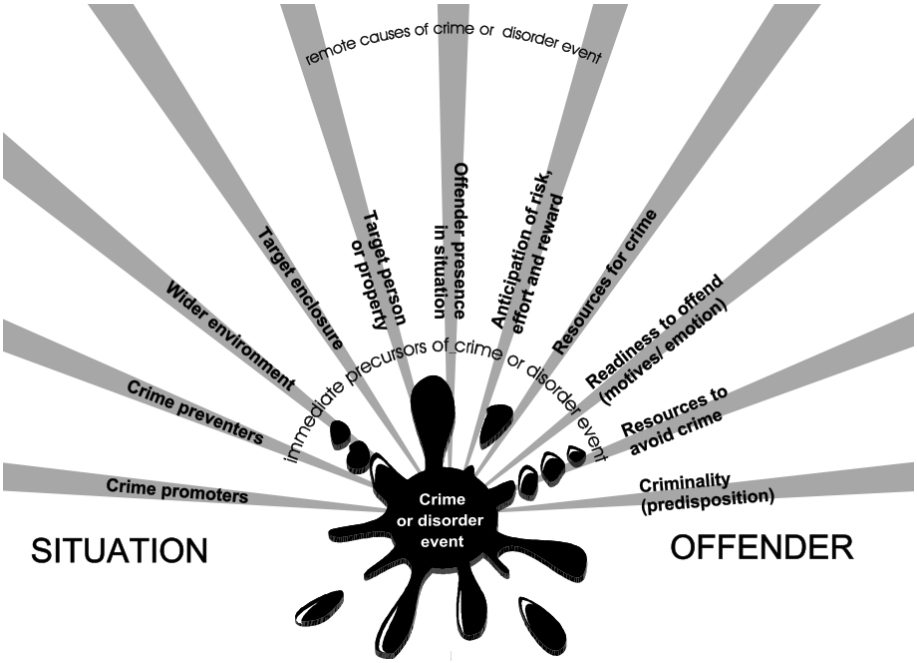


**Figure 1.** A diagram featuring crime causes according to CCO. It portrays the 11 generic causes to crime, represented as rays here and the resulting conjunction of criminal opportunity (CCO), represented as the black blot in the middle. A similar diagram represents the corresponding 11 areas of preventive interventions

and escapism. Yee considers the labels of *achievement* and *eimmersion* to loosely correspond to whether the player is extrinsically or intrinsically motivated respectively. In a recent study by Ruskov and colleagues [8], students were interviewed after playing a leadership simulation game. Collected responses typified Yee's motivational factors.

*Variation* is another feature that game designers have identified as engaging [9]. Even more relevant for the purposes of a serious game, educational researchers [10,11] have argued for the importance of variation in learning. Researchers have reported using interactive tools [12], simulations [13] or even traditional games [14] to expose learners to variation. In the research presented here, we explore possible systematic ways to introduce learning variation in the design of a serious game.

As a way to operationalize variation Marton and Pang [10] identify four necessary conditions for learning: *contrast*, *separation*, *generalization* and *fusion*. *Contrast* stipulates that in order for a quality to be discerned, a mutually exclusive quality has to be experienced in parallel. *Separation* emphasizes that one certain dimension of variation can be discerned only if other dimensions remain invariant or vary independently. *Generalization* complements separation by focusing on the fact that discerning a certain value in a dimension is easier when this value is kept constant when other dimensions change. Finally *fusion* stipulates that the interplay of two dimensions can only be appreciated when both of them are varied in conjunction.

Online social platforms are known for successfully crowd-sourcing knowledge. There are examples like Sermo [15] of living knowledge ecosystems utilizing surveys, tagging, discussions and rating among other features. Collectively constructed practical knowledge, developed within Sermo, is a product that has been considered to be of commercial value, which itself is an indirect evidence of data quality. To our best knowledge there is only limited research on specific attempts to integrate knowledge sharing in games, like e.g. [16], despite the acknowledged potential added value of peer-driven discussion and feedback. In line with the practices of knowledge-sharing applications and in order to allow for easy access in future, our game prototype was developed as a browser-based application.

Started as an exercise without a major development budget, the project reported here tried to engage players and help them learn with a minimalistic serious game. Our project developed incrementally and strived to include only features that are considered necessary. The intention is to avoid escalating cost of development related to more complex game systems. Research [16] has acknowledged importance of visual design for the development of any type of game. Lacking the resources for this, we nonetheless had to devise ways of testing the principle. Our hope was that despite the poor visuals, addressing Yee's motivational factors would result in a prototype that is attractive as interaction itself.

## 3. Method

Although crime prevention practitioners report that they recognize the usefulness of CCO, more often than not they also find it challenging to use, because of its complexity and subsequent difficulty to oversee all the systemic interactions that it represents. The aim of our prototype is to engage players with different motivational factors, and to

get them to experience the variation necessary to effectively learn how to use the framework.

A first approach towards Yee's motivational factors [7] resulted in addressing each of the three wider categories: *achievement*, *social* and *immersion motivations*. *Achievement* is the drive to stand out and excel; it is met in the prototype by the scoring and ranking system, based on peer assessment of user ideas, and dedicated badges for suggestions that are perceived as innovative or described with exceptional detail. The need for meaningful interaction with other people – the *social motivational factor* – is addressed through the opportunity for free-form idea formulation and corresponding user comments. It is also intended that the prototype is also usable in groups, thus fostering discussions. The *immersion factor* – getting engaged in the process of the game – is addressed by the problem-based formulation of the task, and the exploratory breadth provided by the variety of 11 CCO generic causes and counterpart intervention principles.

Initial brainstorming to provide the four necessary conditions of learning [10] resulted in the following way to explicitly implement all four: *contrast*, *separation*, *generalization*, *fusion*. For the early prototype, all four are expressed through role-play in the peer assessment. This means that after generating own ideas, players are asked to assume various roles from the scenario, are given ideas suggested by others and are asked to provide feedback. Seeing new realistic ideas covering the full spectrum of CCO exposes players to *contrast* and *separation*. While role-playing, players provide feedback from the perspective of an offender or potential victim. This allows them to maintain focus on CCO while considering the context of different preventive interventions and perspectives, thus experiencing *generalization*. The prototype allows players to review their own ideas once again at the end and thus *fuse* between their initial ideas and what they have seen during role-play.

Developing a game using rapid prototyping means having two concurrent and interacting streams: development (progressing from paper-based materials to software) and evaluation. These correspond to the materials and procedure of the evaluation studies and are described in dedicated sections below.

## 3.1. Materials

Our approach to rapid prototyping included early paper-based versions of the intended game interaction and using the *Scrum* software development methodology [17]. In response to formative feedback the development process included two paper prototypes and a subsequently and continuously developed software prototype with stable releases every two weeks. Each of those prototypes is based on a scenario that features a recurring crime or disorder event. By using each of the prototypes users are asked to come up with contextualized cause and intervention ideas, and subsequently to assess such ideas, proposed by others. The narrative of this scenario also evolved in parallel with the development of the prototype.

### 3.1.1. Paper Prototypes

The first paper prototype was developed with the intention to encourage participants to both decide how they could re-use existing crime prevention good practices for the scenario, and also be innovative and come up with their own ideas. We designed a board-and-cards prototype to be used by a group. In it the discussed scenario is presented through a narrative text, a map, and a set of photographs of the environment. When using the prototype each participant receives a board with the CCO radial diagram (see *figure 1*) and a stack of 50 of cards with ideas on them. Participants are also given blank cards and a pen to suggest new ideas whenever appropriate.

After the board-and-cards prototype, a second carbon-paper-and-pen prototype was developed. This second prototype uses the same board as the first one. However, instead of providing participants with ideas in the form of cards, it allows them to freely write ideas on the board. They are offered only one idea as a 'starter' example to refer to. A facilitator guides participants through a process of getting to know the scenario, three phases of generation of ideas and three phases of role-play and revision of ideas. At the end the facilitator collects the materials for assessment by an expert.

### 3.1.2. Browser-based Prototype

Participant feedback from the second paper prototype

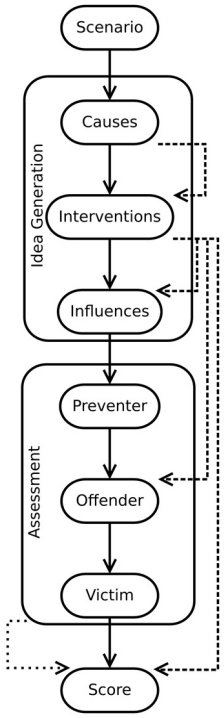


**Figure 2.** The process and data flow established in the browser-based prototype. The solid line in the middle between activities represents the process flow. Dashed lines to the right represent flow of ideas (text-based qualitative data) and the dotted line to the left represents flow of assessments (numeric data), which are similar for all three assessment screens

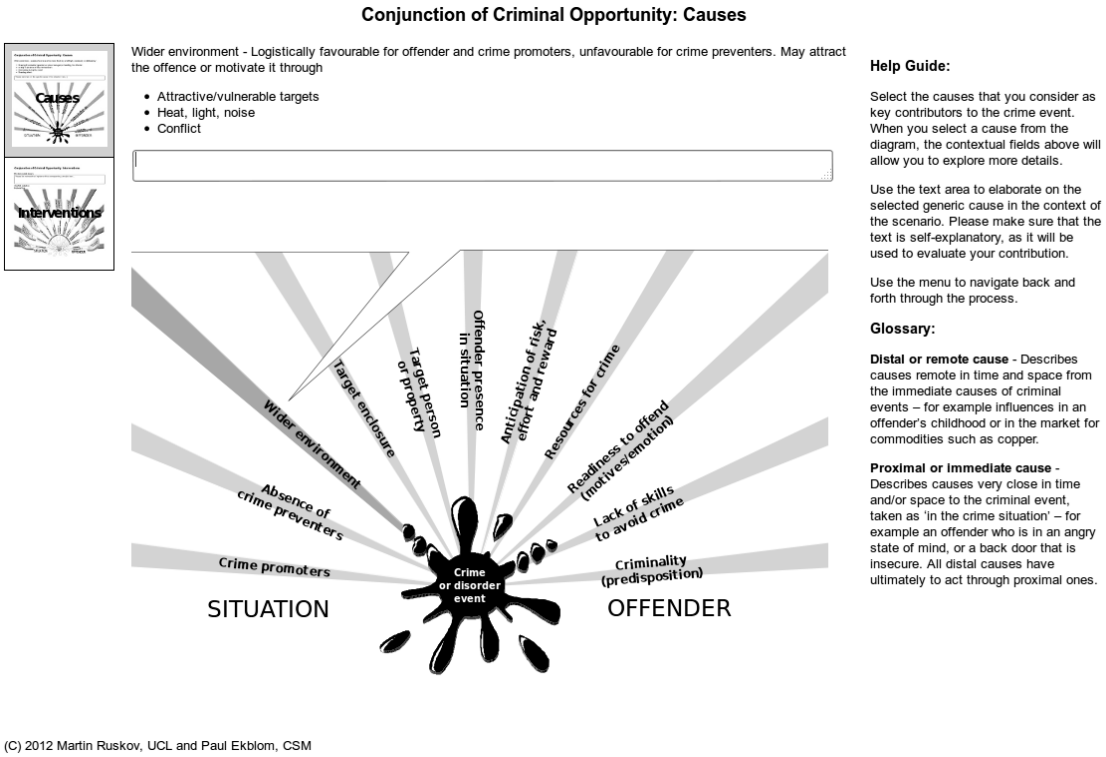


**Figure 3.** Sample screen of the Interactive part of the browser-based prototype also featuring the CCO diagram used throughout the studies. On the left is a navigation menu allowing participants to switch between currently accessible views. On the right there are static context-specific explanations

was positive (more details in the procedure and results sections) and it was chosen as a basis of a computer-based version. For it, a website with a Model-View-Controller architecture was developed. It features the same process, plus a final score screen for immediate automated feedback when possible. The overall process can be split in scenario, idea generation, role-play assessment and score (providing feedback) wider parts, as illustrated on *figure 2*.

After initially reading through the scenario, in the idea generation part, the browser-based version features a clickable version of the CCO diagram. Whenever a participant clicks on one of the 11 contributing causes of CCO, further information appears and the participant is prompted to type ideas in a dedicated dialogue box (see *figure 3*). Participants are sequentially taken through two related screens with the diagram, one for ideas for causes, and another one for ideas for corresponding interventions. The ideas (text-based qualitative data) collected in each of the screens are further re-used. Ideas for causes are prompted as reminders at the interventions screen and ideas for interventions are worked with further as explained further in this section.

After the phases of generation of causes and interventions, participants are given access to a table having the proposed interventions as rows and the 11 CCO generic causes as columns. This way they can further explore the impact certain intervention could have on wider causes.

The assessment part of the process prompts participants to evaluate ideas of interventions generated by other players (for example previous participants). This is done by letting participants grade each idea along a 5-point Likert-scale [18]. This way qualitative text data is given quantitative assessment by other users. Participants are first asked to assess how strongly each idea impacts the criminal opportunity. After this initial assessment, two more follow, this time asking participants to think from a different role perspective. One of the subsequent assessments puts them in the role of the offender assessing how ideas impact upon the criminal opportunity. In the last assessment players are put in the role of neutral citizen who could potentially become victim of crime, helpful preventer (someone who by their action or presence makes crime less likely) or even unintentional crime promoter (someone who inadvertently makes the crime more likely to happen, e.g. by failing to lock a door). In contrast to the previous assessments where probability of criminal events is explored, in the third one players are asked to assess if intervention ideas have impacted the harm that the criminal event can cause once it happens.

The final game screen delivers the score achieved by the player. This includes overall score and ranking of the player, and a table with suggested intervention ideas and a breakdown of the three scores these ideas received from other players. In order to be able to deliver feedback instantly at least some partial assessment of ideas is necessary. To this end, newly suggested ideas are matched against patterns derived from the database of previously suggested ideas. When a new idea can be matched to a pattern with good certainty, it is automatically assigned the average assessment of previous ideas matching that pattern.

A widely used framework for rapid prototyping in software development – *Scrum* [17] – was used. The development effort consisted of 2-week iterations (called *sprints*). In effect overall goals were identified, but priorities of tasks to be implemented were planned only for the following *sprint*. Tasks needed to be broken down to an oversee able complexity. Then the effort needed to implement them is estimated by the developers. As a result of this process there was a growing list of tasks that have been identified as potential improvements, but are considered of too low priority to be implemented in the foreseeable future.

To facilitate this process an online software project management platform was used. The features that are intensively used are version control, ticketing system and milestone/*sprint* planning. In order to allow for browser use and flexibility established web technologies were chosen for the development platform, notably JQuery and SVG.

## 3.3. Procedure

The prototype is designed to address knowledge which requires users that have crime prevention expertise. Graduate students at the Jill Dando Institute of Crime Science at University College London were considered to be subject matter experts (SMEs) and approached with a proposal to be participants in studies with the prototype. So far three small-scale formative evaluations have been conducted with the paper prototypes and two with an early version of the browser-based prototype. These are summarized in *the table* and described in further detail below. For one of the studies it was considered that usability expertise would be useful, so correspondingly usability experts were recruited.

### 3.3.1. Paper Prototype

One evaluation was done with the board-and-cards paper prototype and two with the carbon-paper-and-pen prototype. The first took place as a one-hour game-playing session and a subsequent half-hour focus group with four participants. They were given a personal set of board and cards and a pen to write on blank cards. Participants were explained the scenario and asked to discuss and propose ideas each by putting them on their personal board. After each 15 minutes they were asked to change places and discuss the ideas of others.

The second prototype (carbon-paper-and-pen) was used in two different evaluation sessions. The first one was intended as a focus group with three participants, but due to absent participants actually turned out to be a one-participant one-hour think-aloud session. The second was a deployment of the prototype in a class environment. A class of seven students was split into three groups and each group was given a folder containing the carbon paper version of the prototype. All participants engaged with providing ideas intuitively when they were told they could write on the A3-sized paper diagram they were given, representing the game board. In these circumstances participants were given 45 minutes, but that time was insufficient for the role-play assessment part of the process.

After the successful studies with the second prototype it was decided to move on to a browser-based prototype mimicking the paper-based interaction of writing on segments of the diagram.

**Table 1.** Summary of conducted formative evaluations. As a result of rapid prototyping prototype versions were released every fortnight. The 5th such browser-based version was considered to have sufficient functionalities to start formative evaluations

| # | Version | Participants | Group size | Participant expertise |
|---|---|---|---|---|
| 1 | 1st paper | 4 | 4 | SME |
| 2 | 2nd paper | 1 | 1 | SME |
| 3 | 2nd paper | 7 | 2-3 | SME |
| 4 | 5th browser | 3 | 1 | Usability |
| 5 | 7th browser | 2 | 1 | SME |

### 3.3.2. Browser-based Prototype

The browser-based prototype was under continuous scrutiny and discussion by members of the development team, including non-technical SMEs. So far it has already gone through two evaluation iterations with participants. Three usability experts commented on it and two SME participants used it in a think-aloud session. The usability experts provided a total of 50 recommendation items in total. Recurring ones had to do with the oversight of the process through the navigation menu and distributing information in on-demand tooltips to reduce its perceived volume.

SME participants took about 45 minutes to complete the game process without being pressured by time. In the think-aloud sessions participants were very positive about the idea of providing a dynamic interface to introduce something as complex as CCO.

# 4. Results

The five small evaluations in this case study gave us confidence that we are currently on the right track in our development process. Typical for *Scrum*, this feedback provided us with clarity about short-term steps that need to be taken and some vision how a future browser game should look like.

Early results from the knowledge sharing mechanism piloted with this prototype are encouraging. In the first paper prototype participants got focused in reading the multitude of ideas present to them with the cards. On several occasions they were reminded that they could suggest their own ideas, which resulted in discussions, but it actually required input from the facilitator to get the raised ideas written on new cards. In the focus group they commented that they didn't find the map and photographs useful. This prototype was considered unsuccessful, because it overloaded players with options, thus causing *paralysis by analysis*. Once this obstacle was removed and players found it easier to contribute, they readily completed nearly the whole wide range of contributions, resulting in more than

25 ideas each on average.

SMEs evaluating the browser-based prototype provided suggestions of how to improve the usability and attractiveness of the prototype. They further provided comments that were very different from those of usability experts, but overall there was considerable overlap between the two SME participants. They felt confused about the terminology used by CCO, as it somewhat differs from theories that participants were more familiar with. They also both challenged the design and layout of the CCO diagram, which has essentially remained unchanged since its origin in 1998.

A comparison between feedback from the two evaluations with the browser-based prototype can be made. Whereas naturally usability experts provided very specific ideas about improving the general usability of the prototype, feedback from SMEs was much more focused on the actual way CCO is used. As a result of the evaluations, on a number of occasions development priorities were reshuffled.

Some of the ideas that SME participants proposed are commonly used tactics like police patrols or installing CCTV, others are more specifically tailored and sometimes innovative. In this initial multitude some ideas often get repeated by different players. Of the six instances (four with the second paper prototype and two with the browser-based prototype) when users generated their ideas themselves, there were six ideas that came up three times or more. The pattern matching mechanism managed to match very few of those. As a result scores were not representative in the eyes of participants. However, when one of the participants saw someone else's ideas being the same as the one she had just contributed, she got noticeably intrigued.

## 5. Conclusions and Future Work

The adoption of a rapid prototyping approach gave early feedback and guidance in the development process. Resulting from this approach, evaluation activities had to be adapted accordingly. Taking a more flexible approach towards evaluation allows for earlier insights into the implementation of certain design ideas and consequential early remedial actions in the game design.

This study attempted to minimally deliver for easy learning a complex crime prevention framework. Early feedback that we got indicates that utilizing interactive diagrams where players can drill-down into complex aspects is a promising way to do that.

Furthermore the multitude of commonly recurring ideas might allow for easy and relatively accurate clustering of player ideas. This is possible, because the prototype puts contributions in the context of CCO and its scenario. As a result, wordings are easier to interpret contextually. To do that clustering and classification algorithms will be put in place to better capture repetitive ideas. This part of the development process is data-driven and as a next step ideas will be represented in a bag-of-words form, only counting word occurrences. This representation will be used to define aggregated word clusters and subsequently to match new ideas towards the average word usage. Once such an idea matching mechanism is in place, it would allow for immediate feedback on newly suggested ideas, reuse of assessment and comments on previous similar ideas and higher chances of identification of innovative ideas (those that do not match any existing pattern). In the crime prevention context, such innovation is particularly important given that professional preventers are in an arms race with offenders [19].

Despite its existence in over a decade and positive reception among crime prevention practitioners across the world, feedback collected in these studies, challenged CCO itself. Participants had very specific comments regarding the visual representation of the theory and the terminology used. As a result, efforts have started towards re-phrasing and re-designing the CCO diagram and its terms, but this theoretic and knowledge-management process might continue beyond the scope of the game prototype project.

This research will be continued with a controlled experiment comparing the effects of applying variation. Twenty four participants will be split into two experimental groups – one with role-play as the implementation of variation and one without. The two groups will be given the same amount of time and their final intervention ideas will be assessed.

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