Bomberman Clone AI Intelligent Bomb Placement

A. B. Callao, *BSCS*
M. E. A. Dayrit, *BSCS*
D. J. Llaneza, *BSCS*
I. A. T. Ranario, *BSCS*

I. Introduction

Computer games have a long tradition in the *Artificial Intelligence* (AI) field. Many researchers are looking for ways to develop an AI that will defeat the world human experts. Some of the computer science students around the world use the game to study the field of artificial intelligence. Based on a research conducted from Entertainment Software Association, video games courses and degrees in the U.S. increased by more than 50% in five years, and artificial intelligence does not disappear from the list of courses [1]. Also, in 2016, Entelect has announced the theme of AI challenge centered around the classic 1980's strategy maze-based game, Bomberman. Players will be placed in an unfamiliar environment and must find their way through a maze while avoiding enemies and bombs, the goal of their AI is to outlast their opponent to remain the last one standing [2].

The researchers will be using the strategic maze-based game franchise Bomberman and will make the case for why it is suitable for the algorithm they want to use and very flexible game environment for learning artificial intelligence methodologies.

There are general algorithms to create a non-player character (NPC) for Bomberman game, algorithms used depending on the behavior of AI. Some of the useful algorithms for the game are minimax algorithm, Alpha-beta pruning, Monte Carlo Tree Search, and other algorithms. Also, the most popular choice for pathfinding, A-star (A*) algorithm and it's also applicable to this study because it's fairly flexible and can be used in a wide range of contexts.

II. Project Context

Most of Bomberman version that has the feature of battle mode, which is the goal of the player is to kill the other players or AIs to be the last one standing. But based on the observation of the researchers and some experience of player of this game, there is some version of Bomberman that the AI was not really great, lack of skills, and sometimes they are clumsy and doesn't know how to deal with the player. Example of this is Super Bomberman 4 which has the feature of battle mode, there is a website showing the video of the player while playing a Bomberman. In the caption, he said that "I never had to press a single button", but suddenly he still won the game [3].

Improvement of the game was a great opportunity for the researchers and also in the field of artificial intelligence. Because, as the researchers discussed in their introduction, there are competitions about developing AI for games, and most of the schools teaching their students in this field.

The pathfinding A* algorithm is one of the algorithms that can be used for AI agents to find a safe place to hide and to find the nearest bomb to avoid the explosion. A* is like Dijkstra's algorithm in that it can be used to find the

shortest path and it can use a heuristic to significantly speed up the process.

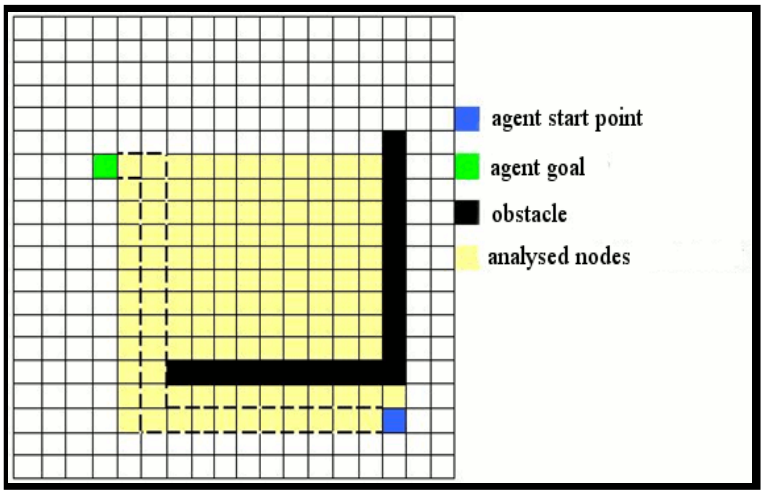

Figure 1. A* Pathfinding

Figure 1. The researchers study the idea of the algorithm and it is more efficient for the AI to discover fast from its starting point to his goal. The researchers intended to use the standard heuristic *Manhattan Distance*, is ideal for grids that allow 4-way movement up, down, left, right.

A. Bomberman Clone Platform

The researchers will be going to implement a simple version of Bomberman. Since they are focusing on the development of their AI, they decided to search for an existing one. The researchers found an article entitled "How to make a Game Like Bomberman", in this website, it provides a tutorial of how to implement the Bomberman in Unity3D using a C-sharp programming language with materials and some kinds of stuff used in the project [4]. It also includes the final project of the game. But there are some missing parts of the project, so the researchers intended to add some features to the game.

In the version of the platform that the researchers intended to implement, it inherits some features of the original Bomberman like bombs, chain reaction, destructible, indestructible walls, and players make an action simultaneously by using up, down, right, left, bomb, and do nothing. There are no power-ups, the radius of the explosion is constant with the value of 3 tile and players can only place 3 bombs at a time to kill the enemy. At most 4 players can play the game simultaneously. And the last player standing will win and end the game.

B. AI Agents

The researchers were looking for the most general solution for their AI which can solve as many types of problems as possible. A program which is capable of changing itself until it reaches a suitable answer to the question. Hence, designing a natural selection based and evolving AI may give us a solution to the problem. The field of Evolutionary Algorithms and Evolutionary Computing has been investigating since late 1970's and is still being investigated today.

Genetic Programming is a type of Evolutionary Algorithm, a subset of machine learning that creates computer programs in the LISP or schemes computer languages as the solution. It represents a tree structure of actions and

values, usually a nested data structure. A program code is coded as a genome and is evaluated using problem instances as an input. The code's output and its relation with pre-defined 'good' solution to the problem are then calculated to obtain fitness.

Solving game algorithms such as Chess, Checkers, Tic-Tac-Toe and other games, was a very big part of using Genetic Program (GP). A game attracted the human mind and the effort to create a human-level AI and still inspires a lot of research. In this study, the researchers will be focusing on the development of GP that gain experience from another player. In order to achieve the evolution of the GP or the researchers called it Evolving AI, they will be using a Tree-based structure and also intended to implement other AI agents for the Evolving AI to train and develop itself.

This study will be aiming to develop an NPC for the game. The researchers can do that by implementing different behaviors for AIs. In order to make interesting for the player to play the game, there are 3 AIs to deal with the player, a Genetic Program or Evolving AI that can train itself properly from the strategy of other players, and 2 AI agents with a pre-defined heuristic, the behaviors for AIs are defensive and aggressive behavior. And the human-player or the person who play the game using keyboard. The total of 4 players plays the game simultaneously.

III. Purpose and Description

The main purpose of this research is precisely to contribute to the educational gaming landscape, by providing an efficient algorithm for the game, focusing on the development of AI agents by giving them different behaviors, and develop an algorithm for the Evolving AI that plays the game and gains experience against a diverse set of players, making it capable of competing against any kind of player.

The researchers only planning on developing the AIs and giving improvements report of the Evolving AI by its learning and its fitness of the game. Evolving the AI by generating the game multiple times or what the researchers called it Generation and adapt or gain experience from aggressive and defensive AI. Thus, to make it more intelligent, playing against the player is also a way for improving the skills and strategies of the Evolving AI.

Researchers also use some sort of open source project for the game platform, in order to reduce the time for developing the game but focusing on the algorithm of AIs. Since the researchers found a useful project for Bomberman platform but it doesn't have a destructible wall, researchers also adding a generate function for a destructible wall that will place in a random tile of a board.

IV. Objectives

The aim of this study is to develop an algorithm using Genetic Programming Technique for evolving AI in the game Bomberman. It is also aimed to implement other AI agents using pre-defined heuristic in order to improve the skills of Evolving AI. Specifically, it is aimed to achieve the following objectives:

1. To design an algorithm using Genetic Programming Technique for the Evolving AI.
2. To apply the pathfinding algorithm for other agents that can be used to their behavior.
3. To implement a simple Bomberman platform for the game environment of the AIs.
4. To test the efficiency and improvements of the algorithm than the other agents.

V. SCOPE AND LIMITATIONS

The objective of this study is to develop an algorithm that can be used to evolve an AI by itself in the Bomberman game. For this study, the algorithm shall only be applied in one AI and the other AIs uses a behavior and some sort of pathfinding algorithm.

The Evolving AI will develop its own strategies for playing the game based on what it has learned from actually playing the game. The principle being that the AI will evolve its own way of playing through trial and error. In order to check its learning, the researchers provide a useful information that will display in the game. It will display the average fitness and the total generation of AI where researchers can analyze the behavior and its learning from the game.

The researchers will use a pathfinding algorithm for other agents and the heuristic function intended to use is Manhattan Distance. Also, the behaviors or our two AI agents are the most commonly used in Bomberman AI are aggressive and defensive. The maximum player in the game is 4, which is the player, aggressive and defensive AI and the Evolving AI. The version of the platform is simple which is there are no power-ups and the maximum bombs that you can place at a time is 3.

By using other agents to train the algorithm, researchers intended to use the two behaviors:

Defensive Behavior:

- Pick the nearest destructible wall where he is able to reach.
- Avoid player, avoid cross paths with bombings in line, avoid corners and dead-end paths.

Aggressive Behavior:

- Chase the player, staying two to three steps ahead of him.
- Avoid corners, but use the bomb space to protect himself if necessary.
- Keep tracking the bombs timers and ranges.

A. Definition of Terms

- **Artificial Intelligence** - is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans.
- **Evolutionary Algorithms** - applies the principles of evolution found in nature to the problem of finding an optimal solution to a Solver problem.
- **Genetic Program** - the problem is encoded in a series of bit strings that are manipulated by the algorithm.
- **Genome** - contains all of the information needed to build and maintain that organism.
- **Heuristic** - involving or serving as an aid to learning, discovery, or problem-solving by experimental and especially trial-and-error methods.
- **LISP** - it provides wide-ranging data types like objects, structures, lists, vectors, adjustable arrays, hash-tables, and symbols.
- **Manhattan Distance** - it is a square grid that allows 4 directions of movement used in a heuristic function.

VI. Related Literature and studies

This study is going to exemplify the facts and information related to the study of the researchers entitled "Bomberman Clone AI Intelligent Bomb Placement". It will start with general information about foreign and local studies related to the study of the researchers.

A. Related Foreign Studies

There are many different approaches in Artificial Intelligence, with generation algorithms for building them, either by hand or automatically by computer. Also, many researchers got interested in creating AI for games and to find a solution to different problems about games.

A project named "Evolving Agents for "Bomberman" Project Report" (2016) made by Yuval Gelbard and Gal Bar-On presented a Bomberman AI and implemented Genetic Algorithm. they only managed to run about 100 generations in 24 hours which utilized an important amount of their time. they realized towards the end that their agent mainly spent time hiding in corners and watching other agents destroy each other, which made it develop a rather inexplicit strategy. It even managed to dodge a few bombs, but would never attempt to attack, or kill another player. They've used decision trees made of 3 types of nodes to implement their GP and create a fitness function based on the score of the player to normalize the formula. [5]

A study made by Manuel António da Cruz Lopes titled "Bomberman as an Artificial Intelligence Platform" (2016), which is the main goal of the study is to develop a Bomberman-based AI platform and to create AI agents using that platform. one of the contribution of the study is an implementation of a set of simple heuristics capable of providing basic capacity for an agent, namely the ability to stay away from explosions, to run along and explore through the maze (by demolishing blocks) and to beat other agents. the study implements one of many different searching algorithms such as the DFS, BFS, and A* algorithm. [6]

The other study is David Churchill's "Heuristic Search Techniques for Real-Time Strategy Games" (2016) wherein it introduces and motivates the main topics of RTS AI research, and modified which areas need the most improvement. he described the RTS AI research he had conducted, which consists of five major contributions. First, the depth-first branch and bound build-order search algorithm, which is capable of providing professional human-quality build-orders in real-time, and was the first heuristic search algorithm to be used on-line in a Starcraft AI competition setting. Second, the RTS combat simulation system: SparCraft, which includes three new algorithms for unit micromanagement (Alpha-Beta Considering Durations (ABCD), UCT Considering Durations (UCT-CD) and Portfolio Greedy Search), each outperforming the previous state-of-the-art. Third, Hierarchical Portfolio Search for games with large search spaces, which was applied to the AI system for the online strategy game Prismata by Lunarch Studios. Fourth, UAlbertaBot: the starcraft AI bot which won the 2013 AIIDE Starcraft AI competition. And fifth: the tournament managing software which is currently used in all three major starcraft AI competitions. [7]

B. Related Local Studies

There are also local studies in the Philippines that are associated with the study of the researchers.

Professor Rafael Cabredo of De La Salle University-Manila has made discussed his research namely "Research Directions in Computer Game AI" in which described the different approach in artificial intelligence in computer games. First, he gave an information about Computer Game Industry that some facts according to his research, 92% of all games are purchased by adults and there will be 131 million online gamers worldwide in 2006 (DFC Intelligence Report). And then he provides guiding behavior of NPC like Steering, Pathfinding, Scripting and Final State Machines. In his research, the most waypoints to help NPCs find a route is A* algorithm and described the Finite State Machine effect under which events or conditions a current state is to be replaced by another. Some games with intelligent opponents in the Philippines are CAN, MAHUSAI, RL Hero, AGIMAT, and UMAGA. [8]

The Students from Ateneo De Manila University, Michelle P. Banawan, Rey R. Alino, Cesar A. Tecson, and Wilfredo B. Badoy Jr., had presented a research titled "Magsasaka: Farming Mobile Game" and it states that This game was also evaluated using a heuristic suitable for games. One of their goals is to be able to verify the implemented game using appropriate heuristics. Their heuristics were based on a survey of usability problems that were mostly experienced with video games. The heuristics are (1) consistency, (2) customizability, (3) predictability, (4) proper views, (5) skip nonplayable content, (6) input mappings, (7) controls, (8) game status, (9) training and help, and (10) visual representations. For the Magsasaka Mobile Game prototype deployment, the evaluations of the game's success were in three general areas, namely: (1) gameplay, (2) interface and other applied multimedia game components, and (3) entertainment. [9]

Another research from the website PWC Philippines, there was an article entitled "Automation and Artificial Intelligence: What it means for every Juan". This research was posted by Angelo L. Basuan on September 14, 2017 and according to his research that the adaption of new technologies has become necessary in order to transform global companies into digitally enabled enterprises. Robotic Process Automation or 'RPA' is part of a wide spectrum of Intelligent Automation, along with Artificial Intelligence. Also, in gaming, both IBM's Watson and Elon Musk's OpenAI defeated game champions in Jeopardy and Dota 2. All of these capabilities are driving innovation at the cutting edge of AI, which can be seen in various applications today. [10]

C. Related Foreign Literature

There's a study entitled "Game Artificial Intelligence Literature Survey on Game AI" (2009) by Venkataramanan.K and it states that Games have long been a popular area of AI research, and become a fast growing software industry since 1990s. Video and symbolic games have become a facet of our daily lives and a major way of entertainment. Despite the fast expansion, research on intelligent games with learning function is still in its initial phase. A game that learns to evolve through interactive actions and plays will make the game more challenging, more attractive, and demand less for labor-intensive script design and planning when

developing a game. The recent research shows that computational intelligence techniques may produce a powerful tool set to solve the difficulties in game learning. Also, the objective of this project is to conduct literature survey on AI games with various learning functions, and develop a simple learning scheme for AI games. [11]

A research that was conducted by S. A. Oke from the University of Lagos, Nigeria named “A Literature Review on Artificial Intelligence” (2008) said that the research on AI field in the last two decades has significantly improved performance of both manufacturing and service systems. Currently, there is serious need for an article that presents an entire literature survey of worldwide, theoretical frameworks and practical experiences in the field of artificial intelligence. This paper reports the state-of-the-art on artificial intelligence in an integrated, brief, and elegantly distilled manner to show the experiences in the field. In particular, this research paper provides a broad review of recent developments within the field of artificial intelligence (AI) and its applications. The work is targeted at the newbies when it comes to the artificial intelligence field. It also reminds the experienced researchers about some of the issue they have known. [12]

“The History of Artificial Intelligence” (2006) by the University of Washington which once the History of AI applied to Chess was discussed and it stated that the Chess has long been considered a game of intellect, and many people are exploring of computing felt that a chess-playing machine would be the hallmark of true artificial intelligence. While the Turing Test is a grand challenge to ascertain machine intelligence, chess too is a good pursuit, one which fortunately has been ‘solved’ by AI researchers; producing programs which can rival if not best the world’s best chess players. However, even the best gameplaying machines still do not understand concepts of the game and merely rely on brute force approaches to play. [13]

D. Related Local Literature

The Genetic Algorithm also use Philippines to solve a complex problem. Rosaly B. Alday one of the researchers of "Genetic Algorithm for Solving Balanced Transportation Problem". Student of Philippines University, Capitol Site, Batangas City. On the basis of the results of their research on genetic algorithm and applying the algorithm to the balanced transportation problem, it was concluded that the GA is a useful tool to help solve the optimization problem especially optimization problems with large search space and will produce good results. However, the study had dealt only with specific applied problems which needs confirmation with the other math classes. In general, there must be a lot testing to be done on many other different problems. Further work may be used in combination with changes in population size, or defined "age" of the individuals involved to determine the evolutionary increase or decrease population size is the natural evolution. [14]

There is also a research in Philippines about Artificial Intelligence of what are the great impact on helping people on making their decision throughout their lives. Perez, Raphael Ray L. student of Polytechnic University of the Philippines, discussed different approach about the field. AI depends on a broad intercourse with computing disciplines and with fields outside computer science, including logic, psychology, linguistics, philosophy, neuroscience, mechanical engineering, statistics, economics, and control theory, among others. This breadth has

been necessitated by the grandness of the dual challenges facing AI, creating mechanical intelligence and understanding the information basis of its human counterpart. AI problems are extremely difficult, far more difficult than was imagined when the field was founded. However, as much as AI has borrowed from many fields, it has returned the favor through its interdisciplinary relationships, AI functions as a channel of ideas between computing and other fields, ideas that have profoundly changed those fields. [15]

Video games have already captivated Filipinos. From online games down to LAN games it truly caught the attention of Filipino gamers. But it's not just the gamers who are trying to make a name from themselves, but also developers as well. Mon Macutay in his blog article *Pinoy-made Video… (Macutay, 2007)* mentioned 2 games that are made by Filipino game developers. Anito: Defend a Land Enraged was released by Anino Games is an RPG game for PC and features 16th century Asia as its setting. The game won 2004 Role Playing Game of the Year in the 2004 Independent Games Festival. Another game that was developed by Filipinos was Terra Wars: NY Invasion released Ladyluck Digital Media. It is a first-person shooter game that involves aliens as enemies. Unfortunately, however for Terra Wars IGN had given them a 2 out of 10 reviews, according to IGN *Terra Wars:(Bitton, 2006)* "Terra Wars is simply the latest addition to the horde of generic first-person shooters available on the market today. Even though Terra Wars did not quite work for Ladyluck Digital Media but through the years they eventually worked with clients such as Activision, Ubisoft, Sony, EA and many more proving that Filipinos has already reached its potential in the field of game development. [16]

VII. METHODOLOGY

The researchers decided to use Agile Software Development which is a highly interactive systems development approach and Agile methodologies facilitate commitment and self-organization by encouraging team members to pull items from a prioritized work list, manage their own work, and focus on improving their work practices. These practices form the basis of self-organization, which is the driving force for achieving results in an agile team.

The researchers preferred Agile as the software methodology due can focus on high-quality development, testing, and collaboration. Also, by producing frequent builds and conducting testing and reviews during each iteration, improved by finding and fixing defects quickly and identifying expectation mismatches early.

Library Method

This method was one of the most suitable methods used. The researchers read books and past thesis projects in the Library to help the researchers in gathering relevant information that is needed. And they found out the study entitled "An Algorithm for Maze Puzzle" and look for the recommendation and they suggested that Depth-First-Search (DFS) can be applied to another game. Suddenly, the researchers came up with the idea of the game Bomberman that uses the board like a maze by providing the path using the DFS algorithm. But using the DFS in the Bomberman AI is not efficient and too slow. So, they try to research using Internet Research Method.

Internet Research Method

This was a way in which the researchers collected data via the internet to broaden their knowledge in the technical aspect of the developed system. The Internet allows the researchers to search for references and articles that

contributed to the development of the system. It also produces also a good support regarding recent information that is not yet available at the Library.

The researchers found another game which is Bomberman that can apply the field of artificial intelligence for NPC. They use a different approach to study the AI to use in the game and found different behaviors and pathfinding algorithm for AI. Also, they also research a genetic programming that is possible to apply in the game.

As the researchers discussed in their related studies, it is possible to develop our research about the game. They study the environment of the game and how they can improve the AI. They found different suggestion and ideas on different website discussion:

http://forums.winamp.com/showthread.php?t=65443
https://www.newgrounds.com/bbs/topic/932262
https://www.scirra.com/forum/bomberman-mechanics-for-ai_t196162
http://theory.stanford.edu/~amitp/GameProgramming/Heuristics.html#S7
https://www.gamedev.net/forums/topic/622051-ai-for-simple-bomberman-game/
https://cs.stackexchange.com/questions/45312/name-of-bomberman-algorithm
https://www.gamedev.net/forums/topic/319837-bomberman-ai-warning---long-post/

Pathfinding

A* Search algorithms, unlike other traversal techniques, it has “brains”. What it means is that it is really a smart algorithm which separates it from the other conventional algorithms. This fact is cleared in detail in below sections. And it is also worth mentioning that many games and web-based maps use this algorithm to find the shortest path very efficiently (approximation).

The pathfinding is a most important algorithm for game Bomberman in order to create an AI because it uses to find the position of his goal in a fast way. By using this algorithm, researchers can possible implement the algorithm in the AI agents and then observe the behaviors to make it more perfect.

Genetic Programming

One of the central challenges of computer science is to get a computer to do what needs to be done, without telling it how to do it. Genetic programming addresses this challenge by providing a method for automatically creating a working computer program from a high-level problem statement of the problem. Genetic programming achieves this goal of automatic programming by genetically breeding a population of computer programs using the principles of Darwinian natural selection and biologically inspired operations. The operations include reproduction, crossover, mutation, and architecture-altering operations patterned after gene duplication and gene deletion in nature.

The researchers also found another solution for Bomberman AI to make it more intelligent to deal with other players. Genetic Programming is one of their solutions to give an evolution for the AI based on its experience from the game. Evolving the AI is more interesting and it will become more challenging for the player. It is also possible to achieve this technique for AI that can learn from its experience based on the population, mutation, and generation of the AI. They commonly use the online research method for this study to gain more knowledge about the field.

REFERENCES

[1] [Online] Entertainment Software Association Research about Video Game Courses and Degrees
http://www.theesa.com/article/video-game-courses-degrees-u-s-increase-50-five-years-2/
[2] [Online] Entelect Challenge 2016 – Strategy maze-based game, Bomberman
https://challenge.entelect.co.za/
[3] [Online] Super Bomberman 4 – Idiot AI
http://curvetube.com/Idiot_AI-Super_Bomberman_4/QorQQVG8pFI.video
[4] [Online] How to make a Game like Bomberman
https://www.raywenderlich.com/125559/make-game-like-Bomberman
[5] [PDF] Evolving Agents for "Bomberman"
http://www.moshesipper.com/uploads/3/0/8/3/30831095/yuval_g._and_gal_b._-_evolving_agents_for_bomberman__spring_2016_.pdf
[6] [PDF] Bomberman as an Artificial Intelligence Platform
https://sigarra.up.pt/flup/pt/pub_geral.show_file?pi_gdoc_id=861067
[7] [PDF] Heuristic Search Techniques for Real-Time Strategy Games
www.cs.mun.ca/~dchurchill/pdf/DavidChurchill_phd_thesis.pdf
[8] [PDF] Research Directions in Computer Game AI
www.dlsu.edu.ph/conferences/etfp/game_ai.pdf
[9] [DOC] Magsasaka: Farming Mobile Game
conference.upd.edu.ph/index.php/coe/11therdt/paper/downloadSuppFile/22/7
[10] [Online] Automation and Artificial Intelligence: What it means for every juan
https://www.pwc.com/ph/en/taxwise-or-otherwise/2017/automation-and-artificial-intelligence.html
[11] [PDF] Game Artificial Intelligence Literature Survey on Game AI
www.nus.edu.sg/nurop/2009/FoE/U058557W.PDF
[12] [PDF] A Literature Review on Artificial Intelligence (2008)
samolds.com/static/files/ai3014.pdf
[13] [Online] The History of Artificial Intelligence (2006)
https://courses.cs.washington.edu/courses/csep590/06au/projects/history-ai.pdf
[14] [Online] Genetic Algorithm for Solving Balanced Transportation Problem
http://www.academia.edu/5024539/Genetic_Algorithm_for_Solving_Balanced_Transportation_Problem
[15] [Online] Artificial Intelligence
https://www.slideshare.net/rap3r/artificial-intelligence-research-4140306
[16] [Online] Filipino made Video Games (2003)
http://team13boom.blogspot.com/2013/01/review-of-related-literature.html